DESIGNING STEM EXPERIENCES FOR THE FAMILY IN ORDER TO DEVELOP

STEM FAMILY HABITUS AND CAPITAL

by

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DEDICATION

This is dedicated to the families that I have taught and learned from over the years. You have always been my reason and inspiration to work towards equity in public education.

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ABSTRACT

Ethnic minority students and low-income students are grossly underrepresented in demonstrating interest and aspirations in science, evidence of science participation, and subsequent capital. Members of these populations do not often embrace a STEM identity or recognize that science, technology, engineering, and math are for them. While schools struggle to innovate in terms of how best to engage and increase aspirations and opportunities in STEM for these underrepresented populations, the family continues to be the most ignored contributor to a student's STEM identity. Families play an important role in influencing their students' attitudes, interests, aspirations, and achievements in STEM. While research exists that points to a family's capital and dispositions towards science - known as habitus - to influence their children's STEM identity, there is no research that examines deliberately-designed STEM experiences for the family, as a direct intervention meant to enhance a students' science identity. Given that identity development is a lengthy process, this study attended to the hypothesized precursors: STEM capital and STEM family habitus. Specifically, this study sought to answer in what ways designed STEM experiences were meaningful for families in the development of STEM capital and the support of STEM habitus. Drawing on parent and student surveys after the family STEM events, observations, and interviews, the findings demonstrate that the designed STEM experiences were significant in building capital through meaningful conversations and connections. The family's burgeoning STEM habitus was also made visible through developing interests, both by parents and students.

The designed STEM experiences were instrumental in connecting families to STEM investigations, developing a community of learners, and providing access to STEM participation they might not have had on their own. Implications of these findings for education stakeholders include deliberate design methods to maximize family engagement and interest, as well as ways to develop a STEM community of practice within underrepresented populations.

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LIST OF ABBREVIATIONS

STEM	Science, technology, engineering, and math
FSN	Family STEM Night
DCI	Discovery Center of Idaho
FSN-DCI	Family STEM Night at Discovery Center of Idaho
FSC	Family STEM Camp
U.S.	United States

CHAPTER ONE: INTRODUCTION

How can anyone hate science at 10 years old? Is that really possible? What profound experience can move an entire classroom of students to say that they 'hate science'? This was the phrase I heard again and again as I got to know my students through home visits early in my teaching career. I met with the families and students prior to the first day of school to introduce myself, start to get to know them, and find out what the students loved about learning. It was my first year teaching fifth grade and repeatedly the students told me they hated science. I had a hard time believing what I heard. "It's boring!" "I can't do it." "My brother says we don't need to know it." "Can't we just skip it?" After further discussion with my new students and families, it was apparent that what little science had been taught to these students had all been from a book, reading chapters with a multiple-choice test at the end. With most of the students, the families had not experienced any other academic science context for their child, nor had the school developed any other science programs, curriculum, or experiences for the students to participate in.

Aside from what I considered the school's responsibility to develop these opportunities for the students, I began to wonder how the families' influence on the students shaped their enthusiasm, curiosity, and aptitude for science. Was there a counternarrative present within the homes to rival the students' distaste for science? I also wondered what the families recognized as science in a formal or informal sense. During these initial home visits, families seemed quick to confirm the value of reading, writing, and math, but hesitant to validate science as a subject central to their student's interest. This warranted further attention and action on my part. I left those home visits with more questions than answers about my students' and families' experiences in science. I already had a fervent commitment to working with my families to be the best teacher I could for the students, but I wondered how I could encourage the relationships families have with each other towards a better attitude and interest for science? How far would my influence get me with students convinced that science wasn't for them?

In my experience, families - whether they are working class, new to country, or families of varying degrees of economic privilege - all influence their children similarly in developing their cultural norms, priorities and value systems, and in the way they see the world. "Parents are a child's first teachers" is a common quote in education and one that generally recognizes the impact of the home on the child, for better or worse (Epstein et al., 2018). These perceptions are validated by the literature in education that states that the family's influence and direct involvement is the more accurate predictor of student success and that families play critical roles in their children's overall development (Weiss et al., 2009; Henderson & Berla, 1994). However, after a child enters into the school system, families do not become obsolete in teaching and guiding their children; they continue to influence students' outlook on education and particular subjects within their education. Within the realm of science or science, technology, engineering, and math (STEM) interest and education, science or STEM identity (a student seeing science as something 'for them'), and science or STEM aspirations among students, what is the family's capacity for influencing the student? Note that the study expands each of these concepts from solely 'science' to 'STEM' so as to be more inclusive of the type of activities and conversations supported by designed social spaces within the investigations.

There is abundant research recognizing and citing the important role families play in developing students' interests, aspirations, and achievements in science (Archer et al., 2012; Archer et al., 2015; Claussen & Osborne, 2012; Dabney et al., 2013; Dewitt, Archer, & Osborne, 2013; Adamuti-Trache & Andres, 2008; Aschbacher et al., 2010; Aschbacher et al., 2014; Gilmartin et al., 2006). Some authors have documented how the family influenced students' attitudes and interest in science by various patterns of participation, family's career choices, and facilitating a student's interest in STEM subjects or activities as a significant source of developing a student's early interest and aspirations in science (Dabney et al., 2013; Archer, DeWitt, & Wong, 2014; Rodrigues et al., 2011; Mau, 2003; Atherton et al., 2009; Burt & Johnson, 2018). Other related research details the influence of the family based on a family's science capital – assets of various kinds in different networks – and how it impacts a student's pattern of aspiration, participation and opportunities in STEM (Gokpinar & Reiss, 2016; Archer et al., 2015; Claussen & Osborne, 2012; Archer et al., 2012; Adamuti-Tache & Andres, 2008).

The vast majority of this research analyzes student surveys, interviews, academic achievement, STEM class participation and completion rates, and STEM career ambition beyond high school. A few examinations of the family's influence in their child's science interest or science learning has been through informal learning or out-of-school learning environments where researchers note how the experience of the family seemed to impact the student's engagement and how the science participation or practice was received by both the family and student (Dawson, 2014; Archer et al., 2016; Bricker & Bell, 2014). In these instances, the data analyzed included surveys, family interviews, and observations. However, the studies suggest that the science education community work more closely with families, particularly those from underrepresented populations, in order to "increase their access to science-related knowledge, resources, and social capital" (Archer et al., 2012, p.905).

Many in the field articulate the gaps in STEM education success, participation, and engagement among K-12 students, but the calls for intervention are consistently aimed at schools to address those disparities (Marks, 2000; Price & McNeil, 2013; Dewitt et al., 2011; Dewitt & Archer, 2015; Claussen & Osborne, 2012; Maltese & Tai, 2010, 2011; Archer DeWitt, & Wong, 2014; Aschbacher et al., 2014; Lee, 2005). A few sources call for interventions directly with the family in order to positively influence their youth in science or math (Aschbacher, et al., 2010; Dabney et al., 2013; Gonzalez et al., 2001), but in general, the family is often left out of the equation when considering how to best reach the student and develop a stronger science or STEM interest and inclination towards the STEM areas.

Schools across the country spend substantial time and money dedicated to giving students resources, materials, classes, and extracurricular opportunities to explore and develop their STEM interests, but if it is recognized that families are an important, if not principal, influencer for students' lives and aspirations, it would be remiss not to explore the possibilities to influence the families' relationships to STEM, along with their children. How, then, can teachers and schools better design and facilitate STEM encounters with families to help broaden their views of STEM? How can schools simultaneously work to influence the families' scope and propensity towards STEM?

How can STEM education stakeholders create access to meaningful STEM for the families with the hopes of shifting students towards a positive STEM identity?

Any efforts to intentionally affect the families' disposition toward STEM subjects has the potential to provide important information on how the efforts may influence their children as well. The implications for developing more effective ways to positively influence a student's capacity for STEM subjects, aspirations, and ambitions would be significant for colleges of education, within the K-12 public education sector, and for business and industry, who may need to innovate their current outreach strategies as they look to fill future STEM-related jobs. Therefore, the purpose of this study was to create designed STEM experiences for families, tailored to minimize constraints and increase access, with the ultimate goal of impacting STEM identity among student. However, STEM identity development is a lengthy process (Brickhouse et al., 2000); consequently, this study attended to the hypothesized precursors: STEM capital and STEM family habitus. Specifically, this study sought to answer the following research questions:

1. In what ways were the designed STEM experiences meaningful for participants in terms of the development of STEM capital?
2. In what ways were the designed STEM experiences meaningful for participants in terms of the support of family habitus?

Definitions of Key Terms

STEM Capital- a mechanism for collecting various types of economic, social and cultural capital that specifically relate to science (Archer et al., 2016)

STEM Habitus- “a practical ‘feel’ for the world, framing ways of thinking, feeling, and being, such as taken-for-granted notions of ‘who we are,’ and ‘what we do,’ and what is ‘usual’ for ‘us’ (Archer et al., 2012, p. 885).

STEM Identity- skills, competence, interactions, etc, and recognizes self and by others as a “science person” (Carlone & Johnson, 2007)

CHAPTER TWO: LITERATURE REVIEW

The Gap in STEM

The National Science Foundation Indicators Report (2018) details that despite the growing demand for STEM workers in the U.S., not all Americans have equal access to STEM education, nor are women and ethnic minorities represented equally in the STEM fields (2018). The inability to meet this need, exacerbated by the underrepresentation of large sectors of the population, can be revealed by distinct gaps that exist in the K-postsecondary pipeline.

The U.S. Department of Education reports STEM education as a top priority for the country "...where all Americans will have lifelong access to high-quality STEM education and the United States will be the global leader in STEM literacy, innovation, and employment" (Charting a Course for Success: American's Strategy for STEM Education, 2018). The vision of this report includes three major goals: building a strong foundation for STEM literacy; increasing diversity, equity, and inclusion in STEM; and preparing the STEM workforce for the future. Citing the National Science Foundation Indicators report (2018), a comprehensive summary on science and engineering, the U.S. Department of Education recognizes the numerous areas in which schools currently fall short of those goals. According to the report, U.S. students' STEM skills continue to fall behind many other countries. Citing data from 2006 through 2015, high school sophomores scored below the international average in math and science and only one in five high school graduates were adequately prepared to take college courses required for

STEM majors. The report states plainly that "other countries are doing a better job preparing their students" (p. 2). The Indicators report (2018) also states that Black, Latino, and American Indian populations are significantly underrepresented in the science and engineering workforce, only representing 11% of the STEM fields. Women, too, are underrepresented, comprising only 30% of the STEM fields. These gaps for underrepresented populations in K-12 education translate to gaps with the STEM workforce.

To add further detail and context to the Indicators report (2018), within schools, there is myriad research that points to the gaffes in STEM education and outreach provided to K-12 youth (Price & McNeil, 2013; Dewitt et al., 2014; Claussen & Osborne, 2013; Haladyna et al., 1982; Calabrese Barton & Berchini, 2013). The critique includes schools' missteps in engaging the majority of students and showing innovation to increase aspirations and opportunities in STEM (Archer, DeWitt, and Wong, 2014; Archbacher et al., 2014; DeWitt & Archer, 2015). Some of the research points to the disparities that exist in current science curriculum, the way it is taught, and the populations who may have limited access (Maltese & Tai, 2010; Calabrese Barton et al., 2008; Calabrese Barton & Tan, 2009; Carlone et al., 2015; Brickhouse et al., 2000; Hurd, 2002). Underrepresented minority students persist to be under-resourced and underserved in STEM education (Aschbacher et al., 2010; Lee, 2005; Rodriguez, 1998; Archer et al., 2010; Wong, 2015; Elias & Haynes, 2008).

The remainder of this chapter will further detail the various missteps that contribute to the 'leaky STEM pipeline' (Archer et al., 2012), factors contributing to the gap in STEM for K-12 schools, the struggle for underrepresented populations to access

STEM, the constructs of habitus, capital, and identity, and the most underutilized resource in developing a STEM identity in students: the family.

Factors Contributing to the Gap in K-12 STEM Education

STEM Kept Out of Reach for Ethnic Minority and Low-Income Students

There are several factors that contribute to the success and challenges of ethnic and racial minority and low-income students in the STEM pipeline within K-12 education. A report for the Association for the Study of Higher Education articulates a number of factors that contribute to minority students' limited success in K-12 STEM education including school funding, course disparities, inexperienced teachers and low expectations, and layered challenges within individual cultures among students (Museus et al., 2011). The study documents that despite initiatives in K-12 public school settings that can and do contribute to preparedness and success among underrepresented students in STEM, it finds that "racial and ethnic minority students are least likely to be academically prepared in K-12 to be successful in the STEM circuit" (Museus et al., 2011, p.51). For example, under the 2008 White House administration, the "Race to the Top" initiative sought to incentivize schools and students from low socioeconomic communities to complete advanced science and math courses. However, in Maltese and Tai's (2011) examination of the STEM pipeline and policy initiatives during President Obama's first term (2008-2012) they found that the endeavor did not yield the results it had hoped citing that, "...it does not appear that requirements or inducements to get students to take more rigorous programs of mathematics and science coursework during high school leads to a large increase in the number of students pursuing STEM degrees" (p.900).

The relationship between ethnic minority students and low-income students is evident in the overrepresentation of youth from these populations demonstrating lack of interest in science, evidence of science participation, and subsequent science capital (Lee, 2005; Wong 2015; Wong, 2016; Dewitt et al., 2011; Archer, DeWitt & Osborne, 2015). Studies suggest that these youth are losing interest in science even before entering high school and are at a higher risk of falling out of the STEM pipeline (Wong, 2016; Tai et al., 2006; Archer et al., 2012). Students that do develop an interest in science and have higher academic achievement in science classes are more likely to be from families with higher socioeconomic status that have access to additional resources to support academic success and develop science identities (Wong 2015; Wong, 2016; Dewitt et al., 2011; Archer, DeWitt, Osborne, 2014; Maltese & Tai, 2011). "Although science learning is demanding for all students, achievement gaps indicate that it is more demanding for non-mainstream students" (Lee, 2005, p. 437), specifically underrepresented populations in STEM.

Significant challenges and barriers exist for low income and minority students to engage in STEM within school, advance their STEM aspirations, and maximize STEM opportunities and resources in order to develop a science/STEM identity during the key developmental years in school. Academic achievement in STEM classes, family members with STEM connections or careers, and educational resources are tenuous among underserved populations in school (Lee, 2005; Wong, 2016; Maltese et al., 2011). While there is evidence of various interventions and strategies to attract and retain minority and low-income students at the secondary and collegiate level, many researchers highlight the need for targeting youth much earlier to develop their interest and aptitude in STEM education (Wong, 2015; Wong, 2016; Dewitt et al. 2011; Tai et al., 2006, Maltese & Tai, 2010; Elias & Haynes, 2008).

<u>Failures in K-12 STEM Programs and Curriculum</u>

While schools are required to provide science and math education with certain benchmarks and standards set to obtain comprehension and mastery, there is mounting evidence that schools fail to do so with any lasting impact. Referring again to the Indicators report from the National Science Foundation (2018) the United States produces only 10% of the world's science and engineering degrees, while being outpaced by India and China whose countries produce almost half of the global total of degrees for science and engineering. This lack of representation and equity in the STEM fields confronts the "science for all" vision held by the Department of Education (2018). Many schools perpetuate underrepresentation in science education, especially in low income communities and within racial minority demographics, by lacking in terms of science opportunities, engaging instruction, and science curriculum that utilizes meaningful contexts and represents real-world application of knowledge (Price & McNeill, 2013; Calabrese Barton & Berchini, 2013; Lee, 2005; Calabrese Barton & Tan, 2008). The hard reality is that schools are failing to engage the majority of the students in the STEM subjects. This critique extends to the schools' ability to innovate in order to meet the challenge of these persistent gaps, increase aspirations and develop diverse opportunities in STEM for students (Archer, DeWitt, & Wong, 2014; Aschbacher et al., 2014; DeWitt & Archer, 2015). Given the body of research that explicitly demonstrates the correlation between early STEM intervention (before middle school) and the development of STEM interest (Archer et al., 2010, 2012; Maltese & Tai, 2010; Aschbacher et al., 2013), one would assume that elementary schools across the country would double-down efforts to teach the STEM subjects early and often in the primary grades. However, data from the National Survey of Science and Mathematics Education (Banilower et al., 2018) show that while almost all elementary classes spend time on math lessons each day, only one in three classes in grades 4-6 and one in five classes in grades K-3 receive daily science instruction. In addition, elementary math and science lessons receive substantially less time than reading and language arts. Finally, only 25% of elementary schools across the U.S. offer computer programming instruction (Banilower et al., 2018). These gaps represent real deficiencies in STEM education across the country.

Limitations of Informal STEM Education

It is not yet clear if there are similarly pervasive gaps present in STEM-related contexts outside of school. Aschbacher, Ing, and Tsai (2013) note that school science *is* the science that most students receive and that after middle school, STEM-related out-of-school opportunities seem to dwindle. However, out-of-school STEM and informal science education activities exist and can have positive impacts on students. Out-of-school STEM activities are based on students' choice and interest, whether structured or unstructured, and can include science clubs or camps, STEM competitions, personal science hobbies, or even reading science or science fiction literature for enjoyment (Dabney et al., 2012). While participation in these activities can help build a STEM community for students, develop confidence and acceptance, there is limited research on the effectiveness of out-of-school science activities and the influence on students long term. Dabney et al. (2012) sought to measure the impact of out-of-school STEM activities on students' future STEM interest and career choice by surveying over 6,800 university students. They found that participation in out-of-school STEM activities greatly increased the likelihood of students to show interest in a STEM career. Specifically, students reporting their participation in science clubs or competitions, even a few times a year, were 1.5 times more likely to select a STEM-related career as their major as opposed to students who did not participate in out-of-school STEM activities. However, similar to the gaps that exist within in-school STEM-related classes, there were barriers to participation, such as cost and access, especially for females and students from low socioeconomic circumstances (Dabney et al., 2012). While the benefit of participating in out-of-school STEM activities clearly benefits youth, the opportunity to access the informal science environments is not the same for all students.

According to the National Science Foundation and the Center for Advancement of Informal Science Education (2019), informal science education promotes life-long learning in the STEM fields that takes place across a variety of designed settings and experiences outside of the formal classroom. They advocate for informal science environments outside of school that provide opportunities and experiences for students and families, citing a critical role those experiences play in developing long-term STEM interests and learning (Bell et al., 2009). Much like out-of-school STEM activities, informal science learning environments can be both structured or unstructured, ranging from visits to a nature center, family discussions about science, or recreational activities outdoors. One familiar institution of informal science education is the science museum or science center.

Comparable with out-of-school STEM activities, there is limited research on institutions of informal science education (Dawson, 2014). While families attending science museums often enjoy the experience, those who take away the most from the experience often already have the cultural capital, knowledge and skills, prior to the museum visit to maximize learning and connections. Directly speaking, informal science education institutions are often not inclusive spaces, as the majority of visitors (in the U.K. and the United States) are middle class and white (Archer et al., 2016; Dawson, 2014). Barriers of inclusion, participation, and engagement are still considerable challenges for those who do not regularly attend institutions of informal science education. Archer et al. (2016) conducted a five-year study in collaboration with King's College and the Science Museum in London seeking to build science capital – a mechanism for collecting various types of economic, social and cultural capital that specifically relate to science – for students and families through a partnership with museums and schools. Part of the research monitored certain families who had not been to the Science Museum before. The study found a serious disconnect between the personal lives of the families and the museum, as families struggled to make connections between their own life to museum content. Being able to extend between scientific contexts and personal or familial knowledge is a significant part of science learning and facilitates the opportunity to develop a science identity, especially for those from underrepresented backgrounds (Calabrese Barton & Tan, 2009; Carlone & Johnson, 2007). The study's findings suggest that the resources that exist for informal science education, like science centers or museums, cluster around those who already attend these institutions and are already likely to seek out science-related opportunities (Archer et al., 2016). The study included that additional support is needed for those families who had little or no experience with an informal science environment, such as the Science Museum.

Bourdieu and Passeron spoke of this as the ‘reproduction of inequalities’ resulting in non-dominant group members being at a significant disadvantage (1990). Just as inequalities in economic capital are perpetuated by systems in place that stand to benefit from those disparities, structures are in place within educational institutions to favor those who already possess the cultural capital of that institution (Bourdieu, 1977; Harker, 1984). As with the science museum central to Archer et al.’s study (2016), the resources that existed within that institution were for those who already possessed the social and cultural capital needed to benefit from those supports. Referring to the conceptual model posed by Archer et al. (2015), science cultural capital plus science behaviors and practices along with accompanying social capital, would give an exchange value able to yield science-related aspirations and science identity. The uneven distribution of resources for families attending informal science learning institutions means that some families are simply better positioned than others to acquire an ‘exchange value’ from their museum visit (Archer, Dawson, et al., 2016). In other words, some families will continue to gain from those experiences, while others may simply not gain the STEM capital, behaviors, and practices to leverage a STEM identity. For the benefit of both the families and their students, fundamental changes are needed within environments of informal science learning in order to maximize connections, facilitate meaning making, and develop STEM capital for *all* participants.

Summary of Factors Contributing to Gaps in K-12 STEM Education

Knowing the gaps in STEM education and the translation of those gaps into the STEM workforce can seem daunting from the viewpoint of a practitioner. What can be done to increase STEM access and opportunity to our most underrepresented populations? How, then, can that access and opportunity render STEM interest, ambition, achievement, identity, and aspirations? While numerous studies demonstrate the significant source of influence families have over these STEM ambitions within their students, like STEM classes and STEM careers, Dabney et al. (2013) researched the association of family influence on students' initial science interest. Their results suggest that the family's interest in science does facilitate early science interest in their youth. Moreover, their study found that the family's interest and influence was the "primary source of initial interest in science above and beyond demographic variables such as gender, race/ethnicity, and parental education" (p. 406). Given the leverage of the family on students, further investigation is warranted.

Theoretical Framework: Communities of Practice and Bourdieu's Toolkit

This work is theoretically framed by the concept of communities of practice (Lave & Wenger, 1991) as a social learning system (Wenger, 2010) and Bourdieu's theorization of habitus, capital and field (1986). Communities of practice articulate a social system where members of the community engage and interact together which magnifies learning through participation (Lave & Wenger, 1991). This relates to Bourdieu's theorization of habitus, capital, and field as it relates to experiences in the social world. Habitus and capital interact within a certain social space, or field, and is supported by the interactions, participation, and experiences of the participants (Bourdieu, 1977, 1984). Both Lave and

Wenger's (1991) concept of communities of practice and Bourdieu's theoretical toolkit of habitus, capital, and field (1977) depend on the interaction and cooperation within a social structure, such as a school or family.

Communities of Practice

Communities of practice are "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger-Trayner & Wenger-Trayner, 2015, para. 2). Both schools and families could be considered communities of practice because they both share a joint passion and mission- their children's education. Wenger (2010) notes that in social learning systems, there are two components involved in the process of meaning-making: *participation* and *reification*. Participation entails conversations, engaging in activities, reflections, and the like. Reification is the construction of physical or conceptual objects around which people participate, such as tools, stories, and documents. Lave and Wenger assert that "...learning is not merely situated in practice – as if it were some independently reifiable process that just happened to be located somewhere; learning is an integral part of generative social practice in the lived-in world" (1991, p. 35). In other words, learning must be real, connected to the world around us, and accessible by all participants. Within communities of practice knowledge is extended by this interaction on an ongoing basis, mutual engagement, and a shared repertoire. According to Wenger (1998), members of these communities develop an understanding of their goals, hold each other accountable such that everyone participates, and develop communal resources such as routine, artifacts, and language. Broadly speaking, there is a STEM community that includes those who know how to participate, communicate, and create such that they are accepted into this STEM community. People in this community of practice include, for example, those who work in STEM careers, those who participate in STEM-related extra-curricular activities, and those who attend STEM-related events on a regular basis.

Within these communities of practice, Lave and Wenger (1991) note that there is a process that takes place called *legitimate peripheral participation* in which communities of practice participants take up, in varying degrees, the practices of a community. Even as a newcomer to the community, the presence of the participant is more than observational. Lave and Wenger (2002) urge that this legitimate peripherality "…. crucially involves *participation* as a way of learning – as both absorbing and being absorbed in – the 'culture of practice'" (pg. 113, emphasis original). However, over longer periods of time, these newcomers identify with the group or community and take up more and more opportunities to practice, making the culture of practice their own. In terms of the research at hand, the various interventions within this study are seen as supporting either a) the movement of families from the periphery of a STEM community of practice to more a central position within this community; or b) families' recognition of what the STEM community of practice entails and acknowledge the possibility of belonging.

Bourdieu's Toolkit of Habitus, Capital and Field

Habitus is a complex theory within the extensive work of Bourdieu that explains the internalized social structure, actions, and practices that form our dispositions as affected by experience in the social world (Bourdieu, 1977). Simply put, habitus focuses on our ways of being, acting, thinking, and feeling. Habitus is likely Bourdieu's most contested concept, with scholars debating over meaning, application, and expansion of the term. While there are both individual habitus and collective habitus, it is cautioned that the term is not used in a single monolith, nor diluted or made too broad (Atkinson, 2001; Reay, 2004). Specifically, it is important not to modify everything into 'habitus' as a construct for explaining dispositions too vaguely. Reay (1998), a foremost scholar on Bourdieu, posits the term 'family habitus' as "the deeply ingrained system of perspectives, experiences and predispositions family members share" (p. 527). The individual and collective family habitus begins at home with our initial encounter with socialization and helps to shape our worldview and function as a guide during one's life (Gokpinar & Reiss, 2016). However, what we begin with at home is ever changing, without end (Harker, 1984; Reay, 1997).

"The relationship between habitus and *capital* is enmeshed. Bourdieu (1986) presents capital in three major forms: economic capital, social capital, and cultural capital. Economic capital refers to resources in monetary or material form and is inherent in the social reproduction of advantage or disadvantage. Social capital includes both material and non-material resources that one might have in a given network of connections. Bourdieu states that social capital can never exist as an independent entity, as

> …the volume of social capital possessed by a given agent thus depends on the size of the network of connections he can effectively mobilize and on the volume of the capital (economic, cultural or symbolic) possessed in his own right by each of those to whom he is connected. (1986, p. 249)

Cultural capital, like education and skills, is gained primarily through economic capital and is in direct proportion. Neither social or cultural capital is naturally given, but rather embodied in an institution, such as a family or specific community (Bourdieu, 1986). Each form of capital is inextricably related to social reproduction at every level, including within education, and has vast consequences for students, families, and the institutions to which they belong (Bourdieu & Passeron, 1990). Therefore, it is possible that a school community or education program could be positioned to support and develop students' and families' social and cultural capital.

Bourdieu stressed that it would be in error to research habitus or capital in isolation and remove them from their relational position with the *field*, or the social world within which they exist. A field, as a social space, could be a school, family, job, or where one lives. Each field has its own characteristics, governing rules, and understanding of the world (Bourdieu and Wacquant, 1992; Reay, Crozier, and Clayton, 2009). Bourdieu (1984) summarizes the relationship between the three constructs by using the following equation:

(*habitus* x *capital*) + *field* = *practice* (p. 101)

This equation can be interpreted such that practice results from the value of one's habitus and capital interrelated, as present in a particular field (Maton, 2014; Gokpinar & Reiss, 2016). No examination of habitus can exist without the exploration of embedded capital within a particular field. For example, if studying students' behaviors and practices in STEM related subjects at school, it is impossible to examine their dispositions or feelings about STEM (habitus) without simultaneously examining their skills, education, and socioeconomic level that has provided opportunities up until that point (capital). Thompson (2008), a scholar on Bourdieu's methodological toolkit consisting of the concepts of habitus, capital, and field, states that Bourdieu argued for the inspection of all three theories interdependently. She relays Bourdieu's concept of field in a metaphor as an actual football field, represented by boundaries, conditions, and constituting a self-contained world of sorts. As a football field is nearly pointless to examine without understanding the action that takes place on it, the field as a social space does not stand alone and must be examined in connection to the demonstrated habitus (Reay, 1997; Gokpinar & Reiss, 2016). Further, Thompson (2008) emphasizes Bourdieu's assertion that a social field is not fixed and should be examined on a case by case basis, with his toolkit of habitus, capital, and field. She reminds us that "field was not developed as grand theory, but as a means of translating practical problems into concrete empirical operations. This work is not done simply in an office or a library, but literally *in the field*" (Thompson, 2008, p. 81, emphasis original). In other words, the 'field' is the social space where individuals can interact within the given rules of that arena, like school or home. Those fields become opportune arenas to explore and influence the exchange and cross-pollination of habitus and capital.

A most apt representation of the interrelation between habitus, capital, and field is through Bourdieu's metaphor that when the interplay between habitus and capital confront a field, or social world, from which it was created, then it is like a 'fish in water' and "does not feel the weight of the water and it takes the world about itself for granted" (Bourdieu & Wacquant, 1992, p. 127). Conversely, Reay (2004) argues that if one's habitus and embedded capital find itself within a field that it is not familiar with, then the disequilibrium can result in change and transformation.

Conceptual Framework: A Possible Mechanism for the Development of STEM Identity

This study draws upon three main bodies of work to conceptually frame this research: science (STEM) capital (Archer et al., 2014), science (STEM) habitus (Archer et al., 2012), and science (STEM) identity (Carlone & Johnson, 2007). Note that the study expands each of these concepts from solely ‘science’ to ‘STEM’ so as to be more inclusive of the type of activities and conversations supported by designed social spaces within the investigations. As demonstrated in Figure 2.1, this framework sees each component building to create the next: By providing opportunities for access to STEM, families can then build STEM capital and a STEM family habitus, which can be seen as mutually reinforcing constructs. Increased STEM capital allows families to see themselves as those who are engaged in STEM (habitus) and the increased engagement builds capital via gained resources and connections. As STEM capital and a STEM family habitus are developed, students are much more likely to develop a STEM identity as they see that the STEM community is one to which they can belong. This sequence exists within the frame of a field in this case, the social space provided for STEM investigations and interventions.

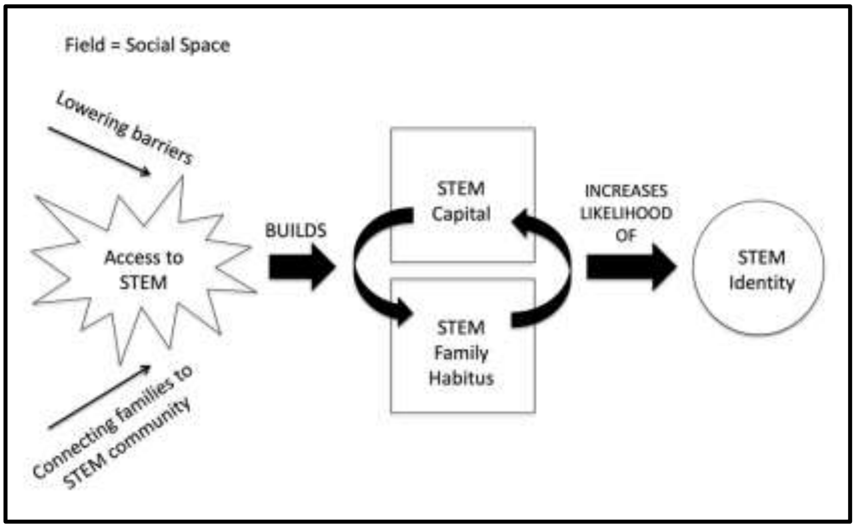

Figure 2.1 Hypothesized Mechanism for the Development of STEM Identity

STEM Capital

The notion of capital has been applied extensively in education and schooling, with the findings typically indicating that more capital (economic, social, cultural, etc.) results in better educational outcomes (e.g., McNeal, 1999; Lareau, 1987; Coleman, 1988; Dika & Singh, 2002; Archer et al., 2015). Science capital as described by Archer et al. (2014) consists of "various types of economic, social, and cultural capital that specifically relate to science" (p. 5); this study expands this definition to consider the inclusion of each discipline within the STEM acronym. The concept of science/STEM capital draws upon Bourdieu's (1977) conceptualization of capital as "legitimate, valuable, and exchangeable resources in a society that can generate forms of social advantage within specific fields…for those who possess it" (Archer et al., 2015, p. 923). Archer et al. (2015) note that Bourdieu's mention of science capital was conceptualized as the symbolic capital of science authority, while their development of the concept seeks to include and expand upon scientific literacy and the social capital within a science context. Specifically, Archer, DeWitt, and Willis (2014) describe the term as:

> ...a conceptual tool for understanding the production of classed patterns in the formation and production of children's science aspirations. We propose that "science capital" is not a separate "type" of capital but rather a conceptual device for collating various types of economic, social and cultural capital that specifically relate to science – notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science. (p. 5)

Further, Archer, DeWitt, and Osborne (2015) see the manifestation of family science capital as families "feel[ing] comfortable and knowledgeable about science and [seeing] its relevance to the lives of parents and children" (p. 233). In the literature, capital leveraged for educational purposes often goes hand in hand with many forms of privilege; however, Archer, DeWitt, and Osborne (2015) found that science capital can indeed be developed by families, including those from underrepresented populations.

STEM Family Habitus

As discussed above, Bourdieu (1986) conceptualized habitus as "long-lasting dispositions of the mind and body" (p. 243) which provide a framework that guides future action. While Bourdieu did not articulate a specific "family habitus", he did offer the collective notion of habitus to include more than just the individual (Bourdieu, 1984; Bourdieu & Passeron, 1990). Additionally, Bourdieu, as cited by Reay (2004), recognized that habitus was complex and multilayered, as well as subject to influence. In their research, Archer et al. (2012) further clarified habitus as providing "a practical 'feel' for the world, framing ways of thinking, feeling, and being, such as taken-for-granted notions of 'who we are,' and 'what we do,' and what is 'usual' for 'us' (p. 885). These authors then extended Bourdieu's (1986) notion of collective habitus to further define *family habitus* in relation to science. They state that family habitus refer[s] to the ways and settings in which families operate" and can be employed to "explore the extent to which families construct a collective relationship with science and the extent to which this is shaped by their possession of particular sorts of economic, social, and cultural capital" (p. 886). Thus, examining the STEM family habitus in relation to science/STEM identity would provide worthwhile as:

> …it provides a lens for attempting to situate and contextualize individual child and parent identities and orientations to science within the family environment – for examining the extent to which the everyday family "landscape" shapes, constrains, or facilitates aspirations and engagement in science through the combination of attitudes, values, practices, and ways of being that they engage in" (Archer et al., 2012, p. 886).

Wong (2016) notes that the habitus of a group (such as a family) "conditions and constrains the possibilities for individuals" (p. 33). Consequently, to understand the genesis of STEM identities in students, one cannot ignore the influence of family habitus. Indeed, Reay (1997) suggests that it is the family habitus that influences identity to no end. Acknowledging Archer et al.'s (2012) finding that "there is no straightforward relationship between family habitus and an individual child's identification with science" (p. 889), it is also believable that a STEM family habitus could serve as "'fertile ground' that renders science more thinkable/desirable" (p. 890-1) for students. As in Figure 2.1, the model relates STEM capital and STEM family habitus as mutually reinforcing, just as Archer et al. (2012) noted the 'interplay' between the two constructs.

STEM Identity

Carlone and Johnson (2007) argued for the use of identity as a framework in their study of women of color in science by stating,

> The identity lens allows us to ask questions about the kinds of people promoted and marginalized by science teaching and learning practices; the ways students come to see science as a set of experiences, skills, knowledge, and beliefs worthy (or unworthy) of their engagement. (p. 1189)

They remind us that viewing science as a community of practice (Lave & Wenger, 1991) in which aspiring members seek to adapt into the community and increase practice, it is critical to examine how new members associate with, interact, and mediate the cultural norms of the community.

Carlone and Johnson's (2007) model of science identity consists of overlapping spheres of performances, competences, and recognition. They explain this model as such: "One cannot pull off being a particular kind of person (enacting a particular identity) unless one makes visible to (*performs for*) others one's *competence* in relevant practices, and, in response, others *recognize* one's performance as credible" (p. 1190, emphasis original). In terms of STEM, performances might include using particular tools or following community norms. Content knowledge in STEM as well as knowledge of STEM careers and systems are examples of competences. Finally, recognition in this model pertains to both recognition by oneself ("I'm a STEM person!") in addition to recognition by meaningful others (those who have made important connections with the student); for elementary students, these meaningful others are often teachers or family members. Hazari et al. (2010) added a fourth overlapping sphere to this model: interest.

These authors asserted that interest was a 'given' in Carlone and Johnson's (2007) study because their participants were already practicing scientists. Hazari et al. (2010) argue that including interest in a model of science identity is important because interest is "critically relevant in influencing the decision of who and what a *student* wants to be" (p. 982, emphasis original). Thus, for the purpose of this study, identity is developed by competent performances and recognition in an area of interest.

From Family Capital and Habitus to Student Interest and Identity

The most intimate social environment a child can experience is that of the home. This setting is multifaceted and complex, but ultimately the largest source of influence for most youth (Coleman, 1987, 1988; Gonzalez et al., 2001; Gonzalez et al., 2005). The work surrounding 'funds of knowledge' by Gonzalez and Moll highlight the academic and personal backgrounds of the student and family, life experiences, skills and knowledge, how they navigate various social context, and belief systems or world views (Gonzalez, 1995; Moll, 1992; Moll & Gonzalez, 2012, Moll et al., 1992). Funds of knowledge are broad and diverse, consisting of the accumulated bodies of knowledge any family may have that represent an often-underestimated understanding of contexts such as medical, business, agriculture, or scientific contexts. Examples of a family's funds of knowledge might include the science knowledge related to roofing, the math related to cooking, or the engineering design skills necessary for construction and architecture (Moll et al., 1992).

I argue that this conceptual framework on which Gonzalez and Moll's extensive research is based is the embodiment of a family's capital and habitus. Gonzalez et al. (2001) assert that those same funds of knowledge influence the academic arena for children; this is supported by other research that explores the social and cultural capital families use as means for their involvement with schools and can often the predictor of the child's academic success (Lareau, 1987; McNeal, 1999; Coleman, 1987, 1988; Reay, 1997; Claussen & Osborne, 2012; Archer, DeWitt, & Osborne, 2015; Dabney et al., 2013).

Within the STEM academic context, the interaction between STEM capital and family habitus are initially formed through the social relationships within the family that are then manifested within the students' various levels of science engagement, aspirations, and capability (Archer et al., 2012; Claussen & Osborne, 2012; Gokpinar & Reiss, 2016): "Family members act as conduits of external motivational factors, providing an immediate interactive social group for stimulating science interest" (Dabney et al., 2013, p. 396). However, the interaction between science/STEM capital and family science/STEM habitus is not the same for all students. Economic, cultural, and social capital are embedded within a family's science/STEM capital and can be impacted by the resources possessed, or lack thereof. The different socioeconomic levels of families can be attributed to various access to resources and opportunities (forms of capital), including those that are science/STEM-related. A family's socioeconomic status can affect children's initial STEM capital, the family's science connections and networks, and the ability to provide science materials and science experiences (Aschbacher et al., 2010; Gokpinar &Reiss, 2016; Adamuti-Trache & Andres; 2008). Limited economic capital can restrict the social capital available to families within a STEM context. Moreover, families from low socioeconomic circumstances have less social and cultural capital to leverage for their students. As a result of this, their children often have lower science aspirations

(Archer, DeWitt, and Osborne, 2015; Archer et al., 2012). For example, families from homes with cultural and economic capital may look for STEM-related opportunities for their children like a science club, robotics competitions, LEGO camps, etc. They often know where to seek out these experiences, the financial capital to pay for them, and the social network to provide support. Conversely, families with less cultural and economic capital may not know where to look for the opportunities, nor have the resources to pay for and/or support their children in these opportunities. Family background and occupations within the family can also impact a student's persistence in science, but more than that, a family's encouragement and social influence can be considerable in developing their capacity for science. In sum, because capital and habitus interact collectively, a family's resources, values, and practice influence a student's science aspirations and science development (Archer et al., 2012; Archer et al., 2013; DeWitt et al., 2011; Aschbacher et al., 2014).

The largest study to date measuring students' and parents' science aspirations, disposition, and identity, is the ASPIRES project in England. Archer et al. (2013) conducted a 5-year longitudinal study with over 9,000 students ages 10-14, collecting data from multiple surveys and repeated interviews with students and their parents. Some of the targeted evaluations included parents' expectations, attitudes towards science, their perceptions of science, and family context. Among other important findings, the ASPIRES study notably found that while families from low socioeconomic households also possessed low science capital, *the family's income level was not an indicator of low support for students in science or low aspirations*. All families, regardless of income, were found to have high aspirations for their children (Archer et al., 2013; Archer et al., 2015; DeWitt et al., 2013).

As might be expected, more affluent families in their study were found to have significant science capital and access to resources and opportunities, with their children documented as higher science achievers. Working class and low income parents recognized that their lack of cultural capital in general did pose challenges for them within their child's school and with the larger system of education. As a result, "they are disproportionately likely to be excluded from the possession of science capital, which will negatively impact on the likelihood of children developing or sustaining science aspiration" (Archer et al., 2015, p.222). Because cultural capital, containing the experiences and opportunities that bring about skills and knowledge, is often proportional to a family's economic capital, it can restrict a student's ambitions. A family's habitus that doesn't include strong science capital may find formal encounters with science contexts challenging, especially when meaning making may depend on families having a specific level of capital to fully connect to the experience (Archer et al., 2016).

Social capital remains strongest amongst white, middle-class, able to navigate networks and systems to benefit their students (McNeil, 1999; Reay, 1998). Middle or upper class families leverage their capital with experiences, opportunities, and even private education. Gokpinar and Reiss, citing Skeggs (2004) note that middle- and upper-class families "...convert economic capital to cultural or science-related capital, which in turn will have exchange value and provide advantages in later life such as employability and social networks" (2016, p. 1286). This exchange value is also noted by Archer et al. (2015) in which science cultural capital and social capital, in addition to science-related practices and contexts, yields a significant value or exchange rate within society. They contend that this earned value can be leveraged into science-related aspirations and science identities for students.

Noting what families can do with substantial capital, within the interconnectedness of their habitus, Reay (1997, 1998) reminds us that the individual or collective habitus is flexible, ever-adapting, and capable of change. The state of a family’s habitus and the social and cultural capital therein, is not fixed. “While habitus reflects the social position in which it was constructed, it also carries with it the genesis of new creative responses that are capable of transcending the social conditions” (Reay, 2004, p. 434-435). A family's habitus is a generative force for students in the development of their individual science identity considering that “the interplay of family habitus and (often substantial) science-specific cultural and social capital produce a sense of being “what we do” and “who we are” (Archer et al., 2012, p. 891).

Habitus as Interest

How, then, does habitus influence interest and identity? Returning to Bourdieu’s (1977) three primary thinking tools of habitus, field, and capital, Bourdieu considered the notion of ‘interest’ within the relationship of field and habitus. In an in-depth analysis of the concept of interest via Bourdieu, Grenfell (2008) asserted that while Bourdieu primarily saw interest as an instrument of economic action, it was nonetheless a social operation permeated with the values linked to the individual’s cultural capital. For example, if a family’s economic capital enabled them to purchase piano lessons for their child, thus gaining the cultural capital of being a skilled pianist, interest could lead the child to also pursue guitar lessons as a result of the cultural capital gained through private music instruction. In addition, he states that a person's interest is based on their particular circumstances, value systems, and context that they find themselves in, within a particular field. In short, "*interest* is *habitus* incarnate, which itself is created by the *field* environments through which individuals pass" (Grenfell, 2008, p. 154, emphasis original).

<u>Student Interest and Identity</u>

If interest is the embodiment of habitus, and the family's habitus helps to shape a child's science development, how does the family directly impact a student's interest in science? The family plays an essential part in helping to form, develop, and support a youth's interest, access, and engagement in science (Archer et al., 2015; Archer, et al., 2012; Archer, DeWitt, & Osborne, 2015; Archer et al., 2014; Archer et al., 2016; Aschbacher et al., 2013; Burt & Johnson, 2018; Dabney et al., 2013; DeWitt et al., 2013; Mau, 2003). There are numerous ways families do this. Families can demonstrate their involvement in and out of the classroom with STEM-related activities and provide role models to help guide science ambitions or career choices. Some of the greatest family influence for students is in the family's ability to help build a student's confidence, give encouragement and support in their STEM aspirations (Archer et al., 2012; Aschbacher et al., 2013: Burt & Johnson, 2018; DeWitt, Archer, & Osborne, 2013).

Referring again to the ASPIRES longitudinal study Archer et al. (2013), cited the family as the most significant source of aspiration in science. Particularly at an early age, families are the primary influence in science for young students. Maltese and Tai (2010), studying the origins of science participation, noted that 65% of their participants developed their science interest prior to middle school. In other research, surveying over

400 students in California, it was rare for students to document an interest in STEM subjects after the seventh grade (Aschbacher et al., 2013), if it was not already developed in elementary school. The STEM influence afforded to students at an early school age translates to STEM interest, aspirations, and even STEM careers. Notably, the National Education Longitudinal Study of 1988 reported on nearly 12,000 eighth grade students surveyed regarding their career ambitions, comparing those responses with their college transcripts and subsequent degrees. Maltese and Tai (2010), analyzed this data and found that "students reporting an interest in science careers in 8th grade were three times more likely to obtain a college degree in a science field than those who did not show that interest" (p. 670). Consequently, the influence that families have on their child's science interest, especially early on, does indeed have a significant impact on the students, their STEM aspirations, and identity.

The Struggle for STEM Identity

Not all things are equal in developing a science identity for many students. The reality is that ethnic minority and low-income youth struggle to obtain a science identity (Calabrese Barton & Tan, 2010; Carlone, et al., 2015; DeWitt et al., 2010; Lee, 2005; Price & McNeill, 2013; Wong, 2015) for a variety of reasons. Stereotypes persist within science education and perceptions of science identity among youth. When considering who science is "for", most students, including ethnic minority and working-class youth, consider the White male science figure as the norm (Archer, DeWitt, Osborne, 2015; Archer et al., 2013; Carlone & Johnson, 2007; Carlone et al., 2015;Wong, 2015). This point of view is extremely limiting for many students and can impede their ability to connect to science and STEM-related content in the classroom.

When the identity and culture of students are not validated in the classroom, it can reinforce that science is not ‘for them’ and thus will continue to be out of reach and out of touch with their own reality. Part of the disconnect that exists between students from ethnically diverse backgrounds and those from low socioeconomic circumstances and traditional science education is the context, choice and agency from the students, and the cultural backgrounds of the students participating (Bricker & Bell, 2014; Calabrese Barton & Tan, 2010; Carlone et al., 2015; Maltese & Tai, 2011; Price & McNeil, 2013). For these students, gaining entry to science contexts can be challenging without the proper support, as “many youth from low-income communities do not have direct access to traditional networks of resources” (Calabrese Barton & Tan, 2010, p.190). Traditional networks for students might include direct support from students’ families in science and STEM-related subjects, formal and informal science opportunities, access to dominant science language and practice, and high quality STEM classes and programs in pre-K-12 education.

What Schools Can Do

Overall, there is still much to understand about how young people develop STEM interest, participation, aspirations, and ultimately career ambitions, as well as who and what influences those choices and direction (Aschbacher et al., 2009; DeWitt et al., 2016). Those conducting research surrounding STEM capital, habitus, and identity see the considerable need for interventions at the institutional, community, and family level. The majority of the calls to action are made to schools, which makes sense, as schools have an active socio-cultural impact on the students within them as well as opportunities to deliberately build social capital with both students and families in order to facilitate learning (Coleman, 1991). In other words, “schools and other institutions can directly shape the habitus and practices of individuals through their organizational forms and collective practices” (Burke et al., 2013, p. 167). At minimum, schools can focus on developing initial STEM interest and fostering better STEM engagement (Maltese & Tai, 2010).

However, if schools are to meaningfully address the pervasive gaps in STEM, it will take action at all levels *in partnership with families*. In addition to calls to grow interest and engagement in the STEM content areas, there are also calls for intervention within science curriculum and the way it is taught (Brickhouse et al., 2000; Calabrese Barton et al., 2008; Calabrese Barton & Tan, 2008; Carlone et al., 2015; Hurd, 2002; Maltese & Tai, 2010). Several researchers report the need for science curriculum to be more relevant to students, current and real-world, as well as connecting directly with students’ lived experiences (e.g., Hurd, 2002; Dewitt et al., 2016; Price & McNeill, 2013). To facilitate this change within science education and curriculum, schools and teachers must embrace students’ funds of knowledge (Gonzalez, 1995; Moll, 1992) – rooted in their family habitus and interactions – as a paramount resource to negotiate meaning-making and to maximize learning within STEM contexts. “For a science curriculum to be lived, it must reach out to the lives, communities, and experiences of students” (Price & McNeill, 2013, p. 502).

Of course, examining the lives and experiences of students must deliberately include those from underrepresented and underserved communities, as well as their families. DeWitt and Archer (2015) contend that teachers should broaden the ways students can engage and participate in science in order to make school science more meaningful for a diverse range of students. By this, they mean to make science more inclusive for a broader scope of cultural histories, perspectives, and ways of being within science teaching (Archer, DeWitt, & Wong, 2014; Calabrese Barton et al., 2013; Calabrese Barton & Tan, 2009; Carlone et al., 2011; Wong, 2015). By utilizing the cultural resources present in the students, students from underserved populations are more likely to engage and connect to the STEM content. An intentional focus to engage underrepresented populations can help to ensure more equitable pedagogy in the classroom, develop and support their STEM aspirations, and overall, ‘level the playing field’ for underserved students (Archer, DeWitt, and Osborne, 2015; Archer, DeWitt, and Wong, 2014; Carlone, 2004). This same deliberate focus should be extended to families, as they maintain a unique and exceptional influence on students’ STEM interest and aspirations.

Working with Families to Influence Students

Given the significance that family habitus can have on individuals’ actions and pathways in life it becomes imperative to provide opportunities for families to cultivate a STEM family habitus (Claussen & Osborne, 2013; Robb et al., 2007). The influence from the school, and equally the home, is crucial for the academic growth of each student and thus pivotal in developing a youth’s STEM capital and deserves much more attention. Researchers suggest that schools could extend their outreach to work directly with families to build capital, help them understand the transferable value of STEM qualifications as well as its relevance to their future and that of their children (Archer et al., 2013; Archer, DeWitt, and Osborne, 2015; Aschbacher, et al., 2013, 2014). These interventions signify a partnership between families and schools, where schools can help facilitate discussions related to STEM and the benefit to their students. Lastly, schools can help to promote science conversations and dialogue with the families (Hartas, 2016) and assist in providing STEM opportunities and experiences to encourage families' access to STEM, regardless of their economic capital. It is important for schools to engage with families, as partners, to provide the social space and facilitated environment that might not otherwise be available for families (Dabney et al., 2013). Therefore, as families build their STEM capital in terms of knowledge, connections, and resources, their STEM family habitus is able to include more activities or conversations about STEM. Similarly, as STEM can be seen as another aspect of 'what we do' in families, they may encourage and support the development of STEM capital and identity within their students.

Call to Action

When considering the families and students who have traditionally been underserved in their access to STEM content, opportunities, connections, and engagement, it is necessary to note the obligation that schools have to innovate and, frankly, do more for those who do not have access to the prevalent forms of cultural capital that can facilitate STEM interest and aspirations. Schools must commit to make changes because "any formal education that fails to remediate for a lack of the dominant cultural capital in underprivileged students simply serves to perpetuate the status quo" (Claussen & Osborne, 2013, p. 64). Schools cannot address the gaps that persist in the STEM pipeline, in STEM interest and achievement among our nation's youth, and in the absence of students pursuing and completing STEM degrees by doing more of the same and leaving the family out of the equation.

If STEM education continues as it is, there will continue to be ‘have’ and ‘have nots’ within schools, for students, and their families. This is an unacceptable outcome when systems of support exist to help schools in their STEM-related endeavors. The family continues to be the largest untapped support system to affect change in students’ STEM capital and habitus. While research has been conducted to document families’ influence on their students’ STEM interest, capital, aspirations, and identity (Archer et al., 2013; Bricker & Bell, 2014; Brickhouse et al., 2000; Calabrese Barton et al., 2010), *there has been no research* centered around a direct intervention done with the families, including their students, in order to influence STEM capital, habitus, and identity. This remains uncharted territory for the field of STEM education, to create interventions designed for the family as much as the student, in order to shape and facilitate STEM experiences for both.

If schools are to consider different frameworks to expand and increase STEM capital, embracing the family as a direct channel for STEM learning holds enormous potential. Therefore, what STEM opportunities and experiences can be meaningful for all families, regardless of income level, to encourage and support the idea that STEM is ‘for them’? Relevant to this question is the concept that underrepresented populations in STEM may not typically feel that STEM is for them (Archer et al., 2015) or ‘worthy of their engagement’ *because* they have been marginalized by traditional STEM teaching and learning practices. Students of underserved backgrounds often struggle to make connections and see themselves within the formal context of the science class (Bricker & Bell, 2014; Calabrese Barton & Tan, 2010; Carlone et al., 2015; Maltese & Tai, 2011; Price & McNeil, 2013). Knowing these barriers can exist for students, and that families would likely have similar dispositions, it is imperative to thoroughly consider the design and execution of the STEM experience, within the social space, where families and students will interact together.

Both students and their families stand to benefit from collaborative efforts to develop family-friendly STEM events that encourage *all* families to participate, contribute, and learn. By accessing the knowledge, interests, and cultural capital already possessed in the home to build a context for STEM that is not removed from the family or familiar experiences, there exists a potential to develop their STEM capital and shift the family habitus collectively. By recognizing the existing capital that families possess and designing inventive avenues to explore STEM learning together as a family, both parents and children can expand their capacity for STEM meaning making. As a result, "parents can provide their children with science-related cultural capital in how they respond to science and bring it into the home" (Claussen & Osborne, 2013, p. 72). Through purposefully designed family STEM events, schools can play a vital role in supporting families and students with the experiences, skills, knowledge and values in STEM. It is then that students are more likely to see themselves as the 'kind of person' (Gee, 1999) who can be involved in STEM.

Summary

The disparities in STEM education and the subsequent lack of pursuit toward STEM careers by those in underserved populations is a significant issue. Despite the government's previous efforts to incentivize schools into producing STEM-capable students and public schools' current efforts to increase STEM achievement, the same populations seem to be left out of the equation and continue to fall out of the 'leaky

STEM pipeline’. Ethnic minority and low-income students are the most vulnerable populations to gaining a STEM identity within the school institution that seems to struggle with innovation in reaching *all* students in STEM. Families continue to be the most meaningful influence on their children and an untapped resource for schools looking to increase STEM interests and STEM identities within their students. To support the development of students' STEM identities, this study will focus on the role of families in providing opportunities for cultivating interests and competence, being an audience for performance and interaction, and recognizing their children as a 'STEM people,’ which is accomplished through the development of STEM capital and STEM family habitus. As Archer et al. (2012) note, “the alignment between family habitus, capital, and the child’s personal interests and identifications produces a strong, mutually reinforcing consensus” (p. 892); thus, in order to support the development of STEM identity, the study will attend to each of these components. Because the development of STEM identity can be a lengthy process, this research will focus on the impact of two STEM events targeting habitus and capital with families and students.

CHAPTER THREE: METHODS

Utilizing data from parent surveys, student surveys, and family interviews, this qualitative study aims to assess the impacts of two designed STEM experiences for families on families' and students' STEM habitus and STEM capital. Below describes my research process beginning with a description of the context of Garfield Elementary and events, continuing with my data collection methods, and finally, sharing my data analysis strategies.

Context

Garfield Elementary is an urban Title I school (87% free and reduced-price lunch) that serves approximately 375 children (30% from racial/ethnic minority groups and speaking 18 different languages) in grades K-6 in Boise, Idaho. Boise is a Federal Refugee Resettlement site, receiving close to 1,000 refugees in FY 2015 (Office of Refugee Resettlement, 2016). Numerous refugee families live within the Garfield school zone. Due to the myriad needs of students and families at Garfield Elementary, it was recently designated a Community School by the school district in 2016. A Community School serves as a central location to assist families with food, clothing, healthcare, housing, and other related needs. The STEM events at Garfield Elementary are designed to work with students and their families in all grade levels.

STEM Events Descriptions

Garfield Elementary Family STEM Night at the Discovery Center of Idaho

This is not the first Family STEM Night (FSN) to be hosted for the Garfield Elementary school population. The first FSN was designed such that each classroom in Garfield would host a community partner (e.g., a university physics club, a local power company, a wildlife organization, etc.) and provide a hands-on activity in which families could participate in a STEM experience and learn more about the local STEM organizations and groups. From 2015-2019, the number of volunteers, community partners, and Garfield students and family participants has increased greatly. During the fall 2019 FSN, there was over 120 volunteers with 24 different community STEM partners, and 600 students and families in attendance. During FSNs, families are actively encouraged to experience the STEM activities along with their children.

The continued success of the FSNs at Garfield led to the creation of a similar event, held out in the community, where the family is central to planning for a hands-on STEM experience. As the first designed experience in this study, Garfield Family STEM Night at the Discovery Center of Idaho (FSN-DCI) was created to give a similar feeling to Garfield FSNs done at the school, but in a new, more formal science environment and with different STEM experiences. The community partner, Discovery Center of Idaho (DCI), accommodated Garfield Elementary school attendance by arranging their space to expand hands-on experiences, provide rooms for dinner, post additional signage for families in Arabic, Swahili, and Spanish, having additional volunteers on hand, and all DCI staff and volunteers receiving culturally responsive training prior to the event.

Culturally responsive training was held with DCI staff and provided by the author. This training included an explanation of the diversity of Garfield Elementary, cultures represented in the families, various languages spoken, and some of the barriers experienced by the school families to attend DCI in the past such as cost, language barriers, feeling as though it is not ‘for them,’ etc.. This training sought to provide a more detailed context for the population and what accommodations might need to be made during the event to create more access points to learning and meaning making based on culture, language, socioeconomic status, and the potential of limited STEM experiences in formal science spaces. This training draws directly from the foundation of culturally responsive teaching that advises that “explicit knowledge about cultural diversity is imperative to meeting the educational needs of ethnically diverse students” (Gay, 2002, p. 107)

Additional efforts were taken to reduce barriers to attend the FSN-DCI and increase family engagement during the event such as a free dinner available to all family members who attended; bus transportation for families from the school to DCI and back; a scavenger hunt mirroring previous FSN ‘passports’ to encourage intentional exploration throughout the space; and activities accompanying exhibits that could be taken home and explored further as a family. See Table 3.1 for details on how successful components from the original FSNs were translated to the FSN-DCI.

Table 3.1 Translation of FSN Components to FSN-DCI

Original FSN Feature	FSN-DCI Feature	Reasoning
Free dinner to all families	Free dinner to all families	Providing dinner removes barriers to attending an evening event
Held at the school	Transportation from the school to DCI	Lower transportation barriers
Teachers and Staff were hosts for the evening, but not the STEM providers	Teachers and Staff were hosts for the evening, but not the STEM providers	Teachers and Staff are the familiar faces for families when with unfamiliar STEM providers
STEM Providers were from local organizations and industry	STEM Providers were from the local science museum	Providing access to STEM means connecting families with the STEM community
STEM “passport” to help guide families throughout the event	STEM “scavenger hunt” to help guide families throughout the exhibits	This supports families with areas of interest, a schedule, location of events
STEM prizes given to students for getting stamps in their “passport”	STEM prizes and a makerspace engineering kit given to families after their “scavenger hunt”	Encouraging STEM investigations at home after the event

Before families left the event, two other invitations to continue STEM exploration as a family were given:

1. Each family attending the FSN at the Discovery Center were given a pass to return with their family for free ($25 for students, $29 for adults). Tickets to return to DCI were valid through the end of the 2018-2019 school year. The return pass ticket design is such that it will document how many adults and children attend DCI for the subsequent visit. (see Fig. 3.1).

2. Each family received a makerspace engineering challenge kit to explore with their children on their own time. The kit foreshadowed the engineering challenges at the Family STEM Camp event held in the Spring of 2019 at Garfield. (see Appendix A; more details concerning the Family STEM Camp in the next section)

Providing these additional invitations to continue STEM explorations and investigations as a family was important to sustain the conversations within the family and provide sustained STEM involvement as a family. This continued access to STEM experiences was intended to lower barriers to participate in structured STEM activities as well as connected families with the STEM community more broadly.

Figure 3.1 DCI Return Ticket

Garfield Family STEM Camp Event

At the conclusion of the Garfield FSN-DCI, families were given an engineering challenge kit to explore with their family at home on their own time. Each kit contained the materials to build a catapult, a stomp rocket, and an egg drop challenge (see Appendix A for details). The kit explained the parameters to build each item, but the families chose how to use the materials any way they saw fit. The engineering challenge kit served as preparation and practice for the Garfield Family STEM Camp (FSC) event in the Spring.

In April of 2019, families were invited to attend the FSC event at Garfield Elementary. Families had three months to design and explore the engineering challenges provided in the kit they received at the FSN-DCI event in February. Families were then invited to compete in the FSC using the same materials from the kit, designing the same items: a catapult, a straw rocket, and an egg drop challenge. Stations for these three challenges were set up around the gymnasium of the school for families to work together with the same materials. Each engineering challenge had a friendly competition component. The egg drop challenged families to spend less and less money (simulated budget) on materials for the drop. The straw rocket challenged families to build the farthest flying rocket. The catapult challenged families to fling their projectiles the farthest. Each challenge for the families came with prizes for the top three scores in each category. Prizes included year memberships to the Discovery Center of Idaho, STEM kits, and STEM books.

Participant Population for the FSN-DCI and FSC

The participants for FSN-DCI and FSC were Garfield Elementary students and families. Garfield is a K-6 school (children roughly 5 to 13 in age). The demographics of attendees for each designed STEM event is listed in the table below, compared to the overall demographics of the school's student population.

Table 3.2 Overall and Event Attendance by Race/Ethnicity

	Overall Garfield School Race/Ethnicity Percentages	**FSN-DCI Participant Race/Ethnicity Percentages**	**FSC Participant Race/Ethnicity Percentages**
White	233/62%	336/64%	93/74%
Latino	45/12%	53/10%	8/6%
Middle Eastern	34/9%	74/14%	23/18%
Black	30/8%	37/7%	1/1%
American Indian	11/3%	11/2%	0%
Asian	23/6%	16/3%	1/1%
Total	376	527	126

Data Collection

Data collected from January 2019 to May 2019 include a Perceptions of STEM survey, parent survey about FSN, student survey about FSN, parent survey about FSC, student survey about FSC, family interviews, and Discovery Center of Idaho return ticket. The methods for both data collection and analysis will be described in detail below.

Family Perceptions of STEM Survey

All Garfield families were asked to complete the Garfield Families' Perceptions of STEM survey before the Garfield Family STEM Night at the Discovery Center of Idaho. The survey consists of ten four-point Likert-scale questions, three open-ended questions, and three demographic questions (see Appendix B). The intent of the survey was to ascertain baseline self-reports of STEM capital and STEM habitus for each Garfield family. Translations for the survey were provided in Arabic, Swahili, and Spanish, in addition to English. It was sent out three weeks prior to the FSN-DCI event. Each family was given an identifier which was written on the survey prior to it being sent out; no names were written on the surveys. Families were asked to respond and return the surveys within two weeks. The surveys were returned with the student and given to the student's teacher, then collected by me each day. Families were incentivized to complete the survey by having their name put into a drawing for a $25 gift card to WalMart. Families were entered one time in the drawing for each of their children at Garfield; two gift cards were drawn per grade level. One hundred thirty parents returned the survey. Of those respondents, eight respondents did not answer one or more of the ten Likert-scale questions. Eight-six of the respondents were female, and 44 respondents were male. Tables 3.3 and 3.4 below provide more information about respondents to this survey.

Table 3.3 Respondents to Perceptions of STEM Survey and Their Relationship to Students

Relationship to Garfield Student	**Mother**	**Father**	**Grand-parent**	**Aunt or Uncle**	**Legal Guardian**	**Other**	**No response**	**TOTAL**
Number of Respondents	84	29	2	0	5	1	9	130

Table 3.4 Race/Ethnicity of Respondents to Perceptions of STEM Survey

Race/ Ethnicity	**Black**	**White**	**Hispanic**	**Asian**	**Middle Eastern**	**Native American**	**Mixed Race/ Ethnicity**	**Prefer Not to Answer**
Number of Respondents	5	79	17	5	2	2	10	10
Percentage of Respondents	4%	61%	13%	4%	1%	1%	8%	8%

Parent Post FSN-DCI Survey

Those families who signed in at the FSN event and consented to the research study were sent a post-event survey after the event at the Discovery Center of Idaho. The survey consisted of ten four-point Likert-scale questions and two open-ended questions (see Appendix C). The intent of this survey was to assess the significance of the FSN event through the lenses of STEM capital and STEM habitus. The Parent Post-FSN Survey was given the same family identifiers as the Family Perception of STEM Survey. Families were asked to respond and return the survey within two weeks in the same manner as the previous surveys. Families were incentivized to complete the survey by having their name put into a drawing for a $10 Dutch Bros gift card. The same drawing parameters as the previous survey were used for this drawing.

Sixty-one parents returned the survey (see Table 3.5a for details). Sixty of parents fully responded to all the Likert-scale questions; 39 parents responded to the first open-ended question, ‘Tell me about an interaction or conversation you had with your child at one of the exhibits at DCI’ and 43 parents responded to the second open-ended question, ‘How do events like the one at the Discovery Center help your whole family develop an interest in STEM?’. No gender or racial/ethnicity data was taken for this survey.

Table 3.5a Grade Level of Respondents to Parent Post FSN-DCI Survey

Grade level of Respondent	**Kindergarten**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**Parent of more than one student/grade level**
Number of Respondents	6	9	7	3	9	9	2	16
Percentage of Respondents	10%	15%	11%	5%	15%	15%	3%	26%

Student Post FSN-DCI Survey

Those students who attended the DCI event and consented/assented to the research study were given a post-event survey after the DCI event that was sent home along with the Parent Post-FSN Survey. The students were asked to complete the survey in their own home, with their parents' assistance if needed. The survey consists of ten four-point Likert-scale questions and one open-ended question (see Appendix D). The Student version of this survey mirrored the Parent version of this survey in terms of questions asked and the completion timeframe. Students were also incentivized to complete the survey by having their name put into a drawing for a $10 Dutch Bros gift card. Two gift cards were drawn per grade level.

Seventy-six students returned the survey. Seventy students fully responded to all the Likert-scale questions; 46 students responded to the open-ended question, 'What is the best part about doing STEM with your family?'. No gender or racial/ethnicity data was taken for this survey. Table 3.5b details the survey respondents by grade level.

Table 3.5b Grade Level of Respondents to Student Post FSN-DCI Survey

Grade level of Respondent	**Kindergarten**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**
Number of Respondents	6	19	11	6	15	17	2
Percentage of Respondents	8%	25%	14%	8%	20%	22%	3%

<u>Parent Post-FSC Survey</u>

Those families who signed in at the Family STEM Camp event and consented to the research study were sent a post-event survey after the event. The survey consisted of ten four-point Likert-scale questions and one open-ended question. The survey also allowed families to indicate if they attended the DCI event and would be interested in participating in a brief interview (see Appendix E). The intent of this survey is to assess the significance of the FSC event through the lenses of STEM capital and STEM habitus.

The completion and drawing procedures for this survey mirrored those of the FSN survey.

Twenty parents returned the survey (see Table 3.6a for details). All parents fully responded to all the Likert-scale questions; 12 parents responded to the first open-ended question, ‘Tell me about an interaction or conversation you had with your child at the Family STEM Camp’ and 12 parents responded to the second open-ended question, ‘How do events like the one at the Family STEM Camp help your whole family develop an interest in STEM’. No gender or racial/ethnicity data was taken for this survey.

Table 3.6a Grade Level of Respondents to Parent Post-FSC Survey

Grade level of Student	Kindergarten	1st	2nd	3rd	4th	5th	6th	Parent of more than one student/grade level
Number of Respondents	1	7	2	1	0	1	1	7
Percentage of Respondents	5%	35%	10%	5%	0%	5%	5%	35%

Student Post-FSC Survey

Those students who attended the Family STEM Camp event and consented/assented to the research study were given a post-event survey, sent home along with the Parent Post-FSC Survey. As before, the Student version of this survey mirrored the Parent version of this survey. The completion and drawing procedures for this survey mirrored those of the FSN survey.

Twenty-eight students returned the survey. Twenty-six students fully responded to all the Likert-scale questions; 18 students responded to the open-ended question, ‘What was the best part about doing the Family STEM Camp with your family?’. No gender or racial/ethnicity data was taken for this survey. Table 3.6b details the survey respondents by grade level.

Table 3.6b Grade Level of Respondents to Student Post-FSC Survey

Grade level of Student	**Kindergarten**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**
Number of Respondents	1	8	4	5	3	6	1
Percentage of Respondents	4%	29%	14%	18%	11%	20%	4%

Family Interviews

Those families who participated in both the FSN and FSC events, consented to the research study, and indicated they would be willing to participate in an interview were contacted in May of 2019. Arrangements were made to meet with families in a space in which they were comfortable, at a time that was convenient for the participants (e.g. their home, or the school). Nine parents from different households were interviewed. These interviews were semi-structured (Roulston, 2010), ten questions long, and will assess the significance of the FSN and FSC events on the family, both parents and students, through the lens of STEM capital and STEM habitus (see Appendix G).

An overview of each parent interview participant is below in Table 3.7. An overall profile of each parent is provided, along with their reflection on their own STEM identity.

Table 3.7 Parent Interview Participant Profiles

Parent Profile*	STEM Identity: Do they consider themselves a STEM person and why?
Olivia Mid-30s, female Ukrainian immigrant, married, 3 children, 4-year degree	Yes: Loved math and science in school Participated in science fairs growing up Enjoys math and science as an adult
Daisy Mid-30s, White American female, married, 3 children, HS diploma	No: Wasn't into science or math subjects in school Considers herself curious, but does not identify as a STEM person
Lily Early-40s, Mexican American female, divorced, 4 children, HS diploma	No: Was never into STEM subjects in school Did like to take things apart when young, but made no STEM connection
Natalie Late-30s, White American female, divorced, 3 children, HS diploma	No: Didn't like STEM subjects in school Considers herself stronger now in reading and writing
Monica Mid-30s, White American female, single, 2 children, homeless, HS diploma	No: Always had trouble in school Was in special education Had specific struggles in school science
Asal Late-20s, Afghanistan refugee female, married, 2 children, some college	Yes: Loved math and science growing up Feels like math and science are all around us

MacKenzie Early-30s, White American female, married, 2 children, 4-year degree	Yes: Participated in science fairs growing up Dad was into science and would help her with projects She and her husband built their own home Science conversations are commonplace in her home
Ryan Early-30s, White American male, married, 1 child, 4-year degree	Yes: Science was his favorite subject growing up Grew up with science conversations in the home STEM is important to his family now and a way of understanding how the world works
Max Early-50s, White American male, married, 2 children, some college	Yes: Went to college on nuclear engineering scholarship Used STEM as a part of his work in the Navy Has always been good at math
* Note that all parent names are pseudonyms throughout this manuscript.	

DCI Return Ticket

As described earlier, families who elected to return to the DCI after the FSN event, free of charge, were asked to mark on their return ticket how many Garfield Elementary students and adults utilized the pass. The tickets were collected at DCI and given to me monthly until the end of the 2018-2019 school year.

Data Analysis

The data collected were both quantitative and qualitative. Table 3.8 notes the specific types of data obtained via each data source.

Table 3.8 Data Collected

Data Source	Qualitative Data	Quantitative Data
Family Perception of STEM Survey	3 open-ended questions	10 4-point Likert Scale questions 3 demographic questions
Parent Post-FSN Survey	2 open-ended questions	10 4-point Likert Scale questions
Student Post-FSN Survey		10 4-point Likert Scale questions
Parent Post-MEC Survey	1 open-ended question	10 4-point Likert Scale questions
Student Post-MEC Survey	1 open-ended question	10 4-point Likert Scale questions
Family Interview	10 open-ended questions	
DCI Return Tickets		Headcounts taken for families

Quantitative Data Analysis

The quantitative data from the Likert scale questions will be calculated for simple descriptive statistics: mean, median, outliers, etc. Since the study sought to evaluate the significance of each designed STEM experience and the components therein, more rudimentary metrics were used for the quantitative data analysis, rather than measurement of questions between designed STEM events.

Qualitative Data Analysis

The qualitative data analysis began with descriptive coding (Saldaña, 2015) of each data source (surveys, interviews, and feedback from short answer responses) to see what patterns emerged. From this round of coding, I merged the coding results from each data source to create categories and then themes (Saldaña, 2015) under topics related to access to create an overall picture of creating opportunities for families to interact with STEM and the impacts of these experiences on students' and families' STEM identity, STEM habitus, and STEM interest. Each of the nine parents interviewed were examined as a case to see if any patterns emerged as a whole unit from the family, parents and students, as they reported on the two STEM events, a return-visit to DCI, and interview regarding the significance of these events on their family.

Questions created for the surveys and interview were designed to learn more about STEM capital and STEM habitus of the parents and students. Having questions that directly address capital and habitus will allow for a consistent measure to help show the significance within the designed STEM event. The post-event surveys for both the FSN-DCI and FSC for the parents and students are nearly identical. The STEM capital and STEM habitus questions are similar in both surveys to possibly demonstrate similar patterns with these STEM components between the parent and their child at each event. Having the Likert questions and surveys coded with a capital and habitus framework allowed me to look for patterns across these different constructs, both individually for the parent and child, and as the family unit.

<u>Subjectivity Statement</u>

In relation to this research, I was involved every step of the way. I am a fifth-grade teacher at Garfield Elementary and the STEM Coordinator for the school. For six years leading up to this study, I had worked with the school population at large to build STEM opportunities and experiences within the school. I have worked closely with the families for the years leading up to the study to increase participation, lower barriers, and facilitate access to the events. I have taught many of the students and the siblings of students that attended the events in the study. It is fair to say that the families know me well, respect my efforts to increase STEM within the school, and are generally supportive of my endeavors specifically.

Having said that, I did strive to ameliorate the bias from my role as the designer and executor of the study. No special announcement was made that the FSN-DCI or FSC event was part of a research study, nor was any coercion employed to have families attend because it was my study. Families were informed before agreeing to participate in the post-event surveys that their responses would remain anonymous. While families, parents, and students were incentivized to respond to the questionnaires with a gift card drawing after the surveys were returned, I had another Garfield staff member draw for those winners and inform the families. The parents selected for the interviews after the designed STEM events were completed were selected from those that volunteered to be interviewed. Only one parent interviewed had a child that had been in my classroom previously.

Measures to Ensure Quality

In order to ensure the quality of the research conducted in this study, certain guidelines and criteria were used to guarantee the reliability of the research methods and data collected. Using the practices and procedures outlined by Tracy (2010) for excellent qualitative research, certain standards were used to guarantee honesty throughout the study. In an effort to maintain credibility, the research applied triangulation methods by including multiple sources and data points, along with the researcher's point of view. Parent and student post-event surveys had qualitative and quantitative response questions to evaluate the event. Detailed planning notes and reflection journals were kept by the researcher for both STEM events. The sample of parents interviewed had to attend both STEM events in order to participate. In order to assess the initial findings and examine emergent themes between the data, parent and student survey data were examined by three different colleagues to inform the interpretation and use of the data in the findings. These findings, along with transcripts of the parent interviews were given to two different colleagues to evaluate perceived themes and relevance within the data.

Lastly, significant effort was employed to develop the readers' understanding of each construct being analyzed within the designed STEM events. Ample qualitative data was used from both parent and student survey responses, assisted by quantitative data to help support the written feedback. Narrative responses from the parent interviews were also used to elaborate the various concepts discussed and add detail to the survey data findings. The analysis provided through the findings, discussion, and implications is meant for the reader to appreciate the framework of the study and the embodied experiences for the families. It is the hope that readers may connect in some way to the intention of the research and the work and apply those findings to their own contexts.

CHAPTER FOUR: FINDINGS

This study focused on the role of families in the development of their collective STEM interests and engagement, facilitating STEM investigations and conversations, and recognizing themselves, as well as their children, as ‘STEM people’. Developing a STEM identity is complex and multifaceted. It takes time to develop and can be challenging to measure. Carlone and Johnson (2007) assert that “identity is not simply what an individual says about her relationship to, abilities in, or aspirations regarding science: it is not purely an emic construct. Identity arises out of the constraints and resources available in a local setting” (p. 1192). Figure 4.1 again provides a visual that suggests how one might support students in developing a STEM identity by purposefully decreasing constraints and increasing resources. By providing opportunities for access to STEM, families can then build STEM capital and a STEM family habitus simultaneously, which can be seen as mutually reinforcing constructs. Increased STEM capital allows families to see themselves as those who are engaged in STEM (family habitus) and the increased engagement builds STEM capital via gained resources and connections. As STEM capital and STEM family habitus are developed, students are much more likely to develop a STEM identity as they see that the STEM community is one to which they can belong. This sequence exists within the frame of a field in this case, the social space provided for STEM investigations and experiences.

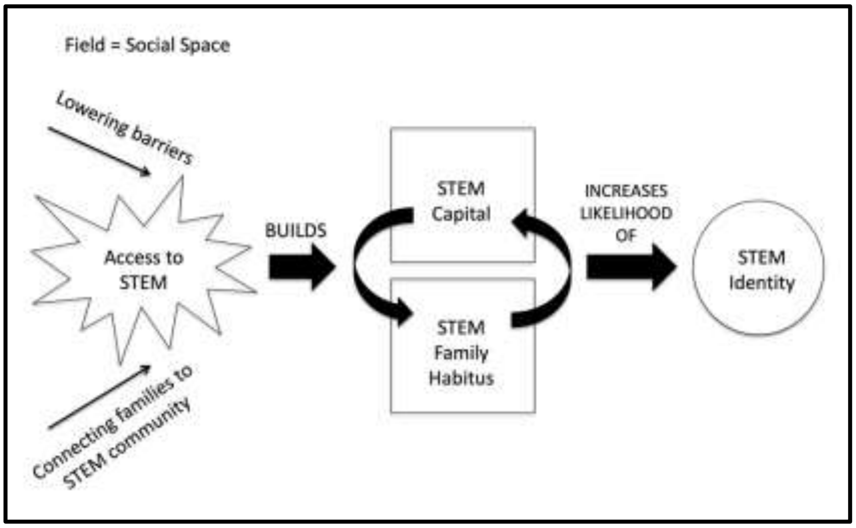

Figure 4.1. Hypothesized Mechanism for STEM Identity Development

Two family-focused, intentionally-designed STEM experiences provided resources and opportunities to support the development of families' interest in STEM, recognizing that if interest is not sustained through practice, it would be difficult for it to grow into identity (Archer et al., 2012). The progress towards a STEM identity is supported by the development of STEM capital and STEM family habitus. As Archer et al. (2012) note, "the alignment between family habitus, capital, and the child's personal interests and identifications produces a strong, mutually reinforcing consensus" (p. 892).

Given that identity development is a lengthy process, this study attended to the hypothesized precursors: STEM capital and STEM family habitus. Specifically, this study sought to answer the following research questions:

1. In what ways were the designed STEM experiences meaningful for participants in terms of the development of STEM capital?
2. In what ways were the designed STEM experiences meaningful for participants in terms of the support of family habitus?

In this study, STEM capital was operationalized by conversations and connections made by both the parent and their child(ren) both during and after the STEM experience. Along with the consideration of STEM capital, it is important to concurrently document the family's STEM habitus (socialized dispositions). A family's STEM habitus was operationalized in this study by both parents' and students' indicated interests. As previously discussed, STEM capital and STEM habitus are related and need to be explored together within this study's STEM experiences. The rationale for this simultaneous examination stems from Bourdieu's (1984) caution against the research of habitus or capital in isolation and/or remove them from their relational position with the field, or the social world within which they exist.

Findings will be reported by research question, and then further broken down by each research focus of 'capital' and 'habitus'. The FSN-DCI was attended by approximately 450 families and the subsequent FSC was attended by approximately 120 families. The findings are supported from the parent and student post-event questionnaires and parent interviews. Special attention will be made to the design choices framing the two STEM events that may support the evidence made visible in the data.

In What Ways Were the Designed STEM Experiences Meaningful for Participants in Terms of the Development of STEM Capital?

Both STEM experiences appear to have enriched the social capital and cultural capital of the families in attendance. Social capital includes relationships and network of connections that exist within a social structure, while cultural capital includes social assets, such as what you have and what you know (Bourdieu, 1984). Archer et al. (2014)

remind us that STEM capital incorporates these types of capital as related to science, "...notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science." Families appreciated the designed STEM experiences because they allowed them to build deeper connections within their own families, and to build relationships with other families from Garfield. These events (and other STEM events prior to this study) have also positioned families to articulate what they need and want in terms of further resources related to STEM. These three themes will be presented for the two family STEM experiences collectively.

Fostering Connections Through Conversations

Part of the intentional design of the FSN-DCI was to position parents as knowers and learners of STEM. The low-threat nature of the event allowed parents to name and notice the STEM capital they already have and share it with their child(ren). Each of the 41 parent responses to the question concerning the interactions and conversations at the FSN-DCI between parents and children were positive and centered on learning together with family and friends. Parents reported interactions with their children at a variety of STEM exhibits like the pulley chair, static electricity, plasma ball, paper airplane, bed of nails, etc. Over half of these 41 parents reported that their conversations centered on the exhibits, how something worked or how the principles of the exhibit applied in real life. Parents reported conversations about helping their students think through the shape of vehicles and aerodynamics, how balance applies to sports, and the connection between electricity and generators.

The bubble wall was a particularly inspiring exhibit at the FSN-DCI. MacKenzie, Asal, Ryan, and Lily all have young children and remember having conversations about the bubble exhibit. The bubble exhibit allows participants to create a bubble wall about four feet wide, then blow a very large bubble from the suspended wall. Lily helped connect that experience with the little bubble wands her children have at home. She talked with her children to extend the context of bubbles, size, and how they are formed helped them to develop their understanding beyond their initial experience. “It made their small world so much larger where they can’t even imagine” (Lily, 5:41). Lily recognized the value of taking the time to help her children make connections and build upon what they know. She stated that,

> …sometimes it's not that easy to make that connection, especially in a fast-paced world but it's there. And when your eyes are open to it, when you get exposed to it, you start to recognize it in little things. Even for me. (Lily, 6:56)

Numerous connections were made by students and parents, as reported in the post DCI event surveys. Parents were able to connect the STEM investigations throughout DCI to real-world applications. Ten parents commented about the connections made by their families to how things work in everyday settings. One parent said that it was nice “to see how science and math makes things function” (I7). Parents also reported that the FSN-DCI helped build context for to STEM phenomena in order to develop new learning for their child(ren). One parent responded that through the FSN-DCI, “children [could] easily experience the events that usually happen in the real world” (I18). Another parent reported that the event could “help children picture how things work” (C13). Specifically addressing new learning, one parent stated that “my kids are asking and learning about physics" (F16). Students also reported learning and making connections to the exhibits at the FSN-DCI. Seven students reported in general about "learning new things". Two students elaborated further by saying the event facilitated "learning about the world we live in and how things actually work" (I15) and "a chance to apply science to real life" (G5). Further, one parent noted that exposing her son "to STEM events helps him to associate real world applications of STEM to everyday things" (C4). Specifically, this parent discussed what is needed to complete an electrical circuit and how electricity can flow through people if they are holding hands (C4). Making these connections in a science museum is important for developing a family STEM habitus because it normalizes the STEM concepts into real-world contexts, allows the parents to draw from their experiences, and helps maximize learning for the students.

MacKenzie noted that she felt it was important to bring in the real-world science connections to her conversations with her children about the exhibits at DCI. For example, MacKenzie mentioned that she completed the arch building challenge exhibit with her children and related it to building techniques from long ago:

> We were talking about Notre Dame [cathedral] and the fire that just happened there. And so we were talking about how back in the day, they didn't have concrete or mortar...they were really held together by tension...and so when you burn one piece of it, the whole thing collapses. (MacKenzie, 8:10)

Asal felt strongly that she wanted her daughter to fully grasp the ideas and real-life connections behind the exhibits: "I want her to engage in science, and understand the concept behind things" (Asal, 1:28). Ryan echoed the same sentiment, wanting his son to understand the "why" behind the science exhibits: "I was always told it's one thing to understand how to do something, but when you know why to do something, you open up this huge ballpark for yourself to do other things" (Ryan, 3:29). While seven parent respondents to the post-DCI survey reported that during their conversations with their children during or after the experience, kids reported "having fun" at the exhibits or at the event in general, Ryan elaborated that it's more than just fun:

> They get to feel like they're learning at the same time, and they're learning at their own rate, 'cause they're doing experiments, so it's like their own... It's them finding out that for themselves and I think that really sets a base on understanding things. (Ryan, 2:52)

Families reported a deliberate effort to make connections based on their experience at the FSN-DCI event. One parent said, "It will be wonderful going back to our experience from DCI when we do some experiments at home or when we experience STEM in everyday life" (C13 post DCI). The survey showed a mean of 3.39 affirming that as a family, they can make personal connections from the exhibits at the Discovery Center to real-world STEM. The connections made by families, both during and after the event, validates their knowledge and the science of the everyday, even as those connections were born from a science museum, which most families were unfamiliar with. From the 61 parent respondents to the post-DCI survey, most indicated that they had STEM-related conversations after the event (mean of 3.43, SD =.72). Within those conversations, parents stated that they discussed the fun their students had at the event, learning and exploring with friends and family. To sustain these conversations, part of the intentional design of the event included the opportunity for families to return to DCI and continue building their STEM capital. In the three months following the FSN-DCI event, 83 Garfield students and families returned to DCI with their free pass.

At the FSC, several parents felt like they were able to lead their students in the investigations. MacKenzie, Max and Ryan both noted that they felt comfortable to guide some of the challenges with strategic questions and real-world connections to use as examples when building. Max discussed the catapult challenge with his children and compared a few different models used throughout history (16:14). He said this helped them pick a design that could launch farther and with more accuracy. MacKenzie examined the egg drop challenge with her children and asked them to relate what they knew about hot air balloons and parachutes, as well as what cars have installed to protect passengers when there is an impact. These parents were able to make their STEM capital in terms of knowledge and connections known to help support their children with the investigation. Again, part of the intention behind the design of the STEM experience was to position families as a capable resource to their children and other families. The accessibility of the STEM challenges allowed families to name and notice what they know and what they can contribute to the investigation.

Part of learning together as a family can include letting the students guide and make attempts on their own. Science is often a collaborative practice and can level the playing field if people have different, yet viable ideas that can be tested. Lily commented that she is sometimes intimidated by STEM subjects because of her lack of formal knowledge in those areas, but that in the FSC investigations, she was able to learn together with her children. Lily, MacKenzie, Ryan, and Monica all remarked that they let their children lead the discussions and direction of the investigation at times. This also positioned parents to learn from their students and from each other. Natalie mentioned that it was interesting to work with her three daughters on an investigation and see how their minds worked, noting the difference between their thinking and her own. All parents who returned the post-FSC survey reported that their interactions and conversations with their children after the FSC focused on the three challenges: rockets, catapults, and an egg drop. Overall, the egg drop was the most discussed, with eight families reporting problem solving discussions of why their egg broke, what they could have done differently, and how to choose materials for the best egg drop success. One parent reported that they continued the egg drop challenge once they got home. Parents were able to showcase and facilitate what they knew about the process of the investigations, how to improve design, and why they got the results they did. Related to the rocket challenge, one parent mentioned that “the rocket was too heavy at first. We talked about why and how to incrementally reduce the weight” (C2). Another parent reported that during the catapult building, they discussed with their child about “what needs to be adjusted to make it work better” (C13). One parent connected the catapult challenge to pirates and “how they used catapults in their time” (C9). Five parents also reported talking about change with their student(s) and what they could do differently with the STEM challenge(s) to get a different result. Lastly, four of the parents mentioned that they spoke to their student(s) about how fun the activities were and how much they enjoyed the event. Like with the conversations and connections made by families at the FSN-DCI, families participating in the FSC were able to draw upon existing STEM capital to help their children, problem solve, and connect to STEM in the real world.

For some parents, the FSN-DCI might have seemed intimidating on their own but that the event made the concepts accessible in order to help their children understand. Olivia reflected that exhibits may seem too complex if you've never encountered them:

> I feel like for some people it [STEM] seems to be so complicated and so just far away from them. But then they see that it's just like in everyday life, that it's right here and that, "I can do it and I can understand it." (Olivia, 3:41)

These connections are significant, as the FSN-DCI affirmed to families that science museum investigations need not be separate from what they already know and do.

Part of developing a community of learners is providing activities that everyone can take part in. This was a strategic design component of the FSC to provide three STEM investigations that were accessible for all families, parents and students, regardless of their background. From the interviews, several parents felt like the engineering and physics investigations presented at the FSC were challenging for the whole family, but still approachable. Lily, Daisy, Olivia, Natalie, MacKenzie, and Ryan all noted how the challenges got their family to work together. Ryan stated that it "really turned into teamwork of trying to figure that out as a group" (Ryan, 6:13). Additionally, Olivia felt that the friendly competition increased the motivation a little more within the families. "I feel like it just added so much energy to all the activities" (Olivia, 14:10). The competition component of the FSC was deliberate to incentivize and challenge families. Parents reported in the post-event survey that their entire family was engaged during the event (mean of 3.75, SD= .44).

A handful of parents connected their experience at the DCI event to the potential opportunity those interests could afford their children. One parent felt like the event was “developing engineering minds in children” (I18) and another parent declared that after the event, “one of the boys wants to become a scientist when he grows up” (D10/F10). While most parents did not articulate in the survey the STEM career connections that could be made at FSN-DCI, a few parents were able to do so. A parent related the fun of the STEM exhibits to “how that translates into STEM fields” (D5) and another parent said that STEM events “help give us ways to explain STEM opportunities for jobs in our kids’ future” (C1/H1). Overall, families were able to articulate and apply their background knowledge to the event and help their children make connections, both personal and real-world.

Building Communities of Practice

All nine of the families interviewed stated that they enjoyed the family-centered event at DCI and the social aspect of learning STEM together. Olivia, Daisy, and Lily all stated that they “loved the event” and expressed that their children were engaged and had fun learning together with the family and with friends. Olivia and her children had been to DCI before but were excited to have that experience with the whole school. Olivia reflected that experiencing DCI as a family outside of a school event is different. She said her children engage differently when it is with their peers. “I can definitely tell that when kids work together with friends, it was more exciting for them. They were exploring more...because they were together with friends, they were working on something” (Olivia, 5:03). Having families interact socially with each other around the STEM investigations was a goal for the event, given the importance of developing social networks within STEM capital, as they build a community of practice. The social aspect of the event also helped some of the children engage with others, not just their parents. Consequently, the FSN-DCI was tailored to maximize social connections by situating the STEM investigations as the focus for collaboration and exploration together as families and a school community. This, and other components of previous FSNs were mirrored in the FSN-DCI to make families feel at ease. Daisy noted that her children had not been to DCI and so didn't know what to expect, but that participating as a school community helped bring familiarity to the event: "I think they felt comfortable because they saw so many people they know, so they just went wild. And had fun" (Daisy, 3:40).

As with the FSN-DCI, all nine of the parents interviewed said they enjoyed the social nature of the FSC as well. Olivia pointed out the difference between participating in a STEM investigation at home and in the social, school community. She commented that while her children enjoyed the kit that was sent home from the FSN-DCI, they were done working with the activities relatively quickly. However, her children were more thoughtful and deliberate when participating in the same investigations at the FSC *because* it was in a social setting. "I feel like just being here [at Garfield] in this environment even motivates her to do more. And I really like...even though it was the same activity, she approached it from a totally different level" (Olivia, 10:44). Ryan remarked that it was valuable to get school families together to engage in STEM and have fun, in that it builds a science community where people can learn together:

> You find people from all over the place with different environments and they don't really understand each other...And so you start bringing that together and I

> think that really fosters an environment where people can be a better community really. (Ryan, 10:36)

In fact, Daisy, Lily, Asal, Ryan, and Olivia all spoke to the social aspect of learning together as a school community. “It’s fun to see our families mix and get to know each other” (Lily, 11:44). The responses from parents regarding being together and learning as a family, with the school community, is noteworthy in that it exemplifies the importance of communities of practice when building STEM capital (Lave & Wenger, 1991). Having a support network to learn, engage, and build interest with supports the enrichment of existing capital as well as gaining new (STEM) capital.

Part of the FSN-DCI’s layout included teachers and DCI employees and docents, positioned throughout the facility to help answer STEM questions and support discussions. These STEM helpers also provided key modeling for asking questions, encouraging connections, and fostering conversations. Similarly, while the three FSC investigations were designed to be accessible for all the families attending, for those families that needed a little guidance, there were DCI personnel at the FSC to assist with prompts, questions, and guidance. These same DCI employees were present at the FSN-DCI, which was another purposeful component in that they had already received culturally responsive training about working with the school community and were familiar with the experiences the families had at the FSN-DCI. The DCI helpers at the FSC were positioned to help families understand the investigation, how to set up a trial, and framed questions to help both parents and students think through the challenges. This was also helpful for the families to build familiarity and connections with those from the community working in STEM.

Families also commented that they relied on each other for assistance with STEM. Lily noted that she was struggling to use less materials with the egg drop challenge, but that another child's grandmother gave her some pointers and helped her daughter think through another design possibility. “And that's why it's nice when it's a family thing and everybody's there because you share” (Lily, 9:35). Sharing and learning together was noted by all 9 parents interviewed. Particularly, Ryan noted that families with more background information or more exposure to STEM can help others feel more comfortable and successful in the investigations. He suggested that “...getting people to engage more and they can have a little bit of fun and then that fun helps them want to do it more. The more they do it, the more they can understand it...as a community” (Ryan, 10:01). AS with the DCI event, this Family STEM Camp allowed the families to gain and build a social network of resources, support, and community.

These efforts to build a STEM community were not lost on Monica, a single mom who brought her two children to the FSC. Monica explained that she had significant struggles during her school years while in special education and never felt successful in any STEM subject. She was honest with her insecurity but recognized this school as a resource and place that could help her engage with her children through STEM. Monica explained,

> I try to come to any STEM event that they have here because that way they're more involved in stuff and learn, and then I can be involved with them... so I appreciate all the stuff that you guys do 'cause I don't know too much of what to go do with the kids. It's like, "Okay, there's the park or whatever," but certain stuff to teach them, so this is a really good thing for them. (Monica, 00:43)

With some assistance, she was able to help her children plan together and brainstorm as a family in order to work through the STEM investigations. Monica noted that her children had a great time and were able to complete the egg drop challenge successfully, which delighted the whole family. Monica reflected that despite her own struggles in school, “this was a fun little activity to be able to learn how physics works and stuff, and so I thought it was really awesome” (2:28). This mother’s experience and reflection is significant because she is actively seeking a network to help her with STEM. Her experience with her children at the FSC was validating to her as a learner and gave her a little more confidence to potentially position herself for lifelong STEM exploration.

The FSC provided a structured space with access points for all families. One parent commented that they appreciated that they were able to access the STEM challenges without having an academic background on the subject. They stated, “you do not have to have a college degree to learn about them” (B5). That was important for Lily too, as she wants to support her young children’s STEM interests, but doesn’t feel confident in STEM just yet. “I’d love to do anything I can to give them more exposure to that, that I’m not able to do on my own” (Lily, 3:50). Lily recognizes the importance of these opportunities, especially for her young daughter:

> I think because I didn't have that exposure growing up, I wanted to make it really important for Lizzy especially...for Lizzy to be able to have that opportunity through the school. I want her, as a woman, to be able to learn the sciences and the math and whatever, it was just important to me. (Lily, 3:23)

Max recognized the events as uncovering new STEM topics for his children. He stated that “at a really basic level, it’s exposure. I think a massive piece of opportunity is realizing that it is" (Max, 32:50). Ryan also appreciated the school's emphasis on STEM. He recognized the school for demonstrating a priority for STEM by hosting the family-centered events. That priority for STEM embraces the family as a catalyst for developing and supporting STEM interests. Drawing on support from each other in these STEM endeavors, both inside the family and as a school community, is meaningful for establishing a community of practice. Through these designed STEM experiences, families were able to develop their common interest and desire to learn from and contribute to this developing community.

Articulating STEM Capital Needs

As stated previously, the nine parents interviewed were asked one additional question that was different than the questions asked the families in the post-event surveys: 'Do you have any suggestions for the school to help families with STEM?' This question was the last question of the interview, after families had been to the school's fall FSN, the FSN-DCI, and after the FSC. The children of these families had also attended several other STEM opportunities at the school, outside the scope of this study. This question sought to explore what parents prioritize in STEM, as well as how parents applied their own STEM capital and STEM priorities into suggestions for the school. For this study, STEM capital was operationalized by the conversations and connections made by the families and students at the events; however, this question acknowledged that STEM capital also includes economic, social, and cultural resources. It is reasonable to argue that the more STEM capital and understanding a person has, the better positioned they are to articulate what you want and need to continue STEM learning. As a result, families' responses to this question could be seen as an increase or refinement of their own STEM capital.

This question also intended to position the parents as thinking partners with the school, valuing their suggestions, and recognizing their stake in advancing STEM endeavors within their families and throughout the school. The nine parents interviewed all had suggestions for how to assist their families with STEM. In each interview, the parents asked that the school continue the school-wide efforts in STEM. Max and Daisy suggested we provide more family events. Daisy also noted her appreciation for the free monthly STEM camps for the older grades, but suggested we provide camps for the younger, primary grades as well. MacKenzie and Asal joined Daisy in the request for more STEM events targeted at the younger elementary students. These three mothers all have younger children, and all noted the eagerness their young children have for STEM activities. Lily, a mother of three young children, also remarked that her children love to explore with science and engineering but wanted advice as to how to do investigations at home.

The request for support and STEM resources in order to engage with STEM at home, was heard from several of the parents. Olivia, Daisy, Lily, and Natalie all expressed a desire for DIY (do-it-yourself) STEM projects to do with their kids at home. To accomplish this, several parents requested physical materials to do the activities as well as the support of *how* to do the activities properly. Daisy, MacKenzie, Asal, Lily, and Monica all expressed a need for items to conduct their STEM investigations, but more than materials, these mothers wanted support with developing their children's STEM interests and guidance on how to do it on their own. In addition, Olivia, MacKenzie, and Daisy recommended that the school promote monthly STEM challenges in the school newsletter. Olivia suggested that the STEM challenge could give ideas to families and tell them what simple, inexpensive materials they should collect to do the activity. MacKenzie added that the monthly STEM challenges could be accompanied by a helpful ‘how-to’ video or supporting websites that go with the investigation. Lily was enthusiastic at the prospect of getting the assistance to run her own STEM activities at home with her children. She was positive that more parents would be eager to try DIY STEM investigations at home if given some support. She commented that,

> Taking home something that they can do that's so simple and so once they grasp that they're like, “Oh my God, this is amazing!” And then the parents feel good, they feel good that they were able to do it with their kids. (Lily, 19:22)

Outside of the support to facilitate STEM projects at home as a family, a few parents also requested information about the STEM opportunities out in the community. Asal and MacKenzie wanted information about where their children could have additional access to STEM outside of school-sponsored events. MacKenzie talked about the resources she knew that existed in the community for free, like robotics at the public library and thought that it would be useful for the school to promote those resources and opportunities to other families. She suggested that “just helping parents be more aware of what is out there” might encourage families to seek STEM engagement and resources provided in the community (MacKenzie, 41:23). In addition to the resources that exist locally, a few parents wanted assistance in promoting awareness of the STEM jobs in the community. Natalie asked for support in this area explaining that making those connections for her daughters is not her strong suit. Ryan also expressed a desire for the school to highlight STEM careers, emphasizing the local jobs associated with STEM. He noted that he didn't have anyone facilitating those connections when he was younger and feels like it's never too early to start those conversations. "I think that would make a big impact on kids, knowing where they can go and set a path for it" (Ryan, 17:28). By parents expressing their wants and needs to advance STEM learning for their children and for the family, it empowers them to be active participants in the process and approach to STEM that serves them well. Acting on their suggestions could give confirmation to their STEM capital and authority to their contributions to STEM efforts in the school community.

In What Ways Were the Designed STEM Experiences Meaningful for Participants in Terms of the Support of STEM Family Habitus?

Archer et al. (2012) states that science (or STEM) "family habitus is used to explore the extent to which families construct a collective relationship with science and the extent to which this is shaped by their possession of particular sorts of economic, social, and cultural capital" (p. 886). One way to assess the construction of a relationship with science is to document interest, within existing and burgeoning capital. For this study, STEM habitus was operationalized by the parents' and students' documented interests in STEM. The particular focus on the themes within families' developing interests embraces the assumption that "interest is habitus incarnate" (Grenfell, 2008, p. 154). Through the parent and student responses from both events, three major themes emerged for how the STEM event helped their family develop STEM interests. Through the parent and student responses from both events, three major themes emerged for how the STEM event helped their family develop STEM interests. In general, families spoke of STEM as fun and engaging, building those STEM interests as a family, and extending their interests into the home after the events.

STEM is Fun and Engaging

A prominent theme that emerged from both designed STEM experiences was that it was fun and engaging as a family. The majority of the parent survey respondents stated that their whole family enjoyed the event at DCI (mean = 3.85, SD = .36). Seventeen parent responses and fourteen student responses remarked on the 'fun' had together and the excitement of the FSN-DCI. One student summarized the experience as "we all get to learn together and we have fun" (I7). The majority of student survey respondents stated that they had fun at the Discovery Center (mean = 3.9, SD = .40), and 14 students also reported that "having fun" was the best part of the FSN-DCI. One student recalled that "it was fun to see things that look like magic" (C9).

The parent respondents indicated overwhelmingly that the whole family not only enjoyed the event (mean of 3.85, SD=.36), but also were engaged at the event as well (mean of 3.71, SD=.49). Two parents noted how nice it was to be able to have conversations with their children and draw STEM connections away from screen time. This, too, was considered in the design of the FSN-DCI. Conditions were considered to maximize family together-time and limit down-time, such as sitting on the sidelines instead of participating. Some intentional strategies meant to limit down-time was to serve dinner all night long, so food was not tied to a specific time; eliminating large seating areas so families could spend their time on the floor with the STEM exhibits; and providing the scavenger hunt (to be turned in for a prize) that intentionally sent families to different parts of the DCI facility.

Part of learning at the FSN-DCI included the hands-on experiences provided through the exhibits. Six parents and students noted that the tangible approach to learning made a positive impression. One student reported that for them “hands-on activities are the best way to learn” (G17) and another parent felt that “hands-on learning makes the biggest impact” (D7). One parent’s response reflected that STEM events “make STEM more common and exciting” for his children (A6). In the pre-survey parents took weeks before the DCI event, many reported that their children are excited about STEM (mean= 3.48, SD=.67). After the FSN-DCI, the mean on this survey question had increased (mean = 3.7, SD=.46). One possible explanation for this increase could be the interest and excitement for of the FSN-DCI. Four parents stated that the event helped show them, as parents, that STEM learning is exciting. This sentiment was repeated by the majority of parent responses stating that as a whole family, they are excited about STEM (mean=3.7, SD=.46).

As with the FSN- DCI, parents and students both reported that they had fun at the FSC and were engaged throughout the event. The majority of parents reported that their whole family enjoyed the engineering challenges at the Family STEM Camp (mean=3.95, SD=.22). One parent reported that the event promoted learning through fun. From the interview, Asal added that the STEM Camp was “very entertaining for everyone and it’s educational at the same time” (16:48). Another parent reported that the excitement she and her partner had for the STEM event “is a great model for my son. He gets excited because we are” (C2). Students also reported having fun with their parents or family members at the FSC (mean=3.82, SD=.39). Twelve students remarked about having a good time with STEM while working through the STEM challenges with their families. Drilling down within this theme of the events being fun and engaging, families consistently framed this in terms of spending quality time together as a family and developing STEM curiosity together.

Quality Family Time Spent Together

The only recurring student comments more prominent than having ‘fun’ together were their responses about being with their family. Nineteen student responses articulated that being together as a family was their favorite part of the FSN-DCI. General comments were made like, “We spent more quality time together,” (B5) and “We all get to hang out and do something together” (B8). The comment of learning and being together was repeated often, but also being with a specific family member. One child reported that “I liked going with my dad [to the FSN-DCI],” (B10) and another said “I liked to talk with my Grandpa about it [STEM]” (B11). One student also responded that her favorite part of the STEM event was that it was “a good opportunity for bonding with my mom” (I26). A parent summarized that she believed the STEM event helps “associate learning with fun and positive feelings” (C13) for spending time together learning as a family. From the interview, Olivia expanded her thoughts on participating in STEM, as an engaging family event:

> I think it builds this little... I don't know if I can call it a culture, but just something that they're gonna remember. I feel it's very important to connect those good feelings of doing something together...usually those things that you enjoyed doing with either friends or family, it's something that stays somewhere. And I feel this is very important. (Olivia, 15:13)

The family-focused design of the FSC seemed to empower parents to negotiate the STEM challenges with their children. From the surveys and interviews, parents commented on the opportunity the camp gave them to work together as a family in STEM. While parents could guide the investigations for their children, many shared that role with their students. One parent from the survey commented about the value of doing the STEM challenges together, but "letting the kids lead me" (Q24). MacKenzie also echoed this response by saying that she encourages her students to teach her what they're learning whenever possible. Part of the approach to the Family STEM Camp was to have support in place for all families to find an access point to the three challenges and feel successful. Parents appreciated the structure and guidance of the Family STEM Camp to help families with whatever they needed. The event framework was helpful to parents with limited formal knowledge in STEM. Both Monica and Lily were candid about their insecurity with STEM subjects but felt supported in their efforts at the STEM Camp. The time spent together was instrumental in focusing a STEM context within the safety and familiarity of the family. It positioned both the student and parent as learners together and invited STEM exploration as a way to connect as a family.

Developing Curiosity

Families noted another part of their engagement with the designed STEM events as developing an active curiosity for STEM. Seven parents responded that the FSN-DCI helped to spark curiosity for STEM with their family and provoked questions and imagination. One parent stated that the DCI event "opened our eyes to so many different sciences and physics related mechanisms" (D4, G2). Three other parents related how their curiosity motivated the family to "do some fact finding together" (J7), explore "how things work" (Q5), and seek to "discover more" (I15) after FSN-DCI. Families interacted with a wide range of exhibits at DCI, and those interactions helped to spark a desire to know more. While the FSN-DCI only provided one evening of STEM investigation for families, parents were able to note and articulate what influence it had on their family. One parent reported that the event helped their family "stimulate questions in their minds and sparks curiosity about the world" (B15, F21).

Parents at the FSC also appreciated the opportunity to engage in the STEM challenges as a family. The majority of the parents felt their whole family was engaged at the event (Mean=3.75, SD=.44). As with the FSN-DCI, parents noted their children's engagement as curiosity. One parent said that they felt the benefit of the FSC was to "solve problems and work together, encouraging curiosity" (B10, B11). Another parent recalled that the FSC helped her child to develop their "imagination to want to discover more" (I15). Lastly, a parent reflected that the designed STEM event helps her children "spark curiosity...shows them learning is fun and exciting" (C9).

Observing both parents' and students' reflections that STEM is fun and engaging is noteworthy because it is indicative of interest. Particularly, noting the parents' sentiment about their children's and their family's level of enthusiasm for STEM is valuable when calculating the potential for long lasting effects of these designed STEM experiences on children. A parent's attitude towards STEM has a significant impact on their children. DeWitt et al. (2010) explain that students' aspirations in science are most strongly predicted by parental attitudes in science, self-concept in science, and engagement in science-related activities outside of school. Because of this, the design of the STEM experiences sought to engage and involve the parents, as well as the students, in order to develop a mutual STEM interest and towards a “collective relationship with science” (Archer et al., 2012, p. 886).

Building STEM Interests as a Family

While ‘interest’ was reported in the research question focused on developing capital, it is worthwhile to distinguish between talk and actually developing an interest. Families noted another part of their engagement with the designed STEM events as developing specific STEM interests. Parents noted how the FSN-DCI helped start conversations and provided opportunities to discover interests as a family. Ten parents discussed working together towards those interests. Some parents commented broadly, such as “we all get to learn new things together” (I7), “it gets conversations started about STEM” (I26), or “it gives us a chance to talk about science in general” (G5). Other parents saw the FSN- DCI as an opportunity to engage in new STEM interests. One parent stated that the FSN- DCI gave the family “exposure to science that we weren’t always exposed to” (C9). Other parents stated that the STEM event allowed for “new ideas or deeper interests in things” (B10/B11) or to “discover different STEM interests” (M1). From the interview, Asal reflected that exploring these interests together “encourages children to think about science and increase their love of science” (12:36).She related that the increased curiosity and love of science continued at home where her daughter wanted to know about how electricity works in their apartment, after they saw it in the circuit exhibit at the FSN-DCI.

Nine students articulated particular areas of interest at the FSN-DCI that was their favorite part with their families that night. While students reported specific exhibits like the shadow maker, bubbles, electric circuits, bed of nails, and building a tower as what interested them most, parents seem to recognize that the FSN- DCI was just the beginning of their STEM interests as a family. One parent stated that the event helped "make it possible for STEM to happen in our lives" (Q27) and another noted that the STEM experience "brought us together to participate in an event that interests us all" (G7). Lastly, one parent felt that the event brought "do-able STEM activities into our busy schedule that we would otherwise just not do" (Q27).

Another opportunity to come together as a family for STEM investigations was at the FSC. One parent commented that "all the activities made us really interested and everyone asks, 'How can we do this?'" (D9). Natalie was excited to try the FSC challenges with her daughters as well. "I wanted to be able to do something as a family that we could do together and just be able to learn something new" (Natalie, 5:38) This comment reflects the intentional design of the FSC, that everyone attending the event, both adults and students, were positioned as learners and doers. This feature allows both the parent and child to develop their disposition as a STEM person and a STEM family.

Eight students referenced a specific detail about working on one or more of the FSC challenges with their family. One student wrote that "My best part is when me and my sister made the straw rocket" (Q2). Both students and parents commented on the fun challenge of the egg drop. The egg drop included a math challenge, giving the families a (simulated) budget to purchase materials for their design. Different materials cost various amounts and families were encouraged to develop a design using less and less money. One student said, "I liked the egg budget and how you had to spend your money wisely" (H2). From the interview, MacKenzie also commented that she loved the math aspect added to the egg drop and working through the cost of buying materials with her kids. Of course, the culmination of budgeting and design was the actual dropping of the egg. Several students noted the pleasure of dropping the egg. One student remarked, “I liked designing and testing it” (C13). Whether with the egg drop or another challenge, parents were engaged and working with their children. A parent summarized the event by saying, “We all had a wonderful time! I think it is great for kids to see parents feeling engaged and excited about activities that not only provide some good family time but also a great learning opportunity” (C13).

Even for parents with confidence in the STEM subjects and a reported STEM identity, the FSC provided a family investigation that probably would not have happened without the support from the school. Both Ryan and Max, who both consider themselves ‘STEM-type people’, agreed that the camp provided a space and an opportunity for them and their children to explore and learn together. Max commented that the event helped expose both students and families to STEM opportunities and develop the foundational building blocks for future activities together. Ryan appreciated the camp and while he felt confident working and talking about science with his son, he recognized that he would not be able to replicate anything better on his own. Ryan liked the family focus of the STEM event stating, “That one [FSC] even made us want to come more [to STEM activities], because that kind of challenged everybody and made everyone as a group work together, so that’s what I liked about it” (Ryan, 5:28). Max, too, felt like the FSC provided a space for he and his children to engage in a way they would not normally, even as someone confident in the STEM subjects. He stated that, “...very basically, without what you’re doing, we wouldn’t even think of it” (Max, 20:10). This speaks to the specific design of the FSC and that everyone, regardless of background and level of STEM confidence, found equal opportunity to participate and learn together.

Providing the opportunities to engage in STEM as a family appears to have promoted a desire to continue these interests. The majority of both students and parents reported after the FSN-DCI, they were interested in additional STEM experiences either at the school or in the community (parent mean=3.8, SD=.40, student mean=3.8, SD=.40). After the FSC, this interest continued, as parents reflected that their child(ren) would be interested in attending additional STEM events at the school or in the community (mean=3.9, SD=.31) and similarly reported that the whole family would be interested in additional STEM events (mean=3.85, SD=.37). Additionally, after the FSC, students noted that they were interested in attending more STEM events at the school or in the community (mean=3.89, SD=.31). This documented interest in attending more STEM events, by both the parents and students, could result from deliberately repeated exposure and opportunities to family STEM events at the school.

Supporting STEM Interests at Home

According to some parents' responses, those applications of STEM included investigations to try at home as well as future careers for their child(ren). A few parents made the connection to hands-on activities they could try outside of FSN-DCI: "I get ideas about experiments to try and home" (A18). This preference was documented from the parents' pre-survey to the parents' post-DCI event survey. The pre-survey reported a mean of 2.87 to the statement, 'As a family, we do STEM activities in our home'. After the FSN-DCI, the parent survey reported a mean of 3.14 to the same statement. While the same respondents were not tracked over time, it is important to note that many of the exhibits at DCI brought a real-world context of a STEM principle into view. These hands-on investigations also inspired replication at home with one parent saying, “We wanted to build or do something, create it by our own selves” (Q8).

After the FSC, Daisy reported that her son continued the egg drop at home for hours after the event. Natalie also stated that she appreciated that the challenges done at the school could be taken home and done too. “You guys help me contain the mess somewhere else and teach me ways that I can do things at home” (Natalie, 00:41). Monica was not able to complete the catapult challenge while at the FSC because they spent so much time working on their egg drop design. She said she appreciated that he was able to take the materials home to do the catapult. MacKenzie echoed this sentiment by noting that the STEM event inspired home activities. “They always come home and make another rendition of whatever they did” (MacKenzie, 22:09). Daisy, Natalie, MacKenzie, Lily, and Monica all described how the STEM events helped them see what is possible in their home environment with their children. Daisy stated, “I think it gives them a broader perspective of what they can do. Like, ‘Oh, I can do this now. And then they’ll come up with their own ideas. I think it’s a good guide” (15:18). This is another example of the purposeful design of the STEM events. The STEM investigations and materials are highly accessible and encourage replication. Monica, Daisy and Lily all noted that the events have been helpful to show parents what to do and how to create STEM projects inexpensively. Lily detailed how she uses the model from the family STEM events to replicate her own projects:

> It's opened my mind at home to all these little new adventures that we do at school. Lizzy will bring it home, and then we look online to see if there's things we can find, and then we go to the thrift stores, we look for things like that. (5:41)

Using the STEM events and experiences as a model for approachable science helps parents make those connections in the home. Something that was unfamiliar, like creating hands-on STEM investigations in the home, became familiar and possible for families after the designed STEM experiences.

Summary

The family-centered FSN-DCI and FSC are critical ways to promote STEM interactions and conversations that may have not taken place otherwise. To begin, both parents and students reported that the designed STEM experiences were both fun and engaging. Families merely finding joy in attending a STEM-related event with their family might not be noteworthy in another context. For example, when Archer et al (2016) studied 'non-traditional' families' visits to a science museum, their findings suggested that while families might have enjoyed their museum visit, that doesn't mean barriers to active participation were eliminated. Archer et al. further caution that "the predominance of 'fun' as a centrally defining aspect of a visit, does not necessarily guarantee wider social benefits, such as social inclusion and/or science learning" (2016, p. 19). However, in this study, 'fun' was not the only theme or important outcome from the designed STEM experiences. Through these events, families – both parents and students – were able to develop their STEM interests together and further enrich their STEM capital (both social and cultural). The events provided structured and accessible

STEM investigations supplemented with STEM conversations and connections made during and after the events.

Throughout the school year, parents leveraged their burgeoning STEM capital – which includes the network of support that existed as a community of learners within the school and families – to make the most of the designed STEM experiences. Numerous parents in both surveys spoke positively about the family STEM events being valued social events and the benefit of engaging with others, as well as with their own family members. The social aspect allowed families to share what they knew about the investigation and support their child's learning throughout. Families also learned from each other, sharing strategies at the FSC to maximize the outcome of the STEM challenge. Parents felt the support of other family members in their STEM endeavors as they began to develop a 'community of practice'. This was demonstrated by interactions and discussions with other families, and within their own family.

Part of developing a community of learners at school includes building confidence among the families to initiate investigations outside of school. The family-focused STEM events empowered parents to continue their curiosity at home and develop their children's STEM interests. Multiple parents referenced extending those connections into additional investigations, either by continuing the ones had at the STEM events or designing their own, based on what they had learned. Each parent interviewed was also able to make detailed and thoughtful suggestions for what they needed in order to support their students' STEM interests, indicating that the attitude toward the events was overwhelmingly positive and supported by both the students and parents. All of the parents interviewed and numerous parents from the surveys commented on their gratitude for having these events for their families and the opportunity it afforded their family. This is noteworthy for underrepresented communities in STEM, as access to STEM events, designed for them specifically, are few and far between.

Lastly, the STEM events have promoted, developed, and increased the STEM interests of both parents and students. Realizing that "*interest* is *habitus* incarnate" [emphasis in original] (Grenfell, 2008, p. 154), any progress gained toward cultivating STEM interest as a family does grow the STEM habitus. In addition to the abundant responses from parents and students commenting about their STEM interests at the events and beyond, the surveys reported a resounding confirmation that the events are advancing the STEM interests of students and that the families want more.

One survey question that was held consistent through all surveys was 'My family is interested in attending more STEM events at Garfield or in the community.' The parents' mean response to this question increased after each event/survey. The mean response to that statement in the pre-survey was 3.53. After the FSN-DCI, the mean response was 3.78, and after the FSC, the mean response to the question was 3.85. Recognizing that there was not a consistent respondent population from one survey to the next, this increase in their mean response could be attributed to an increase in STEM capital and STEM habitus in families. Each designed STEM experience helped to expose families to additional STEM investigations and create the opportunity to discuss, connect, and extend those topics together as a family and school community. The parents interviewed who attended all the year's STEM events described the growth in their STEM capital and articulated the evolution of their STEM family habitus by embracing the experiences, maximizing connections for their children, and presenting other STEM investigations on their own.

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

Discussion

This study focused on the role of families in the development of their collective STEM habitus, as operationalized by interests, and STEM capital, as operationalized by conversations and connections. The study facilitated intentionally designed STEM experiences for the entire family in an effort to create opportunities for the parents to recognize themselves, as well as their children, as 'STEM people'. Developing a STEM identity is complex, takes time to develop, and can be challenging to measure; consequently, this study focused on the hypothesized precursors to a STEM identity: STEM capital and STEM family habitus, as seen in Figure 5.1.

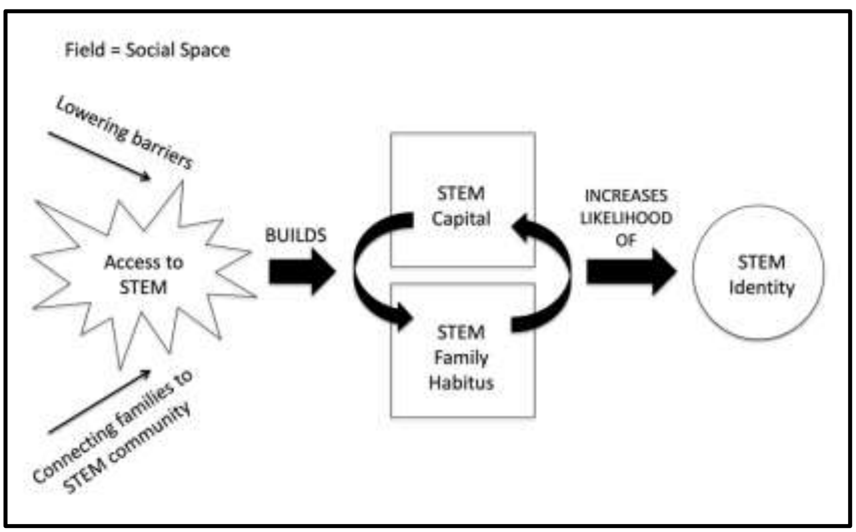

Figure 5.1 Hypothesized Mechanism for the Development of STEM Identity

To explore how to better support the development of STEM capital and STEM family habitus, tailored opportunities for access to STEM were provided. These opportunities were designed such that barriers to accessing STEM were lowered and deliberate attention was paid to supporting connections between families and the broader STEM community. The ways in which these design moves supported the further development of STEM capital and STEM family habitus will be discussed next.

Access to STEM

Lowering Barriers

In this study, part of creating access to STEM meant lowering barriers. Three of the top constraints to school events for families at Garfield, and for many underrepresented communities, are cost, transportation, and food (Ames & Dickerson, 2004). For families from low-income communities, it is important to provide STEM events and opportunities at no or low cost. As such, the FSN-DCI and FSC were completely free. Additionally, by providing a meal at the two STEM experiences, this eliminates the families' worries about feeding their family before an event. Lastly, it is important to support the transportation needs of the various families. Whether a STEM event is at the school or out in the community, transportation can be difficult for some families and a barrier to participation. For this study, the FSN- DCI utilized buses, carpools, shuttle vans, and guided walks to the DCI. Because this was an unfamiliar space for the school families, transportation was key to participation, and coordinating these transportation options allowed for hundreds of Garfield families to attend. Directly addressing all three major barriers to STEM access allowed families to take part in the activity with their peers, and to be present in the moment rather than worrying about these three items.

Connecting Families to the STEM Community

Another factor that supports access to STEM is connecting families to the STEM community. This requires more effort than simply hosting an event at a science museum or bringing in STEM professionals for an event at the school. Those kinds of exposure are not without value, more deliberate facilitation is needed to provide scaffolds for families still growing their STEM capital and habitus. In this study, the designed STEM events asked teachers and school staff to act as cultural brokers for the events – particularly for the FSN-DCI. Families know and trust the teachers and staff of their school; when embarking on a new STEM experience, like with the FSN-DCI or FSC, it is important to provide familiar faces and those that can support the families directly. Teachers and staff, alongside the STEM professionals (e.g., the DCI staff), can model questioning and problem solving.

Equally important, for personnel working with the families who do not know them directly, it is important to provide training and guidance on the culture of the community they are serving. For this study, training the DCI staff for the FSN-DCI and FSC allowed for better understanding of the families' needs, how to maximize their strengths, and how to engage the whole family in the exhibits and investigations. Negotiating this experience with families and supporting them throughout the designed STEM experiences allowed for STEM capital to grow and to feed the family's STEM habitus.

Interaction of Habitus and Capital

The interaction between habitus and capital in this study is important to note. A family's STEM habitus is complex in its own right and is entangled within their existing

STEM capital. Archer et al. (2012) states that “habitus encompasses a broad spectrum of resources, practices, values, discourse, etc.” (p. 886). Thus, it was important to distinguish a specific feature of a family’s habitus to observe. Exploring the data for the family’s interests, both from parents and students, allowed for an examination of a significant feature of habitus. STEM interest is a compelling characteristic of family habitus because “*interest* is *habitus* incarnate” [emphasis in original]” (Grenfell, 2008, p. 154). As it pertains to this study, designing deliberate opportunities to develop the families’ collective interests within STEM experiences can provide the catalyst for that positive change. Because STEM habitus and STEM capital are mutually reinforcing, it would serve the growth of both constructs to rely heavily on families as conductors of their children’s STEM interests. Given the significance that family habitus can have on individuals’ actions and pathways in life it becomes imperative to provide opportunities for families to cultivate a STEM family habitus (Robb et al., 2007; Claussen & Osborne, 2013).

Even with identifying traits of the family’s STEM habitus, such as interests, that seem like logical foundational pieces for a STEM identity, Archer et al. 's (2012) finding is that “there is no straightforward relationship between family habitus and an individual child’s identification with science” (p. 889). However, it is conceivable that a STEM family habitus could serve as “fertile ground that renders science more thinkable/desirable” (Archer et al., 2012, p. 890) for students. Part of that ‘fertile ground’ must include the influence and leverage that families have on student interest. Parents’ scope of interests, can include STEM if given the opportunities and support for students - especially those from underserved populations. It then becomes imperative for schools, STEM programs, and any stakeholder looking to increase STEM interests to incorporate families into the equation. The creation of STEM experiences must be designed with the families' needs at the forefront. The accessibility of the experience can be significantly limited if the event is produced with a singular perspective or in a blanket approach appealing to those who already have STEM capital. For this study, the diversity of the school families informed the framework and composition of both events. It was important for the STEM events to appeal to the newcomer in STEM as well as to those who have had more STEM experiences.

In order to engage a wide variety of people, whether they consider themselves a 'STEM person' or not, it is important to provide as much time as possible for families to work together in order to strengthen the family network within a STEM experience. Throughout the study, parents and students reported the value of spending time together as a family, engaged in STEM, which was one of the aims of the designed experiences. Olivia articulated this point well, commenting on the positivity felt at the STEM events, referring to it as a "culture" in that it builds a value system for the families. Families found both of the STEM experiences to be 'fun and engaging' in that it built their curiosity and left both parents and students wanting more. Parents' attitudes toward the STEM events were overwhelmingly positive and they reported the value of working closely with their child(ren), being challenged, having a model provided for them, and motivating them to investigate the exhibits or STEM challenges. The parents' attitudes towards the events and the experiences is key, as parental attitude plays a large role in shaping the aspirations of their children (Archer et al., 2012). Quite simply, a family's demeanor towards STEM matters for their children.

Conversations, Connections, and Communities of Practice

The family is the first and most important social system to the child and "...act as conduits of external motivational factors, providing an immediate interactive social group for stimulating science interest" (Dabney et al., 2013, p. 396). One way to leverage the families' influence is to create opportunities to spark and enhance their collective STEM interest to feed conversations, maximize connections, and cultivate their communities of practice. Figure 5.2 provides one way to envision how family-centered opportunities might support STEM habitus and STEM capital development.

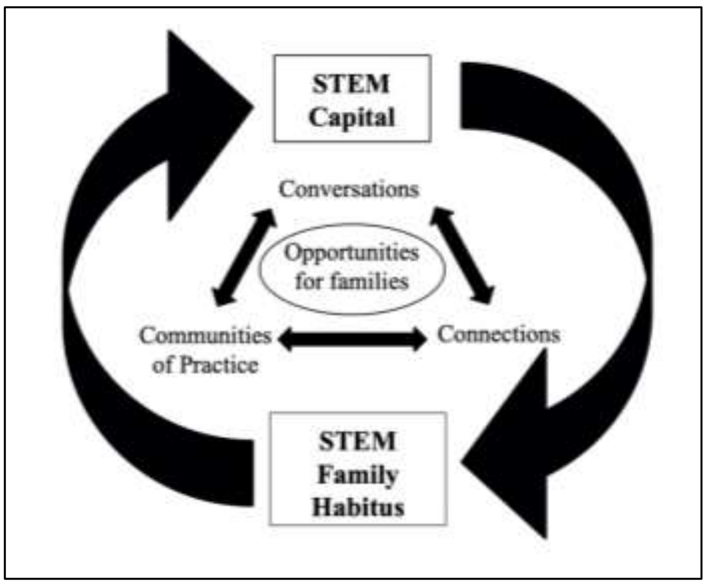

Figure 5.2 Hypothesized Mechanism for the Simultaneous Development of STEM Capital and STEM Family Habitus

Both events emphasized the social aspect of STEM learning, both within the family and between the school families. In order to help build STEM capital within families, it becomes important to facilitate STEM activities and investigations through conversations. Archer et al. (2015) report that families with STEM capital already do this:

> Families with higher levels of science-related resources, have also been found to actively promote, develop, and sustain their children's science interests and aspirations, through the foregrounding of science within everyday family life, for instance, by providing science kits, watching science TV together, discussing science in everyday conversations, going to science museums, and so on (p. 924).

It would stand to reason, then, that modeling and providing opportunities to practice activities which families with higher levels of STEM capital do would serve as a positive example for families that have not had similar opportunities, means, or support.

A significant part of the designed STEM experiences within the study served to model explicitly the conversations, investigations, and events that would be accessible within STEM-rich networks and communities. Further, the activities within the FSN-DCI and the FSC encouraged conversations between parents and their children. Having teachers and school personnel, as well as DCI staff, available to guide and mentor at both events helped families feel supported and served as good models for questioning techniques, drawing connections, and collaborative learning. It was paramount to create a safe space for parents and students to be vulnerable and learn together. Several of the parents in this study did not consider themselves to be STEM people. These parents all spoke of their gratitude for the example the events set for them, the help and support throughout, and the guidance of how to replicate similar conversations and experiences at home. It was essential for these parents, and other parents in attendance, to see that they were capable of holding STEM-related conversations with their children.

The modeling present at both STEM experiences also empowered families to draw upon their background knowledge. This helped to position parents as knowers and doers of STEM, regardless of their background or career. DeWitt et al. (2012) report that it is important for both parents and children to broaden their scope of what and who scientists are and the science-related careers that exist, “in an attempt to disrupt the *otherness* of science and enable it to become *for me*” (p. 1473, emphasis added). It could be said that the desire to ‘disrupt the otherness of science’ is needed to normalize science and STEM, and that the intellectual and practical activity of STEM is well within the parents’ and students’ reach. It was a deliberate decision to host one of the STEM events at a science museum in order to normalize the experience and help demystify the environment as one any family can approach and make connections within.

Giving families the opportunity to talk about STEM, explore exhibits, and problem solve as a family helped expand their experience. Data from the parents after both designed STEM experiences spoke to the connections and conversations the STEM opportunities afforded them. Parents were able to bring their own background knowledge, existing capital, and experience to FSN-DCI and help their students maximize the interaction with the exhibits. Because both STEM experiences allowed parents to be vulnerable and share their connections without pretense, parents felt comfortable connecting to real-world STEM, in terms of common items at home or in the lives of their children. During both designed STEM experiences, families were supported by knowledgeable others, like members of the STEM community, science museum personnel, and teachers and staff. This support came in the form of prompting questions, guided discussions and demonstrations, and a facilitated space for families to engage in STEM investigations together. Parents were also able to problem-solve alongside their child at FSC, displaying an engaging give-and-take, sometimes parents leading and sometimes students leading, through the various challenges. The families' collective interest in the STEM experiences helped set the parents up to continue the investigations at home.

Several parents described how the STEM events helped them see what is possible in their home environment with their children. They reflected that the STEM events sparked ideas and connections for their families and a desire to replicate or elaborate on the investigation at home. Again, the specific design of the STEM experiences was critical as it served as a model to the parents of what is possible, what materials to gather, and how to frame an investigation on their own. An although a few parents considered themselves to be fully competent STEM learners and able to provide meaningful STEM conversations and connections with their child, they also indicated that the design of the events elevates the experience for their children and that they would not be able to replicate the level of engagement and enthusiasm at home.

And although the experiences did model what was possible at home, it is hard to exaggerate the importance of learning with others outside the home. All of the parents interviewed, having attended both designed STEM events in the study, spoke to the social aspect of learning together as a school community and how it enhanced their own experience. For example, Olivia emphasized that being a part of the Garfield community helps her children engage and connect in ways she is not able to create on her own. STEM events need to be more than the materials and a flashy demonstration. Learning with friends, alongside other families, makes the experience richer and more meaningful. Bricker and Bell (2014) remind us that "learning is an integral part of generative social practice” (p. 261) and is different for every STEM learner across contexts and participation.

The encouragement found in a community of practice and social network could increase the social capital of the families exploring STEM, whether confident or novice to the experience. This is noteworthy in that it exemplifies the importance of communities of practice (Lave & Wenger, 1991). Legitimate peripheral participation involves newcomers adopting a group's ways, moving from periphery to the center of a practice. The steps needed to move closer to the center of practice is directly supported by the specific design of family STEM events as a social experience, to learn and grow together. Having a support network to learn and engage with STEM, as well as build interest together, supports the development of existing capital, as well as gaining new capital, and strengthens the family’s STEM habitus.

Limitations

While findings in this study concerning the outcomes of the designed STEM activities are encouraging, there are some limitations to this study. First, while approximately 450 students and families were present at the FSN-DCI, only 61 surveys from parents and 75 student surveys were returned after the event. Similarly, 120 students and family members attended FSC, but only nineteen parent surveys and 27 student surveys were returned after the event. For both events, this is a relatively small percentage of returned surveys compared to attendees. In addition, while most surveys were complete, some parents and students who did return the surveys did not answer all the questions and/or left the open ended questions blank. It should also be noted that all the surveys were optional to complete and return, so any data collected was only from participants willing to do so. Likewise, the nine parents that were interviewed were selected as volunteers from the families who had attended both designed STEM events.

Next, each family was given an identifier, based on their children enrolled in school. However, there was no way to distinguish which parent or guardian filled out the surveys after each event; there is a similar limitation for the broader STEM perceptions survey that was sent in the fall before the first designed STEM event. Additionally, the questions given in the STEM perceptions survey, the post-FSN-DCI survey, and the post-FSC survey were somewhat different, although designed to ask similar questions. For example, one of the questions in the survey after the FSN-DCI event was "How do events like the one at the Discovery Center of Idaho help your whole family develop an interest in STEM?". The similar question given after the FSC event was "How do events like the one at the Family STEM Camp help your whole family develop an interest in STEM?". The questions in the perceptions survey stood alone, gathering data on how families saw themselves and their children related to STEM. Both the post-DCI and post-STEM camp survey, for both parents and students, mirrored each other and were specifically related to the event. Therefore, as a result of the family identifiers and slightly different questions on the different surveys, at best, the post-event surveys could be seen as a recorded observation of each STEM event. No proper comparison can be made between survey responses after an event for a given household.

Finally, as stated previously, STEM capital, habitus, and identity take time to develop and are hard to measure in isolation. In an effort to distinguish and somewhat isolate a given characteristic of capital, the study operationalized the construct by conversations about and connections with STEM. Likewise, to try and recognize and identify the existence or development of habitus, the study operationalized the construct by interest in STEM. The responses to the questions seeking to articulate features or characteristics of these constructs overlapped in some areas. Some responses felt similar or echoed the same sentiment. Again, STEM capital and habitus are seen as mutually reinforcing constructs and should allow for comparable, if not complementary responses.

Given these limitations, efforts were still made to craft a robust study. The data were collected from multiple sources from more than one event, over time. The explanations provided in the open responses, from both students and parents, were rich in description, as were the interviews. The work of developing family STEM capital and habitus was sustained over the majority of the school year and supported in a variety ways study. Although schools and educational interventions are complex and multi-faceted, it is clear that the designed STEM experiences were beneficial and meaningful to families in ways that could reasonably support the development of a STEM identity.

Implications

Schools continue to fall short in showing innovation to increase opportunities and aspirations in STEM (Archer, DeWitt, and Wong, 2014; Aschbacher et al., 2014; DeWitt & Archer, 2015). Many populations continue to have limited access to the high-quality science instruction consistent with best practices in science education. Underrepresented minority students persist in being under-resourced and underserved in STEM education (Maltese & Tai, 2010; Calabrese Barton et al., 2008; Calabrese Barton & Tan, 2008; Carlone et al., 2015; Brickhouse et al., 2000; Hurd, 2002). Many interventions have not led to substantial changes for ethnic minority and low-income students in STEM interest and participation (Aschbacher et al., 2010; Lee, 2005; Archer et al., 2010; Wong, 2015;

Elias & Haynes, 2008). Perhaps this is because the vast majority of the interventions and efforts to increase STEM aspirations, participation, and career paths for youth in the United States continue to circumvent the home. It is unclear why the family are often left out of the equation to develop their children's STEM identity, although it Bourdieu and others have theorized that schools socialize their students towards the status quo and to accept a life of inequality (Claussen & Osborne, 2013). It is therefore up to the STEM education community to reinvent our practice in order to meet the needs of the changing nature of science, employment demands, and STEM society (Price & McNeil, 2013). Moreover, it is imperative to reinvent the current approach to influencing students' STEM ambitions, namely with a deliberate partnership with the family.

The findings in this study demonstrate that designed STEM experiences that focus on the family should be strongly considered as a strategy to help mitigate low levels of STEM capital in families and amongst students. To reiterate, Archer et al. (2015) reported from their research that families with lower science capital are not 'against' science, but their existing capital is often measured by what is absent, not what is present. Their study also highlighted the importance of social capital – ultimately resources and networks – in facilitating or constraining children's science potential. Knowing this, schools and those working in STEM education, need to work to alleviate barriers to give families access to quality STEM and the opportunity to build on their existing (and often unrecognized) STEM capital. It is also important that these interventions begin as early as possible for students and families. Underserved students are already susceptible to fall out of the leaky STEM pipeline (Archer et al., 2012) by the time they leave elementary school; there is a critical window of time, between ages 10-14 years old, to develop children's science attitudes and aspirations in order to pursue science qualifications and careers (Dewitt et al., 2012; 2015). To reiterate, it is not feasible to assume all children would want a career in STEM, even given the proper support for those aspirations. However, it is important that all students have that possibility available to them as a choice. Consequently, more needs to be done to work with families prior to and during that significant period in their children's lives to gain access and resources to STEM.

Focusing on families as a catalyst for students' STEM interest, engagement, and pursuits can influence the home environment and therefore influence individual interests within the home, particularly with children. Dabney et al. (2013) speak to the necessity for public science institutions and schools to provide "science diversions, hobbies, and encouragement among those families both with and without means" (p. 406). Families' interests matter and should be considered when working to build STEM capital within the school community. By recognizing the existing capital that families possess and designing inventive avenues to explore STEM learning together as a family, both parents and children can expand their capacity for STEM meaning making. As a result, "parents can provide their children with science-related cultural capital in how they respond to science and bring it into the home" (Claussen & Osborne, 2013, p. 72).

Schools and STEM institutions also need to make the opportunities and access to STEM equitable and empowering for families. Often underserved communities often do not have adequate resources to bolster their children's achievement through extracurricular activities in STEM (DeWitt et al., 2010). Additionally, many families lack the formal education and confidence to provide those opportunities for their students on their own. Even when they may have access to these opportunities, "they are often positioned as recipients of the expertise rather than participants in the use and further construction of expertise" (Calabrese Barton & Tan, 2010, p. 190). Therefore, schools need to frame the STEM experiences for families in a way that validates the home, maximizes connections from their lives and experiences, and empowers parents to learn along with their children. This will increase the likelihood that they will begin to seek out more STEM opportunities in and out of their home. When empowered as learners and doers of STEM, those interviewed in this study had ideas for further STEM exploration, how to develop the school's STEM resources and community, and could articulate the support they would need to further hands-on STEM with their children at home. The entire family's investment in these endeavors will go a long way to build the STEM identity of the student.

Concentrating on supporting a STEM identity in children through working with the family allows for a more equitable approach to STEM education. Carlone and Johnson (2007) caution that "broadening students' participation in science requires close attention to the kinds of people we ask students to become as they participate in science activities" (p. 1190). Their advice is to temper stereotypes of science identities that may be in contrast to their own lives and realities. What better example of a STEM mentor can be given to a student than a family member? This can allow students to see that STEM is something 'for them.'

The family continues to be the largest untapped resource to affect change in students' STEM capital and habitus. There is adequate research documenting families' influence on their students' STEM interest, capital, aspirations, and identity (Brickhouse et al., 2000; Archer et al., 2013; Calabrese Barton et al., 2001; Bricker & Bell, 2014). It is time to focus policy, resources, and research centered around designed STEM experiences done with the families and their students, in order to influence STEM capital, habitus, and ultimately STEM identity.

Conclusion

The two family-focused, designed STEM experiences intentionally provided resources and opportunity in order to develop the families' interest in STEM, recognizing that if interest is not sustained through practice, it would be difficult for it to grow into identity (Archer, DeWitt, Osborne, 2012). The opportunities provided to build interest, facilitate practice, and develop capital are also conceptualized by Archer et al. (2015) in their equation leading towards a science identity. They state that "science capital + science behaviors and practices + social capital = use/value exchange → science related aspirations and science identity" (p. 932). Similar to the visual model provided in Figures 5.1 and 5. 2, which seek to demonstrate how STEM capital and habitus feed each other and support the development of a STEM identity, the equation suggested by Archer et al. (2015) conceptualizes how to accumulate science capital and science related behaviors in order to obtain a science identity.

Archer et al. (2015) write extensively about the intricacy of capital, and the family habitus, and how difficult it is to capture the complexity of both and how it exists within webs of relationships. Explaining precisely how STEM capital and STEM family habitus interconnect and influence a child, along with how to maximize those constructs in order to advance a child's STEM identity, is nearly impossible. Structural forces such as ethnicity, race, and class, as well different sources of influence, such school, leisure activities, and media all shape a child's identity. Having said that, there is compelling research detailing that a family's science capital is impactful to a student's patterns of aspiration, participation and opportunities in STEM (Gokpinar & Reiss, 2016; Archer et al., 2015; Claussen & Osborne, 2013; Archer et al., 2012; Adamuti-Tache & Andres, 2008). So then, it becomes vital to investigate how to mobilize and increase the family's science capital in order to enrich the STEM family habitus to more deliberately support the student in STEM endeavors.

All of these efforts to build and strengthen STEM habitus and STEM capital is to increase the likelihood of a STEM identity. Carlone and Johnson (2007) assert that "identity is not simply what an individual says about her relationship to, abilities in, or aspirations regarding science: it is not purely an emic construct. Identity arises out of the constraints and resources available in a local setting" (p. 1192). Therefore, when constraints limit participation and resources are lacking, families will struggle to embrace a STEM identity. To this point, it is crucial to lower barriers and increase access to quality, facilitated, family-centered STEM.

It would be an oversight to try to build a student's STEM identity without first attending to the family's capital and habitus. Though there are some in the science education field (e.g. Archer et al., 2012) who do, indeed, propose that the science education community do more to work with families, particularly those from low income communities, there is a dearth of research detailing how to work with families in a purposeful manner to support students in STEM. Therefore, this investigation sought to create intentional opportunities for families to develop their capital and habitus in an environment that embraced what they can contribute, rather than focused on the various STEM gaps. Encouraging participation from underrepresented populations in STEM requires more than lowering barriers. While addressing constraints is definitely part of an intentional design for family STEM engagement, it requires organizers to embrace the language of possibility throughout the process. By this, I mean that it is essential to demonstrate conviction and belief in the population for whom the designed STEM experiences are intended to serve. It is important to assume the underrepresented population can without a doubt build their STEM capital and habitus, given some support, and that STEM is 'for them'. This study created two STEM events that elevated the evolving STEM community of practice within the school. Expanding the social network for families to develop their STEM capital and habitus was critical to reduce inhibitions and provide structures of support within a school community exposed to new STEM concepts and experiences. Carlone and Johnson's (2007) model of science identity (including performance, recognition, and competence) is socially constructed and relies on the requisite social interaction within each construct. They remind us that "one cannot claim an identity all by oneself; being 'somebody' requires the participation of others" (p. 1190). I would emphasize the 'recognition' construct as a vital component to the designed STEM experiences. Believing in the families and seeing them as 'STEM people' already, while working to enhance 'performance' and 'competence' goes a long way in encouraging their confidence in STEM. The findings of this study indicate that it is indeed possible to support the enrichment of a family's STEM capital and STEM habitus through designed STEM experiences and support the development of their STEM interests can be seen as planting the seeds that may bloom into a STEM identity over time.

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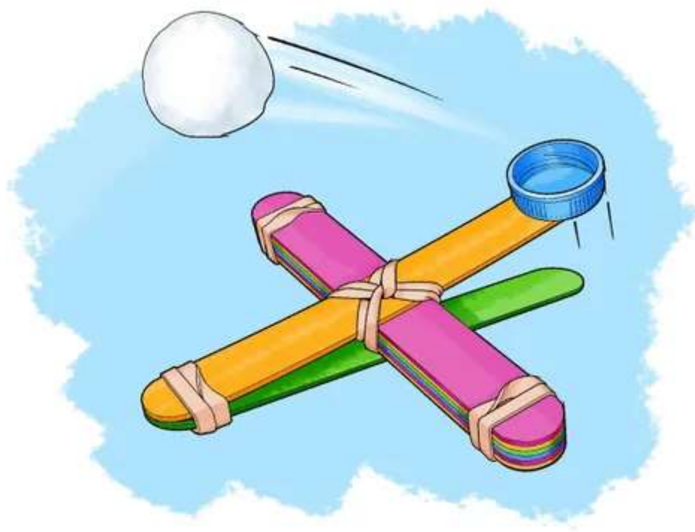
APPENDIX A

Take-Home Activities Post-FSN-DCI

Build a Catapult



Introduction

Catapults were mighty handy for pirates in the golden age of piracy (during the 17th century). And medieval knights used them centuries earlier for taking down massive castle walls. Even Greeks and Romans used catapults about 2,000 years ago! These simple machines are quite handy, as long as you know how to aim them! In this science activity you will try your hand at catapult technology. Can you predict where your missile will land?

Background

A catapult works because energy can be converted from one type to another and transferred from one object to another. When you prepare the catapult to launch, you add energy to it. This energy is stored in the launching device as potential, or stored, energy. The catapult you are about to make uses elastic potential energy stored in a wooden stick as you bend it. When you let go, this stored energy is released, converted into energy of motion and transferred to the missile (the launched object), which then flies through the air. The position of the launching device when the missile becomes airborne is an important parameter of aiming. But would the amount of energy with which you're loading your device factor in as well? Try this activity to find out!

Materials

- Eight craft sticks (popsicle sticks)
- Four or five sturdy rubber bands
- Glue
- Plastic bottle cap to hold a cotton ball
- Cotton ball (If you do not have any available, you can make a small ball by crumbling some paper.)
- Small open area (One square meter will do. It should be a sturdy, flat surface such as a table or floor.)

Preparation

Note: The simple catapult described in this project is safe when used with a cotton ball. Shooting hard objects or using other homemade catapults can be dangerous. Make sure any objects you launch are soft and light so as not to harm anyone or cause any damage to objects around you.

1. Take six craft sticks, stack them one on top of the other. Secure these sticks together by wrapping rubber bands around both ends of the stack. You will anchor the launching stick to this stack, as described in the next step.
2. To add the launching stick take one stick and attach it perpendicular to the stack you just made, around the middle, so you get a cross shape. You can do this with one or two rubber bands that are crossed in an X over the sticks. If you cross it this way, the sticks will stay nicely perpendicular.
3. Next, add the base by attaching a stick to one end of the launching stick with a rubber band. If it were not for the stack of sticks in between, the launching stick would fall flat on top of the base. Now the launching stick and the base form a V shape lying on its side with the stack of sticks in the middle.
4. Put your catapult on its base, locate the end of the launching stick that sticks up and glue the bottle cap there so it forms a small cup to hold the missile.
5. Wait until the glue is dry.

Procedure:

- Put your catapult in an open area with a sturdy, flat surface such as a table or an open space on a hard floor. Clear about a meter of open space for the launched object (the missile) to fly and land.
- Place a cotton ball in the launching cup, push the cup down just a little bit and let go.
- What happened to the ball? Did it fly? Did it go high or low? Where did it land?
- What do you expect will happen when you push the cup farther down? Will this make it fly higher, farther, both higher and farther or take the same path but maybe faster?

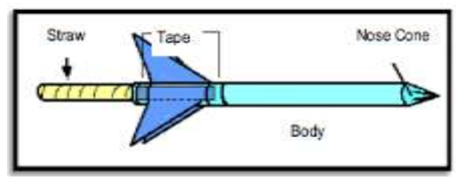
Soda-Straw Rocket

Overview

Soda Straw Rockets is an excellent opportunity for students to practice the engineering design process. This activity provides students with a template that creates a rocket that can be launched from a soda straw. They are then challenged to modify the design to see how the changes impact the rocket performance. Length, fin shape or angle can be changed–one variable at a time–to see how the rocket launch performs, and compares to the control design.

Materials:

- Pencil
- Scissors
- Tape
- Soda straw
- Meter stick or meter measuring tape
- Rocket template



Background:

Modern rocket design began near the beginning of the 20th century. While much has been learned and rockets have grown larger and more powerful, rocket designs are still improving. Engineers developing new rockets must control variables and consider failure points when improving rocket designs. By changing one variable at a time, engineers can determine if that change leads to an increase or decrease in performance. They must also consider how their design might fail, and work to improve their design. These incremental changes allow engineers to improve rocket performance and increase the amount of mass they can lift into space.

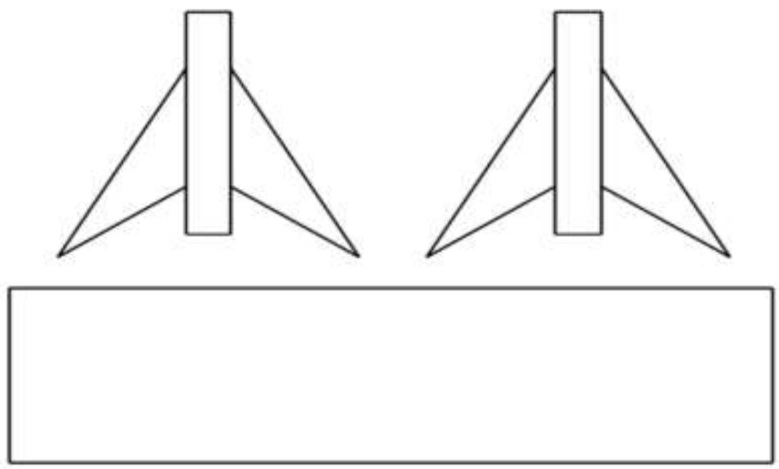
Procedures:

1. Carefully cut out the large rectangle on the rocket template. This will be the body of the rocket. Wrap the rocket body around a pencil length-wise and tape it closed to form a tube.
2. Carefully cut out the two fin units. Align the rectangle in the middle of the fin unit with the end of the rocket body and tape it to the rocket body. Nothing should stick out past the bottom of the rocket body.
3. Do the same thing for the other fin unit, but tape it on the other side of the pencil to make a “fin sandwich.”
4. Bend one fin (triangle) on each fin unit 90 degrees so that each fin is at a right angle to its neighbor. Looking from the bottom of the rocket, the fins should look like a “+” mark.

5. Using the sharpened end of the pencil, twist the top of the rocket body into a nose cone.
6. Measure the nose cone from its base to its tip and record the length in the data log and on the rocket itself. (Once completed, the rocket will be about 13 cm tall (about 5 inches).
7. Remove the pencil and replace it with a soda straw.
8. Blow into the straw to launch the rocket.
9. Use the meter stick to measure, the distance it travels, then record the distance on the data log.
10. Next, make new rockets by altering the template. Try different rocket lengths, fin shape, or angle. Repeat steps 5 and 7 for every launch, recording each design change and distance in the data log.

Need help?:http://www.jpl.nasa.gov/edu/pdfs/sodastrawrocket.pdf

Template:



Egg Drop Challenge

Overview:

Can you design a package that keeps an egg from breaking when it is dropped from 10 feet in the air?

Although it's important not to use too much packaging, some packaging is necessary. If certain kinds of products are not packaged, they will go bad or break while being transported. The trick is to use packaging that is strong but sustainable – packaging that won't harm the environment – and to use as little packaging as possible to get the job done. Your job is to make a sustainable package that is strong enough to keep your egg in one piece while using as little packaging as possible.

Background:

For more information, see the following website.

http://kidsciencechallenge.com/pdfs/2011activities/Zero-Waste_Egg-Drop-Challenge.pdf

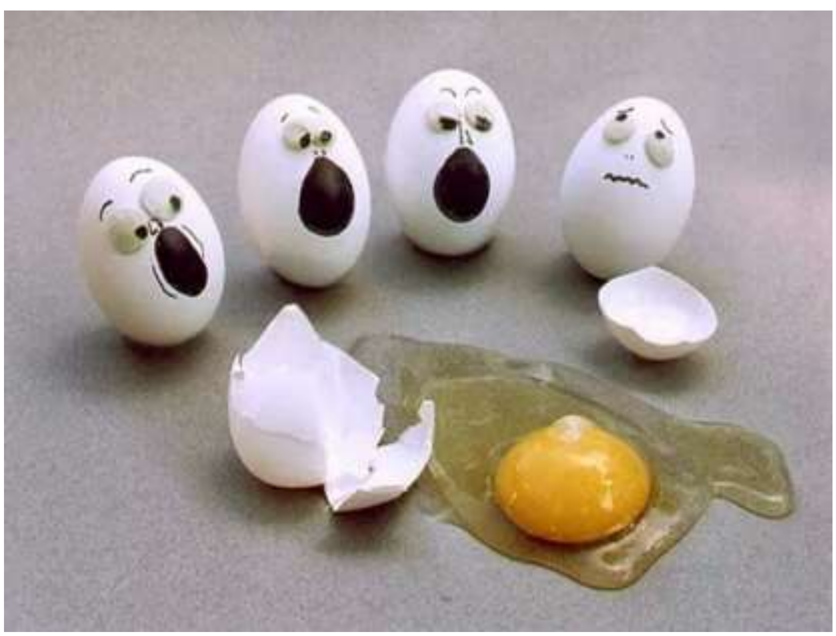
Materials:

- Egg (a marshmallow is provided in this kit instead of a raw egg)
- Balloons
- Straws
- Cardboard
- Toilet paper roll
- Tape
- Cotton balls
- Grocery Bag
- String
- Coffee filter
- Rubber bands
- Bubble wrap

- Paper

Procedures:

1. You will be designing a package that will keep your raw egg safe, even if you drop the egg from 10 feet in the air.
2. You may also choose from any of the materials listed above. Try to use just the materials on the list (they are provided).
3. Brainstorm what you will do to keep your egg safe. Which materials will you use? How will you put your package together?
4. Once you've decided on your design, gather the materials. You are ready to start building.
5. (It's better not to use too much packaging, so the best kind of package is one that does its job without using material you don't really need. Make your package both strong and lightweight.)
6. When you're ready for the drop, go to a second story window, or climb up a ladder. If you are dropping the egg inside, you will want to cover the floor with newspaper or a drop cloth. Make sure you have an adult with you either for climbing up the ladder or for dropping things out the window.
7. Now drop your package and check it out. Did your package keep the egg safe? If yes, can you create a design with *less* materials? Try it again!



APPENDIX B

Garfield Families' Perceptions of STEM Survey

If you have multiple children enrolled at Garfield Elementary, please check their grade levels below and indicate their teachers' names on the line below:

_____K _____1 _____2 _____3 _____4 _____5 _____6

Teacher(s):____

Directions: Please check the appropriate box for each statement in the table below.

STEM: = Science, Technology, Engineering, and Math

	Strongly disagree	**Disagree**	**Agree**	**Strongly Agree**
1. We enjoy STEM activities/events as a family.				
2. We often make personal connections to STEM ideas in our home.				
3. We often have STEM-related conversations at home.				
4. As a family, we attend STEM activities/events at school and in the community whenever we can.				
5. My family is interested in attending *more* STEM events at Garfield or in the community.				
6. My child/children talk(s) to me about math.				
7. My child/children talk(s) to me about science.				
8. My child/children is/are excited about STEM.				
9. My child/children would like to go into a STEM career.				

10. As a family, we do STEM activities in our home.				

11. What school-related STEM activities has your child/children participated in during the last year?

12. If you and your child/children participated in Family STEM Night (2015-2018) how do you feel that experience have affected conversations with your child/children surrounding STEM?

13. What type/kinds of STEM activities or conversations do you do/have in your home as a family?

14. What is your race/ethnicity?

a. Black

b. White

c. Hispanic

d. Asian

e. Middle Eastern

f. Native American

g. Mixed race/ethnicity

h. Prefer not to answer

15. What is your gender?

    a. Female
    b. Male
    c. Non-binary
    d. Prefer not to answer

16. What is your relationship to the child/children at Garfield?

    b. Mother
    c. Father
    d. Grandparent
    e. Aunt/Uncle
    f. Legal Guardian
    g. Other ______________________________ (please indicate)

APPENDIX C

Parent Post-FSN Survey

Directions: Please check the appropriate box for each statement in the table below.

	Strongly disagree	**Disagr ee**	**Agre e**	**Strongly Agree**
1. My family enjoyed the event at the Discovery Center of Idaho.				
2. As a whole, my family was engaged in STEM at the event.				
3. As a family, we were able to make personal connections from the exhibits at the Discovery Center to real-world STEM.				
4. My family had conversations about STEM after the event.				
5. My child is interested in attending more STEM events at Garfield or in the community.				
6. As a family, we are interested in attending more STEM events at Garfield or in the community.				
7. My child asked more questions about STEM after the event.				
8. I felt able to discuss these STEM questions with my child.				
9. I am confident in my ability to help my child/children pursue their STEM interests.				
10. As a family, we are excited about STEM.				

11. How do events like the one at the Discovery Center help your whole family develop an interest in STEM?

12. Does your family plan on participating in the Family STEM Camp?

Yes or No If yes, what makes you want to participate?

APPENDIX D

Student Post-FSN Survey

Directions: Please check the appropriate box for each statement in the table below.

	Strongly disagree	**Disagree**	**Agree**	**Strongly Agree**
1. I enjoyed the event at the Discovery Center of Idaho.				
2. As a whole, my family was engaged in STEM at the event.				
3. As a family, we were able to make personal connections from the exhibits at the Discovery Center to real-world STEM.				
4. My family had conversations about STEM after the event.				
5. I am interested in attending more STEM events at Garfield or in the community.				
6. I think my family is interested in attending more STEM events at Garfield or in the community.				
7. I asked my family more questions about STEM after the event.				
8. My family was able to discuss these STEM questions with me.				
9. I feel confident to pursue my STEM interests.				
10. My family is excited about STEM.				

APPENDIX E

Parent Post-FSC Survey

Directions: Please check the appropriate box for each statement in the table below.

	Strongly disagree	**Disagree**	**Agree**	**Strongly Agree**
1. My family enjoyed the Family STEM Camp at Garfield Elementary.				
2. As a whole, my family was engaged in STEM at the event.				
3. As a family, we were able to make personal connections from the exhibits at the Family STEM Camp to real-world STEM.				
4. My family had conversations about STEM after the event.				
5. My child is interested in attending more STEM events at Garfield or in the community.				
6. As a family, we are interested in attending more STEM events at Garfield or in the community.				
7. My child asked more questions about STEM after the event.				
8. I felt able to discuss these STEM questions with my child.				
9. I am confident in my ability to help my child/children pursue their STEM interests.				
10. As a family, we are excited about STEM.				

11. How do events like the Family STEM Camp at Garfield Elementary help your whole family develop an interest in STEM?

12. Did your family also participate in the event at the Discovery Center of Idaho in Feb. 2019?

Yes____ No____

13. Would you be interested in participating in a short (30 min.), follow-up interview with Sonia Galaviz regarding the Discovery Center and Family STEM Camp event?

____

If yes, please put your name and a good phone number to contact you.

__________________________ Name ______________________________ Phone Number

APPENDIX F

Student Post-FSC Survey

Directions: Please check the appropriate box for each statement in the table below.

	Strongly disagree	**Disagree**	**Agree**	**Strongly Agree**
1. I had fun at the Family STEM Camp event at Garfield Elementary.				
2. My whole family was interested in and participated in STEM at the Family STEM Camp event.				
3. My family made connections between things we saw or did during the Family STEM Camp to real-world STEM in our lives.				
4. My family talked about STEM after the event.				
5. I want to attend more STEM events at Garfield or in the community.				
6. My family wants to attend more STEM events at Garfield or in the community.				
7. I asked my family more questions about STEM after the Family STEM Camp.				
8. My family was able to talk about these STEM questions with me.				
9. I think I can learn more about things in STEM I think are interesting.				
10. My family is excited about STEM.				

11. What was the best part about doing the three STEM challenges at the Family STEM Camp with your family?

APPENDIX G

Parent/Guardian Interview Protocol

1. Do you now or have you ever considered yourself a "science, math, or tech" person? Explain.
2. Do you consider your family a "STEM-y family"? Why or why not?
3. Why did you choose to participate in the DCI-Garfield event?
    a. What did your family think of the event?
    b. What conversations did your family have about STEM during the event?
    c. Did the event foster further conversations after the event? Like what?
4. Why did you choose to participate in the follow-up Family STEM Camp?
    a. What kind of conversations did your family have about your design, plan, and actual making of your game?
    b. What was the Family STEM Camp like for your family?
    c. What kind of conversations did you and your child have after the event?
5. Do events like these do anything to encourage your *family's interest* towards STEM? Explain.
6. Do events like these help you and your family make real-world or personal connections to STEM? Explain.
7. Through these events, did your child show any additional specific interests in STEM? If so, what?
8. Do you feel confident in having conversations about STEM with your child? Why or why not?
9. Do you feel like you can help your child pursue their STEM interests? Why or why not?
10. Do you feel like your interest and curiosity for STEM has an effect on your child? Why or why not? How?
11. Do you have any suggestions for the school about how we can support you in your STEM efforts or STEM interests?