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This study explored the ways in which a Science, Technology, Engineering, and Mathematics (STEM) enrichment program that is free (or as free as possible) of microaggressions and social structural constraints might influence African American (AA) girls to become innovators and to identify themselves as scientists or engineers. There are many beneficial impacts informal STEM experiences can bring to minority youth, such as increasing their interests and sense of competencies in science and engineering. Concurrently, the troubling trend of AA females deemed incapable of succeeding in school science and taking higher-level science courses persists. This study takes up the notion of such “judgment” AA females may face while engaging in STEM and explores how a “judgment-free” (free of oppressive judgment) STEM space in an informal community club can affect AA females’ identity work and agency.

The following research questions were used as a guide to investigate how AA girls engage in an “judgment-free” informal STEM enrichment program: 1. What does it mean to the AA girls to have an informal youth STEM space that is free (as free as possible) of microaggressions and social structure constraints?; 1a. How are the youth in an informal STEM program positioned?; 1b. What are the youth in an informal STEM program able to do (process and products that they would not be able to do in more regimental STEM formal space)?; and 2. How might a setting free (or as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African

American girls' STEM identity/agency and sense of sisterhood? Drawing upon Black feminist thought and identity work, I explore how a "judgment-free" theoretical framework can or cannot influence AA girls' STEM identity and agency.

The methodology used in this study was a longitudinal ethnographic critical case study over the course of 4 years. Creswell (2013) stated that "ethnographies focus on developing a complex, complete description of the culture of a group, a culture sharing group" (p. 91). Through this methodology, the culture of the youth at a community club was described using observations and interviews. I believed ethnography was appropriate because my study focused on a specific group of students—AA females who were engaged in STEM. Using defining features of ethnography, I explored how AA girls identified themselves as scientists or engineers.

My participants were AA girls who attended the community club and the STEM enrichment program, GEC, for a minimum of 2-4 years. The length of time the girls had participated in GEC was an important criterion, given I used longitudinal ethnography. The girls ranged from fourth to ninth grade. I chose AA girls who were interested in science because of the personal connection I have with them; being an AA female who is engaged in STEM, there were times when my science identity was negatively influenced by microaggressions and social structure constraints.

Through the use of this "judgment-free" theoretical framework, I found that STEM identities of the AA girls who attended GEC were influenced by the sisterhood they shared, their positioning as STEM experts, and how they used their STEM knowledge to help their community. The girls' case studies revealed how a space as free as possible of negative judgment influenced the girls' STEM identities and agency.

The girls' involvement in this STEM enrichment program showed that when students are given the space to investigate STEM without feeling negatively judged, they become more engaged in content and better understand how STEM relates to their lives. The AA girls' experiences in this study are an indication that a judgment-free space, which supports sisterhood, embraces community, and promotes open discourse can foster AA girls' STEM-gendered identity and agency so that they can see themselves as scientists and engineers.

EXPLORING THE AFFORDANCES AND CONSTRAINTS OF A "JUDGMENT FREE" INFORMAL STEM SPACE IN SUPPORTING AFRICAN AMERICAN GIRLS' SISTERHOOD AND STEM IDENTITIES

by

Faith Freeman

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Approved by

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Committee Chair

“Love recognizes no barriers. It jumps hurdles, leaps fences, penetrates walls to arrive at its destination full of hope”

—Maya Angelou

This dissertation is dedicated to my husband, the love of my life,
the man who loves me, who has supported me,
pushed me and whose love has no barriers.

APPROVAL PAGE

This dissertation, written by Faith Freeman, has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ______________________________

Committee Members ______________________________

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Date of Acceptance by Committee

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Date of Final Oral Examination

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> In all my life, I have never been free. I have never been able to do anything with freedom, except in the field of my writing. (Langston Hughes)

First, I want to thank my Lord and Savior for creating this opportunity for me and giving me the strength to complete this task. Therefore, when I reflect on the beginning of this journey to get my doctorate degree I have come to the realization that through my writing in this program I was able to say things I could not have said with voice. Hughes's quote speaks personally to me because, being a Black girl in STEM, I have never been able to be free; I have never been able to use my voice where I thought people would listen or even care. This program has supported me in finding a space where I can be free to express myself through my writing. I have also had multiple people who have helped me find my voice throughout my experiences in this program. First, my wonderful husband who has supported me through this process, who has been my shoulder to lean on and cry on every day for the past four and a half years. You struggled with me through assignments, you listened when I needed to bounce my ideas off of you, and most importantly, you nurtured my growth as scholar. Thank you Dramaine for allowing me to be myself and supporting me to find my voice as a Black woman in STEM and in academia. Second, I want to thank my parents, who have always allowed me to follow my dreams and instilled in me the perseverance so that I could accomplish my goals. Next, my two wonderful sons, Neal and Langston, thank you for understanding that mommy is doing work instead of your attending football games or playing in Legos with you. My family has been my foundation throughout this process and without them "having my back" I would not have gotten to this point.

Through my research I have learned what true sisterhood looks like and have experienced it with the bonds I have formed in three spaces. Noami and Ayesha, you all are two wonderful Black women scholars and I want to thank you both for helping me with papers, going through presentations, and being my "sisters" throughout this process. Johnette, Emma, and Becki, my STEM sistas, you all supported me, you were there for me I was stressed, we have struggled together, and most importantly, you all made me laugh when things got too crazy. Last, my little sisters who participated in GEC, I enjoyed being in this STEM space with you all and most importantly learning from you about how to better engage Black girls in STEM.

Lastly, I want to thank my wonderful dissertation committee; I appreciate all of you for supporting and pushing me to find my voice and use it. I am so blessed to have four brilliant women scholars on my committee who have guided me throughout this dissertation process. You all have helped find my freedom through my writing and for that I am grateful.

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CHAPTER I

INTRODUCTION

African American girls are almost nonexistent in Science, Technology, Engineering, and Mathematics (STEM) spaces. Many African American females find STEM spaces as White, masculine, and uninviting. African American girls need to be in spaces where they can actively engage, and spaces that value their voices and foster collaboration among everyone. Girls, especially African American girls, are not expected to excel in STEM spaces (Pringle, Brkich, Adams, West-Olatunii, & Archer-Banks, 2012; Sparks, 2018). However, when they do perform well in these spaces, they are seen as “acting White” or “acting like a boy” (Archer et al., 2012). There is an assumption in our society that African Americans are not equally as intelligent as Whites and are still considered genetically intellectually inferior (Smedley & Smedley, 2005) to Whites, especially in STEM. This notion is present today even though we live in a society where an African American man can run for the presidency of our nation and win, twice; a society where three African American women can contribute to NASA’s first launch into space; and a society where an African American woman can become an astronaut and travel to the moon. However, despite these prominent figures, African Americans are still seen as intellectually deficient.

Imagine a young African American girl who does not see herself as being successful in school, especially in STEM-focused classes. This girl is so shy that she does not want to be in a picture with the rest of her peers. However, in certain spaces she can speak fluently on how to make a light bulb glow using a battery and copper tape. Imagine another African American girl who, when given an engineering problem to solve, works diligently until she comes up with the answer. Imagine a third African American girl who gets suspended from school often, but can create different, innovative objects when given the opportunity, freedom, and space. These girls are not genetically inferior and do not have a "STEM deficiency"; however, some may assume they do because of their gender and the color of their skin. They are engaging in STEM practices in a space that is inviting, a space where they can be girls, a space where they can be African American, and a space where they feel as though they can be successful in STEM. What causes African American girls to become disengaged in STEM? What are the pedagogical practices that educators can adopt to specifically engage African American girls in STEM? How can educators create spaces where African American girls know they are supported if they decide to follow a STEM trajectory?

Purpose

STEM is one of the most talked about acronyms today. STEM fields of study are steadily growing in popularity and doing so at a faster rate than non-STEM fields of study worldwide (National Science Foundation [NSF], 2017). However, there is still an underrepresentation of women pursuing STEM degrees. According to the NSF (2017),

> Older cohorts of S&E workers are disproportionately white and male, women and minorities constitute a smaller percentage of the overall S&E workforce than of degree recipients who recently joined the workforce. (p. 12)

To describe this low representation of minority women in STEM, Blickenstaff (2005) used the metaphor of a “leaky pipeline” to represent the engagement of women in STEM. It has been found that female students may intend to major in a STEM degree and then change their minds when applying to college, causing women to “leak out” of a STEM degree more than men (Blickenstaff, 2005, p. 369). To address this concern, there are various outreach and summer programs aimed at engaging females in STEM as well as special initiatives to encourage African American (AA) girls, in particular, to consider pursuing a STEM field (Koch & Gorges, 2016; Riedinger & Taylor, 2016). However, there is still an underrepresentation of AA girls in STEM (Tan, Calabrese Barton, Kang, & O’Neill, 2013). Although girls have shown great improvement and interest in STEM over the past few years, there is still a significantly higher percentage of boys who pursue postsecondary STEM degrees and careers in STEM fields (Tan et al., 2013). Hanson (2004) stated the reason for the disparity of representation of women in STEM spaces “is a reflection of the continuing bias and gender in equity in science” (p. 96). STEM spaces have historically been White male-dominated, which has created inequities for women in these spaces. There are many factors that contribute to the engagement and disengagement of women, particularly minority women in STEM. Studies have shown that it is imperative that AA girls have a support system that fosters their science identity while positively positioning them on a STEM trajectory (Johnson, Brown, Carlone, & Cuevas, 2011; Lane, 2017).

Research Questions

The following research questions were used as a guide to investigate how 10- to 14-year-old African American girls perceive an informal STEM enrichment program as a judgment-free space. These research questions also focus on how this STEM program influences AA girls' positive STEM identity (if at all and to what degree), so that they see themselves as scientists and engineers (if at all and to what degree).

1. What does it mean to the AA girls to have an informal youth STEM space that is free (or as free as possible) of microaggressions and social structure constraints?
    a. How are the youth in an informal STEM program positioned?
    b. What are the youth in an informal STEM program able to do (process and products that they would not be able to do in a more regimented STEM formal space)?
2. How might a setting free (or as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls' STEM identity/agency and sense of sisterhood?

Overview of Methodology

The methodology I used is a longitudinal critical ethnographic case study approach for a total of 4 years. Utilizing a longitudinal critical ethnographic case study approach, I was able to negotiate and work toward lessening inequalities that related to social structure such as gender and race. Creswell (2013) states that "ethnography's focus on developing a complex, complete description of the culture of a group, a culture sharing group" (p. 91). Throughout this study, I sought to discover the patterns that contributed to the girls' thoughts, expressions, and feelings towards STEM and how they were to be transformed because of the Green Energy Club (GEC), an informal afterschool and summer STEM enrichment program at the Boys' and Girls' Club. I also incorporated descriptive embedded case studies within my critical ethnography. I chose to use an explanatory/descriptive embedded case study approach because I desired to describe and analyze the experiences and evolution of the science identities in each of the AA girls who participated in GEC. I conducted multiple interviews (background, artifact, and judgment interviews) with my participants throughout the 4-year span. I also observed my participants outside of GEC sessions at the Boys' and Girls' club to "describe and interpret the shared and learned patterns of values, behaviors, beliefs and language" (Creswell, 2013, p. 90) of my participants and how these concepts may have influenced or contributed to their STEM identity.

Significance

Chetcuti and Kioko (2012) studied Kenyan girls' perceptions of science and found that even though some of the girls admitted that they did not like science, they saw the importance of science. When girls in the United States were asked the same questions, it was found that they also disliked science; however, unlike the Kenyan girls, they saw no relevance or importance of science. Because of this disconnect that youth in the Unites States have pertaining to science, it is imperative that educators focus on instructional strategies to better engage youth in STEM, especially girls. The purpose of this study is to investigate how a "judgment-free" space influences AA girls to become innovators and identify themselves as scientists or engineers. Because of the underrepresentation of AA females in obtaining STEM degrees, there is a low level of engagement of AA girls in high level science courses once they reach middle grades (Brown et al., 2016; Catsambis, 1995). Although the reason why this underrepresentation of AA females in science is unclear, evidence has shown that there is a specific relationship between gender and race as to why AA females do not pursue STEM majors. The shortage of AA girls pursuing a STEM trajectory can be changed by identifying strategies to better engage them by focusing on their STEM identity. Birmingham and Calabrese Barton (2014) found that when youth were able to be “experts” about science content, they were able to see themselves as scientists. Because of the disparity of representation of AA women in science and engineering to serve as role models for younger AA girls, it is imperative that there is a space that fosters their science identity. My goal was to observe the ways in which a setting that is “judgment-free” (free of negative judgment) can support positive science identities and agency in AA girls.

Overview of Chapters

Chapter II

The “Science for All” initiative is a political slogan that has compelled society to believe that all youth are getting adequate, relevant inquiry-based science in schools. However, “Science for All” can be misleading as it relates to the science instruction that youth of color and girls receive in science classrooms. Chapter II gives a review of the current literature that focuses on how “Science for All” has manifested in today’s classrooms; how race, gender, and Black history has played an essential role in how youth of color engage in STEM; and how youth are engaging in STEM practices in formal and informal spaces. I conclude this chapter by introducing a Judgment Conceptual Framework that educators can use to better understand which strategies work best to engage African American girls in STEM.

Chapter III

A longitudinal critical ethnographic case study for total of 4 and one-half years was the methodological approach used for this study. Through utilizing a longitudinal critical ethnographic case study approach, I was able to negotiate and work towards ameliorating inequalities that related to social structures such as gender and race. In Chapter III, I describe the research site and the participants in the study. I also give a detailed description of how I analyzed my data and categorized my data into specific themes. I conclude this chapter with a specific focus on how my how positionality played a role in this study.

Chapter IV

Narratives can be used to tell someone's story; in Chapter IV, I describe each girl's trajectory in this STEM space and how they navigated tensions and celebrated successes. Each girl's narrative portraits feature key vignettes of the girls' STEM-making knowledge and practices. I conclude Chapter IV with an analysis of the similarities and differences each girl experienced in their participation in GEC.

I conclude Chapter IV with a cross case analysis with the themes that emerged during the initial data analysis. During data analysis I found similarities and differences among the girls in the study. I explain in detail these similarities and differences through a cross case analysis organized by themes.

Chapter V

The final chapter discusses how the findings are related to the proposed conceptual framework and how we can use the data from this study to better understand what a judgment-free STEM space looks like for AA girls and what they can do in this space. I also look at how this study contributes to the current literature on Black Feminist Thought and Identity Work. Last, I review the implications and limitations of this study, concluding with how this study can impact further research.

CHAPTER II

A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING AFRICAN AMERICAN GIRLS' ENGAGEMENT IN STEM

In this chapter I review the current literature as it relates race, educational policy in science education, how formal and informal STEM programs have impacted youth of color, and how African American (AA) girls engage in STEM spaces. The above themes were chosen for the literature review because of how they intersect with one another; for example, race and educational policy have played essential roles in how youth of color engage and are positioned in formal and informal STEM spaces. I then specifically focus on the experiences AA girls have in STEM spaces and the factors that contribute or do not contribute to their STEM engagement. I conclude this chapter with operationalizing a judgment-free theoretical framework and how constructs of Black Feminist Thought and Identity Work can be used to influence AA girls' STEM identity and agency.

Race

Marginalized groups have made great accomplishments since the abolishment of slavery and the end of Jim Crow; for example, African American youth today now see Black astronauts, doctors, and our first Black President of the United States where in the past this was not the case. However, even with these triumphs, many minorities are still treated as second-class citizens and the underlying reason for this mistreatment of minorities is racism. Bonilla-Silva (2014) defines racism as "a structure, and that is, as a network of social relations at social, political, economic and ideological levels that shapes the life chances of the various races" (p. 26). This structure was created and is still run by dominant groups, which in the United States are White males. For centuries, White males have written and voted for laws that have made it difficult for minorities to overcome racism (Alexander, 2010). For example, the *Plessy v Ferguson* case resulted in Jim Crow laws across the south which made Blacks and Whites "separate but equal" in all public places. The disproportionate number of minority students majoring in science compared to their White counterparts, segregated schools, and segregated classrooms are just a few examples of the effect of Jim Crow laws and other policies that have been passed based on the structure of racism. For marginalized groups to be successful in this structure of racism, schools and educators must provide equitable experiences for minority youth, especially in STEM. Youth of color must be given the same resources and educational opportunities that majority youth receive.

Smedley and Smedley (2005) found that for centuries people of color were deemed inferior not just based on the color of their skin but because people of color were found to be genetically intellectually inferior. Unfortunately, this research has become a belief to some educators and negatively altered our educational system. For example, many teachers and counselors have low expectations of African American youth, especially in science, because they have a preconceived notion that science is not a subject in which African Americans can be successful (Pringle et al., 2012; West-Olatunji et al., 2010). These low expectations have then positioned minority youth in lower level science courses, with limited hands on opportunities to actively engage in science. When teachers do not engage youth in the content, youth become disinterested in school

(Pringle et al., 2012; West-Olatunji et al., 2010). This limited engagement can then lead to minority children not being interested in science as they get older. To get minority youth more engaged in science, educators must combat preconceived notions that majority youth are genetically intellectually superior while fostering positive science identities in children of color.

Race plays a salient role in the educational system; for example, Mutegi (2013) stated “that since the 16th century, the perceptions of African Americans promulgated have been those that served to buttress the institutions of slavery, colonization, and segregation” (p. 88), perceptions that have manifested throughout the education for decades. Because African Americans have been expected to colonize as stated in Mutegi’s quote above, especially in academic spaces, this has caused them to be educated “away” from their own culture (Ridgeway & McGee, 2018). This can be problematic because when African Americans are in these academic spaces they can be seen by their own community as “Acting White” (Ogbu, 2004). Access to education empowers people in a variety of ways; for example, education gives people political knowledge which influences the outcomes of educational policy, practically for youth of color. We live in a society where racial tensions still persist, which has affected how youth of color engage in education. Howard and Navarro (2016) stated, “race and education have always been an essential element in the way opportunities for learning has manifested in U.S.’s schools” (p. 253); therefore, it is imperative that educators find strategies that educate people of color where they do not have to assimilate to the dominant culture.

African Americans not only feel as though they have to assimilate when occupying academic spaces, they also feel as though they are invisible in these spaces. For decades, Mutgei (2013) stated that African Americans feel invisible in academic spaces, particularly science spaces and how the sociocultural construction of race plays a role in how African Americans engage in STEM. “Western cultures have systematically (with malice and forethought) portrayed Africans as physically gifted, lazy, happy-go-lucky, mentally incapable sexual predators” (p. 88), in a sense making them invisible in academic spaces, because African Americans have not historically been seen as highly intellectual. Some of this invisibility comes from discrimination and microaggressions that are prevalent in our educational system today. However, the feeling of invisibility also comes from people who contend that they are “colorblind.” Many teacher education programs teach pre-service teachers the importance of being colorblind when they enter the classroom. They are taught that everyone is the same and to overlook youth’s race or ethnicity. However, this can be a very dangerous notion because teachers, in turn, are not appreciating their students’ backgrounds. According to Ullucci and Battey (2011), colorblindness is considered a new form of racism because it portrays Whiteness, merit, and individualism; colorblindness ignores the fact that we are not all the same and it strips people of color of their identity. Whiteness, according to Ullucci and Battey (2011), is the avoidance in identifying with another race. When someone is displaying colorblindness, he or she is not connecting that people are different, which in turn leads to an unappreciation of a racial group. This unappreciation can lead to people of color not seeing their race as important, which can cause negative identities. When educators do not acknowledge the fact that for centuries African Americans were enslaved by Whites, where they were not educated, making it more difficult for African Americans to "catch up" economically with the majority group (Ullucci & Battey, 2011), this could lead to disengagement in the classroom.

Educational Policy

What does "Science for All" really mean and how is it manifested in today's classrooms? For over 20 years this slogan has been used as representation that school science is made accessible, relevant, and engaging to all students (Tippins, Nichols, & Kemp, 1999). Mutegi (2011) stated that "'Science for All' is (as political slogans often are) inherently misleading and consequently dangerous" (p. 302), which positions science educators in a space where they then wonder how to achieve this goal. Though this slogan is simply stated (Mutegi, 2011), it carries various interpretations. For example, what does "Science for All" look like in a formal space compared to an informal space? What does it look like for youth of color? What does "Science for All" look like for girls, especially African American girls? Does "Science for All" really promote inclusivity in STEM education?

We live in a nation where in 1790, Congress passed the Naturalization Act, which declared all free White persons' citizenship (Parsons, 2014). This meant that people of color were not seen as citizens of the United States, even though they worked the farm land and fought in our wars. People of color were not granted citizenship until the passing of the 14th Amendment in 1868, and even after this there were still policies and laws put into place to deny people of color their freedom (i.e., Jim Crow Laws). In a nation that was built on inequality, I wonder how “Science for All” can realistically be accomplished. Our society today is split between the dominant White male leadership and minorities who are not still seen as equal, for example, the numerous acts of violence on Black males and Hispanic families fighting to be together. Because of these inequities in our society, people of color have so many facets of their lives that they have to worry about, so as educators should we expect youth of color to come in understanding what science is and whether or how it matters to them? How can we truly have “Science for All” when youth of color were not allowed, by law, to attend the school of their choice just over 60 years ago? Historically this nation has not supported people of color, especially as that support is related to education. So why would the “Science for All” movement be any different, especially today?

In order to truly address “Science for All,” Mutegi (2011) stated that we must recognize “that the prevailing curricular approach in science education is not likely to meet the social needs of African Americans” and that science education needs to take a “socially transformative approach to science curriculum that is more likely to meet the social needs of African Americans” (p. 302). Throughout this review of the literature I focus on the ways formal and informal STEM spaces (K-12) are either engaging or disengaging youth of color. I then explain how race plays a salient role in how youth of color engage in STEM. Next, I describe how the intersection of race and gender specifically affects African American girls’ engagement in STEM.

Youth of Color in Formal STEM Spaces

Elementary

Elementary Schools are the spaces where most youth are first introduced to the structure and expectations of what it means to be a "good student." Student engagement is regarded by educators as a key factor as to how well a student preforms in class; however, engagement can look a variety of ways, for example how students are participating in content discourse or how often are students engaging in hands-on activities. This lack of interest can also cause students to be unable to identify with school and not relate to the content that is being taught. Not being able to relate to content, specifically STEM content, affects youths' engagement and success in STEM courses. Studies have shown that "Children of color, especially those in poverty, have long ranked amongst the poorest performers in science achievement (Parsons, 2008; U.S. Department of Education, 2001)" (Walls, 2012, p. 4). One of the reasons the performance of children of color in science is lower than that of majority youth is not because they do not aspire to do well in science; it is because they do not identify with science content, and in turn, they do not see themselves in STEM.

Archer and colleagues (2012) found that

> Social structures (e.g., of gender, class, "race") thus play an important role in shaping the identities, choices, and aspirations that people perceive as possible and desirable ("for me"). That is, the scope and limits of an individual's aspirations and "choices" are shaped by the wider social structures within which they are located, even if these forces are often not consciously recognized by people themselves. From this perspective, children's and parents' science aspirations are not simply, "personal" decisions but are socially inflected and a (partial) product of their social locations. (p. 970)

Having these social structures in our society based on class, gender, and race can make it difficult for youth of color to aspire to be scientists or engineers because they do not just have a personal connection to the content, but the social structures are not in place for youth of color to be successful in science. Because of this disconnect it is imperative for educators to find alternative avenues to engage youth in science. For example, Varelas and colleagues (2008) found that when teachers took time to explore ways that engaged urban youth in science without expecting them to assimilate into the dominant culture youth became more engaged in science content. By using material artifacts and science talks where youth were able to explore science using their own experiences and language, Varelas and colleagues (2008) found that youth were able to "bring together" their life world with scientific discourse and made meaning of scientific phenomena. This was explicitly shown in the case of Terrence and his classmates when they conducted science talks with little guidance from their teachers. Through the student-led science talks, the youth in the study better understood science curriculum. This is significant to how minority youth engage in science; these findings provide evidence that when teachers allow youth of color to investigate science through inquiry with little teacher-directed instruction students can better understand science concepts.

Creating formal spaces that foster support and problem solving is imperative to engaging youth of color in STEM. Carlone, Scott, and Lowder (2014) found that when youth of color are in science spaces that foster collaboration among peers, youth of color are more likely to identify with science. Youth in this study found that to be "good" in science is more focused on "thinking critically, persisting, problem-solving, making unique observations, and creating scientific explanations and also being empathetic and nurturing with peers" (p. 858). The findings of this study go against social structures that are in place that may inhibit youth of color to be successful in science, because the youth in this study identified being a "good" science student as someone who was empathetic and nurturing to peers, which is not traditionally found in a regimented science space.

Children typically enter elementary schools questioning, excited, and ready to learn new things. Elementary school is a crucial time in a child's life because they are intrigued to learn about the world around them. However, because of social structures, it is imperative that STEM educators find alternative ways to teach youth, especially youth of color, so that they maintain engagement through their academic trajectory.

Middle School

Middle schools are spaces where youth are beginning to explore their own identity, who they are; in many cases they are searching for a sense of belonging. Middle school youth are also faced with more high stakes testing and a more regimented school day than they experienced in elementary school. Middle school also tends be the space where youth become disinterested in STEM. Studies have shown "that students feel a shift in motivational values for schooling as they transition from elementary to middle" (Carlone et al., 2014, p. 837), which can cause them to become disengaged in content. Middle schools tend to transition youth to a more structure book-orientated school day than opportunities for exploration through inquiry. Because of the lack of hands-on opportunities and social structures that are played out in schools, it can be difficult for youth to engage in content where they do not see themselves as being successful. Carlone and Johnson (2012) found that disengagement in minority youth can be caused by cultural identities not being prevalent in the science classroom. Rockford and Carlone (2011) followed minority youth exploring how they engaged in science throughout their elementary to middle school careers. This study showed that there was a unique difference in how Julio (a young Hispanic boy) engaged in science as he got older, which was directly related to his teacher's instructional practices. The youth's fourth-grade teacher nurtured his Hispanic background; however, in sixth and seventh grade teachers focused more on book work and cookbook labs. These differences in instructional strategies became evident when looking at how the students engaged in science through a cultural difference lens. Ms. Wolfe (fourth-grade teacher) was very supportive of the students' cultural backgrounds by recognizing that the students' cultures and beliefs were not the "norms" for the White western classroom. She acknowledged that the students had strengths (though not consistent with the normative science classroom) and engaged them in science using their cultural background as a basis. However, once the student moved to sixth and seventh grade his cultural difference impacted his science learning. Mr. Campbell's (sixth- and seventh-grade teacher) instructional practices were heavily focused on bookwork, with limited inquiry-based labs. Julio became disengaged in science because his cultural background was not represented the same way it was in Ms. Wolfe's class. Cultural differences are imperative for teachers to identify and incorporate in the classroom because they can be an indicator on how students engage in content.

As seen in the above study, connecting youth culture to content is salient to student success. Various studies have explored the use of Culturally Responsive

Pedagogy (CRP) in the classroom (Howard, 2001; Lee, 2006). Howard (2001) studied the impact teachers had on African American students' engagement in content when their teachers created a family-like environment in the classroom. Lee (2006) used CRP to investigate the "Cultural Modeling Project" framework, which was used to create a curriculum that directly linked everyday knowledge to academic content. Lee (2006) found that students who went through the framework performed better academically than those in the control group. Bishop, Berryman, Cavanagh, and Teddy (2009) found that when teachers build relationships with students, literacy and math scores increased. The above studies went beyond just learning about famous African Americans during Black History month. They all integrated the youths' culture in curriculum. This integration showed relevant connections to the youths' cultural background and content.

Practice theory can also be used to "understand the relationship between individual agency, societal structures, cultural production and cultural reproduction" (Carlone & Johnson, 2012, p. 158). Practice theory as well as CRP relate to how youth adapt when learning and using scientific discourse in the classroom. Calabrese Barton and Tan (2009) investigated students' social worlds and school worlds connected. For example, while studying the parts of a plant, Mr. M (the teacher in the study) assigned his students to go home that evening after school and ask a family member for a favorite salad recipe that they could share with the class. The youth were not only excited about sharing their family's salad recipe but they were able to connect plant anatomy to the different vegetables in their salads. This study shows that when teachers relate school science to youth's home life, youth become more engaged in science content because they understand how science is connected to their lives.

Practice theory and CRP are two imperative concepts when looking at minority academic engagement because they focus on how social structures play out in the classroom and how these affect youths learning. Focusing on specific strategies that relate to youths' lives and culture helps youth better understand how content is relevant to their lives. As shown in the studies above minority youth interest in science is fostered when in a space that appreciates their culture.

High School

High school is time in a student's life when they are figuring out who they want to be and which career pathway they want to take. This is time when youth are negotiating whether they want to attend college, enter the military, or go directly into the workforce. Rahm (2008) stated,

> While ownership may be temporary in some cases, it makes evident that to study science literacy development, we need to move beyond the study of homogenous and monocultural and come to value the kind of cultural pluralism that constitutes learning and becoming of youth today, whether in science or the world at large, whether in school or in other settings. (p. 119)

This quote is especially intriguing because teachers should focus on students' cultural identities when teaching content, as seen in Emdin's (2011) study on communication in a high school science classroom. Emdin investigated how teachers can engage minority youth in science conversations so that they see themselves as scientists. After observing students' out-of-school communication (i.e., students at the neighborhood park or community center), Emdin found that students engaged in rap cyphers; in these cyphers, he found that students were transferring information to one another. Emdin calls this type of communication among young people a "transaction." Emdin (2011) found that when teachers disseminated a large amount of communication between student and teacher (transactions) in their classrooms, students were more engaged in the science content. Emdin (2011) found that cogenerative dialogue is an imperative feature in the science classroom; cogenerative dialogue is positive discourse between student and teacher where youth are able to communicate in the classroom as they would in their peer groups, for example, a rap cypher. Establishing a space where cogenerative dialogue is prevalent supports students to not only engage with science content but it shows students that their culture is valued by their teacher. Students want to know that teachers appreciate their experiences. By teachers appreciating and valuing students' experiences, there is less of a focus on the dominant social practices of the scientific knowledge while breaking down walls to get more AA youth engaged in science.

Understanding STEM concepts and discourse can be a difficult task for many students, especially minority youth. As seen in the formal middle school section of this chapter, Culturally Responsive Pedagogy (CRP) and practice theory are two lenses that can be used to investigate how to foster STEM discourse and engagement in minority youth. Underrepresented youth are faced with the undertaking of not just learning scientific phenomena but also understanding scientific language. Proficiency in the scientific language can be similar to learning a foreign language for some youth. When marginalized youth enter the science classroom, they could be intimidated by the complexity of science content as well as terms with which they are not familiar. Brown (2006) explored how minority high school youth engaged in science and science language through the lenses of language discourse and identity. The youth in the study perceived scientific discourse as its own “unique genre of discourse” (p. 117); they felt that it was not a common way to communicate with others and found it frustrating (at times) to understand. Brown (2006) found that because the youth in the study did not identify with “scientific language” it hindered their engagement in the science content.

Many studies (Berry, 2008; Bishop, 2012; Calabrese Barton, Kang, Tan, O’Neill, & Brecklin, 2013; Tan et al., 2013) have shown that student identities play a significant role in how youth learn. Brown (2006) found that minority youth feel a sense a conflict when engaging in science discourse because they did not identify with scientific culture. The youth in the study also felt as though they could not use scientific language outside the science classroom because they would be ostracized by their peers, similar to the youth in the Archer, Hollingworth, and Halsall (2007) study, where students relied heavily on being accepted by peers based on the clothes they wore. In both cases, minority youth wanted and needed to be accepted by their community to gain social capital. This social approval is based on the cultural capital the youth needed to “fit in” and not feel marginalized by their own peer community.

When engaging in STEM, minority youth can encounter identity conflict. This conflict is found when minority youth are engaged in science but are also trying to be accepted in their own communities. Brown (2006) described the process of minority youth learning scientific language as “problematic” because students have to grapple with conforming to the dominant White culture while trying to be accepted by their peers. Marquelle, one of the youths in the study, stated that once she learned science terminology she felt as though it was not something that could be transferred to other content areas. Marquelle's statement showed that minority youth feel stagnant in their science learning because they cannot see how science relates to other content areas. It is then difficult for them to connect science content to other subject areas. When students can see relevance across content areas, they are more likely to associate their learning with the outside world. Because of this lack of association, Brown (2006) found that once Marquelle learned scientific discourse, it then became difficult for her to "acquire fluency" since scientific discourse was not used in her other courses (p. 119). Conflict arose in her normative discursive behavior as well because she believed that science had its own "slang" that most people could not understand (p. 119). This is comparable to what was found in the Nasir and Vakil (2017) study on youth of color in STEM-focused academies. Nasir and Vakil (2017) followed youth of color in two different STEM focused academies and found that "students of color were not in the rigorous spaces because those spaces were hostile to the cultures, experiences, values, and interests of marginalized groups" (p. 389). Because the spaces that were created for youth of color were not fostering their cultural identity, the adults in the building had a deficit view of the minority youth engagement in STEM, stating, "Black students are just 'not math science kids,'" (Nasir & Vakil, 2017, p. 390). This deficit narrative implies that youth of color are not just disinterested in learning science and math but also lack the intellectual ability to learn math and science.

Chapman and Feldman (2017) found that when youth experience authentic science in high school their science identity is cultivated. The youth in this study had the opportunity to participate in various science practices when in their high school science course. For example, they were able to collect data and samples in a greenhouse which made them feel like an "actual scientist" (Chapman & Feldman, 2017, p. 482). This study found that when youth are given authentic science experiences it influences their science identity. Students were able to see themselves in science because they were "doing science" the way scientists do.

The above examples are some of the central reasons why students of color do not pursue STEM pathways. Minority students may feel that they must assimilate to the dominant culture and lose their cultural identity in order to be successful in science, or they are not given the opportunity because the space was not created for their authentic engagement. It is imperative for science teachers to acknowledge that students come to their classroom from diverse communities. Educators must take the time to explore multiple ways to engage youth in STEM and STEM talk. If minority youth believe that they can learn science in spaces that foster their culture and not feel conflicted through the process, more youth of color could decide to major in STEM.

Formal STEM spaces provide a space for youth to receive science content and engage in science from Kindergarten to the 12th grade. Having formal school spaces that support youth to explore and investigate STEM throughout all of their schooling is imperative to their STEM trajectory. Formal school spaces provide the foundation for youth to learn content, but they should also show youth how content relates to their lives.

As shown in the studies above in elementary, middle, and high schools, youth of color need spaces that foster inquiry while participating in authentic and culturally relevant STEM task.

Youth of Color in Informal STEM Spaces

Informal STEM spaces can have a significant influence on how youth engage in STEM, especially youth of color. Informal STEM spaces can be in community clubs, museums, and aquariums, to name a few. In these spaces youth are not expected to perform on high stakes tests, are supported to explore STEM through inquiry, and can participate in authentic STEM task. The studies below highlight the importance of informal STEM spaces and the impact they have on youth engagement in STEM.

Elementary

Informal STEM spaces can foster learning in youth in various ways. These spaces offer flexibility when youth want to explore and investigate more deeply in a topic that formal spaces often cannot offer because of test constraints. Informal STEM spaces include museums, aquariums, and community clubs. Rahm and Ash (2008) stated that "beyond being linked to improvement in academic standing, participation has shown increases in science literacy, interest, positive attitudes and confidence in science, as well as higher chances of pursuing career trajectories within the sciences" (p. 49). Because of the opportunities that informal STEM spaces afford youth, it is imperative for youth to experience these spaces to increase youths' science identity. Rahm and Ash (2008) found that in some instances when youth visited an aquarium both in and outside of school their interest in science increased and they became more literate in science content. This study also highlighted that minority youth feel as an outsider when in a placed in informal spaces (for example, aquariums, museums, community clubs); however, the youth in this study felt like insiders at the aquarium because the afterschool program allowed them to explore how science connects to their lives in this space. Similarly, Rahm (2008) found that when youth are able to engage in informal STEM spaces, they have more ownership in science activities. Because the youth in this study could engage in science content at their own pace and choose what scientific phenomena they wanted to explore, they were more engaged in science content. Both studies highlighted the importance of how an elementary STEM informal space can influence minority youths' engagement in STEM activities because these spaces offer more flexibility, allowing youth to explore and investigate science and engineering.

Middle School

Middle school is a time in youth's lives when they want to be expressive and explore their own identity; it is time when they are "figuring out" who they want to be. Middle school is also a time when youth become disengaged in STEM; they become disinterested with STEM courses because the courses are more test preparation-focused than inquiry-based. However, informal STEM spaces can foster a sense of wonderment by supporting youth to explore STEM phenomena at their own pace through inquiry. As seen in Tan and colleagues (2013), when youth were involved in an informal science club they became more involved in science content and participated more in groups. For example, Jana (a young girl in the study) wanted to work independently when in her formal classroom setting; however, when she attended the informal science club she participated more and always wanted to work in groups. This informal space also created an atmosphere where Jana felt comfortable asking multiple science questions to renewable energy experts when they came to speak to the youth in the club. Informal spaces fostering confidence in youth was also shown in Birmingham and Calabrese Barton's (2014) work with the youth at GET city, which is an afterschool science enrichment program at the Boys' and Girls' Club. Here, youth were able to show their expertise in effective ways to use green energy by organizing a "Green Carnival" to inform the people in the community about better ways to conserve energy. Here, the youth were the experts; their skills were positively influenced by them being in a safe informal space. Informal spaces include museums, aquariums, or community clubs. Research has shown that when youth engage in enrichment activities in these spaces, they identify as scientists (Birmingham & Calabrese Barton, 2014; Calabrese Barton & Tan, 2018; Tan et al., 2013). The above studies highlight the impact informal STEM spaces have on youth of color by providing a space that foster inquiry and support while engaging in STEM.

High School

High school is space where youth are beginning to think about the career path they want to take. STEM careers are in high demand today and are constantly growing; however, there is a disparity of youth who decided a STEM trajectory. Informal spaces can be specifically important to youth in high school because these spaces can engage and foster youth's STEM identity in different ways than formal spaces can. For example, Gonsalves, Rahm, and Carvalho (2013) stated, "informal settings may be particularly important in offering youth with opportunities to reflect on science and also identify with the scientific enterprise" (p. 1069). Gonsalves and colleagues (2013) found that when high school youth are engaged in an informal science program they not only were more engaged in science but they saw the relevance to science to their lives because they were in a space that connected content to their cultural lives. For example, youth were able to have discussions about how the science they were learning in this space connected to their everyday lives. Creating this type of informal STEM space is salient for youth of color because it not only fosters STEM engagement but it also shows youth relevance to how STEM relates to their lives.

African American Girls in STEM Spaces

Though there has been improvement in the engagement of girls in STEM, there is an underrepresentation of AA females obtaining science (Brown et al., 2016; Catsambis, 1995). This underrepresentation of African American girls is not due to the lack of interest in STEM, it is because they to do not "see themselves" in STEM content. Archer and colleagues (2012) stated, "Gender differences can also be produced and reinforced through the education system, resulting in the 'othering' of girls within science/mathematics and hindering their progression" (p. 969), which is gives evidence as to why girls, especially AA girls, do not see themselves on a STEM trajectory. Calabrese Barton and colleagues (2013) found that weak support systems in schools can have a negative effect on AA girls' science identity. Diane, one of the girls in Calabrese Barton and colleagues' (2013) study, was positively influenced in science when her teacher engaged her in scientific inquiry. Diane felt she could explore and belonged in the science classroom without feeling "judged" because of her race or gender. When students feel safe and supported by the adults around them, their positive identities evolve. Diane's identity altered, however, when she had a teacher who did more bookwork than inquiry-based activities and did not support her in science. She began to become disinterested in science and no longer saw herself as a scientist because of her experiences with this teacher. As seen in Diane's case, teachers impact how students see their identity with science. Similarly, Tan et al. (2013) found that when investigating both narrated and embodied identities one could have a better understanding of youths' STEM trajectory. Tan and colleagues (2013) focused on how girls' narrated and embodied identities contributed to how their teacher saw them as science students and how they were engaged in science. It was found that Meg and Eunice (two youth focused on in the study) were perceived by their teacher very differently, although both girls made A's in their science class. The girls' teacher saw Meg as "good" science student, but felt that Eunice did not have the ability to be successful in science. When asked about Eunice's grades, the girl's teacher was surprised that Eunice was making an A in her science class. Because Meg was not as vocal as Eunice, her teacher positioned Eunice as an "average" science student and Meg as a "good" science student. This negative positioning of Eunice had a huge effect on Eunice's STEM identity and trajectory; once Eunice matriculated into the eighth grade, she no longer aspired to become a veterinarian as she did in the sixth grade. As seen in the above studies, when teachers relate behavior to academic performance or do not support students in scientific inquiry they affect students' science trajectory and identities.

When students have strong systems that allow them to explore science content while incorporating their own interest, a positive science identity is fostered. As seen in Basu, Calabrese Barton, Clairmont, and Locke (2009), the youth studied identified strongly with the physics material and saw themselves as experts in either robotics or scientific issues. The youth in the study were able to identify with scientific content because they saw themselves being successful in an environment the teacher had fostered for them. For example, the teacher in the study allowed Donya, a youth in the study, to co-create and teach a lesson on matter and energy through a class debate. Through this activity, Donya could polish her argumentative skills while engaging in science because she hopes to one day become a lawyer. In both cases, the youth were empowered by their experiences in their teachers' science class because the teacher provided a space wherein they could explore their own interests while incorporating science content.

Though these studies have given good insight as to why AA girls are not engaging in science at the same level as their White counterparts, more research is needed that focuses on how sisterhood, teachers' acknowledgement of intersectionality, STEM discourse, and CRP can better engage AA girls in STEM. Parsons (1997) found that AA girls do not picture themselves as scientists or mathematicians and feel that they will not be supported if they enter a STEM trajectory. Calabrese Barton and colleagues (2013) found that when working with AA girls, weak support systems in schools negatively influenced their science identity. Both studies showed that minority girls need a strong support system in place when engaging in STEM. However, I wonder how educators create spaces that influence AA girls to become innovators and identify themselves as scientists or engineers.

Though the reason why the underrepresentation of AA girls in STEM is unclear, there is evidence that there is a specific relationship between gender and race as to why AA girls do not pursue STEM majors. This can be changed by identifying strategies to better engage them by focusing on sisterhood, intersectionality, and free discourse, and how they affect AA girls' science identity and engagement. There is a lack literature on how to specifically better engage AA girls in STEM through the use of CRP, practice theory, and free discourse. As seen in the studies above (Carlone & Johnson, 2012; Howard, 2001) there has been a strong focus on boys and whole classrooms, but little exploration of how to engage AA girls using these strategies. Birmingham and Calabrese Barton (2014) found that when youth are positioned as "experts" in the classroom and are immersed in science content without assimilating to the dominant culture, they can see themselves as scientists. Because there is a disparity of representation of AA women in STEM fields to serve as role models for younger AA girls, it is imperative that there is a space that fosters a sense of pride in their culture, supports AA girls through a STEM trajectory, and influences sisterhood so that AA girls see themselves as scientists and engineers. How do science educators create these types of STEM spaces for AA girls? What do these STEM spaces look like? What can AA girls do in these STEM spaces? Below I propose a conceptual framework with specific focus on how Black Feminist Theory and Identity Work can be used as a theoretical foundation to foster a "judgment-free" STEM space that fosters AA girls' engagement in STEM meaning and making.

Research Questions

The following research questions were used as a guide to investigate how 10- to 14-year-old African American girls perceive an informal STEM enrichment program as a "judgment-free" space. I operationalize what a "judgment-free" space looks like as it relates to microaggressions and social constraints. These research questions also focus on how this STEM program influences African-American girls' positive STEM identity (if at all and to what degree), so that they see themselves as scientists and engineers (if at all and to what degree).

1. What does it mean to the AA girls to have an informal youth STEM space that is free (or as free as possible) of microaggressions and social structure constraints?
    a. How are the youth in an informal STEM program positioned?
    b. What are the youth in an informal STEM program able to do (process and products that they would not be able to do in more regimented STEM formal space)?
2. How might a setting free (or as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls' STEM identity/agency and sense of sisterhood?

Operationalizing Judgment-Free

In a world of standardized testing it is often difficult for teachers to focus on STEM instruction that engages and fosters the science identity of all students, especially that of African American (AA) girls. Though studies (Boston & Warren, 2017) have given good insights as to why marginalized youth are not engaging in STEM, they have neither given solutions on how to specifically better engage AA girls in STEM, nor have they explored factors that would influence AA girls' science identity. With a focus on AA girls' STEM identity (who AA girls are and who AA girls want to be) and Black Feminist Thought (BFT), we can better understand how strong support systems and the absence of microaggressions could create a space that fosters free discourse and STEM critical agency in AA girls, therefore ameliorating the "leaky pipeline" phenomenon. I will begin with how BFT and identity work allows a theoretical foundation to better understand what has been underemphasized in current literature on AA girls' science identity. I will conclude with an explanation of a "judgment-free" conceptual framework that highlights sisterhood and intersectionality as the lenses through which to explore who AA girls are and who AA girls want to be in their STEM trajectories. By looking through a "judgement-free" lens, by decreasing microaggressions and negative positioning, we could create a space that fosters free STEM discourse and critical STEM agency and doing so could ultimately have an impact on AA girls' STEM engagement, identity, and learning.

Black Feminist Theory

Black Feminist Theory (BFT) has been used to describe AA women's roles as the outsider within; Collins (1986) stated that AA women have served as maids and caregivers to the dominant culture but were never able to express their voices in these spaces. This domination, in turn, united AA women to depend on one another through times of oppression. Johnson and colleagues (2011) found that the successes of minority women (AA, Native American, and Hispanic) relied heavily on the support of family members and other minority women. This study explored how minority women displayed the tenet of "sisterhood" described by BFT to encourage and support one another through different science and engineering tasks. Sisterhood is defined as the sharing and helping of one another through similar concerns within a group of people. As noted in Taylor (1998), AA women were tired of being considered second class citizens and decided to come together as "sisters" to fight against the dominant culture's oppression. For example, African American women started the Student Nonviolent Coordinating Committee (SNCC), which involved students in participating in sit-ins to protest Jim Crow laws. Collins (1986) stated that AA women have supported one another for centuries through childbirth, slavery, and now through forms of academia; this support has been important for the success and perseverance of many AA women, a claim that has been supported in various studies (Johnson et al., 2011). Many AA women have been able to achieve their goals because of the support they received from other women of color (Johnson et al., 2011). This shows that it is imperative for women of color to have women who look like them in similar careers to serve as examples and inspiration. The women in the Johnson and colleagues (2011) study spoke of how important it was for them have other women of color that they could relate to in their academic programs. These women provided support for one another, which is salient in AA women's success in STEM, a "sisterhood" I will describe at a later point.

Intersectionality is the interaction of race, gender, socioeconomic status, and experiences that lead to struggles of empowerment (Davis, 2008). For example, Roxas and Roy (2012) followed a young refugee male to understand why he was unsuccessful in school. Using intersectionality as a basis for their research, Roxas and Roy found that Abdullah (the young man in the study) was failing his courses in school because of the interaction of his race, being new to the country, and not being familiar with the language. AA girls also face intersectionality when participating in science and engineering courses or tasks. Johnson (2006) found that women of color had to persist against various forms of discrimination because of the interaction of their gender, race, and socioeconomic status. The disparity of representation of minority women in STEM careers also interacts with AA girls' science identity because it brings forth another facet of discrimination against which AA girls must struggle.

Sisterhood and intersectionality (tenets of BFT) can be used to explore how AA girls engage in STEM. As seen in the Johnson and colleagues (2011) study, many of the women stated how they had someone who was of their same racial group to support them throughout their degree-obtaining process. Establishing this sense of sisterhood at a young age in an AA girl's life could affect how she maneuvers through STEM spaces and how AA girls see themselves in these spaces. The idea of having that constant support from someone who looks like you while going through the same processes can be imperative in AA girls' STEM engagement.

Current literature has not investigated how sisterhood and intersectionality could positively impact young 10- to 14-year-old AA girls following a STEM trajectory. Incorporating BFT as a theoretical foundation with a focus on young AA girls, we can better understand how a sense of sisterhood and intersectionality can be used to foster AA girls' STEM identity. By acknowledging the intersectionality that AA girls experience, we can address AA girls' STEM identity and their STEM aspirations, because we can better understand the challenges and discrimination they face when pursuing a STEM trajectory. Highlighting sisterhood and intersectionality gives science educators the opportunity to build support systems that positively influence AA girls' STEM identity.

Identity

Bishop (2012) defined identity as "a dynamic view of self, negotiated in a specific social context and informed by past history, events, personal narratives, experiences, routines and ways of participating" (p. 38). A person has a specific view of themselves, and this can fluctuate depending on the situation or space the person is in. There are many aspects that shape one's identity, as shown in Bishop's quote above. One is not born with an exact identity; a person's identity is shaped throughout one's life, with influences from multiple people and spaces. Identity is important in science, especially when exploring the reasons as to why there is a disparity of representation of minorities in this field. Research on marginalized youth in science has shown that if marginalized students do not see themselves as being successful in the science classroom, it is difficult for them to identify themselves as becoming scientists (Calabrese Barton et al., 2013; Tan et al., 2013).

Student identity plays a large role both inside and outside of school. Berry's (2008) research on successful African American males in math showed that youth could have several identities. The males in Berry's (2008) study were active in a variety of spaces. These spaces helped shape their identities in various ways; because many of them were athletes and heavily involved in church, they had a sense of commitment to do well both inside and outside of school. These extracurricular activities also provided them with discipline and structure that they could transfer to the classroom. The young men also had a strong support system at home and parents who advocated for them; these factors that were seen in this study have an influence on one's identity. Children identify with places in which they are successful and benefit from a support system to foster this success.

When students display a positive science identity, this can be transferred into having science agency. As seen in Basu and colleagues (2009), the youth in the case studies identified strongly with the physics material and were then able to become experts in either robotics or debating scientific issues. The youth in the study were able to identify with scientific content because they saw themselves as being successful in the environment the teacher had fostered for them. One of the youths enjoyed working with robots and his teacher provided opportunities for him to meet with engineers and made him an "expert" when it was time for the class to go over circuitry. In both cases the youth were empowered by their experiences in their teachers' science class because their teachers provided a space wherein they could explore their own interests while incorporating science content.

Microaggressions

Microaggressions are inconspicuous actions that people of color feel when the majority group does or says something to oppress them. For example, Solorzano, Ceja, and Yosso (2000) found that AA students felt that their White professors had low expectations of them succeeding academically and ignored their academic concerns. These microaggressions have been shown to have a substantial impact on minorities' academic success. Solorzano and colleagues (2000) explored how AA students on college campuses experience microaggressions from numerous avenues and have a significant effect on how well AA students do in college (especially in predominantly White institutions). It was found that because of the impact of microaggressions, some AA students changed their majors or transferred to other universities. They reported feeling a sense of invisibility with regards to their White professors and peers when they were not acknowledged for their academic contributions. Microaggressions can cause African Americans to be negativity positioned, which in turn could affect their performance in school. For example, in the Tan and colleagues (2013) study, a middle school AA female student, Kay, was seen as a "behavioral problem" by her male science teacher and did not readily engage her in science. However, when Kay was actively engaged and positioned positively in science, it was found that she could be successful. When Kay's teachers actively engaged her in science she made A's in science; however, once she reached middle school Kay became disengaged in science and began making C's. It is imperative for educators to be aware of the negative impact microaggressions may have on children of color because their STEM identity and engagement in STEM content could also decrease because of these microaggressions. This type of negative judgment has been significant when studying the disparity of representation of AA girls pursuing a STEM career trajectory because it gives insight as to why there is low representation of women of color in these fields.

Positioning

The positioning of minority girls by authority figures (e.g., teachers) has played a significant role in their pursuit of STEM careers. There are two types of positioning: negative positioning, which can deter youth from being engaged in STEM and positive positioning, which influences youth in becoming more interested in STEM. Students' peers and adults in their lives (e.g., teachers) can affect how youth are positioned in and outside the classroom.

Pringle and colleagues (2012) found that elementary school teachers positioned minority girls in their classroom as being greatly interested in reading and writing; therefore, many of the science lessons were focused around liberal arts activities. The teachers in this study spoke about how the girls liked subjects with more dialogue; therefore, the girls' teachers took them out of science courses and placed them into more liberal arts courses as they got older without finding discourse strategies that could engage the girls using scientific discourse. Because of this positioning the teachers had low expectations for the girls' interest in science and lacked awareness of their roles as advocates for the girls engaging in science in the future.

Varelas, Martin, and Kane (2012) also found that AA students are often "academically positioned in the lowest level of learning and succeeding in mathematics and science" (p. 323). Similar to Basu and colleagues (2009), when looking at AA youth in this study they found that they needed spaces that feel like a social community wherein the student could be nurtured and supported. Creating a space where AA youth are positioned so that they feel they can be successful in STEM could influence their science identity, as also seen in Tan and colleagues (2013).

As seen in various studies (Kurth, Anderson, & Palincsar, 2002; Solorzano et al., 2000) microaggressions and negative positioning (Pringle et al., 2012; Varelas et al., 2012) can play a large role in how youth engage STEM. Though both of these studies focused on girls' experiences with microaggressions in an academic setting, there is limited literature on how girls, especially AA girls, engage in STEM when in a "judgement-free" space, where there is little to no microaggressions or negative positioning. By reducing or illuminating microaggressions and negative positioning while establishing sisterhood, acknowledging intersectionality and focusing on who AA girls are and who they want to be, we can better understand on how to create a "judgment-free" space that fosters free discourse and AA girls' STEM agency.

Free Discourse

Being able to speak freely is important for all students, especially marginalized youth. Brown (2006) explored how minority high school youth engaged in science and science language through the lenses of language discourse and identity. As seen in multiple studies (Berry, 2008; Bishop, 2012; Calabrese Barton et al., 2013; Tan et al., 2013) student identities play a significant role in how youth learn. At times, minority youth feel if they engage in science discourse (a White male-dominated field) they would be assimilating to the dominant culture, losing their own racial identity. Brown (2006) found that the minority youth in his science classroom felt as though they could not use science discourse outside the science classroom because they may be ostracized by their peers. The youth in the study perceived scientific discourse as its own "unique genre of discourse" (p. 117); they felt that it was not a common way to communicate with others and found it frustrating (at times) to understand. The youth in the Brown (2006) study did not identify with "scientific language" which hindered their engagement in the science content because they were accustomed to using African American vernacular.

As seen in the Varelas and colleagues (2008) study, teachers took time to explore ways that engaged urban youth in science without expecting them to assimilate into the dominant culture. By using material artifacts and science talks, youth were able to explore science using their own experiences and language. Varelas and colleagues (2008) found that when youth were able to "bring together" their life world with scientific discourse, in turn, youth were able to make meaning of scientific phenomena. This was explicitly shown in the case of Terrence and his classmates when they were able to conduct science talks with little guidance from their teachers. Through these student center science talks, the youth in the study better understood science curriculum. This is significant to how minority youth engage in science; these findings provide evidence that when teachers allow students to investigate science through inquiry with little teacher-directed instruction students can understand science concepts.

Though these studies have highlighted how STEM discourse can engage minority youth in STEM, there is no direct focus on AA girls' engagement in STEM discourse. Exploring how creating a sense of sisterhood among AA girls in a judgment-free space can give us the opportunity to better understand the support systems that AA girls need to comfortably engage in STEM discourse.

Critical STEM Agency

In Tan and colleagues' (2013) research, minority girls had a positive science identity when exposed to STEM in an afterschool enrichment program where they could draw on their life experiences and connect them to science. It was discovered that when young minority girls are given the time and opportunity to engage in science outside of school, in informal science spaces, in conjunction with a positive formal school setting (manifested in high expectations, scaffolding), they developed a positive science identity. By teachers and schools supplying outlets for youth to explore science in informal spaces and showing relevant connections to science and students' lives in classrooms, it could better position students to engage in science and see themselves as scientists.

Freire (1998) believed that school should be a place where students are comfortable and appreciated for the knowledge they bring to the classroom. In order to do this, educators must understand the concept of intersecting inequalities, belonging to two or more minority groups (Brickhouse & Potter, 2001, p. 967), for example being an African American female. Recognizing these intersections could create spaces that influence positive critical STEM agency in minority groups especially African American girls. Turner stated, "agency involves individuals' sense of themselves as "agents whose actions" count in, and account for the world" (Tan, Calabrese Barton, Turner, & Gutierrez, 2012, p. 53). Turner found when working with youth in an urban math class that when used math to critique the conditions of their school the youth exhibited positive math agency, because they saw themselves as agents of change. Similarly, Basu and colleagues' (2009) study found that when youth are engaged in science content, that could become agents of change. For example, Donya's and Neil's teacher (the youth featured in the study) made them "experts" in specific physics content based on their career aspirations. When Neil was having a difficult time transitioning to a new school, his teacher decided to incorporate his interest of robotics in her physics course; it was found to that this contributed to his success in the course. By providing him with the opportunity to learn robotics he was able explore his goal of becoming an engineer, which was salient to his engineering identity.

Both Basu and colleagues (2009) and Turner (Tan et al., 2012) found that when minority youth become critical math/science agents they are able to identify themselves as mathematicians, scientists, or engineers. Research has shown that when teachers identify intersecting inequalities and incorporate students' voices, students' STEM identity grows. Creating a space where youth engage in science discourse without feeling as though they could lose their own cultural identity is imperative to fostering STEM agency. As seen in Brown (2006) and Basu and colleagues (2009) when youth were able to talk about science in comfortable spaces they felt like "experts" in the science content. Though these studies highlight what it looks like for AA girls to engage in scientific discourse and how it fosters their science identity and agency, they do not specifically explore how to create a judgement-free space that nurtures scientific discourse and STEM agency in AA girls, with direct focus on sisterhood and identity work.

Proposed Theoretical Framework to Study Judgment-Free STEM Learning Spaces for AA Girls

Drawing on Black Feminist Theory (BFT) and Identity work as the foundation for my theoretical framework, I used these two theories to consider how sisterhood, intersectionality, and Identity work in STEM play salient roles in how AA girls experience a judgment or judgment-free space. A judgment-free space is a place where high expectations are established in conjunction with positive judgment. When negative judgment is prevalent AA girls feel that they must fight against microaggressions and negative positioning. I conjecture that a "judgment-free" space can foster AA girls' agency and provide a place where they can speak freely, which can positively influence their STEM identity (see Figure 1).

Judgment

Judgment has been defined as an opinion based on norms constructed by society (Foucalt, 1977). For this study, I am going to use the definition of judgment as it relates to people; judgment can be used to classify people by comparing them to someone or assuming certain traits of a group of like people. Judgment has and can be used to oppress marginalized groups. When someone asserts certain negative assumptions about different minority groups this can often deter them from certain career paths. Microaggressions and negative positioning (Pringle et al., 2012; Solorzano et al., 2000) are two ways in which marginalized groups experience negative judgment.

“Judgment-Free” Framework

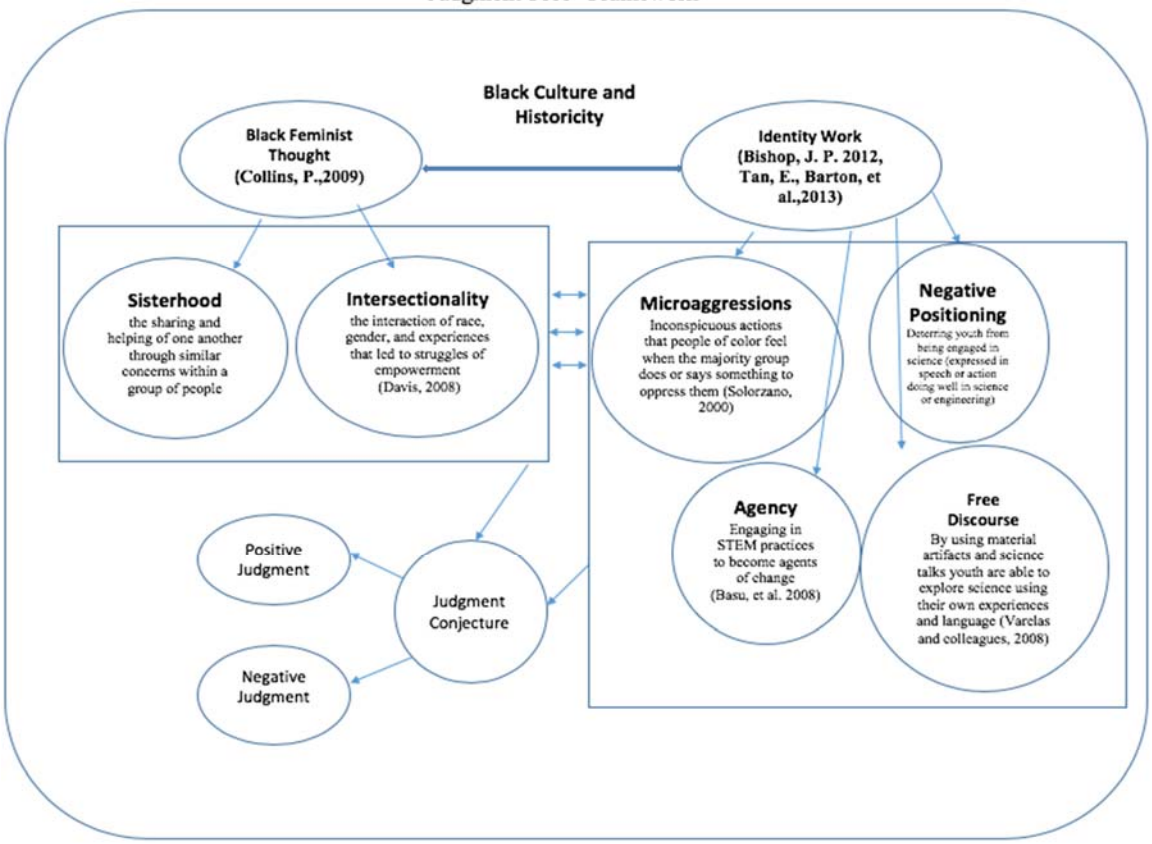

Figure 1. Conceptual Framework.

Judgment Free (Positive Judgment)

The is theoretical framework emphasizes how a judgment-free space influences AA girls’ STEM identity. Judgment is everywhere and can be expressed in numerous ways, positive or negative; however, when creating a judgment-free science enrichment space, we are looking at how positive judgment (free of negative judgment) plays a role in AA girls’ engagement in STEM. The goal of this framework is to explore how a judgment-free space supports AA girls working together to become innovators and see themselves as scientists or engineers. Judgment-free is defined (in this current study) as a space where one is not criticized or oppressed because of gender, race, or socioeconomic status (intersectionality). This type of space is especially important for AA girls pursuing a STEM field because studies have shown that historically AA girls experience microaggressions and negative positioning which leads to them becoming disengaged in STEM practices. High expectations with combination of sisterhood and a judgment-free space can encourage AA girls to speak freely in STEM spaces which will build their STEM identity and agency.

CHAPTER III

METHODOLOGY

In this chapter, I describe the methodological and data analysis approach I took for this study. I begin by explaining the methodology I chose and why I felt it was best suited for this study. I then describe the research site, participants, and curricula aspects of this informal STEM enrichment program. Next, I explain all data sources that were collected for analysis and how I analyzed those data sources. I conclude this chapter with thoughts on the validity of this study, my own positionality, and the limitations that emerged during my research in this space.

Research Questions

The following research questions were used as a guide to investigate how 10- to 14-year-old African American girls perceive an informal STEM enrichment program as a judgment-free space. I will operationalize what a "judgment-free" space looks like as it relates to microaggressions and social constraints. These research questions also focus on how this STEM program influences African American girls' positive STEM identity (if at all and to what degree), so that they see themselves as scientists and engineers (if at all and to what degree).

1. What does it mean to the AA girls to have an informal youth STEM space that is free (or as free as possible) of microaggressions and social structure constraints?

a. How are the youth in an informal STEM program positioned?
b. What are the youth in an informal STEM program able to do (process and products that they would not be able to do in more regimented STEM formal space)?

2. How might a setting free (or as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls' STEM identity/agency and sense of sisterhood?

Research Design

The methodology used in this study was a longitudinal critical ethnographic case study approach for a total of 4 years. Calabrese Barton (2001) stated that "critical ethnography is a methodology for conducting research focused on participatory critique, transformation, empowerment, and social justice" (p. 905). Through utilizing a longitudinal critical ethnographic case study approach, I was able to negotiate and work towards ameliorating inequalities that related to social structures such as gender and race. Through using a critical ethnographic lens, I was able to focus on "'what it is' but also 'what it could be'" (Mena & Vaccaro, 2017, p. 304) when it comes to how AA girls currently engage in STEM and how when given specific support systems how their engagement in STEM could be influenced. Critical ethnographies "address processes of unfairness or injustice within a particular lived domain" (Madison, 2012, p. 5); AA girls experience challenges when pursuing STEM pathways. By researchers exploring the social structures that can contribute to inhibiting AA girls from obtaining a STEM degree, we can better understand the specific strategies AA girls could use to overcome these prejudices. Through this methodology, I was able to describe the culture of the youth at a community club while combating against societal social structures by conducting observations, interviews, and being an AA female. I believe critical ethnography is appropriate for this study because it focused on a specific group of students, specifically AA females who were engaged in STEM, which goes against societal norms that AA females are not interested in STEM practices.

Mena and Vaccaro (2017) draw on a critical theoretical framework when conducting their critical ethnography. Similarly, this study is informed by Black Feminist Theory (BFT), specifically the two tenets of sisterhood and intersectionality. BFT explores how the notion of intersectionality plays a significant role in how AA women engage or disengage in STEM and how components of sisterhood can support and influence AA women to engage in STEM at higher rates. By using critical ethnography, I explored the oppressive structures that have been put into place by the dominant society and how these structures have marginalized AA girls in STEM, while investigating ways AA girls can break down these unjust barriers.

By using the key defining features of ethnography (focusing on an entire culture-sharing group), I explored how AA females identified themselves as scientists and/or engineers. Throughout this study, I wanted to discover the patterns that contributed to the girls' thoughts, expressions, and feelings towards STEM and how they have transformed because of the Green Energy Club (GEC), a STEM enrichment after school program with a summer camp component at the Community Club. I conducted multiple interviews (background, artifact, judgment and adult/mentor interviews) with my participants throughout the 4-year span. I also incorporated descriptive embedded case studies within my critical ethnography. I used a descriptive embedded case study approach (Creswell, 2013) because I described in detail and analyzed the experiences of the STEM identities in the six AA girls who participated in the GEC STEM enrichment program. Yin (2013) stated that the goal of a descriptive case study is to "develop pertinent hypotheses and propositions for further inquiry" (p. 10). By taking a descriptive case study approach, I made suggestions about my six participants' STEM identities throughout their participation in the GEC program.

Site of Research

Boys and Girls of Club Grapeview

This research study was conducted at a Community Club (sponsored by the Salvation Army) in a Southeastern state. This Community Club serves over 200 minority children across the city and recently moved into a new, larger building in order to serve more youth. The cost for youth to attend the club is $40 a month, which includes transportation, snacks, and dinner each day; however, more than 80% of the youth who attend this particular club are on scholarship which pays their monthly fee for them. Gabby, the director of the club and Margret, the assistant director lead a total of 20 adult program aides who serve as group leaders and mentors for the youth who attend the club. Numerous volunteers from local universities, churches, and businesses come daily to assist youth with homework and teach dance, basketball, music, and art. When one first walks into this new building one is greeted by children playing games, lounging on couches, or socializing with friends. This new space is bright and open, so youth can be free to play. The new building has classrooms that are surrounded by glass windows, with brand-new desk and chairs for youth to complete their homework and other projects, which is an exciting feature, because the old building had very few desk and chairs, so some youth had to do their homework on the floor. This new space also has a full-sized basketball court and new playground equipment outside. GEC sessions take place in the Tech room (because this is where the Community club stores the computers) and is the dedicated space for all weekly GEC sessions. The first 2 years, when we were in the old Community club building, we did not have a dedicated space in which to store items or display students' artifacts. In this new space, we are able to display student work and store supplies.

This Community club was chosen as the site for this study because the Community clubs of America have a history of serving youth of color from low-income families, which is the target audience for GEC. As a researcher, I believe it was imperative that youth are in a comfortable space, so they feel free to voice their opinions; the Community club provides a sense of comfort for the youth because it is an informal space in their community. The club serves youth who live in three of the city's largest low-income subsidized housing neighborhoods. Youth from kindergarten to 12th grade attend this community club daily throughout the school year and during the summer. Transportation is provided for the youth who attend the club; buses pick youth up from school and take them home after programming at the Community club has ended. The youth at the club get assistance with homework and can participate in a variety of art and character development programs. This community club constantly has special programs or field trips for the youth to expose them to different parts of the city, not just their own community.

The Green Energy Club (GEC)

The Green Energy Club (GEC) is a STEM enrichment afterschool program that engages youth in becoming makers and innovators for two and a half hours weekly, split into weekly sessions. The first weekly GEC session meets for one and a half hours; this session is a time when youth research how different technologies, "junk" or another mechanism (i.e., stop motion videos, making using little bits) can be used to solve a problem in their community. Youth then begin researching and making their innovation to solve their problem. During these sessions, youth can work with a partner or independently to work on their innovation. For example, youth were posed with the challenge to create something for someone in their community that would help them. Once youth identified the problem they then researched ways to create an innovation using Green Energy (energy that does not hurt the environment) to address the problem. Youth go through a variety of steps, for example, researching, interviewing their peers, and trial runs of their innovation to see what the best additions or deletions for their innovation would be.

The second weekly GEC sessions were put into place for youth to finish projects that were started in the first weekly GEC session and are more open-ended (there is no specific daily agenda that is followed). For example, in the first weekly GEC session youth worked on specific stop motion video, while documenting their progress. In contrast, in the second GEC session youth could begin creating a stop motion video, using a dollhouse they built last school year, in addition to the stop video they started in the first GEC session. The second weekly GEC sessions are opened to everyone; however, girls have been the only ones in attendance for the past year. The second GEC sessions have turned into a space where youth not only can finish projects but to also talk about social and school problems that may be happening in their lives.

GEC initially began in another city at a local Community Club in 2006 in another state, and is still in existence today. GEC was put into place to inspire youth to be change agents in their communities by building in STEM expertise, STEM citizenship, and educating others in the community about Green energy sources. This first site has various sponsors and has been awarded numerous grants; they have also been featured in several newspaper articles and won the National Award for Innovation from the MetLife Foundation. This GEC program has been replicated in this current research study.

GEC is the only STEM- and content discipline-focused program at the club; other featured programs that this Community Club offers are focused on music, art, and dance. Because of this, this particular Community club has a specific commitment to offer this STEM-focused program and is in the process of hiring a STEM specialist to sustain the GEC program at the current Community club with plans to offer GEC to other clubs in the city.

School science in the state of this study is focused on three main disciplines: life, earth/environmental, and physical. Engineering is seen as a separate content area which is not embedded in the school science classroom. GEC builds on science content while integrating engineering into each session, with the expectation that youth use mini-making (using various tools, for example "junk" computers, etc., to make an innovation that would solve a problem) experiences focused on STEM to show how STEM connects to their daily lives.

GEC program principles. The GEC program has several principles that are embedded in all of our sessions, which were set by the first established GEC site, as mentioned above:

1. Youth as experts—GEC values community expertise and youths' voices; we believe that it imperative to support youths' knowledge of their community and have a space where they can express themselves freely.
2. Engineering and making problems are co-negotiated—youth use their engineering and making skills to create innovations to help their community
3. Community ethnography—The youth who participate in GEC learn ethnographic skills by conducting surveys, creating interview questions, and conducting interviews to gather research for their innovation. Youth learn that when engineers, makers, and scientists create something they must keep in mind whom they are serving.

Because we negotiate what issues are salient to youth and their community, our goal during each GEC session is to foster and prioritize youths' ownership of their projects and the engineering/making process.

GEC curriculum. The GEC curriculum focuses on hands-on STEM activities that are connected to youths' lives and communities. All of the units are divided into different lessons, where the youth use what they have learned in the previous lesson to explore a problem in the next lesson. All of the lessons are created to support youth input; for example, we have found that youth may want to spend longer on a specific lesson because they have additional questions on what they are currently doing, if this happens we support them in this process. The GEC curriculum is co-negotiated with the youth in the GEC program, because of this it is salient to have the time for the youths' voices to be expressed throughout GEC sessions, even though this youth discourse can have the sessions run into next week's session, we support youth in these discussions. Table 1 provides a brief synopsis of the units and lessons that are focused on in this study. I have also provided a short description of each lesson in Table 1.

Table 1

GEC Curriculum

Unit	Curriculum Lesson		
Helping my Community	**Little Bits** Youth explored how to LittleBits (small circuits that connect by magnets to create a complete circuit) work and how they can be used with other objects (for example: junk) to make something move or light up.	**Understanding Electric Circuits** Youth used alligator clip, batteries, motors, and LED lights to explore how to create a series circuit. They use these circuits to discover how this circuitry can be used in e-textiles.	**Making something to Help someone in My Community** Youth research a problem that someone in their community has and creates an innovation to solve the problem. Innovations varied. (Alarm Back pack, safety baby gate, safety sweatshirt)
Understanding Paper Circuits	**What my Community means to me!** Youth draw a picture using markers and colored pencils to create a picture about something they like or would like to see in their community. Once picture is drawn youth then use conductible tape to make and LED bulb light up on their picture.	**Happy Valentines** Youth create a Valentine's Day card for someone they care about. After their picture is drawn youth then use conductible tape to make and LED bulb light up on their picture.	

Table 1

Cont.

Unit	Curriculum Lesson			
Toys, Toys, Toys!!!	**Toy Dissection** Youth take apart mechanical toys that move in some way. They then have to annotate what makes the toy move and how that mechanism made the object move.	**Build and Race a Toy Car** Youth create a Styrofoam car by using a Styrofoam cutter and designing a toy car. They then race their car and make adjustments to make their car faster.	**What an Automaton?** Youth explore levers, wheels, and ramps and they can be used to make a something move. Youth used a shoebox, sticks, glue and paper to create an automation.	**Make a Toy for Someone** Youth researched what types of toys school aged youth want. Youth used what they learned from the Toy dissection, Build a Race Car, and Making automaton to create their own toy. Innovations varied.
Using Stop Motion to Express Myself	**What I can Do at the Boys and Girls Club** Youth created a Stop Motion video on what they enjoy doing at the Boys and Girls Club. They had to plan out their video and decide how they would express what they like to do at the Club.	**A Story about my Communities Injustice** Youth created a Stop Motion video on an injustice in their community. They had to plan out their video and decide how they would express the injustice.		

A day at GEC. Youth are greeted by the teachers/researchers when they enter the GEC room at the Community Club. After youth have settled into their seats, we (teachers/researchers) go over the agenda for the day. The daily agendas usually consist of the goal of the day and the steps the youth will take in order to achieve that goal. Youth get to choose whether they would like to work with a partner or independently. The materials and supplies (e.g., computers, paper, glue guns, etc.) youth need for the day are already sitting out on the tables, so youth are able to make their innovations. GEC is in an informal space and we support youth discourse while they are working on their innovations; we encourage youth to talk to one another about their innovations and their ideas during the making process. We also encourage youth to become fully engrossed in their project and ensure them that it is acceptable if they want to do something "out of the box." At the end of each session we have whole group discussions, where youth share their innovation with the group and receive feedback from their peers.

Making units at GEC. In this section I describe the five main making events that are featured in the girls' portraits. Each making event is described through vignettes which are embedded in the each of the participants portraits. The five major making events are community making, paper circuits, toy car, automaton, and toy making.

Community Making. During this unit youth were tasked with making something for someone in their community or for their community. The youth had choice in what they wanted to make; however, it had to be informed by their community. The youth completed community ethnographies, where they went around the community club and asked questions to younger youth at the club. After they chose the innovation they wanted to create, participants then researched the materials they would need to build their innovation. The girls in this study worked either independently or with a partner to make a variety of different innovations for their community. The participants used different types of tools and materials to make their innovations depending on what their innovations were. To end this unit, youth presented at the end-of-year GEC expo, where they were able to showcase their innovations to the community.

Paper Circuits. The paper circuits unit focused on one of the principles of GEC, which is that youth use their engineering skills to make something for someone in their community. During this unit youth had to create a greeting card for someone they deeply cared about or draw a picture that represented something that was important to them in their neighborhood. Once they drew their picture for their greeting card, they then drew out their series circuit on the back of their picture illustrating where they would place their battery, LED light and how the two would be connected with conductible tape, in order to allow the electrons to flow. The youth were able to make an LED bulb glow using conductible tape and a battery by the end of this session.

Toy Car. During the car toy session, the youth made race cars out of Styrofoam. At the beginning of this session I explained that they were going make their very own race car. I showed youth a videos of race cars and race car drivers, including a short video on Danica Patrick, a female race car driver, because I wanted youth to understand how force, motion, and mass worked together to make fast race cars. Youth were tasked with using Styrofoam, metal rods, and plastic wheels to make a race car. Youth had to draw their design on a piece of paper first, before they could begin cutting their Styrofoam. Once youth were done with their drawings, they had to get it approved by an adult mentor in order to receive a piece of Styrofoam to start making their car. Youth drew out their design on the Styrofoam and brought it over to me so that I could assist participants when they used the Styrofoam cutter (a tool with a hot piece of wire used to cut Styrofoam). Once their car's design was cut out the youth could now attach the wheels and metal rods to the car. At the end of this session youth raced their cars against one another to better understand how force, motion, and mass work together.

Automaton. The automaton sessions were put into place so that the youth could better understand how levers, wheels, and pulleys are used in the mechanics of a lot of toys. I began the unit with a short YouTube video that featured multiple examples of the automatons so youth could visualize what they were about to create. The youth were able to use the following materials the to make their own automaton: shoe boxes, wooden kabob sticks, thick foam for the wheels, glue, and a variety of decorating materials. Youth began by drawing out how they wanted their automaton to look before they started the building process. Once their drawing was approved by an adult mentor youth could then begin building their automaton. The youth picked the size shoe box they wanted to use to make their automaton. Once they had their box chosen they had to poke holes in the sides of the box with a pair of scissors to put the kabob skewers through. They then had to cut two small circles from the black foam which were used as a gear to make their decoration on the top of their box move. Once youth had their gears working they then decorated the top and outside of their boxes. This project was displayed in the community club through the school year.

Toy Making. During this unit, youth were tasked with making a toy for a younger youth in their community. Similar to the community making sessions, youth had a choice in what they wanted to make; however, it had to informed by their community. The youth completed community ethnographies and asked questions to younger youth at the club about what kinds of toys they enjoyed playing with. After they chose the toy innovation they wanted to create, participants then researched the materials they would need to build their innovation. The participants in this study worked either independently or with a partner to make a variety of different toy innovations. They used different types of tools and materials to make their toys because of the uniqueness of their products. Youth presented their toys at the end-of-year GEC expo, where they were able to showcase their innovations to the community.

The above section provided a brief summary on the five main making events that are featured in this study. Each of the participants portraits describe in detail how they navigated the making process during each making event.

Participants. My participants are six African American girls who attend the local Community club and the GEC after school STEM enrichment session. There is a total of 12 youth (males and females) in the GEC program; however, for the purpose of this study I chose to focus on six African American girls who have consistently participated in the program for 1-4 years. Attrition has played a role in the choice of my participants because there have been situations where youth have moved or stopped coming to the Community Club program. Acknowledging this fluid attendance with some youth was imperative for the purposes of this study because I wanted to choose youth who consistently attended GEC sessions. I also focused on AA girls because of the personal connection I have with the girls. I believe my presence in this program is essential for the young AA girls, being an AA woman engaged in STEM because of the low representation of AA women in STEM.

Below are brief descriptions of each GEC participant that are focused on this study, I then provide a table with the girls ages, type school they attend, and years of participation in GEC. I conclude this section with brief descriptions of the adult participants, teachers, and researchers.

Getting to Know Jasmine. Jasmine is a cheerful, positive, 11-year-old girl. She is an African American girl going into the sixth grade and lives with both her mother and stepfather and five brothers and sisters. Jasmine wants to be a computer scientist when she gets older. She is the second to the oldest with one sister older than her and a brother and two sisters younger than her. She is very close to her younger siblings; she talks about looking out for them at the community club and school. Jasmine attended a predominantly African American low-income magnet elementary school that has a well-known Spanish immersion program; however, Jasmine is not in the Spanish immersion program at the school; she now attends a STEM charter middle school. Jasmine is a very good student and loves to go to school.

Getting to Know Erin. Erin is a very shy 11-year-old African American girl. When she meets anyone for the first time she does not look at them in the eyes and speaks very softly; it is almost as though she does not want you to know she is there. Erin is in the sixth grade and lives with her mother and her older brother and two younger sisters. In an interview conducted in the Fall of Year 2, Erin stated that she wants to be an engineer when she grows up, but is unsure of which type. She attended a predominantly African American elementary school which has few outside resources, for example, no active Parent and Teacher Association (PTA). Erin now attends a small, low-income middle school in the city. Erin is not the best student and struggles in school, especially with science.

Getting to Know Amber. Amber is a happy, outgoing, 11-year-old African American girl and lives with her mother, father, older sister, and younger sister. Amber attended the same predominantly African American low-income magnet elementary school as Jasmine which has a well-known, Spanish immersion program; however, like Jasmine, Amber was not in the Spanish immersion program at the school. Amber is now in the sixth grade at one of the largest middle schools in the city. The middle school she attends has many resources, but Amber states how she "hates science class." She has participated in GEC for the past year and a half and loves working with the other girls in group. She loves GEC and does not miss a GEC session.

Getting to Know Kia. Kia is an outgoing 12-year-old African American girl who lives with her mother and younger brother. Kia has attended a character school in another city for the past 2 years. She enjoys cheering, dancing, and acting. Kia loves to work independently on all her innovations. She enjoys school, but is not always the best student. Kia has gotten into trouble a few times at the Boys and Girls because of being disrespectful to other adults. Kia comes to GEC sessions focused and ready to get her work done. She has participated in GEC for the past 2 years. Kia wants to be doctor when she grows up.

Getting to Know Sara. Sara is quiet 13-year-old African American girl, in the seventh grade, who lives with her mother. Sara attends one of the largest middle schools in the district, where she gets suspended often because of being disrespectful to adults. She was held back in elementary school and is not the best student. Sara tends to become disengaged in school and acts out toward other students and teachers. Sara enjoys GEC because she can express herself creatively by making innovations. Sara has been participated in GEC for the past 2 years and loves working with other girls in the club.

Sara has stated that she “hates science at school but loves what we do GEC” (Fieldnotes, Year 2).

Getting to Know Shawna. Shawna is a 13-year-old African American girl in the eighth grade who lives with her mother. Shawna attends one of the largest middle schools in the district and loves school. She participates in afterschool clubs, for example, the science club. Shawna has participated in GEC for the past 3 years; she has attended GEC sessions since the beginning of the program at this Community Club site. She is very quiet but enjoys working with other people. Shawna will spend weeks on a project and not get “bored” with it; she always wants to finish what she starts. Shawna walks in with a positive attitude and helps the youth in program when she can.

Table 2

Participant Descriptions Who Participated in This Study

Participant	**Age**	**Grade Level**	**Type of School**	**Years in GEC**
Jasmine	12	6	STEM Charter	3.5
Erin	12	6	Public	3.5
Amber	12	6	Public	2
Kia	12	6	Charter	2
Sara	13	7	Public	2
Shawna	13	8	Public	4

Teachers and researchers at GEC. There are four teachers/researchers who attend GEC sessions—Ms. Mika, Ms. E, Ms. Amy, and myself. All of the teachers and researchers are affiliated with a local university. The Community Club and this local university have established a partnership with the teachers/researchers to conduct the GEC program at this site. During each first weekly session we work with different groups to assist them with the innovation they are creating during the session. Having a low student-to-teacher ratio has been imperative in this setting because of the hands-on activities we are expecting the youth to create. Ms. Mika and I also run the second weekly sessions, which is especially important, because we are two African American females and the second weekly sessions have been a time where only girls attend. The dynamic is different during the second weekly sessions; for example, the girls are more comfortable to be themselves because it is a space where everyone looks like them.

Data Sources and Data Collection Procedures

I observed and recorded fieldnotes of 224 GEC sessions, conducted 33 formal and informal interviews, and used 11 youth artifacts as data sources. The GEC science enrichment sessions run afterschool weekly and 2 weeks in the summer at the Community club. I was a full participant observer because I am one of four teachers in the sessions. I was also a researcher in this space where I observed, collected artifacts, and completed fieldnotes after each session. I had specific lessons that I planned each day and I based my fieldnotes on the focus questions seen in Appendix A. At the end of each GEC session, I drafted my fieldnotes on what happened each session. In my fieldnotes, I included descriptions of the activities we did in each session, how I divided students into groups, conducted whole group discussions, and group and individual student observations. Depending on the day’s activity, I may not answer all focus questions because they may not apply to that day’s lesson.

I also attended the Community club on days when the GEC sessions do not run to conduct interviews of the girls (see Appendixes D, E, and F for the interview protocols). The first interview for all the girls was used to get a general idea of the girls' background and how the girls identified themselves as scientists or engineers. I observed the girls during each session for a total of two and half hours (for a total of 330 hours).

Data Sources

Interviews. Four types of interviews were incorporated as data sources for this research study: background interviews, artifact interviews, GEC experience interviews, and adult/mentor interviews. These four types of interviews were essential because they all informed the study differently (as described below). Maxwell (2013) stated that "interviews can provide additional information that may have been missed in observation and can be used to check the accuracy of the observations" (p. 103), which was evident throughout all of my interviews. Because of my role as a researcher/teacher, interviews were a pertinent data source by ensuring I had not missed anything during a GEC session.

Background Interview. Background interviews were conducted with each participant once they started the GEC program. Each of the six background interviews was conducted with the participant and myself to ensure confidentiality. The background interviews informed me about the participants' family, home life, school life, and how they perceived themselves as a scientist or engineer. All background interviews were audiotaped as well as transcribed and lasted about 15 minutes. Notes were also taken during each background interview so that I could process any additional questions I may have had during the interview.

Artifact Interview. Artifact interviews were conducted after completion of an innovation or product, in either groups of youth or individual; this was based on if the youth worked together on an innovation or by themselves. The youth in this study completed ten innovations and products; however, for purpose of this study I focused on five to six innovations (the number of innovations was dependent on youth attendance). The artifact interviews gave the youth the opportunity to explain their innovation and talk about the process they took to create it. The youth also describe how their innovation works and other important details, which are salient in positioning them as an expert. During these interviews, youth were given the time to think about ways they could improve their innovation if given more time. This was imperative information, because if they expressed they wanted to continue working on their innovation, I could support them with this during unstructured GEC. All 11 artifact interviews were audiotaped as well as transcribed, and lasted about 10 minutes.

GEC Experience Interview. GEC experience interviews (a total of six interviews) were conducted with each participant towards the end of this research study and were done independently. GEC experience interviews were put into place to better understand how youth interpreted and negotiated the GEC space. I wanted to see which aspects of the space worked for the girls and which ones did not. GEC experience interviews also allowed a time for the girls to express their experiences with engaging in STEM in both school and in GEC and how these two spaces were similar and different. All GEC experience interviews were audiotaped and transcribed.

Adult Interview. Adult interviews were conducted with the Director, Gabby, and the Assistant Director, Margaret of the Community club. Gabby and Margaret are both employed by the Community club and do not participate in GEC. These interviews lasted 30-45 minutes and were audiotaped and transcribed. In these interviews I asked questions about my participants' home life, school life, how the girls performed academically in school, and the observations of the girls since they began GEC. These interviews were salient in this research because these adults gave different perspectives of the girls' identities before they began the GEC program, during the GEC program, and how the girls acted outside of the GEC program (total of three interviews for each adult).

Fieldnotes/Observations. Fieldnotes were taken after each GEC session. The fieldnotes began with a summary of how I or one of the other researchers/teachers started the session, observations of the youths' reactions, and how they broke into groups. During most sessions the other teachers and myself split the youth up and worked with a small number to ensure they were well supported during their making process; because of this, the bulk of my fieldnotes are focused on the youth I am working with during that session. Pictures taken from that day's session were also added to each fieldnote and described in detail. Adding pictures with descriptions to the fieldnotes gave me better visual insight on the trajectory the youth had taken throughout the creation of their innovations.

The fieldnotes that were taken after each session recorded my observations for that day. On the way home after each session I made an audiorecording of events that transpired during each session to ensure I captured salient incidents. Once I got home, I completed my fieldnotes and added any pictures that were taken during the day's session that depicted important events. I also had access to fieldnotes written by other researchers on the team. Documenting my observations using fieldnotes was particularly important because the fieldnotes served as a GEC session diary, where I could go back to past sessions and look at the fluidity of my participants' STEM identities and the factors that affected those identities.

I also included the audiotaped session group discussions and cross referenced my transcripts with my fieldnotes. I decided to add the group session discussion transcripts because I felt as though they directly impacted my fieldnotes by adding the youth voices to my observations, which was salient when I described the youths' STEM making experiences. I facilitated group session discussions at the end of many of the first weekly sessions, to get the youth's feedback on how the day went and give youth a time to share information on their own innovations. During these group discussions we also talked about youth experiences in this space and how it supports them as a scientist or engineer. Each group session discussion lasted 10-15 minutes. Group session discussion were put into place to support STEM discourse among the youth in a space where youth felt comfortable.

Research questions crosswalks. Research question crosswalks provided a visual representation of how my data sources informed my research questions for this study. The crosswalk in Table 3 indicates how the data were triangulated to answer a specific research question.

Table 3

Research Data Source Crosswalk

	Data Collection Methods					
			Interviews			
Research Questions:	**Fieldnotes/ Observations**	**Artifacts**	**Background**	**Club/GEC Adult**	**Artifact**	**GEC Experience**
1. What does it mean to have an informal youth STEM enrichment afterschool program space that is free (as free as possible) of microaggressions and social structure constraints?	X					X
a. How are the youth in an informal STEM enrichment afterschool program positioned?	X		X	X		
b. What are the youth in an informal STEM enrichment afterschool program able to do (process and products that they would not be able to do in more regimental STEM formal space)?	X	X			X	
2. How might a setting free (as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls' STEM identity/agency and sense of sisterhood?	X		X	X		X

Data Analysis Procedures

Coding Interviews/Fieldnotes/Observations

I conducted interviews and completed fieldnotes after each GEC session and observations during non-GEC sessions of all the AA youth in GEC (which is a total of 12 participants), but for the purpose of this study I concentrated on six of the girls because of attrition. After I completed my fieldnotes each day, a two-column memo was created to show which focus question related to my fieldnotes during each session by providing evidence (picture, quotes from the girls) from my observations as shown in Appendix C. The last question on the field note protocol focused on the pictures that captured the youth engaging in STEM. I took pictures of drawings, youths' creations, and all of the girls' innovations that exhibited specific STEM making processes that youth displayed during each session.

After data collection was complete, I then coded each data source by looking for specific patterns that emerged from the transcribed interview (Saldaña, 2013). For example, many of the participants had shared characteristics in their school experiences which resulted in the specific code, science identity. I open coded all data sources for each girl resulting in the following codes that focused on the girls' STEM engagement in this space: science knowledge/practices, technology knowledge/practices, math knowledge/practices, engineering knowledge/practices, making knowledge, and how their innovations related to state standards and Next Generation Science Standards. I then coded for the patterns that emerged relating to the girls' social interactions during GEC, which resulted in the following codes: collaboration, free discourse, disagreements, and community. Next, I looked across the codes and found relations between each set of open coded patterns. For example, in Shawna's case, I looked at key moments during each making session, where she may have exhibited STEM knowledges/practices, her making process, and how she interacted with her GEC peers and placed in descriptions of those instances in a chart (as seen in Chapter IV, Table 6). I then looked across the girls for patterns of their shared GEC experiences as they related to the above coded categories, STEM knowledges and practices, and social interactions. By doing this I was able to see relationships in the girls' experiences in this STEM program based on the organization of the girls' portraits in Chapter IV of these relationships. Lastly, I used axial coding to find emerging themes with the combined open coded data, which I further analyzed and explain in the theming data section below.

Theming the Data (Axial Codes)

After I completed all the fieldnotes, interviews, and observations, I began organizing the coded data from all the sources into themes. According to Saldaña (2013), "a theme is an outcome of coding, categorization, and analytic reflection, not something that is, in itself, coded" (p. 198). I decided to use themes to organize the data, especially for the cross-case analysis, because it helped me find the relationships between my data and the proposed theoretical framework (explained in Chapter II). After reviewing all data sources, the following themes emerged:

1. Collaboration: Storytelling and joint activity
2. Sisterhood: Safe spaces, mutual support, and working through disagreement

3. Community: STEM expertise to Serve, Build, and Leverage resources of the Community
4. Identity Work: Gendered Identity and STEM Identity

These themes emerged because of similarities that I found throughout the data sources among the participants. After I determined my themes, I then generated theoretical constructs that related to the themes that emerged from the data. For example, storytelling and joint activity were theoretical constructs that materialized out of collaboration, because the participants socialized while working on their innovations. The theoretical constructs that emerged from sisterhood were safe spaces, mutual support, and working through disagreements, because these were salient components in how the girls navigated this space through their sisterhood. Community played an essential role in how the girls used their STEM expertise to build and leverage resources in their community. Last, the girls' gender identities and STEM identities were the two main theoretical constructs of identity work because they both contributed to the fluidity of the girls' identities. Theming the data was imperative in organizing my findings when completing the cross-case analysis section. The themes enabled me to better organize the similarities that were found throughout all of the data sources.

Validity

According to Maxwell (2013), a key component of a research design is to conceptualize the validity threats and the strategies that could be used to deal with the threats. Two validity threats with which I have had to grapple are researcher biases and reactivity. Being an African American female, I brought my own beliefs and experiences to my research, which could have influenced how I conducted interviews and observed the participants. Examining these biases ahead of time allowed me to find strategies to eliminate my own biases. Being a participant observer, I am fully immersed in the research and the GEC program; therefore, it was imperative that I did not "react" or influence the research setting. Acknowledging these threats on validity informed the strategies I used in this study.

In this critical ethnographic case study, I have had a long-term involvement with the youth and adults at the community club; because of this extensive involvement I am able to increase value and accuracy, which contribute to the validity of my study. Creswell (2013) defines validation in "qualitative research to be an attempt to assess the accuracy of findings, as best described by the researcher and the participants" (p. 249); I followed this definition of validity by ensuring that I followed Creswell's (2013) validation strategies and Tracey's (2010) eight "Big-Tent" criteria for qualitative research.

I used a combination of Creswell's (2013) validation and the following "Big-Tent" criteria listed in Table 4, which strengthened the validity of my research and assisted me in ensuring my data were accurate. Through acknowledgment of the threats of validity and using the above strategies and criteria, I increased the validity of this research study.

Table 4

"Big-Tent" Criteria as it Relates to This Study

Criteria		Methods to achieve in current study
Worthy Topic	-	Timely topic: This study focused on the disparity of AA girls following a STEM trajectory.
Rich Rigor	-	Time in the field: I spent four years at this research site and with participants
Sincerity	-	Transparency: I have acknowledged my own biases, for example my experiences being an AA woman engaged in STEM
Creditability	-	I have multiple data sources to ensure triangulation. For example, multiple of interviews from my participant and the adults in this space, observations, fieldnotes, and artifacts.
Significant Contribution	-	This study provided a conceptual framework in which I followed throughout this study.
Ethical	-	I have taken all ethical procedures in this research study for example IRB processes.
Meaningful Coherence	-	This study connected to my research questions and the current literature on minority youth engagement in STEM.

Note. Source: Tracey, S. J. (2010). Qualitative quality: Eight "big-tent" criteria for excellent qualitative research. *Qualitative Inquiry, 16*(10), 837–851.

Positionality

As a researcher, I am fully aware I brought my own beliefs, perceptions, biases, and experiences to the study. Peshkin (1988) expressed the importance of being aware of one's subjectivity. The concept of subjectivity plays a large role in my research because of my own intersectionality of being an African American woman who is also engaged in STEM and has experienced discrimination in the form of macro and microaggressions while obtaining a STEM undergraduate degree. I am an African American female who was trained as chemist, who decided to pursue a career in education because of a passion to increase the engagement of other African American females in science. This research is personal for me because during my undergraduate career, I was the only African American female in my program and I was told by a White woman professor that I did not have the ability to major in chemistry and be successful. She suggested I choose another major that would be less challenging for me. After this conversation I made it my purpose to graduate with a degree in chemistry and to help others who look like me who may experience similar discrimination. Through this experience I made it my mission to equip other African American (AA) girls with the perseverance to fight against such discrimination and to follow their dreams. I then realized throughout my teaching career that many African American girls have been positioned in low-level science courses because someone told them they could not do science. For years, while teaching high school science, many of my AA female students expressed their disinterest in science because they said they never had a teacher who felt they could be successful in science. It was my mission to change my AA female students' science experiences and show them that they too can be successful in STEM. As an educator and an African American female, I want to influence AA girls' positive STEM identities.

Being an African American woman in this research space, I have formed a "sisterhood" relationship among the girls in this study. During both weekly sessions, the girls expressed their accomplishments, disappointments, and tensions they face daily at school with me. I am researcher in this space, but I am also an encourager, someone who the girls can talk to openly, and most importantly, a "big sister." I have chosen not to view the girls through a deficit lens because I believe African American girls are capable of engaging in STEM when given a space that fosters them to be themselves.

Obtaining Permission

Creswell and Plano Clark (2011) describe using a gatekeeper to ease access into the study. The gatekeepers for this study are a local university professor and researcher who are part of the GEC initiative. Approval had to be given from the Community Club to host GEC and all procedures had been completed and approved through the Institutional Review Boards (IRB). Parental and student consent documents were signed and collected. It was imperative that these safeguards were completed in order to protect the participants who are part of this study.

Limitations

A limitation of this study was my role as a full participant-observer. It was difficult at times for me to focus on everything that my participants were experiencing during GEC sessions because I may have been working with other youth. Being in the research space for the past 4 years helped alleviate this limitation because I had relationships with my participants and was able to ask them questions after a session or during an interview. I also had access to other researchers' fieldnotes and the research team met weekly to go over significant experiences they may have seen when working with participants. Being one of four teachers at GEC at times created biases on how I viewed the lessons being taught and how the girls engaged in the GEC session. Though I was very reflective after each session and completed my fieldnotes daily, I still wonder if I privileged my own instruction when reflecting on the days lesson.

Another methodological limitation was the unevenness of the data sources. Though many of my participants were consistent, there were instances when one of the girls may not have attended GEC during a making unit, which affected the amount of data I was able to collect on that specific participant. However, because this was a 4-year longitudinal study I was able to collect enough data from each of my participants to analyze, enabling me to find themes.

I am an AA female in STEM and bring my own values and beliefs to this research study. When conducting interviews and observations, I was fully aware of my own biases, experiences, and beliefs with the hopes I did not cloud my perceptions of the girls' experiences with my own. However, this limitation overlapped affordances; for example, I am an AA woman and can relate to the girls' experiences, lives, and schooling, maybe even more so than other researchers in this space. I have faced adversity as an I woman in STEM and I am passionate about influencing other AA females to pursue a STEM trajectory. Because of this, I was always aware not to let my passion overtake or skew my perceptions of the experiences of the AA girls in this STEM enrichment program.

CHAPTER IV

FINDINGS

In this findings chapter I will answer Research Question 1 using the girls' narrative portraits: "What does it mean to the AA girls to have an informal youth STEM space that is free (or as free as possible) of microaggressions and social structure constraints? How are the youth in an informal STEM program positioned and what are the youth in an informal STEM program able to do (process and products that they would not be able to do in more regimented STEM formal space)?" I begin this chapter with a brief description of the contents of the girls' portraits and vignettes. Within each portrait I have featured the girls' engagement in three ways where applicable: the structural building of artifacts, STEM knowledges and practices leveraged, and the artistic aspects—how the girls went about decorating their innovations.

I have arranged each of the portraits in the following order, Shawna, Erin, Jasmine, Amber, Sara, and Kia, because of how they aligned with shared making event vignettes between girls. For example, Shawna and Erin worked together on a toy innovation for younger youth at the community club. Because they shared this making event, I placed Erin after Shawna, describing how this making unit affected their individual STEM identities in this STEM space. I did the same ordering for all the girls in this study, based on how they shared making events. I begin the portrait section with Shawna, our longest participating GEC member (four years), she began GEC as a shy elementary school student and is now an outspoken high school teenager. Shawna's participation in this program she has served as the encourager in GEC for many of the AA girls in this STEM space, but especially for Erin. Erin (the second featured portrait), similar to Shawna, was also a shy girl at the beginning of her participation in GEC. However, after support from Shawna and Jasmine, she was positioned as a STEM expert. Jasmine's portrait follows Erin's because they started GEC together during the GEC summer camp and have supported one another on various projects. Amber's (forth featured portrait) portrait highlights how Jasmine and Amber worked together during GEC, but also showed how this STEM space influenced their friendship. Following Amber, is Sara's portrait, because the two girls shared similar experiences in participation in GEC and navigating their STEM expertise. I end with Kia's portrait, because Sara and Kia supported one another during STEM task, in various ways. The girls' portraits showcase what the girls can do in this STEM space and the STEM-rich products they can make.

At the conclusion of the girls' portraits I have a detailed table that summarizes the girls' innovations, the STEM knowledge and practices the girls used during the making process and how they correlate with Next Generations Science Standards and Math/Science state standards. I conclude this chapter with a cross case analysis that addresses Research Question 2: How might a setting free (as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls' STEM identity/agency and sense of sisterhood? Through this cross-case analysis, I describe how collaboration, sisterhood, and community contribute to the girls' STEM identity and agency.

Portraits

The following portraits showcase six African American girls who participated in GEC for two to four years. I begin each portrait with a description of the girls' background and how they positioned themselves in their school science classes and how they identified themselves as scientists and engineers (drawn from interview data). In each of the girl's portraits I include a description of each girl's skin tone to highlight how they see themselves as AA girls. This descriptive factor was imperative to how some of the girls racialized school and how the color of their skin affected their engagement in STEM. Some of the girls felt as though their skin tone impacted how they were treated in school and how it contributed to their experiences in school. For example, Erin, a dark-skinned AA girl, expressed how she gets picked on by youth at school.

I then highlight the girls making experiences in this STEM space and how they negotiated participating in the STEM task, while being an AA girl through four to five vignettes for each girl (drawn from ethnographic data). I conclude each vignette focusing on how this STEM space, engaged or disengaged the AA girls in this study in STEM and the fluidity of their STEM identity through the 2-4 years in this space.

Shawna

Shawna is a 13-year-old dark brown AA girl in the eighth grade who lives with her mother. Shawna attended one of the largest middle schools in the district and does well in school, making A's and B's. She is very active in her schools' extra-curricular clubs, for example she participated in the schools the science club. Shawna has participated in GEC for the past four years and has attended GEC sessions since the beginning of the program. She is very quiet but enjoys working with other people. Shawna will spend weeks on a project and not get "bored" with it, she always wants to finish what she starts. For example, when working on a project, she stated to her partner, "I know this is looks like a lot, but we have to finish it" (Fieldnote, Year 2). Shawna walks in each GEC session with a positive attitude and wants to help the other youth in the GEC program when she can.

Shawna has participated in GEC for the past four years and she was one of our first youth in the program when we were located in the old building. Shawna has been engaged in GEC from day one; before she transitioned to the teen group, she was very consistent with her attendance. She loved the activities we do in GEC, for example, Shawna stated,

Researcher: Why do you enjoy GEC city?

Shawna: Because it's fun and I get to play with stuff I have never played with before.

Researcher: Ok, umm do you enjoy the activities?

Shawna: Yeah

Researcher: Yeah, umm which activities have you enjoyed the most?

Shawna: The little bits. When we play with the little bits.

Researcher: Why?

Shawna: Because, I get to like see how things work on the inside of electronics instead of on the outside where you usually don't't' see much. (Fieldnotes, Year 2)

Even though Shawna was engaged and excited during GEC sessions, and enjoyed participating in STEM task, she still had a very White male-dominated view on what a scientist looked like (see Figure 2).

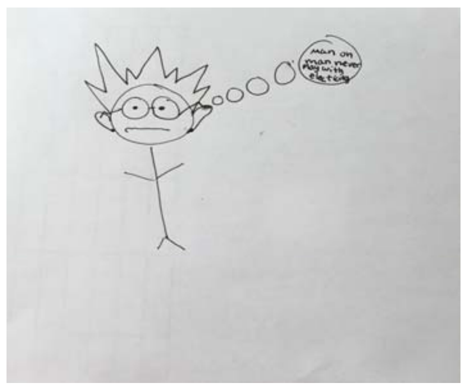

Figure 2. Shawna's Drawing Representation of a Scientist.

When I asked her to draw a scientist during the background interview and describe her drawing, Shawna stated,

Shawna: Yeah, umm this person is probably Albert Einstein or somebody. His hair is like that because he shocked by electricity.

Researcher: Ok

Shawna: And when you wear big glasses to me it makes you like a big scientist.

Researcher: Ok

Shawna: And then he has that look on his face because that when he got shocked by lightning or electricity.

Researcher: That's why he's not smiling

Shawna: Yeah

Researcher: Ok

Researcher: Ok, so why did you think about Albert Einstein?

Shawna: Because he's famous for a lot of stuff. I also think of Newton.

Researcher: Ok

Shawna: Because the three laws of gravity, force and stuff.

After she described her picture to me, I asked how she identified herself pertaining to science, because she drew and described the scientist as a White male.

Researcher: So, do you see yourself as a scientist?

Shawna: Maybe, I wouldn't shock myself.

Researcher: Ok, why. Why maybe?

Shawna: Because I want to be a doctor, but if a doctor doesn't work out I'm gonna be a scientist.

Researcher: Ok

Shawna: It just seems fun, fun playing with all the chemicals and stuff.

Researcher: Ok, umm.

Researcher: Do know the difference, so you said you have a doctor, right? You have a scientist. So, do you know the difference between being a scientist, or a doctor, or an engineer?

Shawna: Umm the difference between a doctor and a scientist is . . . a doctor . . . you just help people with sickness and health and give them yearly checkups. When you're a scientist you can do experiments and you can make and do new things that no one has ever done before.

Shawna can come off shy when you first meet her; however, through her engagement in GEC over the past 4 years she has become more comfortable with seeing herself as scientist and an engineer through the STEM activities she had participated in and the innovations she has created.

The following vignettes explore Shawna's journey through GEC and how she has engaged in STEM task. Shawna has spent the past 4 years making numerous items; however, for the purpose of this study I will focus five making episodes that highlight Shawna's experiences in GEC that contributed to her STEM identity and agency.

Music hoodie (Year 1, Summer Camp). It was the beginning of our first summer camp for GEC, and we challenged the youth to make something for someone in their community that will help them with a problem. For example, if someone is in danger, creating a jacket that has an alarm built in. We did not give limits on what the youth could create, we wanted them to think about the problems they see in their community and how they could create something to help or eliminate the problem. During each GEC session we embed engineering practices, for example, the youth have drawn out their designs on paper before they can start the building process. Youth at GEC also understand that they may have to go through several of iterations of their design before they get to the final project, which is a central aspect of the engineering process. Many of the activities the youth participate in at GEC are expected to answer questions and define the problems, where they develop small innovations to solve the problem they have identified.

Shawna, with help from Monique (an older teen at GEC) used science and engineering practices to solve a problem and develop a model to help fix the problem. Shawna wanted to make the hoodie so that people who had a long bus ride to and from work could listen to music without purchasing a cell phone. The girls began their making process by drawing out a diagram that they used to plan out their music hoodie, so that they could make a feasible prototype of their innovation. Shawna and Monique worked together using computers, an Arduino, a memory card, soft wires, thread, needles and sewing machine to create a prototype of a hoodie that plays music.

Shawna was very excited about this task, during this first summer camp session after I posed the challenge to the group, she blurted out "I want to make a hoodie that plays music!!!" (Fieldnote, Year 1). Shawna wanted to make a hoodie that plays music for people who have long bus rides and who could not afford a phone. She believed that having the ability to listen to music on the way home would give the person "something to do and relax them" (Fieldnote, Year 1). I encouraged her to describe and draw in detail, what she meant by a hoodie that plays music, what would the electrical components of the hoodie be to make the music and how would the person listen to the music? Shawna really wanted to use LittleBits (small electrical circuits that come together through magnetism) to make her hoodie play music. She decided to work with Monique on this project, an older AA girl who had participated in GEC for the past few months prior to summer camp. They began their project by sketching out where they wanted to place the cords and speakers on the hoodie. At first, they wanted to place the speaker on the chest of the hoodie; however, once they looked at their sketch more they decided that the chest was not the best place, because the person wearing the hoodie may not be able to hear the music clearly, so they decided to place the speakers in the hood of the hoodie.

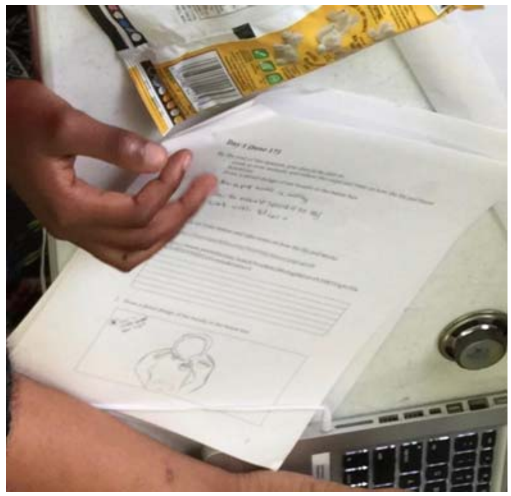

Figure 3. Shawna's and Monique's Sketch of Their Music Hoodie.

Figure 4. Two Girls Planning Out and Researching What They Want Their Hoodie to Look Like and Where They Wanted to Place the Speakers and Small MP3 Player.

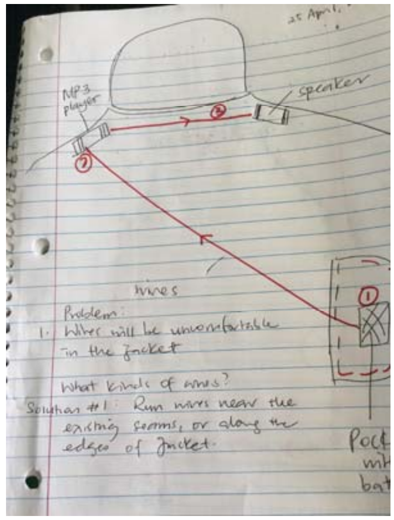

Figure 5. Diagram of the Girls' Hoodie That Displays How They Wanted to Place the Speakers and Arduino Inside the Hoodie. Ms. E. Assisted Them in Drawing the Picture.

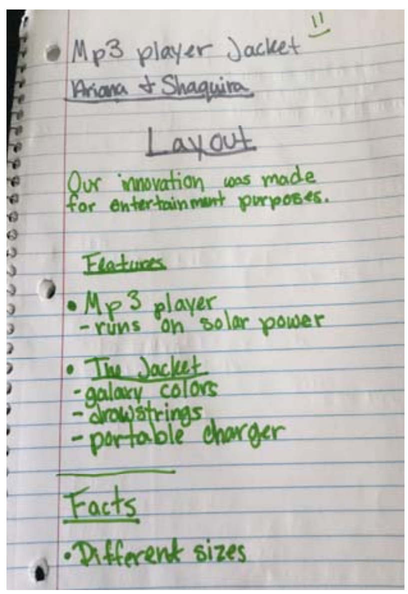

Figure 6. The Girls Notes on the Features They Wanted to Place on the Hoodie and the Reason They Wanted to Make the Hoodie.

After the girls planned out where they wanted to place all of the components of their music hoodie, they then began to investigate how to program their Arduino (a small device, that can be programed to play music). The girls began their structural building of their hooding, by first choosing a song to download on the Arduino; the three of us sat and went through my music library on my phone to see if I had any music they would like to download onto their Arduino player. Shawna and Monique decided on “See You Again” by Wiz Khalifa. Shawna ended the first session of summer camp so excited, because she was beginning to see music hoodie coming together, she left the session smiling from ear to ear.

During the next summer camp session, the girls and myself began by sitting down at the computer and began the downloading process of the song on to a small memory card that went into the Arduino. After the girls chose they had converted their song so that it would play on an mp3 player. The girls used directions they had found from the internet that guided them in how to convert the file and program their Arduino to play music. Monique sat at the computer and convert their song to an mp3 file by clicking on the drop-down box in the music library. Once the file was converted, Monique then placed the memory card into the computer to download and program it to be played. She then used the code (that I found on internet for them) to program the memory card to play the song using the Arduino. Once they were done typing in the sample code, the Arduino could now play “See You Again.” Once the Monique completed this task the girls realized they needed to figure out where they wanted to place, the speakers, Arduino, soft wires and battery pack on the hoodie and start the sewing these items on the hoodie.

Figure 7. Shawna and Monique Planning out Where on the Hoodie They Were Going to Place the Arduino and How They Were Going to Complete the Circuit in Order for the Arduino to Work Properly. The Girls Also Had Figure Out Where They Wanted the Speakers to be Placed in the Hoodie and How They Were Going to Sew Those Down.

Once the girls decided where they wanted all the pieces of their electrical circuit to be placed, they then began sewing the speakers, soft wires, and Arduino using pink sewing thread onto the hoodie. When Shawna began this process, she was very nervous because she had never sewn before. She did not know how to thread a needle, let alone stitch something onto a sweatshirt. Monique assisted her through the process and she ended up sewing more than half of the electrical pieces onto the sweat shirt. The girls ended up making a pocket for the Arduino and sewed it onto the sweatshirt (picture below). Unfortunately, the girls were not able to get the music playing through the speakers, because they ran out time during the GEC camp session. However, they were able to program the Arduino correctly because they were able to hear the song they chose through a pair of headphones. Shawna stated during the last session of GEC camp "I can't believe I did all this and sewed too!" (Fieldnote, Year 1).

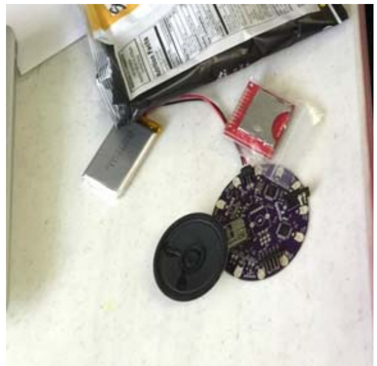

Figure 8. The Arduino the Girls Used to Program the Music as an MP3 File. A Small Memory Card is Placed on the Arduino, Which Enables Music to Be Played.

Figure 9. The Small Pouch the Girls Created in Which to Place the Arduino.

Birdhouse (Year 2, Fall). It was the beginning of the fall semester at GEC and we shared some of the work that the youth who participate in GEC at another site (in another state) had done the following years, for example, a light-up football so kids could play outside in the dark. We began this first session having an open discussion with the youth about the importance of helping their community through making. After our conversation, we challenged the youth to build something to help an animal or a person in their community. Shawna and Laura (another AA girl who participated in GEC) decided to help the Carolina Wren, a non-migratory bird in the winter and because of this, they believed the bird is cold in the winter months and hot in the summer. The girls wanted to create a home to keep the birds comfortable throughout all the season changes. The two girls sat beside one another and planned out a birdhouse with lights, heaters and a fan inside a small wooden house. After Shawna and Laura were finished with their design, they began the structural building of their birdhouse. We provided a variety of materials that the youth could use to make their innovations, for example, scrap popsicle sticks, wood pieces, cardboard, fabric, glue, cotton balls, and other decorating objects, such as buttons and glitter. The girls grabbed all the popsicle sticks they could find for the outside of their house and were able to find five pieces of wood to use for the sides, base and roof of their bird house. For two sessions the girls sat beside one another and used the hot glue gun to put together their pieces of wood in the shape of a tiny house.

During the following sessions Laura suddenly stopped attending GEC and Shawna had to finish the birdhouse by herself. Shawna sat by herself at a small table, by the one of the only windows in the room and began to craft the birdhouse. She added fabric on the front of the house, to keep the birds warm in the winter. Shawna used her STEM knowledges and practices to manipulate LittleBits which were powered by a battery. She connected the small magnetic LittleBits so that a fan runs to keep the birds cool and lights, so the birds can see in the dark. Once she built the circuit using the LittleBits she attached it on the top of the birdhouse using duct tape. Shawna also used duct tape as “extra” insulation and brown felt that lined the bottom of the birdhouse for the cold winter days.

Figure 10. Shawna Making Sure She Cuts Out the Correct Amount of Brown Felt for the Bottom of the Birdhouse.

She then decorated the top of the birdhouse with colorful fabric and cotton balls "to make the birds want to come into the house" (Shawna, fieldnotes, Year 2). She spent two sessions decorating the top of the birdhouse, until got it the way she wanted it to look. Shawna worked on the birdhouse for the remaining sessions during this making unit by herself and finished (picture of finished birdhouse below).

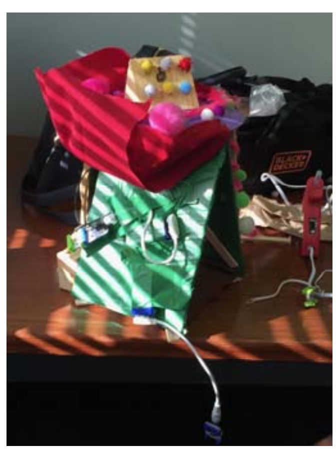

Figure 11. How Shawna Attached the LittleBits to the Side of the Birdhouse.

Figure 12. Shawna Putting the Finishing Touches on Her Birdhouse.

Toy dissection (Year 3, Fall). We were introducing our new toy unit to the youth and wanted them to explore how the mechanisms inside toys that moved, worked. I asked the youth to work with a partner to take apart a toy in order to better understand the components of moving toys. Shawna was very excited about this activity. She stated, "Really Ms. Faith? I get to take this apart?!" (Fieldnote, Year 3). I answered, "Yep" (Fieldnote, Year 3) and handed her a screw driver. We supplied the youth with different types screw drivers, hammers, tweezers, and scissors that they could use to dissect their toys. I also expressed to the youth the importance of not cutting wires or other important components of the toy, when breaking the toy open. She and Amy (another AA girl who participated in GEC) began by taking the outer furry cover off their mobile penguin. I reminded the girls they had to draw out what was making the toy move, plus all the other components of the toy. They also had to label the parts of the toy they were dissecting.

Figure 13. Shawna Beginning to Take Apart the Toy with A Screwdriver. We Asked the Youth to Wear Goggles for Safety Reasons Because of the Small Pieces That Were Involved.

Figure 14. The Diagram Shawna Drew of the Toy She and Amy Dissected. Shawna Took the Lead in Drawing Out the Picture and Labeling the Diagram.

During this activity youth were encouraged to focus on the following science and engineering practices:

1. Using tools to understand the different types of energy
2. Drawing out the different components of the toy that makes the toy move

The using science and engineering practices, to explore how a mechanical toy works and how all the small components that make a toy up connect with one another to make the toy move, was imperative to their understanding in how energy is transferred in mechanical toys. Before the youth could take apart their mechanical toy they had to ask themselves questions, for example:

1. What is making my toy move up and down, forward or backward?
2. How are the wires connected to make my toy move?
3. What does it look like inside?

The youth then had to try to answer their posed questions based on the movement of the toy and their prior knowledge of mechanics and electrical circuits. Before it became time for Shawna to start opening up her toy, she had to plan out the best method to open her penguin. It was important that when youth were opening their toy that they did not destroy the components on the inside. Shawna used a screw driver to pry the two pieces of plastic that formed the penguin's body. Once Shawna opened her toy, she used tweezers to take out the other components of the toy because they were so small and delicate. Shawna took all the parts out of the toy and placed them on the big white paper she and her partner where using to draw out the inside of their toy. After they carried out their investigation and were able to construct explanations as to why their toy penguin moved a certain way, they better understood how mechanical toys are made and how they move by using their science and engineering practices.

After Shawna drew out her diagram of the toy penguin she then labeled the parts that moved and the electrical component that made them move. She was also very careful with the small mechanisms ensuring to place them aside so that they would not break. Using her science and engineering practices throughout this session, Shawna better understood how mechanical toys worked because she saw how the battery was connected to two small gears which were connected by wires. She stated, “Look Ms. Faith, this looks like the circuit when I made the music hoodie” (Fieldnote, Year 3). At the end of the session she asked me, “Can we do this next week with a different toy?” (Fieldnote, Year 3).

Figure 15. The Battery and Gear Component That Made Shawna’s Penguin Move.

Automaton (Year 3, Spring). “Ms. Faith, I don’t know what you are talking about and I don’t know what to do” (Fieldnote, Year 2), Shawna stated when she walked into the GEC room and asked what we were doing today. We were continuing with our unit on toys and wanted the youth to understand how levers, wheels and pulleys are used in the mechanics of a lot of toys. I began with a short you-tube video that featured multiple types of the automatons, for example, automatons that featured objects going up and down and side to side. During introductory GEC sessions I try to provide examples of the items we are creating, so youth can visualize what they were about to create. Next, I went over the materials the youth would use to make their own automaton, for example, shoe boxes, wooden kabob sticks, thick foam for the wheels, glue, and a variety of decorating materials. Youth then had to draw out what they wanted their automaton to look before they could start the building process. For this project, the youth had the choice to either work independently or by themselves. Shawna decided to work by herself.

Shawna sat by herself to design what she wanted her automaton to look like. It took her a while to get started, she kept debating what she wanted on her automaton to do and the design of it. Shawna finally decided on an automaton with that featured Pac Man. When I asked her why she chose Pac Man, Shawna stated, "Because it is cool game, I played this weekend and I liked it" (Fieldnote, Year 3). She drew out how she wanted her automaton to look on top of the shoe box and then grabbed a brown shoebox. Shawna's automaton featured the actual Pac Man character with one blue ghosts. She wanted both of them to go up and down, so she realized she needed make two-wheel systems. In order to make the characters go up and down Shawna had to cut small triangular gaps in one of the wheels for each character she wanted move, this gap made it possible for the character to go up and down, because it was rotating against the circle with no gaps. She began the structural building of her automaton, by finding four foam black pieces and cut circles in all of them, Shawna then poked holes in the four circles, that way the kabob sticks would go through them. She then marked holes on the sides of the box, that indicated where the kabobs sticks would go and took scissors to poke the holes in the cardboard box. She put the kabobs with the black pieces of foam through the box and then tried them out to ensure they went in the direction she wanted them to, she confirmed this when she saw when the two pieces of foam rotated against each other when turning the kabob stick the stick that was poked through the top of the box moved up and down. Shawna then began decorating the top of her box by getting a yellow and blue piece of foam and traced out the Pac Man and the ghost, to cut out. She cut both pieces out and glued them on the top on the kabob sticks.

Figure 16. Shawna Working on Her Automaton. It Took Her a While to Get Started on Her Automaton. She Was Not Present When We Went to the Local University to Work on the Automatons. When Shawna First Started GEC She Wanted Someone to Sit Beside Her Through the Whole Process. During the Project I Noticed That She Had Reverted Back to Doing the Same Thing. She Would Not Do Any Step Without Me Reassuring Her That She Could Do it or What She Should Do Next.

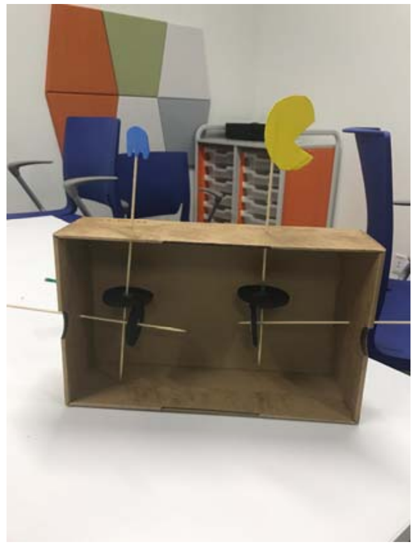

Figure 17. Shawna’s Automaton. She Did a Good Job Incorporating Two Mechanisms in Her Automaton. She Decided to Focus on a Pac Man Theme Because She Likes to Play the Game.

Erin saw that Shawna needed some assistance finishing up her automaton, so she stepped in and helped Shawna by gluing on the Pac Man piece and blue ghost. The two girls also found that they needed to add some glue on the black foam so that it would stay in place, when the wheels were against each other to make the items go up and down.

Geodesic play-dome (Year 3, Spring). The GEC youth were finishing up the toy unit and Shawna was trying to decide what type of toy she wanted to make. Shawna, similar to the other youth at GEC, completed a community ethnography, where she went around the community club and ask younger youth questions about what kinds of toys they would like to have at the club. After a lot of researching on the internet, Shawna decided to make a small dome house that youth go instead and play, because of the lack of structures children currently have to play in. It is also very hot during a good part of the year and younger youth wanted something that was covered to shade them from the sun. Shawna needed some assistance with this project, because the dome was going to large enough for younger youth to go in to, so I suggested she Erin and work together. Shawna is older than Erin; however, the two girls have worked together in the past. The girls began their project by drawing out what they wanted their play dome to look like. The girls searched the internet for examples of other dome play houses that they could use as a format to make their own dome. Shawna with another adult mentor, Ms. E, decided to make their dome out of triangles out of cardboard, so that it looked geometric. The girls ended the first session of this innovation excited about how their project was going to turn out.

During the next GEC session, the Erin and Shawna looked online for the correct dimensions they needed to make the triangles for their dome. The girls used their math practices and realized they would need a total of 30 AAB isosceles triangles; 10 BBB equilateral triangles, 10 BB squares (A: 10.34 inches; B: 12 inches) cardboard triangles to make their dome. They started the building process by drawing the triangles on the cardboard they drew out a pattern of how they wanted the triangle to look on the cardboard with all the correct dimensions. Erin was a little overwhelmed when she found this out how many triangles they had to draw. However, Shawna told Erin, “It’s ok we got this, we can do it” (Fieldnotes, Year 3). Erin and Shawna began drawing out and measuring triangles on big pieces of brown cardboard. During the next four sessions the girls drew out and began cutting out triangles (with support from Ms. E.).

During the fourth GEC session you could see the frustration come across Shawna’s face, she was very tired cutting out cardboard pieces, because of this we asked a local university partner to assist the girls with cutting out the triangles by using a laser cutter. The cardboard that the girls were using is very thick and awkward in shape, so this made it difficult at times to cut out all the pieces. Below is a picture of the girls' cardboard filled with triangles they drew by tracing the pattern.

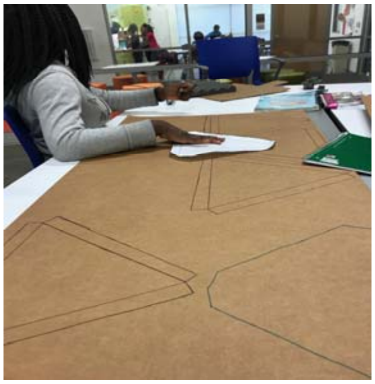

Figure 18. The Girls' Cardboard Filled with Triangles They Later Cut Out and Attached to Make Their Dome.

In the last two sessions the girls had cut out all the triangles for the dome and began to attach them together. The girls tried hot glue (as per instructions they found on the internet) but Shawna realized that the hot glue was not strong enough to hold the pieces together. So, they switched to cardboard connectors, which meant the girl needed to learn how to use a power drill to drill holes for one side of the connectors, and to use a clamp to attach the connectors together across two pieces of cardboard. The girls had to use small black brackets to attach the triangles into make their dome. The folded the rectangular piece (as seen in the picture above) and attached the rectangles that way. Once Shawna attached (with the help from Ms. E) the triangles with the brackets she began get excited about how the dome was going to look. The girls worked diligently on the putting the triangles together. Erin was in the cutting of the triangle process and became very overwhelmed and wanted to give up several times, Shawna told Erin "No, you can't give up! You have to keep working on the project, so we can finish it" (Fieldnotes, Year 3). The picture below shows the Shawna putting the triangle together and the excitement that came across their face being able to see their dome come together.

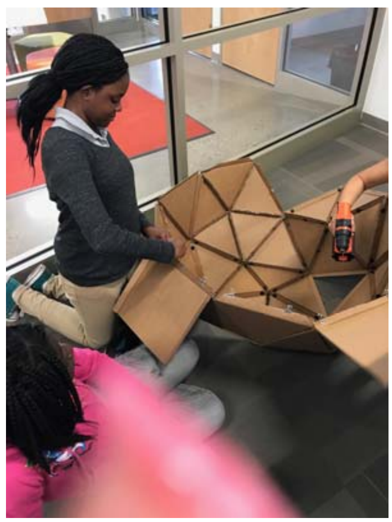

Figure 19. Shawna Putting Their Dome Together.

On the day of the GEC Expo Shawna was very excited that they were able to finish the dome. The girls added lights and a fan that would be run off of solar energy and were able to talk about their how they worked. Both girls were able to talk about how electrons traveled from the solar panels that in turn make the lights and fan work.

Figure 20. The Girls with Their Finished Dome at the GEC Expo.

Shawna was too shy to present the dome the girls had built to the youth and group leaders at the community club, so Erin took the lead in that process. However, Shawna did step in and explain how and why they added the solar panels to the top to the dome. Shawna also talked about why they decided to make dome; so that other younger youth would have something plan in at the club.

Shawna's portrait conclusion. Throughout the 4 years Shawna has participated in GEC she has engaged in STEM task differently. As shown in the above vignettes, Shawna, has played the leader role, the encourager role and also been the girl that was too shy to present (as shown in Table 5 later in this chapter). However, Shawna's engagement in GEC was consistent, until she transitioned to the teen center, where she attended only about once a month, because she would either leave early or have to finish homework. Now, that the community club has established teen GEC sessions, she is back to being consistent in her attendance. Shawna is a positive young lady, who wants to help her peers while having fun doing STEM task.

Erin

Erin is a very shy 11-year-old AA girl, who gets bullied at school because of her dark skin, and because of this, is consistently worried about her appearance. When she meets anyone for the first time she does not look at them in the eye and speaks very softly; it is as though she does not want you to know she is there. Erin is in the sixth grade and lives with her mother and her older brother and two younger sisters. In an interview conducted in the Year 3 of GEC, Erin stated that she wanted to be an engineer when she grows up but is unsure which type. She attends a predominantly African American middle school which has few outside resources; for example, there is no active Parent and Teacher Association (PTA). Erin is not the best student and struggles in school, especially science. Erin does not like school science because she says, "we only do worksheets, nothing hands on" (Background interview, Year 2); Erin does not feel like she learns anything when she does worksheets all day. Erin has stated on many occasions how she has had to take care of her younger siblings while her mother is at work. She feels that she is responsible for her siblings.

Erin has participated in GEC's STEM after school enrichment program for the two and half years. Though Erin comes off very introverted when you first meet her, when she is around her friends or adults she knows well she begins to open up and she almost becomes a different person. For example, on the first day of GEC camp, I sat with her and started helping her with her project, she then began telling me about her family, her brother's girlfriends, and the close relationship she has with her grandparents. Throughout her participation in GEC she informed me that she gets picked on a lot because of her dark skin. Erin stated, "I wish I was light skinned Ms. Faith, like you" (Background Interview, Year 1). Erin would talk about wanting to be light skinned, like some of the other girls in GEC. The other girls in GEC would also talk about Erin's dark skin and sometimes pick on her skin color. When the girls picked on her about her skin complexation, Erin was positioned negatively in this STEM space which sometimes affected how she engaged in STEM tasks. For example, Erin would withdraw from the group and start working by herself.

Erin is very close to her maternal grandparents; she talks about spending evenings and summers at their home. Erin's grandmother is especially supportive of her in everything she does, particularly her academics. Her grandmother wants her to attend college and go into "a science career" (Erin, Background interview, summer Year 2).

Light-up head-band (Year 2, Summer). Erin did not attend the first session of summer camp; however, she was there early on day two, though shy and timid. We were beginning a new unit in GEC summer camp on making an innovation for someone in the community that would assist them with a problem. Youth had to think of a problem, then research the problem and think of an innovation to assist someone with the problem. During this session the youth were expected to get their innovations planned out on paper, then once it was approved by myself they could then start making their innovation. Youth also were expected to begin of each session writing down their goals for the day, of things they wanted to finish during the session. This process served as check list for the youth and made them accountable for the task they needed to complete during the session. After I introduced the expectations youth gathered their materials (i.e., markers, paper, rulers) and began working. The youth could choose whether they wanted to create a mini theater using paper circuitry or a plush electric light up toy and were exposed to various examples, pictures, and videos of both so that they could make a well-informed decision about what they wanted to work on for the next two weeks. I introduced the choice of innovations and youth had to decide whether they wanted to work together or independently on their innovations; most of the youth split into pairs; however, Jasmine and Erin decided they wanted to work independently. I sat down next to Erin and asked her "What would you like to make?" (Field note discussion, Year 2), she was quiet for a few minutes, she then looked up to me and asked, "Can I make a light up headband, instead of plush toy?" (Field note discussion, Year 2). Because one of the goals of this STEM space is to give youth choice and the freedom to voice what they want to create; I supported her choice to make a light up headband. Erin decided that she wanted a multi-color headband, so she laid several multiple color pieces of fabric in front of her and talked through what she wanted her headband to look like. In the beginning, she was very unsure of how she was going to turn these pieces of fabric into a headband that lights up. She kept asking, "How is this going work?" (Field note discussion, Year 2), by these questions I could tell they she needed to draw out how she wanted her headband to look. Erin stated "YES!! Ms. Faith, I like that idea. But could you draw it and I tell you what to write?" (Field note discussion, Year 2), when offered this suggestion. Erin was very apprehensive of the making process; therefore, I was overly supportive.

Erin and I sat together the rest of that camp session drawing out what she wanted her headband to look like. She began the making and artistic process by choosing different color fabric options and deciding where on the headband she wanted to place the LED light. Once Erin decided on the design of her headband she was very enthusiastic about making it, she smiled and started clapping her hands from all her excitement. When informed that she would have to wait for our next GEC session because our camp session was about over for that day, disappointment came across her face and she asked if she could skip lunch and stay in camp to at least start on it. I told her "Unfortunately no, however we will start on it first thing in the morning" (Field note discussion, Year 2). Erin walked into the GEC summer camp for the first time introverted and keeping to herself; however, by the end of day one she was eager and ready to work on her innovation the next day.

Erin spent the last few days of camp sewing her pieces together. On the second to last day of camp she was ready to sew in the light bulb (LED light bulb) and battery pack (small battery pack that hold a dime size battery) into her headband with conductible thread (metallic thread that passes electricity from the battery to the LED light bulb). Before Erin began sewing the light bulb on her headband, I reminded her that she needed to use conductible thread, not the regular thread she had been using to sew her pieces of fabric together for the headband. Once this was brought to her attention Erin asked, "Ms. Faith, why do I have to use a different kind of thread today, I haven't been using this thread" (Field note discussion, Year 2). Once Erin understood that her light bulb would not work if we used regular thread because the regular thread did not conduct electricity like the metallic conductible thread, she understood the importance of the change in thread. We also talked about how the conductible thread needed to be sewn from the positive end of the battery holder needed to the positive end of the LED light so that the electrons would flow through the conductible thread easily. Erin took the threaded needle and started attaching the battery holder to the fabric and then began sewing to the positive end of her LED light to the fabric, she did the same process for the negative end of her batter holder and LED light. When it was time for her to sew the negative ends, Erin got the conductible thread tangled and got frustrated with her mistake. Her good friend Jasmine consoled her and informed her "It's ok, we all make mistakes. Just start sewing that part again. You will still be able to get finished today" (Field note discussion, Year 2). Erin needed this support to keep going and not give up. Jasmine's support gave Erin the confidence to start over and finish her headband.

Once she completed sewing her circuit, Erin was very anxious and wanted to test out her headband to see if it worked. She popped the battery in the battery holder and all she saw was a bright blue light coming from the fabric. Erin was so proud of herself, she screamed "Ms. Faith, look, IT WORKS!!!!" (Field note discussion, Year 2).

On the last day of camp, the youth had the opportunity to present their innovations to, their peers, the other club members, club staff and their family members. All of the youth were expected to put together a power point presentation that documented their making process during the two-week GEC camp and explain the science and engineering that enabled their innovation to work. They also had the opportunity to talk about the challenges and successes they experienced during the two-week camp. Once it was time to set up for the expo, Erin insisted on helping with every aspect of the event, she moved tables and set up the computers for the presentations. She was very excited about sharing her headband with her peers and family members. She talked about how her grandmother was coming to see her and I could feel the excitement she had in wanting to show her grandmother what she had made.

The expo started around 4:30 in the afternoon on the last day of the summer camp. When the expo began Erin talked to everyone who came to her table about what she had made her headband. Her grandmother was in attendance and she pulled me aside to tell me “I am very proud of Erin she is usually shy and doesn’t talk to people, but she has really opened up” (Field note discussion, Year 2). By the conclusion of the camp, Erin could describe how she made her headband and the circuitry that went behind making her headband light up. She was very proud of all the work she put in to it making; she said, “that making a headband colorful would allow people to see it in the dark better and that more people would like it” (Field note discussion, Year 2). Erin was bubbly and excited to talk about her headband; she had come out of her shell.

Paper circuits (Year 3, Fall). Paper circuits was our first session of the GEC program for Year 3 in the new building. One of the principles of GEC is for youth to use their engineering practices to make something for someone in their community, because of this we began our first session of Year 3 with introducing using paper circuits to create a greeting card for someone they deeply cared about or a drawing a picture that represented something that was important to them in their neighborhood. After youth drew their picture for their greeting card, they then drew out their circuit on the back of their picture illustrating where they would place their battery, LED light and how the two would be connected with conductible tape, in order to allow the electrons to flow.

When Erin saw the process of making the electrical circuit, she became very nervous and stated, “I can’t do that” (Field note, Year 3). To build her confidence I reminded her of headband the past summer and informed her that creating a paper circuit is similar to e-textile she made that summer. This motivated Erin to begin drawing a heart with the big works “THANK YOU” in the middle of a pink folded piece of car stock. After she drew her design on the front of the card, she thought about where to put her LED light on her card. She decided to put it the left of her heart. Erin drew a map of her circuit on the back of the cardstock. She and I again talked about how this was similar to what she had done during the summer, Erin stated, “I remember that the positive end of the battery and the positive end of the LED light had to be connected” (Field note, Year 3). Erin started taping down the battery with conductible tape with the positive end facing up and then guided the tape towards the positive end of the LED, she did the same thing for the negative side. Erin was very enthusiastic to complete her circuit and make the LED bulb light up. She ended the session by saying “I did It, Miss Faith!” (Field note, Year 3). Below is a picture of Erin’s card to her family.

Figure 21. Erin’s Picture, which is a Thank You Card to Her Family. Erin is Very Close to Her Family, Especially Her Maternal Grandparents.

Toy car (Year 3, Spring). During this GEC session youth were expected to build a toy car out of Styrofoam and test how effective their design was when they raced their car against their fellow peers. Erin and Jasmine usually work together on projects like this; however, Jasmine decided work with another AA girl in GEC. This left Erin working by herself. Erin is very shy, which makes it difficult for to ask to be a part of a group. In all of the projects prior to this, Jasmine would initiate her and Erin working together, when this was not the case for this innovation, Erin found herself working independently. I sat with Erin to assist her with thinking about how she wanted her race car to look. Erin began drawing out her design on a blue piece of paper; her design began with various features, for example car doors, the trunk and four big wheels. Erin and I talked about the you-tube I showed at the beginning of the session and asked if Erin remembered how it is important for race cars to have a low weight so that they can go faster. After our conversation she decided to make her wheels smaller and the body of her car smaller also (she was going to make it a SUV). It was very important to Erin to make her car colorful, because she said she was "feeling colorful, I am in the mood of a lot different color" (Artifact interview, Year 3).

Once Erin's design was drawn, she moved onto the structural building of the toy car. She began drawing out her race car on the Styrofoam, she used three pieces of Styrofoam because she kept stating she was "messing up." On the third try she was happy with her design and cut out her design using the Styrofoam cutter, with assistance from me. Erin added the wheels to the bottom of her car and she was now ready to race against her peers. Erin wanted to test out her car before she raced against anyone. Erin and I went over to the cardboard and ramp and Erin and pushed her car; the car only traveled half way down the ramp and look of disappointment came across Erin's face. I expressed to Erin that she needed to make a few adjustments to her car and asked Erin what she felt they may be. Erin decided to make her car smaller and take off a set of wheels, she went to the Styrofoam cutter and trimmed some of her car off. After she made the adjustment she tried her new design which worked a lot better. I asked Erin why she believed this new design work, Erin stated, "Because the car is weighs less without the other two wheels" (Field Notes, Year 3).

Erin's first race was against Kia, both girls put their cars back wheels against the edge of the ramp and let go. Erin's car won the race!! Erin was very excited she jumped and screamed. She was now ready to race against another group's car, which was against a group of boys. She won this race also. Erin stated, "I loved the racing against my friends, I felt great during the racing part" (Artifact interview, Year 3).

Automaton (Year 3, Spring). "Ms. Faith, what's an automaton?" (Fieldnotes, Year 3), Erin asked when she walked into the GEC room. We were continuing our toy unit, by having the youth explore the mechanics of moving toys. After I explained the what an automaton was and the expectations for the day the youth were able to break into their groups to start designing their automaton. Jasmine and Erin decided to work together to build their automaton. The two girls sat beside one another and began drawing out what they wanted their automaton to look like. The girls decided to have a unicorn theme, that was full of color. I asked the girls why they decided on the unicorn theme, they stated, "Unicorns and a lot of color make us happy" (Fieldnotes, Year 3). Erin began building process, by drawing a unicorn to put on top of their shoebox, she was going to color the majority of it pink. However, Jasmine, did not like Erin's unicorn and want the picture of the unicorn bigger. Jasmine began to take over the project by telling Erin what to do and how to draw it; Erin began to shut down. Erin shut down to the point where she stopped contributing to the group, she began looking out the window and talking to other in the session. This first session on making automaton was coming to an end and the girls were not close to being finished.

Before the next GEC session, I spoke with Erin, expressing to her the importance of making sure she contributed to the group. Erin's feelings were hurt because she felt as though Jasmine was not listening to her ideas. This tends to happen often with Erin when she is groups, because of her shyness, Erin tends not express her ideas. After speaking to both of the girls, they sat together during the next session and both worked on the automaton. Erin contributed to the group and Jasmine listened to Erin's suggestions. Erin decided to focus on making the foam circles for the gears. After Erin cut out all the circles the girls needed and put the kabob sticks through each circle, I asked her what the circles were going to be used for, Erin stated, "These are to make the unicorns move on top of the box" (Fieldnotes, Year 3). The girls end product was very colorful (as seen in Figure 22) and full of unicorns.

Erin and Jasmine were able to complete their automaton together. Though Erin stopped working on the decorating portion of the project she was able to tell I how automatons work, Erin stated, "Look Ms. Faith! If I turn this stick the circles make the unicorns go up and down" (Fieldnotes, Year 3). She was very excited to see the automaton work, she was smiling from ear to ear when she would turn the stick. However, Erin and Jasmine did not work on the next GEC project together.

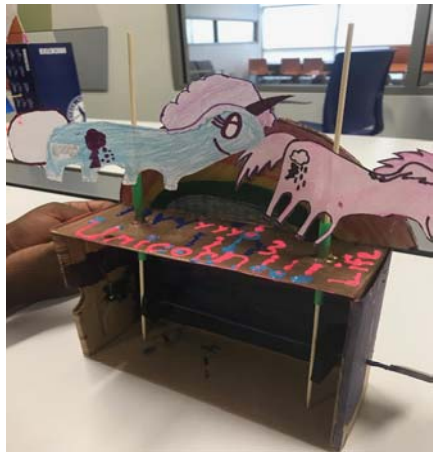

Figure 22. Features of Jasmine's and Erin's Finished Automaton.

Dome (Year 3, Spring). The GEC youth were finishing up the toy unit and were trying to decide what type of toy they wanted to make. Shawna and Erin decided to work on their toy together. As shown in Shawna's Dome vignette, the girls completed a community ethnography, to inform the toy they were going to make. Erin was excited about working with Shawna on this project, because Shawna is older than Erin and Shawna has helped Erin on various projects in the past. The girls began their project by drawing out what they wanted their Dome house to look like. The girls searched the internet for examples of other dome play houses that they could use as a format to make their own dome. Erin and Shawna decided to make their dome out of triangles out of cardboard, so that it looks geometric. The girls ended the first session of this innovation excited about how their project was going to turn out.

During the next GEC session, the Erin and Shawna looked online for the correct dimensions they needed to make the triangles for their dome as seen in Shawna's vignette. Erin was a little overwhelmed when she found this out all the cutting they were going to have to do to complete this project, because she asked me, "Ms. Faith do we really need all those triangles? Can we make less and make it smaller?" Shawna (who is generally very positive), reassured Erin that they could do it. Erin used her math practices and began drawing out and measuring triangles on big pieces of brown cardboard. During the next four sessions the girls drew out and began cutting out triangles.

During the fourth GEC sessions Erin began to get frustrated with all of the triangle cutting. The cardboard that the girls were using is very thick and awkward in shape, so this made it difficult at times to cut out all the pieces. Shawna had also missed a couple of sessions which left Erin by herself cutting out triangles. Erin is left handed, which added some difficulty to her cutting out the triangles, because we did not have left handed scissors for her. Below is a picture of the girls' cardboard filled with triangles they drew by tracing the pattern.

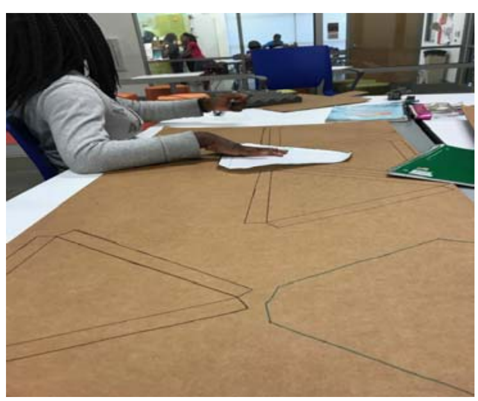

Figure 23. The Girls' Cardboard Filled with Triangles They Later Cut Out and Attached to Make Their Dome.

In the last two sessions the girls had cut out all the triangles (with help from Ms. E and Mr. M, a university partner who used a laser cutter to cut a few triangles) for the dome and began to attach them together. The girls had to use small black brackets to attach the triangles into make their dome. They folded the rectangular piece (as seen in the picture above) and attached the rectangles that way. Once Erin attached (with the help from Ms. E's help) the triangles with the brackets she began get excited about how the dome was going to look. While Erin was cutting of the triangles she became very overwhelmed and wanted to give up several times, Erin relied on Shawna's encouragement not give up and to keep working to the finished product. The picture below shows the girls putting the triangle together and the excitement that came across their face being able to see their dome come together.

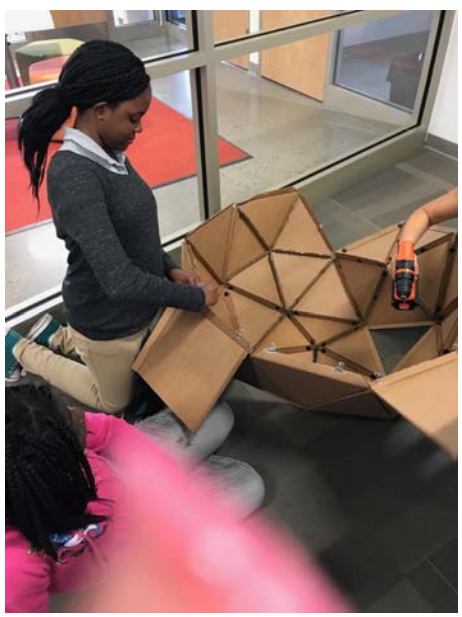

Figure 24. The Girls Putting Their Dome Together.

On the day of the GEC Expo Erin was very excited that they were able to finish the dome. Before the GEC Expo the girls created a circuit that contained lights and a fan that would be run off of solar energy and were able to talk about their how they worked. Erin lead the presentations during the expo. Erin told the audience the process the girls went through make the dome and the math and engineering they used. Erin was able to talk about how electrons traveled from the solar panels that in turn make the lights and fan work. Erin had a great time sharing her dome making process with her peers at the community club and the community club's adult leaders.

Figure 25. The Girls with Their Finished Dome at the GEC Expo.

Erin's portrait conclusion. Erin has participated in GEC for over two years and with each session she her engagement and confidence in STEM task increases as shown in the above vignettes. Erin entered GEC as a shy, quiet girl, who would talk to very few people, throughout the years of her participation she has grown as an expert in many STEM practices and has been able to use her knowledge to assist her peers with STEM task. Though there were times when Erin felt as though she could not a particular task, with the encouragement of her peers she was able to complete her projects. Erin's story shows that when AA girls can be engaged in STEM when given the support and space to freely explore without feeling negatively judged.

Jasmine

Jasmine is a cheerful, positive, 12-year-old pre-teen. She is a lighter brown-skinned African American seventh grader who lives with her mother, step-father, and younger brother and sister. She is very close with her younger siblings, she talks about looking out for her little brother at the community club and she shows pictures of her baby sister during GEC sessions. Jasmine attends a charter middle school with a STEM focus. Last year, she attended a low-income elementary school (44% of the students are economically disadvantaged) with a well-known Spanish immersion program; however, Jasmine did not participate in the Spanish immersion program at the school.

Jasmine is very good student (she has stated that she makes A in all classes, background interview, Year 2), who loves to go to school. She has talked on numerous occasions about wanting to attend college. On a college visit to a local university, she talked about how "cool it was to be on a college campus and she could not wait to be college student" (Fieldnote, Year 2). When I asked her if she thought of herself as good science student she replied "Yes, I do good in science" (Background interview); however, in Year 3 of the study she started making D's in science, because she said thinks school science is boring (Fieldnote, Year 3). During each initial background interview, I have the girls go through the classic "draw a scientist test," where I ask them to draw a picture of a scientist and describe to me what they had drawn. I choose this test because in the state of this study the youth are more exposed to science than they are engineering. When I asked Jasmine to draw a picture of a scientist, she insisted on drawing an engineer. The engineer that Jasmine drew was an African American girl like herself. When I asked her why she decided to draw an African American girl, she stated “that a lot people think boys can do everything, but girls can do anything that a boy can do” (Background interview, Year 2). Jasmine exudes a level of confidence that is not usual for a girl her age. She loves everything “girly”; she loves the color pink and likes dancing and gymnastics. Jasmine believes that girls can still be “girly” and be interested in science and engineering.

Light-up pillow (Year 2, Summer). Jasmine walked into GEC ready to work. She was smiling from ear to ear and was excited about being able to participate in the GEC enrichment program. She was not old enough to participate last school year in the afterschool program, so she was very euthanistic to get started with the activities we had planned. The youth in GEC were tasked with making something to help someone in their community, as described in Erin’s vignette on page 21. Jasmine worked by herself on a stuffed light-up pillow. When I asked her how she came up with the idea of a light up pillow she stated: “I want to make a light up pillow because it will comfort younger children who were afraid of the dark at night when they are alone in their rooms” (Fieldnote, Year 2).

When I looked over Jasmine’s goals for this session, I noticed that it was to complete all of the sewing needed to construct her light up pillow. Once, Jasmine started the making process of sewing realized that this process was going to be longer and more difficult than she originally thought; because she had never sewn before. Because of this, she and I started with a mini-lesson on how to thread a needle and tie knots. Once she started sewing her pillow, she decided to alter her original and add her initial to the front of her pillow. For sewing of her pillow and her initial on the front of the pillow I explained to her that she would have to use regular sewing thread. Once she finished sewing the sides of her pillow and her initial on the front, she was ready to sew in the LED bulb. I explained to her because we are creating an e-textile, we discussed all of the materials she would need to get started and what they are used for. I started with explaining that we were going to use conductible thread instead of regular sewing thread. We talked about how the conductible thread is used to transfer electrons from the battery to the LED bulb. Before she began sewing her circuit with conductible thread, we drew out how the circuit would look on the back of her fabric. Drawing the circuit helped Jasmine visualize how the electrons flowed and the importance of the positive and negative ends of the battery and the light bulb. We placed the battery and LED bulb on the fabric so that the positive end of the LED bulb pointed towards the positive end of the battery and same with the negative ends of the light bulbs and battery. Through this conversation I could tell Jasmine was starting to understand how a simple circuit works.

After much practice, it was time for Jasmine to sew in her circuit with the conductible thread. Jasmine’s smile soon disappeared, and a sense of frustration came across her face. I knew that I needed to step in and help her figure out the problem. Until this point Jasmine had been very independent while working on her project, but when her positivity turned to worry about not being able to finish her project, I knew that it was time she needed some assistance. One of the goals of GEC is show youth how they can investigate ways to solve problems. So, together we watched a You-Tube video on how make an LED bulb light up using conductible thread. After watching the video, we realized that she had her battery holder and light bulb going from negative to positive instead of negative to negative. Once she corrected her mistake, we discussed the reasons why it was not working when she had the opposite ends of the battery holder and light bulb connected. Jasmine ended the GEC session excited to see that her conductive thread issue was resolved. She walked out of the session stating that, “we problem solved by using the Internet with the combination of not giving up” (Fieldnote, Year 2).

Jasmine finished her pillow the day before the GEC summer expo. On the last of day of GEC summer camp, she started on her PowerPoint presentation for the expo. During the expo the youth were expected to talk community members and community club staff about their innovations and their successes and challenges they experienced throughout the making process. One of the challenges Jasmine expressed in her PowerPoint was being able to get the LED bulb working and how

> this task was especially hard for me because in the beginning I could not understand why the light was not working. I had to sew the circuit several times in order to get to get the light bulb to work. After the third time I realized that I had been sewing the LED light in the wrong direction, with my positive end going to the negative end of the battery. (Field note, summer session, Year 2).

Jasmine documented in her PowerPoint that once she realized that the positive end to the battery and the light bulb need to go in the same direction she was able to light up the

LED light. However, her perseverance enabled her to overcome this obstacle and complete her project.

Jasmine loves talking with people and telling them what she has learned in GEC sessions. On the day of the GEC summer camp expo, she was very excited to show off her innovation and share with the audience how she completed her light up pillow. However, when her a family member showed up to watch her presentation she became very shy, I had to heavily support her while she presented in front of him. This was the opposite in how she acted through the whole camp, Jasmine was never shy or apprehensive when talking to an adult.

Paper circuits (Year 3, Fall). As stated earlier in vignette paper circuits was how we began Year 3's GEC STEM enrichment session. Similar to how Jasmine was the past summer she walked in bubbly and ready to get to work. She kept asking, "Ms. Faith, what are we working on today?" (Field note discussion, Year 2). In this first session the youth were expected to make paper circuit card for either someone they deeply cared about or a card that represented something that was important to them. Jasmine decided to make a greeting card that spelled out LOVE on the front cover, when I asked why she chose to put that on front cover she simply said she "Loves Love" (Field note, Year 2). Jasmine also demanded that the color of her card be pink, she has told me on several occasions that even though she considers herself a girly girl, she believes that girls can do anything boys can do. Below is a picture of Jasmine's card and description. Once Jasmine was finished with her card, she decided to help Erin with her circuit. Jasmine is friends with all the youth in GEC, but she is especially helpful. She constantly reassures Erin and serves as her encourager.

Figure 26. Jasmine's Card, which is Pick and Purple, with the Word Love. She Decided to Place the LED Bulb in the Middle of the Heart Because She Stated, "The Heart Shows Love" (Summer Camp, Year 2, Field Note Discussion).

Because Jasmine was the first one finished with her greeting card. She decided to draw a picture about something she liked about her community; however, it was difficult for Jasmine to get started on this task, she struggled with highlighting something she liked about her community. Because she was having such a difficult time I asked her to draw something she would want to change about her community; after a lot of brainstorming she decided to draw a picture of herself doing gymnastics. When I asked Jasmine why she chose gymnastics, she stated, "I wish my neighborhood had a place where I could take gymnastics for free, because gymnastics is very expensive and there is nowhere around here to do it" (Year 3, field note discussion). Once, she drew her picture, determined where she wanted the LED bulb, she drew an outline of circuit on the back of her cardstock and completed her circuit. She had become an expert in making paper circuit, because she was one of the only youth to complete both activities, she spent time assisting Erin with the circuit. Below is a picture of Jasmine's circuit.

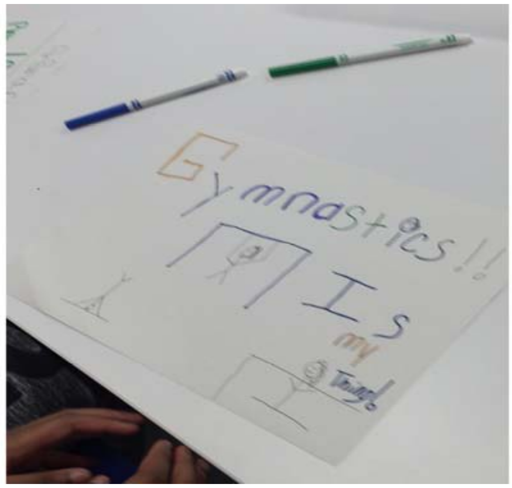

Figure 27. Jasmine's Drawing Reads, "Gymnastics is My Thing." Jasmine Drew This Picture Because She Would Like to Participate in Gymnastics in Her Own Community.

Toy car (Year 3, Spring). During this GEC session, we were expounding on our toy unit, by making Styrofoam cars. Jasmine was the first person to walk in, as usual, and asked, "What are we making today?" (Fieldnote, Year 3). I explained that they were going make their very own race car, Jasmine looked confused, she was not sure if I was talking about a real race car or a toy. Once all the youth got settled in their seats, I showed youth a videos of race cars and race car drivers, including a short video on Danica Patrick, a female race car driver. We wanted the youth to understand how force, motion and mass worked together to make fast race cars and we wanted them to use this knowledge to build their own race car. During this session youth were tasked with the challenge to a race out of Styrofoam, metal rods and plastic wheels. The youth could either work independently or with a partner; Jasmine decided to work with Tia (another

AA girl in GEC). The two girls sat beside one another and drew out their car. Tia wanted to make the car look like a unicorn and Jasmine quietly agreed. When asked why the pair chose a unicorn, they stated, “Unicorns are happy, and we don’t like bad thoughts, we like good thoughts” (Artifact interview, Year 3) Jasmine let Tia almost take over the drawing of their car because Jasmine stated, “Tia is a better drawer” (Fieldnotes, Year 3). Once the girls were done with their drawing, they showed it to I to see if they could get a piece of Styrofoam in order to start making their car. I supported them in continuing with their car and the pair took their Styrofoam. Tia drew out the outline of the car on the Styrofoam and brought it over to I to assist the girls with using the Styrofoam cutter (a tool with a hot piece of wire used to cut Styrofoam). The first piece of Styrofoam they brought over had a very small unicorn drawn on it. I cut out this very tiny unicorn car and handed to the girls. When Jasmine and Tia were trying to put the wheels on the car they realized that it was too small to attach four wheels, so they decided to make their car bigger. It was nearing the end of the session, but I, assisted the girls in getting their second car cut out before they left.

During the second toy car session, the youth were expected to finish their cars and race them. Tia and Jasmine, put the finishing touches on their unicorn car, added the wheels and were race against their fellow GET citians. The youth were expected to run several trials, to see how they could make their car faster. Jasmine’s and Tia’s car however, beat all the of their peer’s cars in the race, so they decided they did not have to make any changes to their car. When asked how they felt about the race, Jasmine stated, “We felt good! Because we beat everyone else” (Fieldnotes, Year 3).

Automaton (Year 3, Spring). "What is an Automaton?" (Field note, Year 3) Jasmine asked when she walked into the GEC session, looked at the board at the agenda for the day. We were continuing with our unit on toys and wanted the youth to understand how levers, wheels and pulleys are used in the mechanics of a lot of toys. I began the with a short you-tube video that featured multiple examples of the automatons, so youth could visualize what they were about to create. Next, I went over the materials the youth would use to make their own automaton, for example, shoe boxes, wooden kabob sticks, thick foam for the wheels, glue, and a variety of decorating materials. Youth then had to draw out what they wanted their automaton to look before they could start the building process. For this project, youth had the choice to either work independently or by themselves. Jasmine and Erin decided to work with one another to create their automaton. The two girls sat beside each to plan out what they wanted their automaton to look like. Jasmine took over this process, by insisting they would have a unicorn theme. Erin very shyly agreed and let Jasmine continue to draw. Jasmine took over this project by not allowing Erin to express what she wanted to the automaton. Erin, let Jasmine take over, and then Erin eventually stopped engaging in the project.

Jasmine and Erin worked on the plan a good part of the session and once they finished the girls showed I their drawing for their automaton. However, I could tell that Jasmine was frustrated, because she was rolling her eyes and huffing whenever Erin spoke about the drawing. At the end of the session I asked Jasmine what was bothering her, Jasmine stated: "Ms. Faith, I did all of it Erin, just sat there. I do not want to work with her anymore to make this. Can I change groups?" (Fieldnotes, Year 3). I expressed the importance of giving Erin another chance and to try again during the next session. Jasmine still wanted to leave the pair and work with another group of girls, because one they were finished, and she complained that Erin was not doing anything.

Because of what happened during the previous week's session I spoke with both Jasmine and Erin before the week's GEC session about work ethic and how important it is too work as a team. I expressed to the girls that everyone needed to participate in the making of the automaton and explained to that everyone has to contribute to the group. I also explained to Jasmine that she had to be patient with Erin and she could not leave her friend behind when things are not working the way she wanted.

The pair sat and began decorating and putting together their automaton. Jasmine supported Erin when she had an idea. Erin now felt part of the project. After the talk, the pair worked well with one another, Erin was contributing to the team and Jasmine supported her in doing so.

Jasmine and Erin finished their automaton in total of three GEC sessions. After the first session and once we had out talk, both girls contributed to the making of their automaton where able to speak fluently on how they made it and how it worked. When I asked the pair could they explain how their automaton worked they stated,

Jasmine: We used foam and cut circles like wheels and them out stick in them to make the unicorns move.

Erin: Then we cut out unicorns that Jasmine drew and put them on top of the shoe box.

Researcher: How does it work?

Jasmine: The two foam circles hit these two sticks (pointing at the two vertical sticks and that makes the unicorns go up and down.

Figure 28. Features of Jasmine’s and Erin’s Finished Automaton.

Jasmine and Erin smiled after they explained how their automaton worked to me. The enthusiasm in how they were explaining what they had created showed they even though they had some challenges they were excited they finished. However, they did not work together on the next project.

Dollhouse (Year 3, Spring). The last project of the toy unit was to use the skills the youth learned throughout the other GEC sessions to make a toy for another youth in their community. Youth had a choice to work independently or with a partner; Jasmine, Amber and Tia (another AA girl not featured in the study) decided to work together on a Dollhouse that would have working lights. The girls were very excited about this project and were started planning how their dollhouse would look immediately. The girls sat together during this GEC session drawing their dollhouse, adding all rooms they wanted and features they felt would make the dollhouse special. I sat with girls once they finished their sketch of their dollhouse, to help them make a list material they would need for the next session to starting make their dollhouse. Their list included cardboard, LED lights, glue, fabric, cotton, batteries, copper tape and paint for decorating.

Before they could begin building their dollhouse the girls had to do a community ethnography with other who attend the community club. The purpose of this community ethnography was for the youth get suggestions from other youth at the club on what they would like to see in a dollhouse.

Throughout the next four GEC sessions the girls worked together to build their dollhouse. The girls also attended the second weekly sessions to put the finishing touches on their dollhouse. During one of the second weekly GEC sessions the youth had a choice on whether they wanted to go on field trip that they community club had organized for that day. The girls decided to stay and attend the GEC session to work on their dollhouse. The girls were very dedicated to not only getting the dollhouse finished but also, ensuring that it was "pretty." Their dollhouse had three stories with a balcony, bathrooms and stairs. The girls worked on the diligently on their dollhouse during most of the sessions. However, in the middle of one of the sessions Amber said stated, "I don't want to work with them anymore, I want to work with someone else" (Field note, Year 3). Amber felt like Tia and Jasmine were taking over the building and designing of the dollhouse, so she decided to leave the group and work with another AA girl in GEC.

Though Amber left the group, Jasmine and Tia continued to work on the structural building of the dollhouse for the next three weeks they added, stairs, rooms and lights to the bedrooms. The girls worked during both first and second GEC sessions. Tia and Jasmine would ask if they could stay after the sessions were over to continue to work to the dollhouse. During the fourth week of making Amber, decided that she wanted to join the Dollhouse group again, Tia and Jasmine welcomed her with open arms. During this session, the girls began to paint the outside of the house, to make it colorful instead of keeping the brown cardboard. When it was time for the girls to clean up, I noticed the girls were arguing, so she walked over to the group. The girls were arguing with Tia about her not helping them clean up and wanted to her to assist with task. I explained to the girls the importance of everyone contributing to every part of the project. Tia began helping the Jasmine and Amber.

During the session before the youth were expected to have their projects, I expressed to the girls how they needed to add some working lights their dollhouse. I reminded them that was in their original plan. The girls decided while Tia and Amber finished up decorating the dollhouse, Jasmine would make paper circuits for the lights in the bedrooms. In the beginning Jasmine was having difficulty remembering how to connect the battery with the copper tape and LED bulb. It was hard for to remember which side of the battery should be connected to the LED bulb with the copper tape. At first, she used the copper tape to the negative end of the battery to the positive end of the LED bulb; the bulb did not glow. Relying on her STEM knowledges and practices, Jasmine realized she needed to switch the direction of the battery and LED bulb, so that the copper tape was connecting the positive ends of the battery and LED bulb. Jasmine made two paper circuits and attached them on the ceiling of the bedrooms in the dollhouse (see Figure 29).

Figure 29. Jasmine's Paper Circuit with LED Attached, Taped to the Ceiling of the Dollhouse.

The girls finished the dollhouse just in time for the end-of-year GEC session expo. The GEC session expo was a time where the youth could explain their innovations to the other youth and adults at the community club. The girls were very excited about showing the youth and adults their finished product. During the expo three girls talked about the dollhouse and showed their audience how to the dollhouse worked.

Figure 30. Finished Dollhouse That Girls Featured at the GEC Expo.

Figure 31. The Girls at the Expo about to Present Their Dollhouse to the Other Youth in the Community Club.

Jasmine's portrait conclusion. Jasmine participated in GEC for over 2 years and continues to be engaged in this STEM space. Though Jasmine has experienced times when she felt like she could not finish projects or had disagreements with her peers she persevered and finished every project she started in GEC. Once Jasmine entered middle school she became disengaged in her school science class; however, her engagement in GEC continued to grow. The vignettes above show how Jasmine not only sees herself as a "girlie" scientist and engineer, but also helps her peers through STEM task.

Amber

Amber is a happy, outgoing, 11-year-old brown-skinned African American girl who lives with her mother, father, her older brother and four sisters. Amber attended the same predominantly African American low-income magnet elementary school as Jasmine, that has a well-known Spanish immersion program; however, like Jasmine, Amber was not in the Spanish immersion program at the school. Amber is now in the sixth grade at one of the largest middle schools in the city. The middle school she attends has a lot of resources, but Amber states how she "hates science class."

Amber comes has troubled past for a child as young as she, but she now has some stability in her life. When she began GEC, she complained a lot about doing different projects, but throughout the sessions she has begun to jump right into the project, without any complaint. Amber never works by herself, she loves collaborating with other youth during the sessions, especially other girls. She has participated in GEC for the past year and a half and loves working with the other girls in group. Amber is very dedicated to GEC, she does not miss a session and if her mother picks her up early she gets very upset. She truly loves GEC and does not miss a GEC session.

Amber does not like science at her school. She makes F's and D's in her science class this school year. She stated that in her current science class she does not do a lot of hands on activities like we do in GEC. Amber also does not see herself as a scientist or an engineer; when I asked her to draw a picture of a scientist and engineer she drew men with messed up hair. When I asked Amber to describe her picture to me stated the following:

Amber: He's in a classroom, with kids. He's explaining something to the kids. He's like ok guys.

Researcher: So, you chose a male, why did you choose a male?

Amber: Because scientists are guys that you see.

Researcher: Ok, so now I want to you draw an engineer.

Amber: WHAT! I don't know what no engineer looks like.

Researcher: Just your best

Amber: He's working on a car

Researcher: Is it a man or woman?

Amber: A man

Amber may not be engaged in school; however, she loves GEC, because she says, "it's engineering, and boys and girls can do engineering" (Background interview, Year 3)!

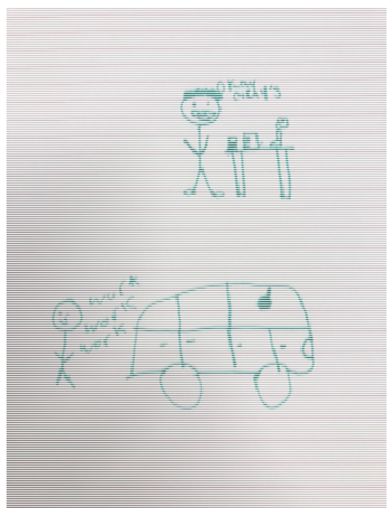

Figure 32. Amber's Drawings of Both the Scientist and Engineer.

Toy car (Year 3, Spring). We wanted the youth to better understand how toys work, because of this we expounded on our toy unit, by making Styrofoam cars. Amber walks in like she normally does, smiling from ear to ear, asked how I was doing and what we were doing in today's session. I explained that they were going make their very own race car. Once all the youth got settled in their seats, I went over the lesson for the day as seen in Erin's and Jasmine's vignettes. As stated in the above toy car vignettes, the youth could either work independently or with a partner; Amber decided to work by herself. The girls that she normally works with decided to work together, which left Amber by herself. In the beginning she was disappointed because she had felt left out the group, but I sat beside her and asked her what she wanted her car to look like. She looked at me and shrugged her shoulders as if she did not know where to start. I pushed her to think about it and she began drawing car that looked like a right triangle. Amber finished her drawing and brought it to me, so that I could approve going onto the next step, which was cutting out her car. She then grabbed a piece of Styrofoam and traced her car on the piece of Styrofoam. The diagonal side of her car had small indentations in it, I asked why she chose to cut the car that way, Amber stated, "That will make it go faster" (Fieldnote, Year 3). She attached the four wheels before this session was over. She did not get a chance to decorate it, because she ran out of time. Amber was not present at the session where the youth go to race their cars, she had doctor's appointment.

Figure 33. Amber with Her Car.

Automaton (Year 3, Spring). We were continuing with our unit on toys and wanted the youth to understand how levers, wheels and pulleys are used in the mechanics of a lot of toys. As stated in the above vignettes, youth were expected to use their science and engineering practices to make an automaton. For this project, youth had the choice to either work independently or by themselves. Amber and Tia (another AA girl who attends GEC) decided to work with one another to create their automaton. The two girls sat beside each to plan out what they wanted their automaton to look like. Tia took over this process while Amber sat beside her and let Tia draw out how she wanted the automaton to look. At the beginning of projects Amber tends to let the other person take over the project, she will help once someone else has already planned out the project.

Tia and Amber worked on the design plan for their automaton a good part of the GEC session and once the girls finished they showed me their proposed drawing for their automaton. I supported them to move on to the building process, which was picking out a shoebox and gathering all of their materials. The girls had chosen a fish theme, very similar to Finding Nemo. Amber and Tia spent the next two sessions decorating their box. Amber did help with decorating the box because she likes to that part of the process of making. When I walked over to the girls and asked Amber what she was doing, she simply stated, “I am making it look pretty, Ms. Faith” (Fieldnote, Year 3).

The pair cut out the all the small fish out of different colored pieces of foam. Using their STEM knowledges and practices the girls determined the best way to cut the small black foam circles so that their fish would move up and down. They grabbed pieces of black foam to make their circles so that one of the fishes would move up and down.

Amber did all of the cutting of the foam, while Tia placed the small fish on the top of the box with the glue gun. The two girls worked to together to poke holes in the sides of the box, so that the kabob sticks would go through. The two were able to get their Automaton working first time they put their mechanism together. Amber smiled brightly when saw the fish go up and down when she turned the wooden kabob stick. She was so proud of herself!

Figure 34. Amber and Tia's Automaton. The Orange and Blue Fish are the Two Fish That Move Up and Down.

Dollhouse (Year 3, Spring). The last project of the toy unit was to use the skills the youth learned throughout the other GEC sessions to make a toy for another youth in their community. Youth had a choice to work independently or with a partner; Jasmine, Tia and Amber decided to work together on a Dollhouse that would have working lights. The girls were very excited about this project and were started planning how their dollhouse would look immediately. The girls sat together during this GEC session drawing their dollhouse, adding all rooms they wanted and features they felt would make the dollhouse special. I sat with girls once they finished their sketch of their dollhouse, to help them make a list of materials they would need for the next session to starting make their dollhouse. Their list included cardboard, LED lights, glue, fabric, cotton, batteries, copper tape and paint for decorating.

Before they could begin building their dollhouse the girls had to do a community ethnography with other who attend the community club. The purpose of this community ethnography was for the youth to receive feedback on what features youth would want in a toy dollhouse. Through community ethnography the girls found that they needed to a play area and a bathroom.

Throughout the next four GEC sessions the girls worked together to build their dollhouse. The girls also attended the second weekly sessions to put the finishing touches on their dollhouse. During one of the second weekly GEC sessions the youth had a choice on whether they wanted to go on field trip that they community club had organized for that day. The girls decided to stay and attend the GEC session to work on their dollhouse. The girls were very dedicated to not only getting the dollhouse finished but also, ensuring that it was "pretty." Their dollhouse had three stories with a balcony, bathrooms and stairs. The girls worked on the diligently on their dollhouse during most of the sessions. However, in the middle of one of the sessions Amber said stated, "I don't want to work with them anymore, I want to work with someone else" (Field note, Year 3). Amber felt like Tia and Jasmine were taking over the building and designing of the dollhouse, so she decided to leave the group and work with another AA girl in GEC. Amber worked with

Tanya (another AA girl who participated in GEC) on a light up Hula hoop for younger youth. Tanya had her project already designed, Amber was going to help her put it hula hoop together.

Though Amber left the group, Jasmine and Tia continued to work on the dollhouse for the next three weeks adding structural features for example; stairs, rooms and lights to the bedrooms. During the fourth week of making Amber, decided that she wanted to join the dollhouse group again, Tia and Jasmine welcomed her with open arms. Tanya did not come to GEC consistently, which made it difficult for Amber to finish the project. Amber depends on the collaboration of others, when Tanya stopped coming to session Amber became frustrated and wanted to join Jasmine and Tia on the building the dollhouse again.

During the third to last session, the girls began to paint the outside of the house, to make it colorful instead of keeping the brown cardboard. When it was time for the girls to clean up, I noticed the girls were arguing, so she walked over to the group. The girls were arguing with Tia about her not helping them clean up and wanted to her to assist with task. Amber was the main one cleaning up the paint and washing the paint brushes. She told me “Ms. Faith, Tia needs to help!” (Fieldnotes, Year 3), I explained to the girls the importance of everyone contributing to every part of the project and that included cleaning up at the end of sessions. Tia began helping the Jasmine and Amber.

During the session before the youth were expected to have their projects, I expressed to the girls how they needed to add some working lights their dollhouse. I reminded them that was in their original plan. The girls decided while Amber and Tia finished up decorating the dollhouse, Jasmine would make paper circuits for the lights in the bedrooms.

The girls finished the dollhouse just in time for the end-of-year GEC session expo. Amber put together a PowerPoint presentation that showcased the three girls process of putting together the dollhouse. She put in all the pictures that featured hoe their dollhouse had changed throughout the past few weeks. The GEC session expo was a time where the youth could explain their innovations to the other youth and adults at the community club. The girls were very excited about showing the youth and adults their finished product. During the expo three girls talked about the dollhouse and showed their audience how to the dollhouse worked.

Figure 35. The Finished Dollhouse That Girls Featured at the GEC Expo.

Figure 36. The Girls at the Expo about to Present Their Dollhouse to the Other Youth in the Community Club.

Stop motion (Year 4, Fall). We began the fourth year of the GEC with having the youth make stop motion videos. As always, Amber was the first person in this year's GEC session and was ready to get started on the project. Ms. A and I began this session by showing the youth some examples of stop motion video's and how to use the Stop Motion app on the iPad. After we showed the youth examples of stop motion videos we then showed them how to make their stop motion videos. Youth had to take a series a photo in the stop motion app; once they were done taking their photos they could then edit their video the way they wanted it to look. Amber and Jasmine decided to work together on their stop motion video. They sat beside one another during the first session to plan out what they wanted in their stop motion video. The two girls decided to replay how they met and how their participation in the community club contributed to their friendship. After Amber and Jasmine were done organizing their video they handed me their ideas and I supported them to go start taking pictures at the different spaces they indicated on in their plan.

During the next three sessions the girls and I went around the community club to take pictures in the different spaces they felt was important to the development of their friendship. Amber and Jasmine also choreographed a dance they did in one of the common areas of the community club, because the girls stated, “We love to dance, Ms. Faith and that one thing we do at the club” (Fieldnote, Year 4). The two girls walked around from room to room and I took pictures of them acting out different activities they do at the community, for example, homework time, dance, and socializing with friends. Once they got to over 120 pictures they were ready to edit their video and go through the pictures they wanted to keep. The girls sat and edited their photos and while going through the editing process they decided they wanted to add music to their stop video. They called me over to their table and asked, “Ms. Faith, can we add music to our video and how do we do it?” (Fieldnote, Year 4). I then sat down and helped them choose a song from my music library on my phone. The girls listened to three songs until they chose “Girls Run the World” by Beyoncé. The girls went to a quiet room to add their song choice to the stop motion video, so that other sounds in the club would not be heard in their video.

In the last stop motion session Amber and Jasmine finished their stop motion video and were very excited about showing the finished product to me. The girls worked together on every aspect of the project. They collaborated with one another on what to add to the video and the dance steps they would do during the dancing portion of their stop motion video. Amber and Jasmine used their technology practices to express themselves, their sisterhood, and how this community space impacted their lives.

3D printing (Year 4, Spring). During the spring semester of the fourth year of GEC we introduced the youth to 3D printing. We wanted the youth to create a 3D printed object about themselves using the program TinkerCad and the 3D printer that they would then place on a cardboard nameplate. The nameplates were pieces of square cardboard that the youth were going to use to spell out their name using different objects (i.e., straws, thumb tacks, string) and their 3D-printed item. Amber was especially excited about this project because she likes working on the computer. Amber and Jasmine began the unit working with one another on the interactive sheet that walked the youth through how to use TinkerCad. The youth were expected to make different objects in TinkerCad to familiarize themselves with the program before they were able to create their object. Amber and Jasmine sat the whole session going through the interactive sheet to make their boat and house and learning how to manipulate the size of the objects in TinkerCad, by using the computers mouse to alter the dimensions of the width, length and height in millimeters.

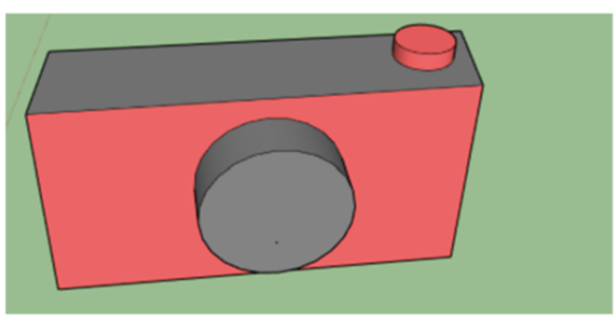

Figure 37. Amber’s Camera She Created in TinkerCad.

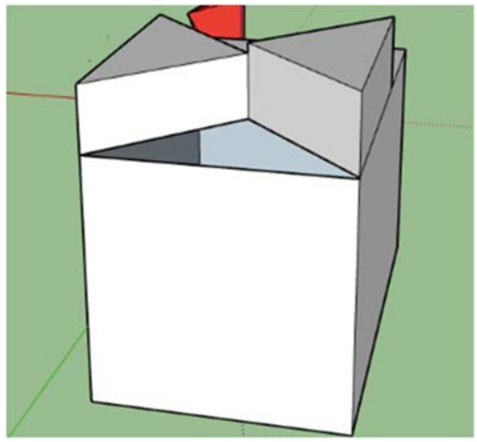

Figure 38. Amber's 3D House She Created in TinkerCad.

During the next few sessions Amber decided to work by herself on her 3D object she was going to place on her name plate. She first decided to make an explanation mark for her nameplate, when I asked her why chose an explanation mark, she stated, "Because Ms. Faith, I like to talk, and people think I can get loud" (Fieldnote, Year 4). Amber is usually quiet; however, in the past couple of months she has opened up and started talking more. Amber sat at the computer for most of the session and manipulated her explanation mark to the correct size, so that it would print in a short amount of time. She looked at the dimensions of the explanation to ensure that it was not too big or too small. Once Amber was able to get explanation mark to 25mm x 25mm x 25mm she yelled, "Ms. Faith, I am done and I am ready to print!!!" (Fieldnote, Year 4). She brought her computer to me and we went uploaded to an USB drive to place in the printer to print. Amber was so excited about her explanation mark and was the first youth done she decided to make a second object to place on her nameplate.

Amber's second object was the "A" for her first letter in her name. Again, similar to the explanation mark she sat, ensured she had the correct dimensions for her letter "A" and was ready to print. This time however, because she had watched me upload her first 3D object she decided to upload her "A" on her own. I supported her in this endeavor and a few later I heard the 3D printer printing her "A." Because Amber was the youth done with her objects she decided to help her peers. Dana (another AA girl in GEC), was having difficulty finding the correct dimensions for her object, so that it would print correctly. Amber sat with Dana and showed her how to manipulate objects so that they are the correct width, length and height to print. Amber was the expert during this unit, she helped assist other in making their 3D printed objects.

Amber's portrait conclusion. When Amber first started GEC, she depended a lot on her peers to complete STEM task; however, in time she began to work by herself to complete STEM task, while assisting others with innovations. As seen in the above vignettes, Amber relied on the support of her peers to engage and explore STEM, this support then evolved into her supporting other youth in GEC. At the beginning of her participation in GEC Amber did not see herself as a scientist or an engineer, but through her participation she is now positioned as a scientist or an engineer.

Sara

Sara is quiet 13-year-old dark-skinned African American girl, in the seventh grade, who lives with her mother. She has two older brothers, but neither one of them live with Sara and her mother. Sara attends one of the largest middle schools in the district, where she would get suspended often. Sara would get into trouble for being disrespectful to her teachers and fighting with her peers. Sara has been arrested and sent to detention center briefly, because of some trouble she had gotten into in her neighborhood. She was held back in elementary school (had to stay in a grade level for two years) and is not the best student, because she made C's and D's on her report card. Sara tends to become disengaged in school, which can cause her to act out towards other students and teachers. Sara stated, "The teachers at school try to me feel like I don't know nothing and don't help me" (Fieldnote, Year 3). Sara has stated numerous times during GEC sessions that she enjoys GEC because she can express herself creatively by making innovations (Fieldnote, Year 3). Sara has participated in GEC for the past 3 years and loves working with other girls in the club, especially Kia. Sara has stated how she feels about science and engineering:

Sara: I hate science at school.

Researcher: Why?

Sara: It's boring, we don't do nothing

Researcher: What would you like to do?

Sara: The stuff we do here at GEC. (Fieldnotes, Year 2)

Though Sara had participated in GEC for the past 3 years she has not been consistent with her attendance in GEC, she has stopped attending a for months at a time and then want to rejoin. We always welcomed her back with open arms. She and Kia are very good friends and though they do work together sometimes, they often work on projects individually.

Figure 39. Even Though Both of the Girls Are New to the Group This School Year, They Both Felt Very Comfortable Presenting. Sara Insisted on One of the Expectations Being That Everyone Participating in GEC Has an Opportunity to Express Themselves and That Their Voices are Heard.

During GEC sessions the girls sit beside one another and talk about different things that are going at school and at the community club. Sara, similar to Kia, wants her voice to be heard, she wants to ensure that people do not ignore her; Sara felt so strongly about this that she insisted that one of the expectations for the GEC was that everyone's voice is hear.

Paper circuits (Year 3, Fall). As stated in the earlier vignettes, we began Year 3's GEC STEM enrichment session with the youth making paper circuits. During this session we asked the youth to draw something that they liked about their community. Sara, sat at the end of table not drawing; after about 5 min she asked me, "Ms. Faith, can I draw something I like about myself, instead of something in my community?" (Field Note, Year 3). I supported her in this change to the today's activity and said, "Go for it!" (Field Note, Year 3). I sat in between Kia and Sara, Sara enjoys sitting near Kia, because they are able to catch up on the happenings of the day. Sara and Kia do not attend the same middle school, so they have a lot to talk about once they arrive at the community club and to GEC. Sara began drawing out how she wanted her paper circuit to look. She sat quietly making sure she added the correct colors to her picture. She drew what looked like a magnifying glass, however I was confused about why she chose a magnifying glass. I asked,

Researcher: Why did you chose to draw a magnifying glass?

Sara: Because I am always looking for something interesting, Ms. Faith. I like interesting things!

Researcher: Ok Sara, Great go for it. (Field Note, Year 3)

Once Sara finished her drawing, she began to work on the electronical circuit component of her paper circuit. She wanted two LED light at the top of her magnifying glass because she said, “the lights help people find things easier, so that it looks the magnifying glass had small lights attached to the top of it” (Fieldnote, Year 3). She than began to draw her electrical circuit on the back of her cardstock (Picture 3). She informed me that the lights on the top of the magnifying glass were there, so people could see whatever they are looking at better. Sara drew two series circuits on the back of her paper, she then made sure to put dots where she wanted her lights to go and a circle for where the battery would go. She then attached the copper tape (to enable electrons to flow) on top of the lines she drew, and poked holes for her lights. Because Sara had participated in GEC in the past years, she was familiar with making paper circuits, so once she got the conductible tape down on the paper her lights worked instantly. Below are pictures of Sara and her magnifying glass drawing.

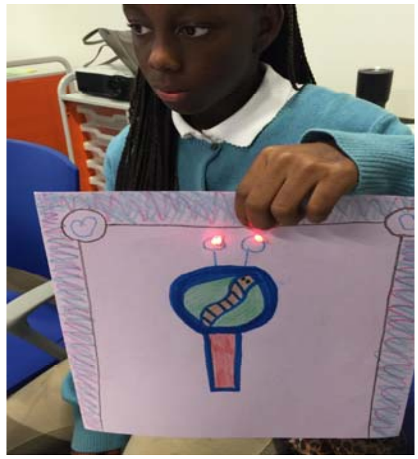

Figure 40. Sara with Her Paper Circuit; She Chose To Do a Magnifying Glass Because She Said That She Is Always Looking for Interesting Things. Once I Reminded Her How to Put Down the Conductible Tape She Was Able to Finish the Rest of the Circuit by Herself.

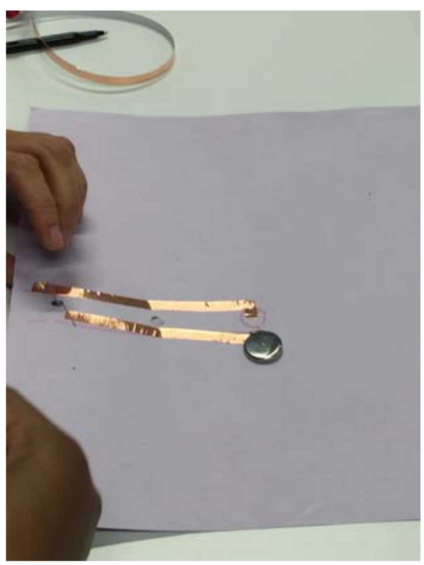

Figure 41. Sara's Circuit. She Was Able to Complete Her Circuit with Very Little Help from Me. Last Year Sara Was Pretty Quiet and Depended a Lot on the Other Girls in Her Group; However, During Year 3 She Had Become Very Independent and Doing Things on Her Own.

At the end of the session, I asked Sara about her drawing, she stated the following:

Researcher: Can you tell me about your drawing?

Sara: It's a magnifying glass, with lights.

Researcher: Why did you draw it?

Sara: Because I like to see interesting things.

Researcher: What interesting about you?

Sara: I like to fight with my brother (laughing)! (Video Diary, Year 3)

Valentine's Day paper circuit (Year 3, Spring). On Valentine's Day we had the youth make cards for someone they care about or a thank you card for someone special in their lives. Sara decided to make a card for her mother, because she stated her mom was her hero. She grabbed a piece of pink card stock and began to draw out her card. Sara wanted it to have a candy theme, because she talked about how much her mom loved candy, all kinds of candy. Sara had no difficulty creating her circuit on the back of her card she tackled the circuit very similarly to how she created her series circuit for her magnifying glass. She wanted to ensure her LED bulb lite up, so she grabbed a small battery and placed the LED bulb on it, where the positive end of the LED bulb and the positive end of the battery were touching one another, Sara smiled when she saw the bulb lit up with no problem.

Figure 42. Sara Testing out Her LED. She Decided to Make a Valentine’s Day Card for Her Mother Because She Said That Her Mother is Her Hero and Her Inspiration. Sara Was So Focused During This Project That She Was Able to Finish Her Project in One Session!

Figure 43. Sara’s Finished Card for Her Mother. Sara Stated, “I Really Love My Mom and I Want to Thank Her for All She Does for Me” (Fieldnote, Year 3).

Sara also wanted to make the Valentine's Day card a pop-up card. She decided to draw a Hersey chocolate bar in the middle of the card and make that piece pop out of the card. The pop-up Hersey bar was also going to be the part of the card that lit up. After, Sara created her series circuit on the back part of the pop-up Hersey bar she, then wrote the following on the bottom of her card; "Happy Valentines mommy, I love you so much and I hope you the best" (Fieldnote, Year 3). Sara was very proud of what she had created for her mother, she asked if she could take it home to get to her mother at the end of the GEC session, I stated: "Sure! I know your mother will love it" (Fieldnote, Year 3).

Strawbees (Year 3, Fall). At the beginning of the toy unit we wanted the youth to explore the different ways toys are made and the different types of toys that exist. We decided to take the youth to a local universities Makerspace so that they could explore making toys through a tool call Strawbees. Sara, was very excited about using the Strawbees to make innovative toys. One of the teachers at the local universities MakerSpace showed the GEC youth how to put straws together, by using small plastic hinge like mechanisms. Once the teacher and I showed the group of GEC youth how to put the straws together, Sara instantly grabbed her supplies and to begin building process. We offered print outs of directions that featured some ideas that the youth could use to make toys out of the strawbees. Sara looked through all the print outs and decided to make a round dome. She sat quietly and began snapping together the straws and the small hinge like mechanisms that held the straws together. Sara began her toy innovation by making a small round dome made out of green straws. She looked around after she was done with her small straw dome and realized she was the first one done with her project;

so, I pushed and supported her to build upon what she had already done. Without any directions she built a larger dome out of the Strawbees and figured out a way to attach the smaller dome inside the larger red one, by using small hinge mechanism and small straw (the directions to connect the two domes were not in any of the printed directions we supplied for the youth).

Sara immediately understood how to use the strawbees and the ways she could connect them to make an innovative toy. When it was time for the GEC youth to leave the Makerspace to head back to the community club, she asked if she could take her Strawbee toy project with her to show her mom. Sara was very proud of what she had done, she stated to me when she was leaving, “Ms. Faith, I actually finished today!” (Fieldnote, Year 3).

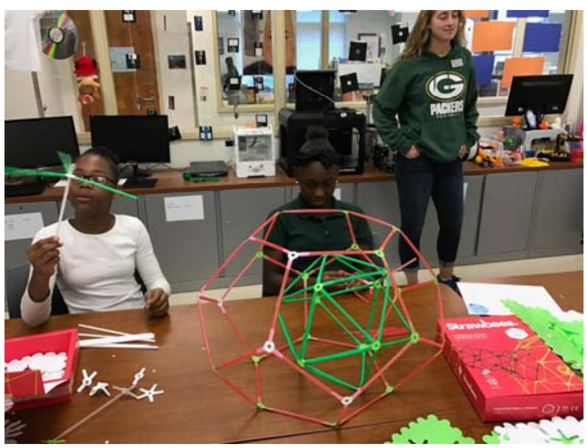

Figure 44. Sara with Her Strawbee Toy Innovation. She Was Proud of Herself for Finishing Her Project.

Toy car (Year 3, Spring). As stated in earlier vignettes, in this week’s GEC session, we were expounding on our toy unit, by making Styrofoam cars. I explained to the GEC group that they were going make their own race car, Sara, looked disinterested and was not sure how she was going to complete the task. Sara was not in the best mood at the beginning of this session, something had happened at school earlier, that affected Sara's attitude in becoming engaged in the project. Kia (Sara's good friend) was also not in a good mood at the beginning of this session. Sometimes when things happen at school or home to Sara, her attitude can become deeply affected. Once Sara sat down and all the youth got settled in their seats, I began the session by showing the youth videos of race cars and race car drivers; including a short video on Danica Patrick, a female race car driver. We wanted the youth to understand how force, motion and mass worked together to make fast race cars and we wanted them to use this knowledge to build their own race car. During this GEC session youth were tasked with the challenge to make a race car out of Styrofoam, metal rods and plastic wheels. The youth could either work independently or with a partner; Sara and Kia decided to work together; often times when the two girls work together they argue and fight. This GEC session was not any different than when they girls work together. The two girls sat beside one another and drew out their car, but argued about how it should look, how big it should be, and how they should decorate it. Sara, began to disengage as she normally does, when they start arguing and Kia began to draw out how she wanted the car to look. Because of Sara's disengagement, the girls decided to work independently for this rest of the project. Sara wanted her car to look like a regular race car and began drawing her design on a piece of paper. Once Sara was done with her drawing, she showed it to me to see if she could get a piece of Styrofoam in order to start making her car. Sara, like all the youth who began the building process by drawing out the outline of the car on the Styrofoam and brought it over to me to assist so that I could her with using the Styrofoam cutter (a tool with a hot piece of wire used to cut Styrofoam). After, Sara grabbed a piece Styrofoam, she to draw an outline of her car on the Styrofoam. Sara then brought her piece of Styrofoam where she drawn a medium sized race car on it. I cut out Sara's car, using the Styrofoam cutter and handed her the finished product. Sara attached the four wheels to the car, 2 in the front and 2 in the back. Sara then began decorating her car with markers and toothpicks.

During the second toy car session, the youth were expected to finish their cars and race them. Sara was so excited to race her car. Sara stated, "I feel good about my car, but I also I felt bad about it, but it was ok because I still won some races, but I didn't' like it, because it was slow" (Video Diary, Year 3). I asked Sara, why she felt her car was slower than other cars, Sara stated, "Because I put all the toothpicks on it, that made it weigh more" (Video Diary, Year 3). Sara also noticed that the ramp was uneven and that affected how her car raced. Sara and Kia insisted on filming their video diary together, even though they argued at the beginning of the project. During the video diary for this project, Kia and Sara, wanted to be interviewed together, though both made their own car. During the video diary I asked Sara the following:

Researcher: What inspired you about your car?

Sara: I wanted to add a little details, but when I did it made the car a little slower, like the toothpicks. (Video Diary, Year 3)

Figure 45. Sara with Her Styrofoam Car.

Lonely flower box (Year 3, Spring). We had been exploring different types of toys and how toys are made for about 3 months; it was now time for the GEC youth to make their own toys. I started the toy making session, challenging the youth to think of a toy innovation for a child in their community. The GEC youth were to plan out their toy and come up with a materials list with the items they needed in order to make their toy innovation. After I explained to the GEC youth the expectations of the next few sessions, I sat beside Sara and asked her to what she wanted to make, she shook her head, and stated, "I don't know, Ms. Faith" (Fieldnote, Year 3). I got up and started helping another youth in order to leave her to think for a few minutes. After I checked on the other youth around the room, I came back over to Sara. I saw she had drawn a small box with the flower on it. I asked,

Researcher: What is your drawing about? What do you want to make?

Sara: A toy, so kids can put their toys in it.

Researcher: That's a great idea, but what type of electrical component will add to it?

Sara: Ummmmm, I don't know, Ms. Faith

Researcher: We need to think of something, but why don't you go ahead and make the box.

Sara looked for a box, some construction paper and makers. She sat the rest of the session drawing out the design for her box.

During the second toy making session, Sara spent her time decorating the outside of the box. She glued construction paper on the outside of the box and also painted the box and construction paper. Towards the end of the session she glued the picture she had been working on in the following session. She slid her box to me and stated, "Look Ms. Faith, I am finished" (Fieldnote, Year 3). I read the words Sara printed on the outside of her box, "Lonely flower." I asked Sara, why she chose to write that on the front of the box? She stated, "Because I feel lonely" (Fieldnote, Year 3). Sara was absent for the next two weeks, because she had been suspended at school, she never got to finish her toy box.

Figure 46. Sara with Her Toy Box She Wanted to Make for Youth to Put Their Toys In.

GEC expo (Year 3, Spring). It was the last GEC session for youth for the school year and we wanted to close the year with an expo. We wanted to give youth the time and space where they could show off their toy innovations and other projects that had created through the school year. Sara was not present the last couple of sessions because she had gotten suspended from school which prohibited her from attending the community and participating in GEC. She walked in while we were sitting up the tables in gymnasium of community club and asked, “What can I do, Ms. Faith?” (Fieldnote, Year 3). I could tell by the tone in Sara’s voice she really wanted to participate in the end-of-year GEC expo. However, she knew she had not finished her project, so she did not know how she was going to participate. I saw a frown came across her face and Sara looked very disappointed. I then remembered we had a table set up with the Styrofoam cars on it, that the youth had built earlier in the semester and we needed someone to sit at the table to explain the process the GEC citians went through to make the Styrofoam cars and to let the younger youth who were going around to all the tables play with the cars. Sara was very excited to do this; a huge smile came across her face. She sat at the table and explained to everyone who visited the table what the GEC youth had done to make the Styrofoam cars, she also helped youth try out a car of their choice, by pushing it down the cardboard ramp. Sara was very happy she was still able to participate in the Expo, and even though she had not finished her “Lonely Flower Toy Box” when she left for that evening, she said, “Thank You Ms. Faith, for letting me help” (Fieldnote, Year 3).

Figure 47. Sara Sitting at the Table with the Toy Cars on it. She Was Waiting and Ready to Talk to People about What We Had Done, and the GEC Youth Made the Styrofoam Cars.

Figure 48. Sara Talking to Other Youth at the Club Who Do Not Participate in GEC about the Styrofoam Cars.

Stop motion (Year 4, Fall). As seen in Jasmine's vignette, we decided to begin the fourth year of the GEC by introducing Stop motion to the youth. I began this session by showing the youth some examples of stop motion videos on you-tube, so that they could better understand what stop motion was. Sara enjoyed viewing the Stop motion videos, because she stated, “Wow, kids our age can do this?” (Fieldnotes, Year 4). Once I was done showing them example Ms. A and I showed the youth how to use the stop motion app on the iPad. Youth were expected to take a series a photos in the stop motion app, once they were done taking their photos they could then edit their video the way they wanted it to look. Sara and Kia decided to work together on their stop motion video. They sat beside one another during the first session to planned out what they wanted in their stop motion video and decided to the feature community club and all the places they enjoy at the community club. The two girls planned out a dance choreography and danced their routine in front of spaces at the community club that they enjoyed. For two sessions wen around the community club took pictures of them dancing in front of the club, on the playground and in front of the GEC room. Once they over 150 pictures, they sat and edited their stop motion video, to narrow their video down to only use 135 pictures. The girls decided to delete some of them because they felt they should focus on the outside of the club where they met and because the community club was a special for both of them. Kia and Sara really wanted to add a song to their stop motion, so after they completed the editing process they began looking for songs on my phone, that they could play in the background. The song they chose was “Survivor” by Destiny’s Child, because they really like Destiny’s Child. Sara, Kia, and I went into a quiet room so that they could add the song so that the microphone would not pick up any background noise. The girls also wanted to ensure that they song started playing in their stop motion video in the correct place. Once they added their song they viewed their video to make sure it looked the way they wanted it to look. Sara and Kia were happy with finished their stop motion video, they ran over to me and stated, “Look Ms. Faith, look at the video we made about us!” (Year 4, fieldnotes).

3D printing (Year 4, Spring). Sara had not attended GEC all semester because she had not transitioned into the Teen community club. Once youth turn the age of 13 they are able to move to the Teen community club which is located in another building behind the larger community club. Because of a strong interest from the teens and stakeholders of the community, they decided to expand the program to the teens, and I began supporting Teen GEC on separate day of the week, for an hour. To get the teen youth “hooked” into the new Teen GEC sessions, Mr. Justin (the Teen center director) and I decided to introduce the youth to 3D printing using TinkerCad. During this first GEC session I taught the youth how to use TinkerCad, a 3D printing platform where they youth could create objects and then print them out using a 3D printer. The teen youth very excited to use the Mac laptop computers to start 3D printing.

All the laptops were sitting out on the tables, with the google doc, with the instructions on how to use Tinkercad, I had already loaded on the desktop (Appendix F). Sara was very excited to be in GEC again. When she walked in she asked, “What are we making today?” (Fieldnote, Year 4). Because of the low number of youth who attended teen GEC, they were all able to work independently on their 3D object. Though the handout I provided guided through the TinkerCad platform, I felt it was imperative for the youth to create and explore. Therefore, after each set of steps the youth had to screenshot their progress. Sara understood how to use TinkerCad very fast. After youth went through the instructions and exercises on how to create 3D object using TinkerCad, I then challenged them to make something that described them; I told them it could be a word or a symbol, but they could not use their own name. Sara was done with the introduction exercises and she was ready to create her own 3D object.

Sara sat at the computer quietly while she found the perfect shapes to create her 3D object. Once she was done, her hand flew up and stated, “Ms. Faith, I am done!” (Fieldnote, Year 4). I asked for her computer to ensure her design was the correct dimensions. Because of the time it takes for a 3D object to print, I informed them to make sure their object was 25in by 25in, this way their 3D object would take about 15-20-minutes to print. Sara passed her computer, and all I saw in big purple letter was the work LOUD. I asked,

Researcher:	Why did you choose loud to describe yourself?
Sara:	Because I am loud and like being loud, Ms. Faith . . .
Researcher:	Ok, are you sure there is nothing else you want to say to symbolize you?
Sara:	Nope, I like it! (Fieldnote, Year 4)

I downloaded it onto a USB card to place in the MakerBot (3D printer). Sara’s purple 3D object, with the word loud printed on it, came out perfectly. Sara was so engaged with the 3D printing process, she stayed after one session, to see and touch the filament that is used in the 3D printer. During the last two weeks of the 3D printing unit, Sara helped other three other youth finish up their symbols using TinkerCad.

Sara’s portrait conclusion. Sara began the GEC program disengaged in science and attending sessions on a consistent basis. Though Sara had instances throughout the program where she did not always agree with her peers, she worked through them and was able to finish her innovations. By the end of this study Sara was the expert in how to do certain STEM task and helped her peers accomplish their goals in GEC.

Kia

Kia is an outgoing 12-year-old dark-skinned African American girl who lives with her mother and younger brother. Kia has attended a charter school in another city for the past 2 years. She enjoys cheering, dancing and acting. Kia loves to work independently on all her innovations. She enjoys school, but is not the best student. Kia has gotten into trouble a few times at the community club because of being disrespectful to other adults. Kia comes to GEC sessions focused and ready to get her work done, most days. She has participated in GEC for the past two years. Kia wants to be doctor when she grows up.

Kia attends a private charter school in a different city in which she lives. She and her siblings, like many of the youth who attend the club are bused to the club from school where they are able to participate in the programing that is available at the community club. Kia is not the best student and does not really like school science. She stated, "the reason why I do not like science at school is because we don't do experiments and stuff." (Background interview, Year 3). She has a close relationship with one of the club's assistant directors, who influenced her to participate in GEC. Kia started GEC at the beginning of our third year and was very enthusiastic about joining the program, because she heard that she "would be able to make things using engineering" (Interview, Year 3). During the initial interview I asked Kia to draw a scientist; she sat quietly and began to draw an old male with a beaker in his hand. When I asked her the reasoning behind her drawing she stated, “This is how I see scientists on TV” (Background interview, Year 3); she was not able to draw an engineer.

Kia began the program at the same time one of her best friends, decided to join GEC. On the first day of GEC for the Year 3, I asked the group to come up with manifesto’s (expectations for the group). For this activity Kia and Sara (another AA girl featured in the study) decided to work with one another to present their suggestions for expectations to the group. Even though both of the girls are new to the group they both felt very comfortable with presenting, because when they got up to speak they both carried sort of confidence that is not usual for girls their age. Kia and Sara felt that is was important to add to the GEC manifesto that everyone who participates in GEC, “Treat each other with respect.”

Paper circuits (Year 3, Fall). As stated earlier in vignettes, paper circuits were how we began Year 3’s GEC STEM enrichment session. During this session we asked the youth to draw something they liked about the community they lived in. Kia, sat at the table for while not drawing anything she was stated, “There is nothing I like about where I live” (Field Note, Year 3). After sitting with her over 10 minutes asking her questions to help of think of something she liked about her community, she finally stated, “Oh yeah the community center! I like the community center because the remodeled and it looks better” (Field Note, Year 3). Once she came to realization she began to draw a picture on purple paper of the newly remodeled community center in her neighborhood. Once she was finished with her drawing, I reminder her that she needed to add an electronical circuit and choose where she wanted to attach her LED's. She decided to put green lights where had drawn 2 shrubs. Kia drew two series circuit on the back of her paper, she made sure to put dots where she wanted her lights to go and a circle for where the battery would go. Kia then attached the copper tape (to enable electrons to flow) on top of the lines she drew, and poked holes for her lights. Kia was able to get the lights instantly, she was so happy once the first light lit up, she stated, "Look Ms. Faith it's working!!" (Field Note, Year 3). Kia went through the same process for her other green light in the shrub. Below are pictures of Kia drawing the community center and after she attached the green LED's.

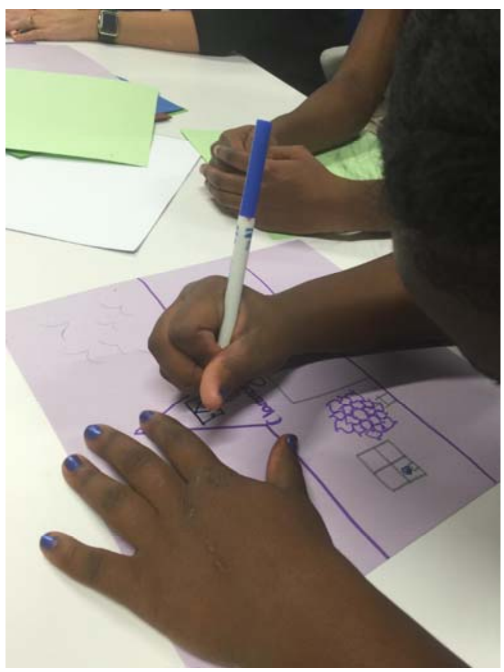

Figure 49. Kia Drawing out Her Picture of the Community Center. She Insisted on a Purple Paper, because it is was Bright and Pretty.

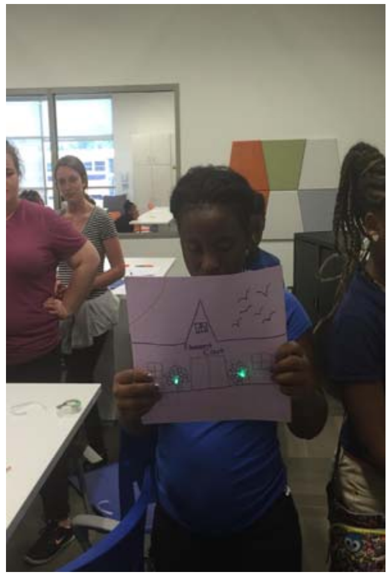

Figure 50. Kia with Her Finished Product. Kia: “I Wanted to Draw a Community Center because They Had Remodeled and Made it Better. So Now They Can Go in It and Do Different Activities.”

Toy car (Year 3, Spring). In this week’s GEC session, we were building the youths knowledge on how toys work by making Styrofoam cars. Kia walked in and asked, “What we doing today?” (Fieldnote, Year 3). I explained that they were going make their very own race car, Kia, looked as at me in disbelief. She does this often at the beginning of GEC sessions when we are introducing a new unit. At the beginning of this session I could tell that Kia was not having a good day, because she did not to talk to any of her peers and she had sat isolated from the group. Sometimes things happen at school or home that really affect her attitude in GEC. Once she sat down and all the youth got settled in their seats, I showed youth videos of race cars and race car drivers. During this session youth were tasked with the challenge to a build a race car out of Styrofoam, metal rods and plastic wheels. The youth could either work independently or with a partner; Kia decided to work with Sara (another AA girl in the study). Often times when the two girls work together they argue and fight. This session was not any different. The two girls sat beside one another and drew out their car, but argued about how it should look, how big it should be, and how they should decorate it. Sara, began to disengage as she normally does, when they start arguing and Kia began to draw out how she wanted the car to look. Because of Sara's disengagement, the girls decided to work independently for this project. Kia wanted to make her car look like the letter K (for the first letter in her name) and add a lot decoration to make it look "pretty" as she stated. Once Kia was done with her drawing, she showed it to me to see if she could begin the building process and get a piece of Styrofoam in order to start making her car. Kia drew out the outline of the car on the Styrofoam and brought it over to me to assist so that I could her with using the Styrofoam cutter (a tool with a hot piece of wire used to cut Styrofoam). The first piece of Styrofoam she brought over had a very large K drawn on it. I cut out the K car using the Styrofoam cutter and handed it to Kia. Kia decided only to attach her four wheels very close to each other on her race car (side by side), instead of placing two wheels in the back and two wheels in the front. I asked Kia why she decided to position the wheels on her race car so close, she stated "I think it will make the car weigh less and make the car faster, Ms. Faith" (Fieldnote, Year 3). Kia felt the plastic black wheels weighed too much, so putting them closer together would help with the car weighing less.

During the second toy car making session, the youth were expected to finish their cars and race them. Kia began putting the finishing touches on her K car as soon as she walked in. She added cotton balls, colored parts of her K car with a maker and added a button for decoration. Once Kia was finished with all her decorating she was ready to race against her fellow GET citians. The youth were expected to run several trials, to see how they could make their car faster. Kia's car did not do well in the first run of races, because on of wheels kept coming off during the race and her car was one of the biggest cars in the group. After this first run she realized she need to make her car smaller. She went back into the GEC room and cut her K car down to about the original size. This modification worked, Kia's car began winning races. During the video dairy Kia stated the following:

Researcher: Can you describe your cars design to me?

Kia: At first, I going to add just the foam and the wheels, then I thought, that I needed to make my K a little bit smaller.

Researcher: Did making your car smaller help?

Kia: Yes, I began to win races after I made my car smaller.

Researcher: How did you feel during this making process?

Kia: I liked it! I felt creative! (Video Diary, Year 3).

Figure 51. Kia's K Race Car after Two of the Wheels Fell Off.

Automaton (Year 3, Spring). "Ms. Faith, what in world is an Automata?" (Field note, Year 3), Kia asked me when she walked into the GEC session and looked at the board at the agenda for the day. I stated, "it is automaton, not automata" (Field note, Year 3). We usually don't correct the GEC citians when they say something incorrectly; however, I wanted Kia to get used to saying the term correctly, so when she it was time for her to present the community, during the GEC expo, her audience would understand her. The automaton unit was a continuation of our unit on toys, we felt it was imperative that the youth to understand how levers, wheels and pulleys are used in the mechanics of a lot of toys. I began the with a short you-tube video that featured multiple examples of the automatons, so youth could visualize what they were about to create. Next, I went over the materials the youth would use to make their own automaton, for example, shoe boxes, wooden kabob sticks, thick foam for the wheels, glue, and a variety of decorating materials. Youth then had to draw out what they wanted their automaton to look before they could start the building process. For this project, youth had the choice to either work independently or by themselves. Kia decided to work by herself to create her automaton. Kia sat beside me to plan out what she wanted her automaton to look like. She chose a to decorate the box with decorative tape and put a crown on the top of the box. I asked Kia why she wanted to put a crown (a pink crown specifically) on top of the box, she simply stated that she was a princess. After Kia decided on who she wanted the outside of the box to look, I informed that she now had to decided how she wanted her crown to move, whether she wanted it to go up and down or side to side.

Kia found a shoebox to use for her automaton; this process took a while because she wanted just the right box. She finally picked a medium sized shoe box. Kia began making her automaton by poking holes in the sides of the box with a pair of scissors. Kia thought this process was difficult because she had to poke holes into a cardboard box.

Kia: My Faith poking holes in cardboard was hard!

Researcher: Keep trying, you will get it!

Kia really wanted to give up on the whole process of making an automaton; however, within about 5 minutes, she got the hang of it and was able to poke all of her holes for her skewer sticks. Kia then started making her two wheels to make her crown go up and down. Kia cut two small circles from the black foam. One circle had a small triangle cut into it, so that the crown would go up and down, Kia made her last circle with no cut outs. After Kia cut the circles out, she then pokes holes in both the circles so that the skewers we go through them. After she placed the skewers inside the circles, she then put the skewer with the Circle that had the triangle through the shoebox. she then put the skewer with the full circle through the top at the shoebox. this skewer had her pink, felt, crown attached to it. The was crown decorated with cotton balls and markers, to make it look like the crown of princess (Fieldnote, Year 3). Once Kia finished putting her skewers through the shoebox she started decorating the outside of the box. She used decorative tape too make her shoebox colorful and bright. When I asked Kia about the decoration on her Automaton she stated the following:

Kia: I added the stuff on the back, because I think it looks too plain with nothing on there and I felt it needed to be decorated. It was really hard for me to poke the holes in the box, but I realized that I had use different forces in order to poke the holes in the box. I feel pretty sure that I would give to a kid who is homeless and show them they could do anything or a child at shelter and let them play with it.

Kia finished her automaton in total of two GEC sessions. Kia also ended up finishing her automaton today. However, while she was finishing her automaton she also made herself a phone case with the materials we supplied for the automaton. She was very proud of her phone case creation.

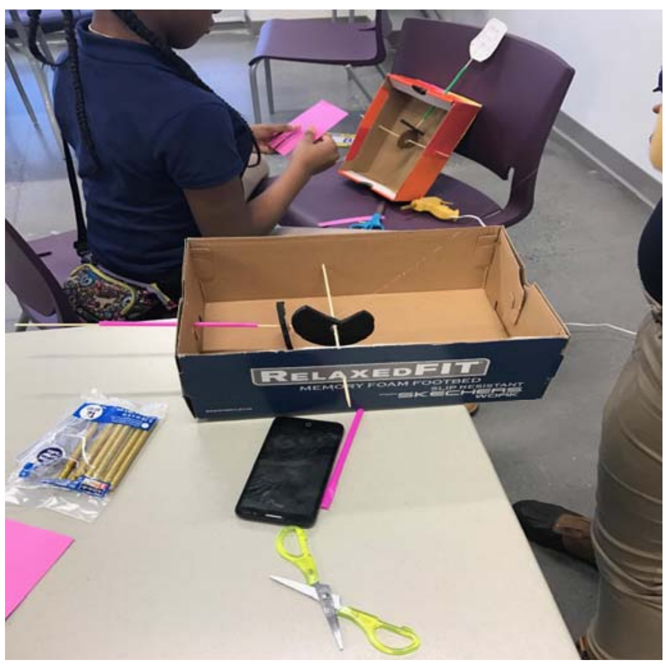

Figure 52. Kia’s Automaton after She Had Put the Wooden Skewers and the Black Pieces of Foam through Her Shoe Box.

Figure 53. Kia’s Finished Project. When I asked Her Why She Chose to Put a Crown on Top of Her Automaton She Stated That Her Family Considers Herself a Princess. Kiera Did an Excellent Job with Staying Focused and Getting Her Automaton Done.

Toy purse (Year 3, Spring). We were coming to an end of our toy unit and we wanted the youth to make toys for other youth, especially those who are younger than themselves. Kia decided to work by herself on this project. Kia sat beside me as she normally does and began researching what she wanted to make. She went from a shirt that lights up, to a hat that has sparkly lights and she finally decided to make a purse with on LED light on the front of it. Once she decided on what she wanted to make, Kia then began to design her purse. She looked Pinterest to get ideas on how she wanted her purse to look. She decided that she wanted her purse to be shaped like a half circle. We then looked for the type of material Kia could use to make her purse. She wanted the purse to be “girlie” so she picked out a pink piece of fabric with white polka dots. She began sewing together the two pieces of fabric with pink thread; in the beginning she was sewing the two pieces together by leaving wide gaps between each stitch. I showed by making such wide stitches she was going to leave holes in her purse. We turned the purse inside out and I showed her how fingers poked through the holes. She laughed and she said, “Yeah, Ms. Faith I need to re-sew it.”

Figure 54. Kia Sewing Her Purse Together. She Did Not Finish Her Purse during the First Toy Making Session.

Once Kia had the two pieces of pink and with white polka dots fabric together, she then picked out a bright blue piece of fabric for the strap for her purse and began sewing it onto the purse. Kia then decided to try something different with her LED light bulb. She found a piece of plastic that had a flower printed on it, so she decided to use that piece of plastic, not just as decoration, but she also wanted to attach her LED bulb on the plastic flower. I told her that instead of using conductible thread as planned, we will have to use conductible tape, because the circuit that she was completing is not on fabric it is will be on plastic. Kia stated, “Oh, like what we did with the paper cards?” I told her yes, and she began looking through the bins for some conductible tape. Kia sat down and began to complete her circuit. She checked to see if the LED bulb worked by placing the positive and negative end on the battery and once it lit up she began placing the conductible tape on the plastic to complete her circuit. She poked a hole in the middle of the plastic flower and put the battery on the opposite end of the conductible tape, Kia said, “Look Ms. Faith, it works!”

Figure 55. Kia’s Purse with the Plastic Flower She Sewed on it for Decoration. She Decided to Put the LED Bulb at the Top of the Flower.

Kia was the first youth finished with her toy, so she decided to that she wanted to make another toy innovation. She was so excited about her purse, she said “That was easy, I want to make something else for a kid who needs it.”

Toy safe (Year 3, Spring). Kia grabbed a computer and began looking for ideas of toys to make for a child. A toy safe that actually locks caught her attention instantly. She stated, “Look Ms. Faith!! I want to make this!,” pointing at the computer of cardboard safe with a small cap on it for the handle. I said ok, we can do that. Kia ended the session by making a list of all the materials she needs in order to make the safe.

The next I brought all the materials Kia needed in order to make her toy safe. I brought her a white cardboard box, rubber bands, a motor, battery, small and large popsicle sticks, a bottle cap and wires, she was so excited when she all the materials I brought her. We sat down together and searched for a you-tube video to help guide her through the process. She found a video, that helped her step by step on what she is supposed to do. She began by cutting a small door in the middle of the box, Kia then moved onto the electrical circuit that would make the box lock and unlock. She hot glued the popsicle sticks down in the formation that was indicated in the video, she then glued down the motor on the door of the box. Kia began to complete her circuit by placing the battery in the bottom of the box and attach the wires from the motor to the battery. She ran in some difficulty when this did not work as planned. She tried several times and she when it would work the third try, Kia began to get very frustrated and almost gave up. I decided to step in and guide her through the process. Together we sat down and began to work on the circuit. After watching the YouTube video several times we finally, saw the rubber band move the popsicle stick to open the latch on the door. Kia was proud of herself that it finally worked the way she wanted. She finished up her toy safe adding a green bottle cap, that served as the knob to open up the small white door.

Figure 56. The Mechanics in the Toy Safe. The Picture Shows the Popsicle Sticks and Rubber Band Attached to the Motor, which Served as the Locking and Unlocking Component of the Toy Safe.

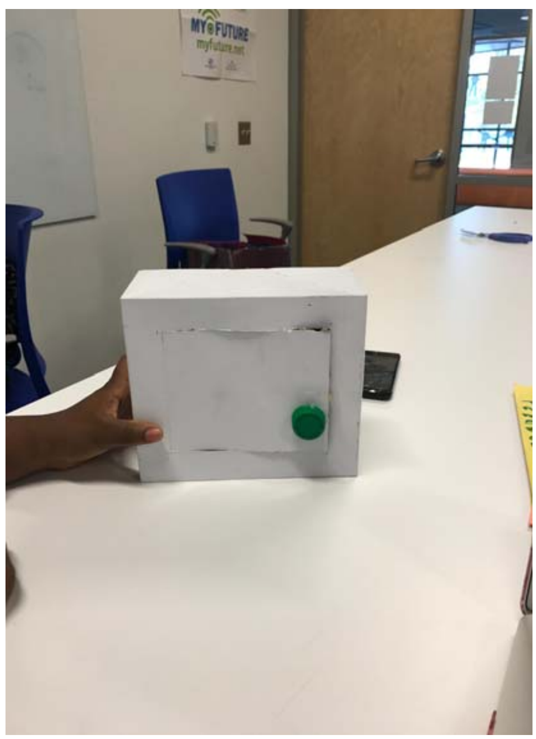

Figure 57. Kia’s Finished Product, with Addition of the Green Cap That Served as the Knob for the Safe.

Kia's portrait conclusion. Kia has been in GEC for the past 2 years and has enjoyed a space where she could use her STEM knowledge and practices to make innovations for others and herself. Kia likes to work by herself as seen in the above vignettes, she like the freedom to talk with her peers will working through her assigned STEM task. Kia like all of the girls in this study faced tensions while engaging in STEM however, she persevered with the support from her "sister" in GEC. GEC was space where Kia, a girl who been classified as a loud Black girl, could go against that stereotype and show her community what she could accomplish.

Summary of Portraits

The above portraits highlight the AA girls in this study experiences in GEC. As shown through various making vignettes the AA girls in this study were supported by their peers and adult mentors while participating in this informal STEM space. The AA girls in this study used their STEM knowledges and practices in numerous ways to create innovations for the people in their community. Each of the above portraits describe instances of how the AA girls in this study built products that focused on the needs of their community while incorporating STEM practices so that they could become agents of change.

Participants' Description While in GEC

Table 5 depicts the AA girls in this study identity markers while participating in GEC. The identity markers were determined by how each participant's identity was impacted while they were participating in GEC. For example, Jasmine displayed a positive STEM identity throughout her years in GEC; in contrast, Erin's STEM identity fluctuated throughout her participation in GEC.

Table 5

Participants' Description While in GEC

Participant	Age	Grade Level	Type of School	Years in GEC	ID Marker
Jasmine	12	6	STEM Charter	2	Positive STEM ID
Erin	12	6	Public	2	Fluidity in STEM ID
Amber	12	6	Public	1.5	Fluidity in STEM ID
Kia	12	6	Charter	2	Positive STEM ID
Sara	13	7	Public	2	Fluidity in STEM ID
Shawna	13	8	Public	4	Positive STEM ID

AA Girls' Engagement in STEM Practices in the GEC

Table 6 describes the participants making projects and how they correlate with their science, making, engineering, technology, and math knowledge and practices in conjunction to state Math/Science standards and Next Generation Science Standards.

Table 6

Girls' Engagement in STEM Practices

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Essential Math and/or Science Standards	Next Generation Science Standards
Paper circuit electric art	Electricity, electron flow, closed circuit, power source, load, energy demands, different energy requirements of different color LED light bulbs	How to lay down copper tape smoothly, how to turn "sharp" corners, how to sandwich LED "legs" between pieces of copper tape, using other material for the artistic part of the card, e.g., card stock. pipe cleaners, etc. Using hot glue gun.	Design constraints - how the art component has implications on the layout of the circuitry		Understanding the length of the conductible tape when creating a circuit, ensuring that is the correct length for the paper and not too long or short	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. Explain open and closed circuits. · Compare series and parallel circuits. · Conceptually explore the flow of electricity in series and parallel circuits. · Explain how the flow of electricity through series and parallel circuits is affected by voltage and resistance.	HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Table 6

Cont.

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Essential Math and/or Science Standards	Next Generation Science Standards
Toy Car	Toy Car: Mass, acceleration, force, ramp height, ramp width, length of ramp, length of car, dimensions of car, kinetic energy, mechanical energy, potential energy	How to design a car that will win races, ensuring the car design does not weigh too much, the designing of the car that does not weigh the car down	Designing the car in multiple iterations to make the car go faster when in a race		Dimensions: how to ensure that the dimensions of the car are a good length to make the car race well	7.P.2 Understand forms of energy, energy transfer and transformation and conservation in mechanical systems. 7.P.2.1 Explain how kinetic and potential energy contribute to the mechanical energy of an object. 7.P.2.2 Explain how energy can be transformed from one form to another (specifically potential energy and kinetic energy) using a model or diagram of a	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Table 6

Cont.

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Essential Math and/or Science Standards	Next Generation Science Standards
Toy Car (cont.)						moving object (roller coaster, pendulum, or cars on ramps as examples). 7.P.2.4 Explain how simple machines such as inclined planes, pulleys, levers and wheel and axles are used to create mechanical advantage and increase efficiency.	
Doll House	Paper Circuits: to make lights in bedrooms in the house, energy demands, color of lights in the rooms, Electricity, electron flow, closed circuit, power source,	How to design the dollhouse the correct size, how to make the paper circuits, and lay the copper tape correctly, using hot glue gun, paint, and	Designing multiple iterations of the dollhouse to ensure that all the components are there and work correctly, for example putting lights in	Putting together the PowerPoint for the GEC expo, downloading pictures, adding amination and music to the PowerPoint	Dimensions: how to ensure that the dimensions of the rooms are the correct size, width and length, measuring to make the	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. · Explain open and closed circuits. · Compare series and	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an

Table 6

Cont.

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Doll House (cont.)	load, energy demands, different energy requirements of different color LED light bulbs	decorate the dollhouse	the room and engineering the room the correct size for the paper circuit.		furniture are the correct size to go into the rooms	parallel circuits. · Conceptually explore the flow of electricity in series and parallel circuits.	optimal design can be achieved.
Automaton	Automaton: levers, pulleys, ramps, wheels, gears, how toys move with levers, pulleys, mechanical energy, kinetic energy	Making the foam circles the correct size to make the object on top of the skewer move either up and down or side to side, make sure the black foam pieces are placed in the correct place for so that they object moves the correct way	Creating a design for the automaton, then making the design ensuring that the design works. Altering the design if the design of the automaton does not work. Having to create multiple iterations of the automaton to make sure it works.		Dimensions: ensuring foam circles were the correct circumference, making sure the sticks are the correct length in the shoebox, measuring to ensure the characters for the theme are the correct size for the top of the shoebox.	7.P.2 Understand forms of energy, energy transfer and transformation and conservation in mechanical systems. 7.P.2.4 Explain how simple machines such as inclined planes, pulleys, levers and wheel and axels are used to create	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Table 6

Cont.

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Automaton (cont.)						mechanical advantage and increase efficiency.	
Toy Purse	E-textiles: conductible thread, electricity, closing circuit, battery, power source	Picking out the fabric for the purse and cutting out the fabric for the design Kia created. Sewing the two pieces of fabric together to ensure there were now holes during the sewing process. Sewing the strap onto the purse. Sewing the plastic flower and adding the LED bulb.	Examine the purse after started sewing the two pieces of fabric together and then having to re-sew because Kia noticed that there were holes between the stitches. Having make a couple iterations of her original design.		Measuring out the shape of her design ensuring that it was not big enough or too small. Measuring out the strap of her purse. Ensuring the conductible tape is not too long to for the small flower that was sewn on the front of the purse	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. · Explain open and closed circuits. · Compare series and parallel circuits. · Conceptually explore the flow of electricity in series and parallel circuits.	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Table 6

Cont.

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Toy Purse (cont.)							3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Toy Safe	Electricity, battery, how a motor works, using alligator clips to make a motor work with a battery	How to use the card box to make the toy safe, cutting out the door for the box, attaching the popsicle sticks to make the lock for the toy safe. Adding the rubber band and motor for the lock of the	Making a couple iterations for the safe to ensure that prototype of the lock worked correctly so that the lock would work		Ensuring the popsicle sticks were the correct for the inside of the box to create the lock. Making sure the rubber had the correct circumference when attaching it to the paperclip and the popsicles. Ensuring the	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. · Explain open and closed circuits. · Compare series and parallel circuits. Conceptually explore the flow of electricity in series and	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 2. Generate and compare multiple

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Toy Safe (cont.)		safe. Also attaching the battery to make a circuit to lock the safe.			box door was the correct width and length so that items would fit inside the box.	parallel circuits.	possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Table 6

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Light up Pillow	E-textiles: conductible thread, electricity, closing circuit, battery, power source	Designing the pillow before making. Deciding on the color of the fabric, using both regular sewing thread and conductible thread, sewing the fabric together ensuring there are no gaps in the fabric so that cotton falls out of the pillow. Making the front piece with the initial on it and sewing it on the front of the pillow.	Having to make alterations to add the felt piece on the front of the pillow so that the cotton would interfere with the circuit. Making several attempts to the electrical circuit for the LED bulb.	Putting together the PowerPoint for the GEC expo, downloading pictures, adding amination and music to the PowerPoint	Measuring the heart to make sure it is not too big or too small. Measuring out the conductible for the circuit so that it reaches the battery pack and the LED bulb.	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. · Explain open and closed circuits. · Compare series and parallel circuits. Conceptually explore the flow of electricity in series and parallel circuits.	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3.Plan and carry out fair tests in which variables are

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Light Up Pillow (cont.)							controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Light Up Head Band	E-textiles: conductible thread, electricity, closing circuit, battery, power source	Picking out fabric for the headband, placing the specific pieces of the headband in a certain order. Sewing the pieces of the fabric together for the headband. Using conductible thread and regular thread to make the headband	Making several iterations of the headband making sure the headband is the correct length. Making several attempts to the electrical circuit for the LED bulb.	Putting together the PowerPoint for the GEC expo, downloading pictures, adding amination and music to the PowerPoint	Measuring the fabric pieces to ensure they are not long or short. Measuring the conductible thread and regular thread making sure they were long enough to make the headband and complete the electrical circuit.	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. · Explain open and closed circuits. · Compare series and parallel circuits. · Conceptually explore the flow of electricity in series and parallel circuits.	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 2. Generate and compare multiple possible solutions to a problem based on how well

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Light Up Head Band (cont.)							each is likely to meet the criteria and constraints of the problem. 3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Music Hoodie	E-textiles: conductible thread, electricity, closing circuit, battery, power source	Determining how to create a circuit on the hoodie. Learning how to sew and how to place the wires on the hoodie.	Making several iterations of the hoodie, trying to figure where to place the speakers on the hoodie so that they can easily hear the music. Learning how	Learning and understanding how to program the Arduino, how download music as an mp3 file	Measuring out the wires to place them on the hoodie. Measuring out the thread to make sure they were long enough to	PSc.3.3.2 · Interpret simple circuit diagrams using symbols. · Explain open and closed circuits. · Compare series and	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on

Table 6

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Music Hoodie (cont.)			to place the soft wires on the hoodie to ensure that the hoodie's wires would be hidden. Programming the Arduino to play music.		complete the circuit.	parallel circuits. Conceptually explore the flow of electricity in series and parallel circuits.	materials, time, or cost. 2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
3D Printing	Calibrating the table so that the 3D object prints correctly, the heating and cooling of the filament	Using TinkerCad to make an object of the name plate. Designing out the nameplate and determining which objects to make the parts of the name 3D.	Drawing and making the letters so that they are not too big and choosing the correct materials for the 3D letters	Learning how to use TinkerCad in order to make the 3D objects, how to download the 3D object to a USD to print, how to move the 3D object to the MakerBot program to print	Measuring out the object to ensure it is not too big for to be printed in a certain amount of time. Paying close attention to the width, length, and depth of the object.		Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
Stop Motion	Connecting topics learned in GEC and their science classes at school highlighting them through stop motion using the iPad	Editing the stop motion video adding and deleting the pictures the girls wanted to feature in the stop motion video	Taking several pictures to make sure backgrounds that the girls wanted	Learning how to use the stop motion platform to make stop motion videos			Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Dome	Connecting the triangles so that they connect in order to make a dome figure	Cutting out triangles ensuring they were the right dimensions. Attaching the triangles, the correct way. Designing the dome, the correct way so that younger youth could climb into it.	Trying several different ways to cut out the triangles. Trying different ways to attach the triangles to each other.	Putting together the PowerPoint for the GEC expo, downloading pictures, adding amination and music to the PowerPoint	Measuring the length and width of the pieces to make the dome, ensuring that the dimensions work together to put together.	NC.6.G.1 Create geometric models to solve real-world and mathematical problems to: • Find the area of triangles by composing into rectangles and decomposing into right triangles. • Find the area of special quadrilaterals and polygons by decomposing into triangles or rectangles.	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3.Plan and carry out fair tests in which variables are

Table 6

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Dome (cont.)							controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Toy Dissection	Using tools to Understand how toys work, how energy is transferred to make a toy move in certain directions. How batteries make toys move because of the flow of electrons.		Drawing the components of the toy to better understand how the toy moves and works			NC.7.P.2 Understand forms of energy, energy transfer and transformation and conservation in mechanical systems.7.P.2.4 Explain how simple machines such as inclined planes, pulleys, levers and wheel and axels are used to create	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Table 6

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Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Toy Dissection (cont.)						mechanical advantage and increase efficiency.	
Lonely Flower		Using a cardboard box to build a toy box to put toys in for the toys that were being made. Deciding on how big to make the box and how to decorate the box	Drawing out a design on how the box should look and using the design to determine how the big the box should and how the box should be decorated.		Measuring the length and width of the pieces to make the dome, ensuring that the dimensions work together to put together.	NC.7.G.4 Solve real-world and mathematical problems involving area, surface area, and volume.	1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Table 6

Cont.

Making Project	Science Knowledge & Practices	Making Knowledge & Practices	Engineering Knowledge & Practices	Technology Knowledge & Practices	Math Knowledge & Practices	Math and/or Science Standards	Next Generation Science Standards
Lonely Flower (cont.)							3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Cross Case Analyses

In this section I construct four cross case analyses drawing on the data presented in the above portraits to answer Research Question 2, “How might a setting free (or as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls’ STEM identity/agency and sense of sisterhood?” Each cross-case analysis’s theme emerged from looking across the data of case study participants, and each theme builds on one another. The first cross case theme illustrates how collaboration shaped girls’ engagement in STEM tasks. This culture of collaboration, I argue, created a space for girls to connect and support one another in multiple ways, setting the stage for an ethic of sisterhood. In the second theme, I argue that the enactment of sisterhood created a safe space where the girls felt supported and worked together, which became salient to the girls’ participation in GEC and how they navigated tensions when they arose. This is slightly different than collaboration in that the girls bond helped them navigate through struggles to complete STEM tasks. I unpack how the girls’ ethic of sisterhood connected with the ways they used their STEM expertise to serve, build, and leverage their GEC and neighborhood community resources, which is the focus of the third theme, Community. My final cross case theme focuses on the girls’ identity work in this STEM space. I argue that the girls’ gendered and STEM identity work was interconnected, a phenomenon which GEC supported and normalized with the cultural norms created in the setting. Throughout all four cross case themes, I illustrate the ways girls’ STEM expertise was developed and leveraged as integral parts of their activities. In other words, all of their projects demanded authentic, rigorous STEM learning and developing expertise.

Cross Case Analysis Theme 1—Collaboration: Storytelling and Joint Activity

Collaboration can look different depending on the space, the people in the space and the activity that is taking place in the space. Collaboration can simply be defined as working with someone or a group of people who are working together to solve a problem or build a new innovation. Collaborative discourse in the classroom and workplace is imperative, because it supports youths' and adults' ability to share ideas and talk through problems with one another. Specifically, STEM professionals collaborate with one another on regular basis in order to accomplish goals (Fowler, 1997; Thomas, 2015). I have found during GEC sessions that collaboration was significant to the girls' engagement in STEM tasks. The girls depended on the time and space to talk through problems, collaborate with one another on how to create innovations when given a STEM task or just given the freedom to talk about the happenings of their day. Having a space where the girls could engage socially, even if they're not working on the same product was imperative to how they engaged in STEM. They enjoyed a STEM space that embraced porous boundaries, a space where they could share narratives and storytelling that may not have been completely focused on STEM. The girls could talk, be social and help each other, without feeling as though they had to conform to a more regimented quiet STEM space. The girls in this study were able to use their own narratives and storytelling while working on STEM task which was a central aspect of their work at

GEC, because in this STEM space they felt their stories were important and would be heard.

GEC encouraged socializing, narrative, and storytelling practices which was found to be important to the girls because it was a safe space for them work together, share feedback, wisdom, ideas, STEM-related and not. Having a space where storytelling is embraced can be significant for African American women and girls, because storytelling is used “to connect with others and find meaning in our individual and shared experiences” (Lawrence & Paige, 2016, p. 66). GEC gave the girls in this study a space where they could more freely be themselves and share their experiences through discourse while working together on STEM task.

Socializing, Storytelling

Sara and Kia. Sara and Kia were good friends and would spend their time together in GEC to catch up on the day’s happenings, for example, the activities the community club may have for the youth during the week or what happened at school that day. The girls did not attend the same school, so GEC sessions were times when the two girls could work on STEM tasks, while chatting with one another, about new things going on in their lives, what they did during the weekend and what they were going to do the next weekend. Sara and Kia would sit beside one another during every GEC session so that they could converse, while supporting one another during projects. Even though, Sara and Kia did not work together on projects often, they would assist one another during each GEC session on their individual projects. Sara and Kia enjoyed having the freedom to sit and talk at GEC, which was imperative to how they worked on their projects and how they engaged in STEM. Each of them seemed to need this time to be social, as evidenced by the following examples.

Sara. Sara thrived in a setting that supported her freedom to talk with her peers. This was apparent when she was able to communicate with her peers on how use TinkerCad. During the 3D printing unit, Sara sat behind her computer and talked to whomever was sitting around her. It was evident that she needed that space to ask questions, talk through how to use TinkerCad or simply chat. Even though she spent much of the 3D printing GEC sessions talking she was the first one finished with her design. Sara created an image with LOUD spelled out in capital letters, because she said people think she is loud. Sara stated, “I don’t get to talk like this in school, I get in trouble and then I get upset” (Fieldnote, Year 4). Because Sara had the freedom to talk with her peers, while working on STEM tasks, she did not feel as though she had to conform to a more restricted science space, which based on Sara’s experiences have been quiet, with limited opportunities for student discourse. The limited student discourse was frustrating to Sara as seen in the above quote because she felt as though she could use her voice in school STEM spaces, like she could in GEC.

GEC provided the space where Sara and Kia could socialize and work on STEM task; which was imperative in how they engaged in STEM, because they understood that their freedom of discourse was supported in this space.

Sharing the Load: Co-own the Labor

In this sub-section, I describe three cases that illustrate a consistent practice of girls “sharing the load” during their GEC projects. The atmosphere was not at all competitive, which in and of itself is a contestation of typical school STEM spaces. They did not try to outdo one another in this space. Instead, they supported one another's efforts, often dividing up a larger project into smaller pieces in which they could each tackle individually or in pairs. The cases below illustrate this productive collaboration and co-ownership.

Amber and Tia. Amber depended on the collaboration with her peers during many of the GEC sessions. For example, during the automaton task, Amber and her partner, Tia talked through the building of their automaton. The girls sat together and planned out what the theme of their automaton would be, the characters they wanted to focus on and how those characters would move. Amber and Tia stated,

> Amber: What should we make?
>
> Tia: Let's do something from Nemo, like some fish.
>
> Amber: Ok, let's make Nemo move up and down, like he's swimming in the ocean.
>
> Tia: I want to make it colorful, let's use these foam pieces (pointing at foam that was laid out on the table). (Fieldnote discussion, Year 3)

The two girls sat on the floor with one another after they had planned how their automaton would look and how little Nemo would move on top of the shoe box. Amber served as the helper through much of the making process; however, there were times when Amber would question Tia on getting a specific item or designing the Automaton a certain way. For example, Tia wanted to deviate from their planned design and make Nemo (their foam fish) move side to side. Amber reminded Tia that by making that change, that Nemo would not look as though he were swimming. I found, it was essential for the two girls to be given the freedom to talk about the design and making process, share ideas and assign task to one another. This space provided them opportunities to be creative and problem solve, essential practices of science and engineering.

The dollhouse project. Another example of how collaboration can further engage AA girls in STEM practices was the GEC making toy unit. Amber, Jasmine and Tia (another AA girl in GEC, not featured in this study) worked with one another on a Dollhouse. During the making of the dollhouse Amber and her partners would sit on the floor and talk through the items they wanted to add to the dollhouse, for example, bedrooms, a play area, lights and furniture. After the girls designed their dollhouse they then sat together and talked about the materials they needed to complete their innovation. The girls' list included: cardboard, LED lights, glue, fabric, cotton, batteries, copper tape and paint for decorating. The girls sat together during each GEC session working their dollhouse, adding all rooms and features they felt would make their dollhouse special. Through collaboration the girls decided while Tia and Amber finished decorating the dollhouse, Jasmine would use her STEM expertise and make the paper circuits for the lights in the bedrooms. Tia and Amber worked on measuring and cutting the cardboard pieces the correct sizes for the rooms and floors. Because, Jasmine was fluent in circuity the group appointed her to make the paper circuits for the lights in the bedrooms. Creating a space that supports the freedom of collaboration to work through the design and making process helped the girls finish their dollhouse. Since the dollhouse was such an involved, long-term project, I refer to it in later cross-case analyses, too. My point here is that the dollhouse offered a way for each girl to contribute to some aspect of the whole project. The girls broke the huge task down into subparts, and each played essential roles in completing the project. There was a shared sense of accomplishment when they finally, after months of work, finished the task. For example, once Jasmine was able to get the LED bulb working the girls celebrated together that the dollhouse now had lights in each room.

3D printing. Co-owning the labor was also significant during the GEC session 3D printing activity, Amber and her peer sat together, shared a laptop, and helped one another go through the different exercises in order to learn how to use TinkerCad. Through Amber's collaboration with Jasmine during the 3D printing activity, Amber became an expert in TinkerCad. Amber was able to talk through the 3D internet-based platform with her peer as they were going through TinkerCad. For example, Amber's partner would read through the instructions on the interactive sheet and Amber would then do the task in TinkerCad. The goal of this 3D printing session was for the youth to understand how to make an object, so the girls worked to together manipulating the millimeters of a rectangle to make the base of a boat. This collaboration was beneficial to Amber's engagement in the 3D printing activity because through co-owning the project with Jasmine, Amber understood how to manipulate an object in TinkerCad.

The above examples provide evidence in how co-owning can influence AA girls' participation in STEM task. Providing spaces that support socializing and free discourse can be important in how AA girls navigate STEM spaces. Various forms of discourse that was facilitated from having a porous STEM space, now included robust STEM discourse integrated with social discourse. Resulting in the sisterhood that the girls established being anchored in STEM knowledges and practices.

Cross Case Analysis Theme 2—Sisterhood: Safe Spaces, Mutual Support, and Working through Disagreement

Sisterhood is the sharing of ideas, struggles and celebrations with someone who shares an identical oppression. Sisterhood is also taking ownership of someone else's struggle as your own. Collins (1986) stated that AA women have supported one another for centuries through childbirth, slavery and now, through forms of academia. This support has been key for the success and perseverance of many AA women, a claim that has been supported in various studies (Johnson et al., 2011). Sisterhood is more than girls being good friends. It includes: supporting each other through all tasks, struggling with the person when they do not have to, helping other AA girls work through a task as a group, and the creation of a safe space, where AA girls can be AA girls. However, there can be tensions within sisterhood that result in disagreements. Using sisterhood as way to work through these tensions and continuously support and celebrate one another is the central aspect of a true sisterhood.

All of the girls who participate in GEC share the same markers of oppression, for example, gender, race, and socioeconomic status, and similar kinds of marginalizing experiences when it comes to STEM and AA girls' positionality. Through these commonalties and sharing oppressive experiences (with the acknowledgement that each girls' experience within the matrix of oppression is unique to her), the AA girls in GEC have formed their own sense of sisterhood in this STEM space. For example, during some of the weekly GEC sessions, the girls in this study celebrated the times when this

STEM space was all girls (i.e., when no boy was present that session) and that they were able to use their STEM identity as a resource to help other AA girls in GEC. For example, when Amber saw Donna having a difficult time understanding how to use TinkerCad, she stepped over to assist her in how to use the program and helped Donna throughout the 3D printing unit so that Donna would be successful with printing a 3D object.

This cross-case analysis paints a portrait of what this sisterhood looked like, what practices supported it, and how the girls enacted sisterhood in light of some serious disagreements. Sisterhood, as I illustrate below, is not an automatic outcome of a gathering of girls facing similar kinds of oppression. It was, however, an ongoing negotiation, performance and solidification in the GEC setting, one that became a resource for girls' meaningful and fulfilling STEM engagement.

Safe Spaces

Amber and Sara: Leaving GEC and returning to GEC. The AA girls who participate in GEC exhibit sisterhood in a variety of ways, for example celebrating one another's accomplishments, assisting each other when someone is struggling during a STEM task, encouraging one another through STEM tasks, and working together to accomplish a common goal by sharing ideas with one another. Establishing a space that supports sisterhood also influences safe spaces for AA girls. This was evident in Amber and Sara cases, because both girls had time periods through their years of participating in GEC when they stopped attending GEC sessions. Amber had come from a troubled home life which made her attendance inconsistent for almost a year. She had times when she would not attend GEC sessions for months, because of things going on at home. Sara also had moments when her attendance was inconsistent, for reasons such as disinterest in the community club or school suspensions which inhibited her from attending the community club and GEC. Sara, who is one of the older youths in GEC, would become disengaged, if she felt there were no other girls in attendance her age. However, during Year 4, Amber and Sara began attending GEC on a consistent basis because, both girls felt that GEC was a space they could always come back to when they were ready; they felt it was a safe space. Sara and Amber found "safe-ness" in GEC, because of the relationships that they formed in this space. Both girls had times in their lives when they faced troubling experiences at home and at school; however, both girls enjoyed engaging in the STEM activities at GEC. The established sisterhood at GEC created a safe space which played a significant role as to why Sara and Amber kept participating, even after periods of inconsistent attendance.

We Argue, But We Support Each Other

Amber leaves, and then comes back to her dollhouse group. An example of a strong sisterhood was evident during the dollhouse making sessions. Another example of a strong sisterhood was evident during the dollhouse making sessions. Amber was the "sister" who gathered the materials and helped her group members accomplish the goal of the project. She supported her group members throughout the making process and assisted them when they ran into difficulties, for example Amber did the majority of the cutting the cardboard for the house and she helped Jasmine by sewing small pillows for the beds and while Jasmine created the electrical circuits for the lights. However, in the middle of the dollhouse unit, the girls got into a disagreement. Amber decided to leave her group and work with someone else. Amber felt like Tia and Jasmine were taking over the building and designing of the dollhouse and were not listening to her ideas. The girls spent most of that session arguing about design ideas for the dollhouse, which made Amber frustrated and she decided to leave the group. After two sessions Amber decided that she wanted to rejoin the dollhouse group again; Tia and Jasmine welcomed Amber back with open arms. At the end of completing the Dollhouse, in preparation for the end-of-year GEC expo, Amber volunteered to put together the group's PowerPoint presentation, so that her group members could finish putting the last-minute touches on their dollhouse. This shows that though the girls got into a disagreement, that through their sisterhood they were still able to come together and co-own the labor of finishing their dollhouse

Sara and Kia and the toy car unit. Another example of the girls displaying sisterhood was during the toy car unit. Sara and Kia were going to work on their toy car together; however, they began arguing which hindered the progress of her project. This disagreement resulted in Sara leaving the group to make her own Styrofoam Car. However, the two girls still wanted to sit next to one another during each GEC session. Sara and Kia liked talking to one another during GEC sessions, but they also supported one another through the assigned STEM task. Sara and Kia helped each other through the making process of the toy cars they were creating. At the end of the toy car unit the girls insisted on doing their video diary together, even though they worked on their toy cars separately. Throughout the video diary they supported one another when one of them had difficult time explaining how their car worked. For example:

> Researcher: Can you describe your car to me?
>
> Sara: We used this weird looking cutting thing . . .
>
> Kia: A foam cutter, yeah
>
> Sara: Ok, which question am I on?
>
> Kia: This one, how you felt when you were making the car?
>
> Sara: I felt that, I felt good about it. After it was done, I didn't feel good, because I lost races. Even Kia's and she only had one wheel (Both girls began laughing) (Artifact Interview, Spring, 3)

The above conversation shows that even though the girls did not work together on this project they were able to help each other complete their video diaries and laugh with one another during the process.

Erin and the importance of her "sisters." Erin's and Jasmine's stories also highlight the importance of sisterhood during STEM tasks and investigations. Erin relied on the encouragement of Jasmine and I, her AA female teacher to finish her projects. For example, there were instances during the GEC camp and afterschool sessions when Erin wanted to quit her project, but when one of her AA female peers pushed her to work through the challenges and persevere, she finished the task at hand. In contrast, Erin stated, "At school I hardly ever finish projects, because kids don't want to work with me or help me, because they don't think I am smart" (GEC session interview, Year 3). Erin having the support of her "sister" was important to her completion of her projects.

One of the components of sisterhood is working together to achieve a common goal; however, it was shown that the AA girls in this study exhibited sisterhood even when working individually. The girls' sisterhood, though expressed in different ways, was salient in how they navigated and finished STEM task, while working independently on projects. For example, during GEC summer camp, Erin got the conductible thread tangled and got frustrated with her mistake. Jasmine consoled her and informed her "It's ok, we all make mistakes. Just start sewing that part again. You will still finish today" (Summer Camp, Year 2, Fieldnote discussion). Erin needed this support to keep going and not give up. Jasmine's support gave Erin the confidence to finish her headband, even though the two girls were working on their projects independently.

Amber helping her sisters. Amber helped her "sisters" finish up their nameplates (a piece of cardboard the GEC youth used that featured their name using objects to make their names look 3D) and assisted them in how to use TinkerCad, by helping with creating objects, changing dimensions of objects, and downloading images to print. For example, Donna (another AA girl who participates in GEC) was having a difficult time using TinkerCad to make her 3D object to print for her nameplate, Amber stepped in as an "expert" to assist her with the manipulations of shapes and finding the correct dimensions for printing by showing Donna how to change the millimeters of the objects so that they were not too big to be printed. Amber also showed her how to download her image to printed using the 3D printer and then supported her sister in 3D printing her object.

Automaton. Lastly, during the automaton making unit, Jasmine and Erin got into an argument that hindered the progress of their project. Erin's feelings were hurt because she felt as though Jasmine was not listening to her ideas. After speaking to both of the girls, they sat together during the next session and both worked on the automaton. Erin and Jasmine were able to complete their automaton together.

Throughout the years at GEC, I have found that the girls do have moments of tension while participating in STEM tasks. However, though these arguments may hinder the making process for a moment, the girls are able to refocus and complete the STEM task either together or separately, because of their sense of sisterhood. I explore this intersection of sisterhood and disagreements below.

Sisterhood and Disagreements Intersection

As mentioned above sisterhood can look different depending on the time, space and activity the girls are engaging in. Sisterhood and disagreements can intersect, however, as seen in this study. It is how the girls navigated and negotiated during their disagreements, which played a significant role to the girls' sisterhood. As we have seen in the girls' vignettes, there were moments when they disagreed, which then lead to an argument. However, after these arguments, the girls made up relatively quickly and continued to be friends. For example, Tia and Jasmine did not question Amber on rejoining the dollhouse group or hold any grudges, Amber continued to work with the group as though she had never left.

Toy car. Sara and Kia also got into a large argument when making the Styrofoam car, the argument had gotten so bad that Sara ended up leaving the group, similar to

Amber's argument in the dollhouse case. However, at the end of the toy car session, when it was time to for the youth to complete their video diaries, Sara and Kia insisted on completing their video diaries on their toy cars together. They helped each other explain how mass affects acceleration and laughed with each other if they made a silly mistake. They went through the video diary process as though they were best friends. Sisterhood is respecting each other's differences, through arguments and welcoming one another after the argument is over. Media has portrayed women's friendships with one another as "aggression, contempt and competitiveness" (hooks, 2015, p. 48); however, sisterhood combats the assumption that women-to-women relationships have to be based on verbally abusing one another and gossip (hooks, 2015). Sisterhood is not a shallow relationship between women, it is bond that is used to work through tensions in order to overcome today's socialization and oppression of women. This study highlights that sisterhood is also present in young girls through the way the girls worked through disagreements and were still able to complete STEM task together. For example, during Jasmine and Erin's automaton making unit. Jasmine began to take over the making process and not allowing Erin to express what she wanted on the automaton. This led Erin to disengage in the project and Jasmine wanting to change groups. I sat down with both girls and expressed the importance of giving one another chance and to try again during the next GEC session. The pair sat together during the next session and began decorating and putting together their automaton, Erin now felt part of the project. Erin and Jasmine, with the assistance from me (their big "sister") fought through tensions and worked together, to complete the making of their innovation. The girls' sisterhood lead Jasmine and Erin to not just reconciling but supporting one another mutually.

The AA girls who participate in GEC spoke about how much they loved this STEM space, because they could talk to one another while working on their projects, it was space where they could be girls (GEC session interviews, Year 3), specifically AA girls. Erin described GEC as space, that is, "GREAT, I don't have worry about what I am saying" (GEC session interview, Year 3). The girls in this space feel free to say and do what they want with the support of their "sisters." The concept of sisterhood tends to be focused on Black women encouraging one another through difficult times or task, but this can also be seen in young AA girls, as shown in the cases above. The AA girls who participate in GEC enjoyed helping their "sister" through STEM task, so that everyone was able to feel successful and celebrated.

Cross Case Analysis Theme 3: Community

STEM Expertise to Serve, Build, and Leverage Resources of the Community

Incorporating youths' community in content is a central aspect to their learning. Our communities shape who we are and where we want to go, therefore it is imperative that youth feel they can share community with others. It is also important that the learning spaces youth inhabit foster a sense of community. At the beginning of each school year we have the youth collaborative author a GEC manifesto for the school year. This manifesto is a list of expectations to promote a positive community during GEC sessions. For example, being respectful to one another, respecting the tools and equipment in GEC and being able to "spill their ideas without judgment" (Fieldnotes, Year 2). Community is an important component of GEC. One of the goals of GEC, is to provide a space where youth feel comfortable, have the freedom to express themselves, and feel that everyone who participates in GEC supports one another through STEM tasks. We also embed the youth's community in all STEM tasks we assign. Many of the youth who attend GEC live in communities that have been negatively profiled because of socio-economic status or violence. We believe it is imperative that the youth in GEC, not just look at ways to use their STEM expertise to help their community, but that we also find provide a space where they can show that they value their community.

I also found that by becoming a STEM expert, AA girls learn how to use their STEM knowledge and practices to their help community. There were various ways the AA girls in this study used their STEM expertise to help, establish and inform their community. For example, they used their STEM expertise to serve the community by making innovations to solve a need or a problem. The girls built a GEC community with other youth in the community club using their STEM expertise through GEC expos and showcases. Lastly, they were able to draw on the existing community knowledge to engage in STEM, through community ethnographies. Below I unpack how these examples which contributed to the girls' community by them using their STEM expertise.

Co-owning the community club and GEC spaces. I begin by providing two cases that illustrate the girls' comfort with the GEC and community club spaces where they used Stop Motion videos as way to highlight important aspects of their community. The following examples provide evidence that the girls considered themselves co-owners of this space which is an important part of building and sustaining the local community.

During the fall of Year 4 we tasked the youth to use stop motion videos to express what they liked about their community. Sara and Kia decided to work together on a video that featured the community club and all the facets they liked about the community club through dance. The two girls sat beside one another during the first session and planned out the dance choreography they were going to use and the song they wanted to play in the background. During the following two sessions they used the iPads to create their stop motion, expressing themselves through a dance routine they choregraphed in front of their favorite spaces at the community club. After they had taken 135 pictures, they sat and edited their stop motion video. The girls had a lot of pictures of themselves on the playground and decided to delete some of them because they felt they should focus on the outside of the club where they met and because the community club was a special for both of them. At the end of the editing process they wanted to add a song in the background, the song they chose was "Survivor" by Destiny's Child. The Sara, Kia, and I went into a quiet room so that they could add the song and to ensure it started playing in the stop video the place they wanted it to. Sara and Kia were very proud of their stop motion video, once they were done with the edits and putting all the pictures together, they stated, "Look Ms. Faith, look at the video we made about us!" (Year 4, fieldnotes).

Amber and Jasmine also worked together on a stop motion video, however they focused on how their friendship grew because of the community club. Similar to Kia and Sara, they sat and planned out the different spaces they were going to feature in their video. Amber and Jasmine decided to combine a story line and dance in their video, because they felt it was important to show that even though they both love to dance, homework and school is important and large part of their daily lives. The girls and I went around the community club to all the different spaces they wanted to feature as a background for their video. Once they were done taking all their pictures they sat and edited the pictures they wanted to use in their video. Amber and Jasmine wanted to add music to their video and felt that the song that best represented them was Beyoncé's "Girls Run the World." The girls added the song and completed their stop motion video. They, like Sara and Kia were very proud of their video, because it was about them, their community, and the important relationships they formed in their community. It was evident that the community club was an important aspect of the girls' lives, because both groups featured the outside of the community club and the spaces within the community club that were significant to them, one of those spaces being the GEC room.

As seen in Sara, Kia, Amber, and Jasmine's stories it was found that girls can use STEM as tool to express themselves and their communities, where they may not have been able to in a more regimental STEM space. It was also found that by becoming a STEM expert, AA girls learn how to use their STEM knowledge and practices to their help community. There were various ways the AA girls in this study used their STEM expertise to help, establish and inform their community. For example, they used their STEM expertise to serve the community by making innovations to meet a need or address a problem. The girls built a GEC community with other youth in the community club using their STEM expertise through GEC expos and showcases. Lastly, they were able to draw on the existing community knowledge to engage in STEM, through community ethnographies. Below I will unpack how the girls used their STEM expertise to contribute to their community.

STEM expertise to serve the community. Serving the community is interwoven across the girls' GEC projects and GEC experiences. This was evident in Erin's case when on the last day of GEC camp (Year 2), she insisted on helping with every aspect of the event, for example, she moved tables and set up the computers for the presentations. Erin also helped others finish their PowerPoint presentations for the expo. Another example was Shawna's music jacket, she wanted to make the jacket so that people who rode the bus could listen to music without purchasing a phone. In both of these cases, Erin and Shawna were developing into community experts with robust STEM practices and were able to use their STEM knowledge to start concretely designing and making artifacts to help the people in their community.

On Valentine's Day we had the youth make cards for someone they care about or a thank you card for someone special in their lives. We informed youth that making and giving a personalized greeting cards to someone is also way in helping the community, because greeting cards express appreciation and thoughtfulness. For this project, Sara decided to make a Valentine's Day card for her mother. She grabbed a piece of pink card stock and began to draw out her card. Sara wanted it to have a candy theme, because she talked about how much her mom loved candy, all kinds of candy. After, Sara created her series circuit on the back part of the pop-up Hersey bar, so that the LED light would shine through one of the hearts she drew under the candy bar. Sara then wrote the following on the bottom of her card; "Happy Valentines mommy, I love you so much and I hope you the best" (Fieldnote, Year 3). Sara was very proud of what she had created for her mother, she asked if she could take it home to get to her mother at the end of the GEC session, I stated, "Sure! I know your mother will love it" (Fieldnote, Year 3). GEC gave Sara the space to make a Valentine's day card for her mother, using her STEM knowledge to make the card, light up. Sara's card is similar to Kia making the toy purse for a younger youth and Jasmine making the light up pillow for youth when they are scared of the dark. All of the girls used their STEM expertise to make something for someone in their community.

The girls in this study also used their STEM knowledge to help their peers in GEC. This was evident when Amber, Jasmine, Erin and Sara observed when someone in their GEC community was struggling with a project and they stepped in to help their peers by using their STEM expertise on various task as shown in the portraits in section one. The girls used their STEM expertise to help people in their community complete STEM task, which also positioned them as STEM experts.

Building an expansive GEC community with youth using their STEM expertise. One of the goals of GEC, is to make people in the youth's community aware of the ways GEC youth are using their STEM expertise to solve problems. Erin, for example was very excited to present her light up headband to her peers and the community club adults. When the expo began Erin talked to everyone who came to her table about how she had made her headband and how it worked. She stated, "I put the light bulb on the headband with conductible thread so that energy would flow through" (Fieldnote, Year 2). Erin was able to describe how she made her headband and the circuitry that went behind making her headband light up. Erin's innovation was for youth to see at night and to keep them safe if they were in a dark place.

Sara also used her STEM expertise to inform other youth in her community was also during an end-of-year GEC expo. Sara was able to explain to other youth in the community club how mass and acceleration are related by racing the toy cars with them. During this event we had table set up as stations where the community club members could go around to each table to learn about the innovations that the youth made. Sara's race car table was the busiest, everyone wanted race a car and once Sara explained the relationship between mass and acceleration. Sara informed her audience that "the smaller cars with not a lot of decoration, went faster" (Fieldnote, Year 3). The younger youth then understood the science behind racing and wanted to race the smallest cars first.

Shawna and Erin's geometric dome was yet another example of the girls building a GEC community in the community club. After the girls finished building the dome and showcased it at the expo, the community club staff supported the Shawna and Erin's idea to place it in the lobby of the community club. The younger youth at the community club loved having the dome in the lobby, they would go in the dome for some quiet time or to take a nap. Ms. Margaret (the community club's assistant director) stated, "This was one of my favorite projects that the kids made at GEC" (Fieldnotes, Year 3). Ms. Margret liked that all of the youth at the community club used, it was an innovation that everyone was interested in playing in.

During the stop motion unit, we encouraged the girls to feature what they liked about their community. Jasmine and Amber used this unit and their STEM expertise to feature the community club as space where they engage STEM practices and use their STEM knowledge to solve problems. As shown throughout this study there were instances when the girls used their STEM expertise to engage their community in STEM. Because of this community engagement the community club has made GEC part of their regular programing and have started a Teen GEC so that they girls can continue participating in STEM GEC activities as they get older.

Drawing on the existing community knowledge to engage in STEM. During many of the GEC making units we encourage the youth to conduct community ethnographies. All of the AA girls in this study would go around the community club to ask questions and receive feedback on their innovations. Through this project the girls gained ethnographic skills, for example, they were equipped with the knowledge of how to write interview questions, how to conduct interviews and how to write survey questions. Using these ethnographic interview skills during the community ethnography process was especially important to Amber and Jasmine's dollhouse; because of the feedback they received on their dollhouse design, they added rooms and a play area to their dollhouse. Kia's community ethnography was also important to the completion of her toy purse project. When Kia interviewed youth at the community club about her design for her toy purse, she found she needed make the strap of her purse longer.

Before the making process the youth in GEC solicit feedback from their peers in GEC and at the community club. Similar, to the community ethnographies youth asked their peers questions on what types of innovations they would like to see the GEC youth make. For example, before the girls started making their toys they interviewed their peers at club to see what type of toys they would be interested in playing with. This process was especially helpful to Kia, who ended up making a toy safe in addition to her light up toy purse. Through this process Kia, found that some of the youth she interviewed talked wanting to keep their toys locked away from younger siblings. Through the youth feedback she decided to make her second innovation, the toy safe.

Throughout this study it was found that AA girls want share what they have learned in STEM spaces and use their STEM expertise to help and make change in their communities. Through community ethnographies the AA girls in this study were able to create and share innovations that helped their peers and loved ones. The AA girls in this study used the STEM task we presented to them as opportunities to tell their community who they are and the things they like to do and are interested in. The AA girls in this study showed us how they can use their STEM expertise to help their community, while expressing who they are, who they want to be, without conforming to societal structures.

Cross Case Analysis Theme 4—Identity Work

GEC is a STEM space where AA girls can express themselves through making, while developing STEM knowledge and practices. Historically, STEM spaces are predominantly White, male and follow regimented STEM practices. When the AA girls in this study begun to create innovations, we found that their innovations did not just encompass science and engineering practices, but they also showcased the girls' femininity. Because of this, it was evident that their gendered and race identity work is interconnected with their STEM-linked identity work, and this space supported that connection. Throughout the four years, we found that they girls in this study were persistent, makers, engineers, problem solvers, scientists and encouragers, and that they were not competitive in the ways one might expect in a male-dominated STEM space. The girls in this study wanted to finish their projects in GEC and become authors their own designs. They displayed agency and, in many instances, they displayed more agency and independence than the boys in this space. They were able to do all of this without sacrificing their feminine identities. The following examples showcase how the AA girls in this study leveraged their gendered identities to complete STEM activities in GEC and how these two kinds of identity work were not at odds with one another.

Jasmine's Pink Light-up Pillow

During the GEC summer camp (Year 2) Jasmine decided to work by herself on a stuffed light-up pillow. Jasmine chose to use bright pink felt for the outside of her pillow. Once she started sewing her pillow, she decided to alter her original design and to personalize it by adding her initial and a purple LED bulb on the front of her pillow. Once she finished her light up pillow, that was made with colorful fabric and a bright LED bulb, she displayed it during the GEC summer camp expo. Jasmine was very proud of her pillow because; "It's something I made, the way I wanted to make it" (Artifact interview, Year 2). Through this task Jasmine was able to create an innovation using her STEM knowledge and practices, while expressing who she is as an AA girl, who wants to help the youth in her community.

Erin's Light-up Headband

Erin's light-up headband is another example of an AA girl expressing her gendered STEM identity during GEC sessions. Erin sat for more of most of the first GEC camp session (Year 2) drawing out what she wanted her headband to look like; choosing different color fabric options and deciding where on the headband she wanted to place the LED light. Once Erin decided on the design of her headband she was very enthusiastic about making it, she smiled from ear to ear showing all of her excitement. Erin then sewed her pieces of colorful fabric together and sewed her green LED bulb onto the headband. Like Jasmine, Erin experienced success in making an innovation that was specifically personalized by her, for her. She was able to design her light-up headband the way she wanted it to look, without feeling as though she had to conform to social structures, Erin was not expected to make a more masculine innovation, without a lot of color. Through making the light-up colorful headband, Erin was able to engage in STEM in ways unlike one would see in a regimental STEM setting.

Kia's Princess Automaton

Similar to Erin and Jasmine, during the toy unit the youth explored toy mechanisms by making an automaton using a cardboard shoebox. Kia who works independently often and decided to work by herself to create her automaton, sat beside me to plan out what she wanted her automaton to look like. She chose to decorate the box with decorative tape and put a pink crown on the top of the box. Kia wanted her crown to be pink and sparkly, because as she stated, "I am a princess, Ms. Faith" (Year 3, fieldnote). Kia's crown was decorated with cotton balls and brightly colored markers, to make it look like the crown of a princess (Fieldnote, Year 3). Once Kia finished putting her skewers through the shoebox she started decorating the outside of the box. She used decorative tape to make her shoebox colorful and bright. When I asked Kia about the decoration on her Automaton she stated the following:

> Kia: I added the stuff on the back, because I think it looks too plain with nothing on there and I felt it needed to be decorated . . . I feel pretty sure that I would give to a kid who is homeless and show them they could do anything or a child at shelter and let them play with it. (Fieldnote, Year 3)

Kia's automaton shows that when given the space, AA girls can use STEM practices to create innovations that represent themselves. Shown in Kia's above quote, she believes that her automaton can inspire others to do the same she did, it shows her automaton was more than a STEM task to complete, it showed that it was a project that could be as an expressive tool.

In the next example, Kia decided to work by herself to design a purse with that had LED lights on the front of it. Kia sat and began to design her purse, she decided to make her purse the shape of a half circle. We then looked for what type of material Kia could use to make her first. Kia stated, "I want the purse to look 'girlie'" (fieldnote, Year 2), so she picked out a piece of fabric that was pink and white for the body of her purse and a bright blue piece of fabric for the strap for her. Kia then decided to try something different with her LED light bulb. She found a piece of plastic with a flower printed on it and sewed on the front of the purse for decoration and attached her LED bulb to the plastic flower. Kia wanted to make her purse for a little girl who attended the community club. It was important to Kia that the purse be pink and colorful, because she likes to things that are bright and colorful. For example, when picking out the fabric for the purse, Kia stated "Ms. Faith, I want colorful fabric, not fabric that is boring" (Fieldnote, Year

3). During the making of Kia's purse, she was not only supported in making the innovation that she wanted to make, she was supported in making an innovation that represents girls.

There were instances when some of the girls in GEC felt like they could not complete STEM task because they did see themselves as "STEM people." For example, both Shawna and Erin, when asked to draw a scientist both girls drew White men. When asked why, Shawna stated "That's who does science" (Background interview, spring, Year 1) and Erin could not give a reason. Shawna and Erin also had times throughout GEC when they experienced frustration and felt as though they could not complete STEM tasks, because they could not always see themselves as Black girls doing science. During the play dome making sessions, both girls had periods when they wanted to give up and build some that was "easier"; however, through the support from each other they were able to work through this tension and finish their project. An example of the girls feeling as though they "can't do this" was Erin's light-up headband making session. Everyday Erin began the session saying that she could not make her headband; however, after encouragement from Jasmine and myself she left each session proud of her accomplishments and was STEM expert during the GEC end of summer expo. Erin and Shawna's cases show that AA girls do not always identify themselves as scientists or engineers, however, when given the space and support AA girls can see themselves in STEM.

The above cross case analyses highlight how collaboration, sisterhood, the girls' community and their gendered STEM identities played an essential role in how they used their STEM expertise in GEC and community club. These analyses showcase that when educators create spaces that are as free as possible of microaggressions and social structure constraints AA girls' STEM identity/agency and sense of sisterhood can be influenced positioning them as STEM experts in their community. This study shows that creating these types of judgment-free spaces can be important to AA girls' STEM identity, trajectory and the future of AA girls' STEM engagement.

CHAPTER V

DISCUSSION

In this chapter I revisit the research questions and further elaborate on specific instances of how the girls' experiences in this STEM space influenced their engagement in STEM practices. I then reexamine the theoretical framework that was introduced in the literature review with a discussion on how the findings are related to the proposed "judgment-free" theoretical framework.

How African American Girls Engage in Informal STEM Spaces

I begin this section revisiting all components of Research Question 1, Research Question 2, and how the findings from this study answer these questions. Research Question 1 asked, "What does it mean to the AA girls to have an informal youth STEM space that is free (or as free as possible) of microaggressions and social structure constraints?" Studies have shown that AA students feel as though they have to assimilate to the dominant White male social structures, while compromising their own cultural identity in order to be successful in STEM which then hinders their authentic engagement in STEM practices (Brown, 2006; Nasir & Vakil, 2017). This study highlights that participants appreciated and enjoyed a space where they could be AA girls who engaged in STEM tasks. For example, all of the girls in this study completed multiple innovations that helped someone in the community or their community as a whole. Kia was able to make a pink and white purse with an LED bulb attached for a younger youth in her community. Kia did not feel as though she had to conform to traditional STEM ideals, where making a pink and white purse may have been seen as not an authentic STEM task. The above example provides evidence that in this informal STEM space, AA girls do not have to follow traditional regimented STEM social structures to engage in STEM practices. Through the reduced number of microaggressions and ameliorating social constraints as much as possible, the AA girls in this study made innovations that were relevant to them and their communities.

Students positioning in STEM spaces can be related to the how they see themselves in STEM and how they engage in STEM practices. Varelas and colleagues (2012) found that AA youth are negatively positioned in the low-level science and math classes; Pringle and colleagues (2012) found that school teachers were positioning AA girls on a liberal arts trajectory as opposed to a STEM pathway by infusing more liberal arts activities in science lessons. The AA girls in this study were positioned by the adult mentors and their peers in various ways. For example, Sara and Amber were positioned as STEM experts when they assisted their peers in how to use TinkerCad to 3D print an object. Another example of the girls being positioned as STEM experts was during GEC expos, an event when the adult mentors, the girls' peers, family members, and community club members positively positioned the girls as community STEM experts (Calabrese Barton & Tan, 2009) because they were all able to present in detail on the innovations they had made. Also, during many of the GEC sessions there were instances when the girls assisted one another on a STEM-related task; for example, Erin assisted her peers with making the PowerPoint for the GEC summer camp expo. The above examples show how GEC was a space where the girls in this study were able to complete a range of STEM tasks, and also share their STEM knowledge with their community.

STEM classes should be a space where youth can explore and investigate STEM knowledges and practices through inquiry. It is imperative that youth experience an authentic engagement in STEM that takes into consideration youths' lives, concerns, and agency. The AA girls in this study were able to make products that they were interested in and related to themselves and their community. Many of the girls in this study spent multiple sessions making their products, so that the details of the product represented who they are. For example, during the dollhouse making sessions (which lasted over a year), Jasmine and Amber spent hours ensuring the dimensions of the rooms were the way they wanted them to be, that the color of the outside of the house was painted correctly, and that all the LED bulbs worked correctly. Jasmine and Amber were able to make an innovation that represented who they are as girls and who they are as engineers and makers. Shawna's music hoodie is another example of an AA girl being supported in making a product that she may not have been able to make in a more regimented STEM space. Shawna's pink music hoodie was influenced by the need of people wanting to listen to music but who could not afford a phone. GEC was the space where she could intersect her community's need while exploring how to make a STEM product. Shawna was able to make a product using her STEM knowledges and practices to help her community. The above cases above show how AA girls in GEC can engage in STEM to make products that are authentic to them and their communities.

Themes that Contributed to African American Girls STEM Identity

In Chapter IV, I used cross case analyses to answer Research Question 2, "How might a setting free (or as free as possible) of microaggressions and social structure constraints influence 10- to 14-year-old African American girls' STEM identity/agency and sense of sisterhood?" I began by constructing themes found throughout the girls' portraits. I was able to answer Research Question 2, using the following four themes: Collaboration, Sisterhood, Community, and Identity Work. I found that the girls used various forms of collaboration to complete STEM task and support one another in GEC. For example, GEC encouraged the girls' socializing and storytelling practices while they were working on their projects. As seen in the vignettes, Kia and Sara relied heavily on this free discourse while they were participating in the making process. Sisterhood was another key theme found throughout the girls' portraits. The AA girls in this study struggled with one another to complete STEM tasks, disagreed at times, but also encouraged and supported one another throughout the making process. For example, Kia and Sara disagreed during the toy car unit to the point that they could not work together. However, when it was time to do their video dairies, they insisted on completing them together; they also helped each other when one of them had difficulty explaining science content that related to the toy car activity. Community is a central aspect to GEC. Throughout each making session, we engage the youth in conversation to collaboratively and collectively connect the youth's products to their community or the people in their community. The AA girls in this study used their ethnographic skills to interview the younger youth in the community club to better understand what their community wants in certain products. It was found that the community ethnographies played a salient role in AA girls' making process. For example, during the dollhouse making session the girls presented their design to youth in the community club, to find out that they needed to add a bathroom and play area to their house. Last, identity work was an important theme described in the cross-case analysis, because it was found that GEC nurtured the girls' gendered STEM identities and supported them in becoming community makers and community peer leaders in the making (through GEC expos and workshops). All of the girls in this study were supported in making products that represented who they are as girls by using their STEM knowledges and practices. There were instances when some of the girls (Erin and Sara) did not see themselves and scientists or engineers, but throughout their participation in GEC they soon identified themselves in STEM.

The next section explains how the findings from Chapter IV relate to the proposed "judgment-free" theoretical framework. I further unpack the findings from this study to describe what facilitates a judgment-free space, how that space is maintained, and how it impacts the girls' identity work.

Unpacking and Troubling the Notion of a Judgment-Free STEM Space

In this section I revisit the "judgment-free" theoretical framework from Chapter II and relate the underpinnings of the framework with the findings from this study. As stated in Chapter II, judgment can be used to negatively classify or assume something about a group of people, which can be expressed through microaggressions and negative positioning. In contrast, positive judgment is creating a space that is as free as possible of microaggression and negative positioning, with the intent to influence STEM engagement through sisterhood, positive positioning, and free discourse. Using this judgment-free theoretical framework (Figure 58), I have found that AA girls' STEM identities and agency can be positively impacted when they are given the space to investigate STEM while acknowledging the key components of a judgment-free space. Figure 59 shows how the findings from this study relate to the underpinnings of the "Judgment-Free" Theoretical Framework.

"Judgment-Free" Framework

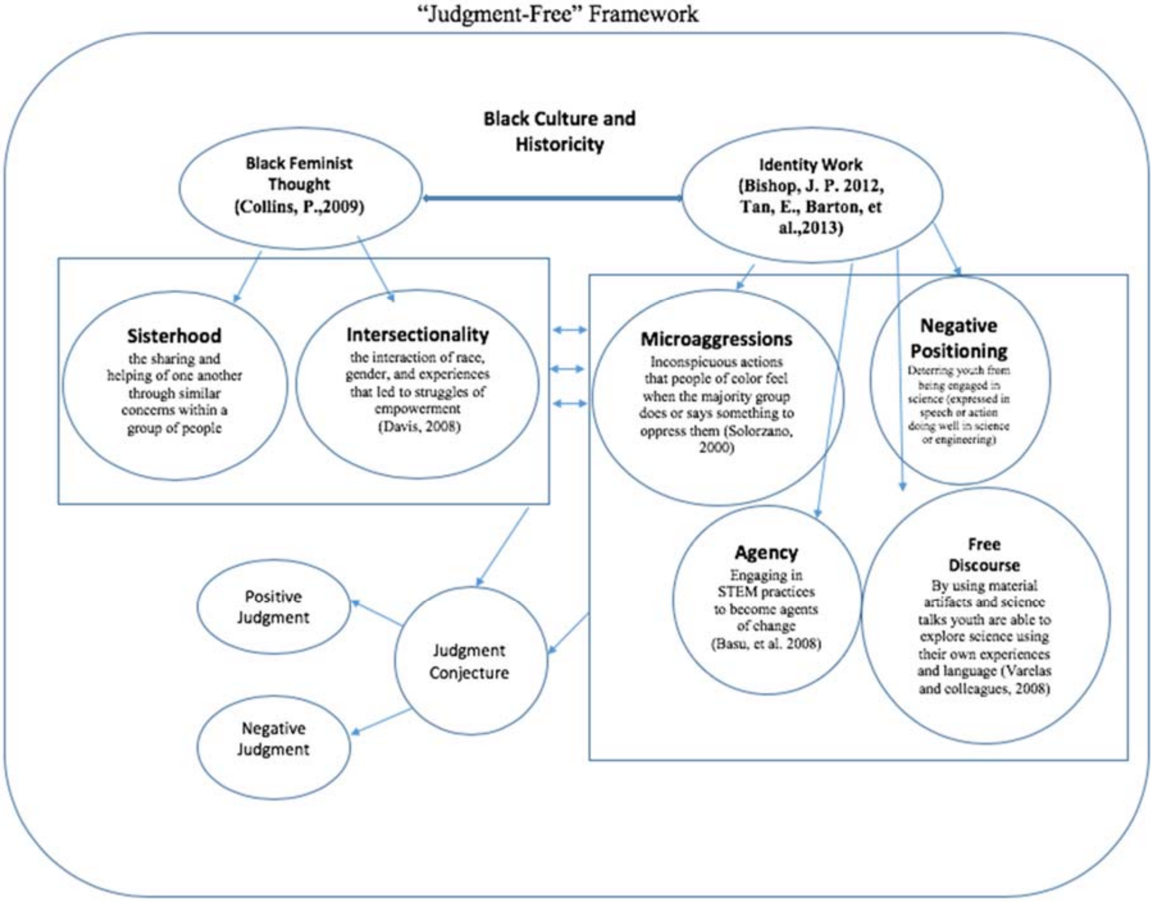

Figure 58. Judgment Free Framework.

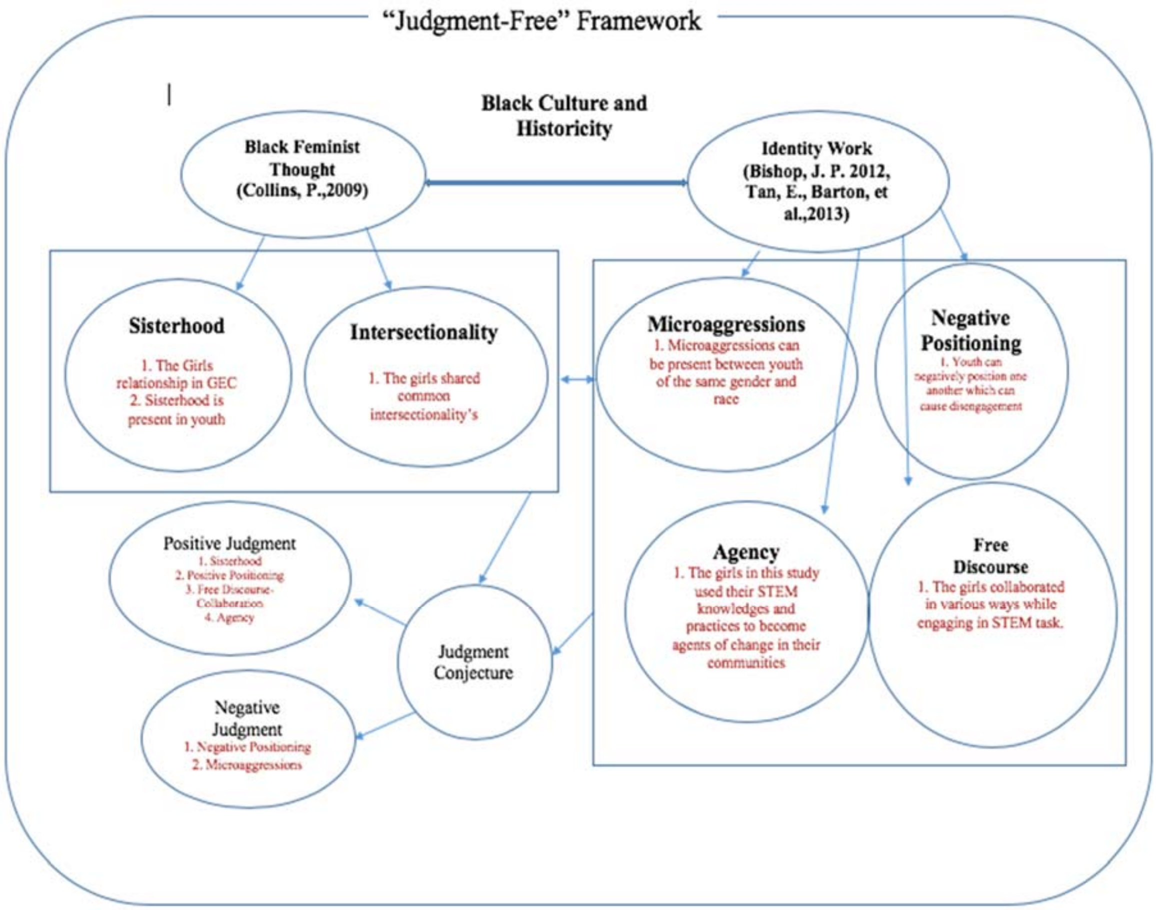

Figure 59. Judgment Free Framework with Findings.

I begin this section by looking at the fluidity in the girls' identity work in this space, how the girls' sisterhood and identity work are related, and the pedagogical approaches that were used in GEC to support the girls' STEM identities. I close this section by conjecturing why GEC supported or did not support the girls' identity work by looking at how the girls were positioned, the role microaggressions may have played in this space, and how the girls' sisterhood and intersectionality contributed to their identity work.

AA Girls' Identity Work in GEC

Studies have shown (Calabrese Barton et al., 2013; Tan et al., 2013) that marginalized youth do not see themselves as being successful in the sciences; therefore; it is difficult for them to identify themselves as becoming scientists or engineers. Because of the disparity of representation of AA women in STEM, it can be difficult for AA girls to identify themselves as scientists or engineers. This was shown in the background interviews of many of the girls when they first started to participate in GEC. For example, Shawna drew a scientist as a White male because that is who she saw "do science." Amber also drew a male when asked to draw a picture of a scientist. Both girls did not identify themselves as being a scientist or an engineer when they first started GEC, which is shown by their drawing; however, throughout their participation their STEM identities began to flourish. For example, Amber was an "expert" in 3D printing and was able to help peers during the 3D printing sessions.

The activities the girls were able to participate in at GEC also played a salient role in how they engaged in identity work that led to new ways that the girls identified themselves in STEM. For example, before one of the GEC end-of-year expos, Sara walked in while we were sitting up the tables in gymnasium of community club and asked, "What can I do, Ms. Faith?" (Fieldnote, Year 3). During this moment I could tell by the tone in Sara's voice she really wanted to participate in the end-of-year GEC expo. However, she knew she had not finished her project, so she did not know how she was going to participate. I supported her interest in participating by suggesting that she facilitate the toy car table, which ended up being the most popular table of the expo.

Thus, being flexible in creating new modes of engagement and new ways of being seemed productive in supporting Sara's identity work at GEC.

Throughout the 4 years of this study there were instances when the girls did not finish their projects, which led to them expressing doubts in their ability to engage in GEC. For example, Sara did not finish her Lonely Flower Toy Box because she stopped attending GEC once she moved to the teen center of the community club. Shawna and Erin also had times in their participation when they wanted to give up and stop working on their projects. Though these occasions were few they still had an impact on the girls' identity work because they hindered girls making process in that moment. However, because of the girls' established sisterhood they were able work through these tensions, in turn influencing their STEM identities—a salient point which I will unpack further in this chapter.

The girls' gender identity work also played an important role in how they engaged in STEM tasks. When girls are in STEM spaces many times they are expected to conform to societal structures, resulting in the inability for them to express themselves freely (Archer et al., 2012; Sparks, 2018). This study shows how a space that fosters girls' expression of their femininity supported AA girls gendered STEM identity work. For example, during the GEC summer camp Jasmine and Erin made innovations that represented who they were as girls, but also incorporated science content in their products by sewing in an electrical circuit. Kia also displayed her STEM identity when she created the pink and white purse with an LED bulb sewn on to it. The girls in this study pushed against stereotypical narratives that AA girls are not able or are not interested in learning

STEM practices and identified themselves as science and engineers. The above examples show this STEM space played a significant role in the girls' identity work, related to who they are and who they want to be.

Pedagogical Approaches in GEC

Specific pedagogical approaches were used throughout the 4 years of this study. STEM exploration and investigation are an essential component of this STEM space; therefore, the adult mentors found it imperative to plan lessons that integrated inquiry. Many of the girls talked about their school science courses having a primary focus on worksheets instead of hands-on opportunities. Two pedagogical approaches that were found to be significant to the girls' identity work were Just-in-time STEM activities and community ethnographies. During each unit we supported youth starting with the exploration phase and once questions arose pertaining to STEM content, we stepped in and explained the STEM concept. For example, Erin had question about how the LED bulb would work on her headband after she sewed it in using conductible thread. I explained to her that conductible thread is made out of metal, which can transfer electrons and make her LED bulb light up. I then showed her how we were going to connect the LED bulb to the battery to make the LED bulb work properly. This moment was an example of a "just in time" STEM exploration. These "just in time" explorations (Calabrese Barton, Tan, & Greenberg, 2017) assist youth in better understanding STEM concepts while applying them to the making process. When youth discover STEM concepts during the making process, they better understand science and math content which is salient to a student's STEM development.

As stated in the cross-case analysis in Chapter IV, the girls' community was embedded in many of the STEM activities in GEC. Community ethnographies played a key pedagogical approach used throughout the 4 years of this study. The girls in this study used their ethnographic skills to gather information from their community about the different innovations they were making. For example, through a community ethnography Amber and Jasmine received feedback on their dollhouse design and as a result added a feature. When Kia interviewed youth during a community ethnography she found she needed make the strap of her toy pink and white purse longer. The community ethnographies that the girls conducted supported the girls' identity work in STEM making because it enabled them to draw on their community members to make a product that related to them. For example, Kia's toy safe was made because of a statement one her peers stated during a community ethnography about keeping their toys locked away from their younger siblings.

Just in time activities and community ethnographies were essential to the girls' engagement in STEM and to their productive identity work in this space because they were able to engage in STEM while drawing on their communities' resources, insights, and wisdom. Utilizing these pedagogical approaches supported and influenced the girls' STEM identities.

Supportive and Non-supportive Aspects of GEC

How the girls were positioned, and who they were positioned by, played a salient role in how supported the girls felt in GEC. There were two types of positioning that played a central aspect in this space; adult positioning and peer positioning. All GEC youth, including the girls, are positioned as capable in engaging in robust STEM-rich tasks during every GEC session, which is day-to-day norm at GEC. There were many instances when the adult mentors in GEC positioned the girls as STEM experts. For example, during the GEC expos the adult mentors expected the girls to present their innovations in front of their peers and community members. All of the girls experienced presenting at a GEC expo during the 4 years of this study, where they were positioned as STEM experts when describing their innovations to stakeholders in their community whom they care about. They were all able to explain in detail how their innovation worked scientifically. Erin, who is shy, could fluently talk about how electrons moved from the battery to the LED bulb through the conductible thread. This positioning during the GEC summer camp was imperative to Erin's engagement in GEC, because she saw she was able to finish a project and present what she had done. The adult mentors at GEC would also have the girls help one another through STEM tasks. For example, Amber helped Donna during the 3D printing unit. The girls' STEM identity was nurtured by the way the adult mentors at GEC positioned the girls in this STEM space, because the girls were supported when using their STEM knowledges and practices to help others.

As shown above, the AA girls in this study were positioned as STEM experts by the adults at GEC, but most importantly they were also positioned as STEM experts by their peers. All of the girls had times throughout their participation in GEC that influenced their STEM expertise, because of the way their peers positively positioned them. For example, Sara and Amber were positioned as STEM experts by their peers during the 3D printing unit, when they assisted other GEC youth in how to use TinkerCad to manipulate an object to be 3D printed. Jasmine was also positioned by her peers as a STEM expert during the paper circuit unit because she helped her fellow peers with placing the conductible tape correctly on the paper. The above examples show that when AA girls are positively positioned in STEM spaces, their gendered STEM identity and agency are influenced.

Though there were many times when the girls were positively positioned, there were also instances when they were negatively positioned in this STEM space. For example, Erin had moments during units when other girls did not want to work with her because they felt like Erin would not contribute to the project. This was the case during the automaton project when Jasmine did not want to work with Erin to finish the project because Erin had become disengaged. This was also the case during the dollhouse making process, when Amber ended up leaving the group for a few sessions because she felt like Jasmine and Tia were not listening to her. These examples correlated studies that have highlighted how AA girls feel in STEM spaces that are majority White and male. Oftentimes AA girls feel as though their voices are not heard and then disengage, which results in them being negative positioned in that STEM space. However, in Erin and Amber's cases, they were negatively positioned by their peers for a short moment, which made them feel unsupported. However, the sisterhood the girls shared with their group members and support from myself (also a sister) helped them negotiate the conflict, positively positioning them back into the group. The girls' sisterhood supported them to work beyond the tensions that were happening in this space and come together to finish a task. Because of this longstanding sisterhood that had been cultivated and solidified through their long-term engagement in this space, it allowed for a quicker reconciliation and for the girls to come back together as sisters in STEM. This was an essential component of this STEM space, which is different from other STEM spaces, because Amber and Erin felt supported even though they experienced times of conflict.

Microaggressions in GEC

School science can be intimidating for youth, especially for AA girls. Microaggressions can negatively position AA girls outside of STEM as seen in the Kurth and colleagues (2002) study, where a young AA girl experienced microaggressions brought on by social structures when inhabiting STEM settings from her White female teacher, who had lower expectations for work done in science by the AA girl. Focusing on a judgment-free theoretical framework supports how AA girls resist negative biases that are expressed through certain microaggressions, while positively positioning them as STEM experts. Creating a space that is as free as possible of microaggressions can better influence AA girls' STEM identities agency through establishing sisterhood, free discourse, and collaboration. The judgment-free framework also allows us to better understand how these two constructs affect AA girls' STEM engagement, and how the power of a judgment-free space could foster their STEM identity and agency.

When the girls were negatively positioned in GEC it resulted in the girls expressing microaggression against one another. As shown throughout this study, the girls experienced great success while working on STEM tasks; however, there were times when tensions arose. Microaggressions can manifest in different ways; they are not limited to race, they can also evolve within gender groups. This was evident in many of the girls' cases when they got into disagreements with their peers, which hindered their making process. However, the girls were able to work through these microaggressions and work to complete their STEM task, exhibiting that their sisterhood was greater than the tension. For example, Kia refused to work with Sara during the toy car unit because Sara became so disengaged. Jasmine also displayed microaggressions to Erin during the automaton unit when she did not want to work with her any longer and insisted on joining another group. These cases showcased how the girls experienced microaggressions in a space where people look like them. However, these cases also highlight the importance of establishing sisterhood in STEM spaces so that AA girls can work through these microaggressions.

In order to discover who AA girls are and who they want to be, I propose using a judgment-free lens for a deeper look at who AA girls are, the problems they face when engaging in STEM, how they are positioned, and how to support them when they engage in a STEM task. It is salient to explore how AA girls experience microaggressions (both within their racial group and outside of their racial group) and how negative positioning manifests in STEM spaces.

Sisterhood and Intersectionality

Sisterhood and intersectionality are two key components of the judgment-free theoretical framework. As noted in Chapter IV, the girls share the same markers of oppression, gender, race, and socioeconomic status. Through these commonalties the AA girls in GEC have formed their own sense of sisterhood in this STEM space. By utilizing this judgment-free theoretical framework, researchers can highlight how a judgment-free space can influence AA girls' STEM identity and build a sense of sisterhood among AA girls while undergirded in intersectionality, which could weather microaggressions and negative positioning when these occur. As stated in Chapter II, sisterhood is the sharing and helping one another through similar concerns within a similar group of people. The girls in this study helped another when saw that another girl (their "sister") was struggling through a STEM task. For example, during the light up headband making process, Erin got the conductible thread tangled and got frustrated with her mistake. Jasmine consoled her and informed her, "It's ok, we all make mistakes. Just start sewing that part again. You will still going to get finish today" (Field note discussion, Year 2). Erin needed this support to keep going and not give up. Jasmine's support gave Erin the confidence to start over and finish her headband. Sisterhood was also prevalent during the making of the dome; Shawna and Erin encouraged one another to continue cutting the cardboard triangles to complete their dome. Both of the above cases showcase girls struggling with one another to complete a task.

Sisterhood is more than the girls showing solidarity to one another; it is also related to how the girls use their STEM knowledge and practices. Through the girls' sisterhood they were able to help one another with STEM tasks and complete STEM tasks that they may not have if they were not working through the struggle together. As they became more skilled at STEM making, they positioned their "sister" to perform at the same level of rigor as they did. For example, Amber positioned Donna to learn TinkerCad at the same level of fluency as she did through helping her manipulate objects.

The concept of sisterhood tends to be focused on Black women encouraging one another through difficult times or task, but this can also be seen in young AA girls, as shown in the cases above. The AA girls who participated in GEC enjoyed helping their "sister" through STEM tasks, so that everyone was able to feel successful and celebrated. Becoming community STEM makers is a "new frontier" for the girls and their sisterhood is anchored in not only their shared identities as AA girls but also their emerging shared identities as AA female community STEM experts.

Sisterhood and Discourse

Creating a judgment-free space where youth work together on hands-on activities can be salient to the success of AA girls. Brown (2006) found that minority youth find it difficult to balance science discourse with their own cultural discourse; therefore, it is imperative to create spaces that not only look and feel judgment-free, but also support open collaboration and discourse among peers, which had an evident influence on how Kia and Sara engaged in a STEM task. GEC provided the space where Sara and Kia could socialize and work on a STEM task, which was imperative in how they engaged in STEM, because they understood that their freedom of discourse was supported in this space. Supporting AA girls' need for collaboration and fostering sisterhood created a foundation where AA girls are comfortable to explore STEM. The girls in this study enjoyed a STEM space that embraced porous boundaries, where they shared their own narratives that were not always completely focused on STEM. The girls in this study were able to use their voices while working on STEM task which was salient to their work at GEC, because they felt their stories were important and would be heard in a

STEM space. By establishing this type of space AA girls' STEM identity can be positively influenced because they feel comfortable engaging in STEM content. Because of the disparity of representation of AA women in STEM, AA girls struggle with believing they belong in STEM fields. By creating an atmosphere of collaboration and support among youth who are of the same gender and ethnic group, AA girls can support each other through a STEM task and in turn be able to see themselves in STEM.

Implications for Designing "Judgment Free" STEM Spaces for AA Girls

Affordances of a Longitudinal Informal STEM Program

This study highlights the importance of longitudinal informal STEM programs. Studies have shown that when youth have the opportunity to engage in an informal science program, their science identity is influenced, and they become interested in science (Rahm & Ash, 2008). As seen in Tan and colleagues (2013), a young girl who participated in an afterschool STEM program was more engaged in science discourse and the science activities than she was in the formal STEM setting. Birmingham and Calabrese Barton (2014) found that long-term programs can foster youth's science expertise, because they have the time and space to investigate science phenomena. Similar to the above studies, this study showcases the affordances of youth engaging in STEM for a long time period versus a short time period for following two reasons: youth are able to build on their STEM knowledges and practices, and sisterhood is nurtured when in a space for a longitudinal time period.

Most of the innovations we task the youth with in GEC require them to be engaged in GEC for weeks at time. The youth use this time to build on their STEM knowledge and practices with each activity. For example, Amber and Jasmine used their math, science, and engineering knowledge to build their dollhouse, which took them a year to create. They had to understand how heavy the floors had to be so that the cardboard could hold the floors up, they had to understand circuitry for the lights, and measurement for the height of the stairs and width and length of rooms. There were instances throughout the girls' making process when they had to tear down what they created and start over; therefore, it was imperative that Amber and Jasmine had the time and space to do this.

The girls' sisterhood was also fostered because they were in GEC for a long period of time. Sisterhood, as stated above is not a shallow relationship between girls; it is bond that is built and nurtured through time. The girls' sisterhood manifested because of the community aspect of this space. The girls were able to talk freely with one another and myself, not feeling as though they had to conform to existing social constraints. The girls spent at least 2-4 years in this space, learning how to work and solve problems together. However, there were times when the girls had disagreements among one another that were negatively positioned in that moment. This negative positioning may have left a girl working by herself (Sara in the toy car making unit) or leaving the group for a time period (Amber in the dollhouse making unit). The longitudinal length of this program is salient to the girls' sisterhood because this time supported them in getting to know each other well enough to form a sincere sisterhood bond. Throughout this time the girls spent in GEC they better understood how to navigate tensions and what working through disagreements looked like. The longitudinal component was an essential piece of this “judgment-free” STEM space because it cultivated the girls’ sisterhood while supporting them during their making process.

Next Steps for STEM Education with Elementary/Middle Grades AA Girls

Although studies have given good insight into why AA girls are not engaging in STEM at the same level as their White counterparts, more research is needed that focuses on how sisterhood, teachers’ acknowledgement of intersectionality, and STEM discourse can better engage AA girls in STEM. Parsons (1997) found that AA girls do not picture themselves as scientists or mathematicians and feel that they will not be supported if they enter a STEM trajectory. Calabrese and colleagues (2013) found that when working with AA girls, weak support systems in schools negatively influenced their science identity. Both studies showed that minority girls need a strong support system when engaging in STEM. The question is, “How can educators create spaces that influence AA girls to become innovators and identify themselves as scientists or engineers?”

Informal STEM programs can play an important role in how youth become interested in STEM. Rahm (2008) found that when youth are engaged in informal science programs they take more ownership than when engaged in a formal STEM setting. This was also found with the girls who participated in GEC, because once they engaged in the making process the took ownership in finishing their innovations (e.g., Jasmine and Amber’s dollhouse toy). Tan and colleagues (2013) found that when young girls participated in an informal science club they felt more comfortable to explore and talk about science. This was also evident with the girls in this study, because all of them finished a STEM innovation and presented on their innovations during GEC expos. As seen in the above examples, informal STEM programs can provide a space that supports AA girls to investigate and talk about STEM knowledge and practices, while fostering their STEM identities.

Although the reason for the underrepresentation of AA girls in STEM is unclear, there is evidence that there is a specific relationship between gender and race as to why AA girls do not pursue STEM majors. This can be changed by identifying strategies that can be used in formal STEM spaces to better engage them by focusing on sisterhood, intersectionality, and free discourse and how they affect AA girls' STEM identity and agency. Carlone and colleagues (2014) found that when youth are given the space to collaborate they are more likely to identify themselves as scientists. As seen in this study, the girls' collaboration was a central aspect in how and why the girls engaged in GEC. The AA girls in this study appreciated a space where they could share ideas with one another, while sharing stories from their days. This STEM "judgment-free" space fostered the girls' discourse and sisterhood, which was imperative to how they engaged in STEM task. More research needs to explore how a "judgment-free" framework can be used in a formal STEM space to specifically better engage AA girls in STEM through sisterhood and free discourse.

Birmingham and Calabrese Barton (2014) found that when youth are positioned as "experts" in the classroom and are immersed in science content without assimilating to the dominant culture they can see themselves as scientists. This was highlighted in Amber's and Sara's cases when they were positioned as experts during the 3D unit by their peers. This positive positioning is significant because of the disparity of representation of AA women in STEM fields to serve as role models for younger AA girls. It is imperative that there is a space that fosters a sense of pride in their culture, supports AA girls' STEM expertise, and influences sisterhood so that AA girls see themselves as scientists and engineers.

Possibilities and Tensions: Sisterhood as a Culturally Responsive Pedagogical Approach

Sisterhood is a form of solidarity that is found when women share a similar oppression brought on by social structures. Sisterhood has been explored between African American women in academic spaces as a way to resist oppressive powers that inhibit African American women from being successful. However, there is very limited literature on how sisterhood can or is manifested in young African American girls (ages 10-14). This study highlighted how sisterhood was used as tool to support and encourage young AA girls to go against current deficit narratives of AA girls and how they engage in STEM. The girls in this study depended on their sisterhood to finish STEM task, while showing their community that AA girls can be STEM experts.

Sisterhood in not a shallow relationship among women or girls; it is a special bond that is established when women have the time and space to understand one another's goals, aspirations, and how their intersectionalities may affect the accomplishment of their goals. Sisterhood is a bond that cannot be broken in midst of disagreements or tension; it is used to surpass negative positioning and microaggressions. The girls in this study understood and supported one another, even through instances of tension and disagreements. Their sisterhood allowed them to support one another's work through their disagreements in order to accomplish their goals in this STEM space, for example when Sara and Kia insisted on completing their video diary after they had gotten into a disagreement.

As shown above it is imperative to explore how sisterhood could be used as a culturally responsive pedagogical strategy and how sisterhood can give insight into ways to better engage AA girls in STEM. However, sisterhood cannot be used as way to engage girls in STEM through shallow friendships or putting AA girls in classroom and expecting them to bond. Sisterhood has to be fostered and nurtured through a long period of time, as shown in this study. The girls in GEC were able to foster their sisterhood because of the longitudinal feature of GEC. Sisterhood is not something that occurs superficially; in contrast, it is a supportive bond between females. By using sisterhood as a culturally responsive pedagogical strategy in STEM courses, educators can engage AA girls in STEM by creating a space that supports AA girls, while disrupting the current deficit narrative of how AA girls engage in STEM.

Limitations

Though this study featured key constructs of what a judgment-free STEM space looks like, limitations still arose. As stated in Chapter III, there were three main limitations that surfaced in the methodology of this study: (a) my role as a participant-observer, (b) uneven data among girls, and (c) ensuring that my own experiences in STEM did not overtake the girls' voices. For example, my role as a participant-observer sometimes limited me in seeing all participants' making processes; however, because of access to other researchers' fieldnotes, I was able to fill in missing gaps. Uneven data among the girls was also a methodological limitation because I was not able to compare shared experiences of the girls' making process as it related to innovations; however, because of the longitudinal nature of the study I was able to compare the girls' STEM knowledges and practices during making units.

When looking at this study as whole there were three primary limitations that also developed: (a) this study focused on AA girls without considering the males in this STEM space, (b) there was no correlation in how or if the girls' STEM identities fluctuated in a formal school science space, and (c) there was not a direct focus on how my presence as an AA woman influenced the girls' sisterhood in this space. First, this study focused on the AA girls who consistently participated in GEC for 2-4 years, with no consideration of the male's impact on the girls in this space or how the males engaged in STEM tasks. There is a need for further research on how the males in GEC affected or did not affect the girls' engagement in STEM and the girls' sisterhood. This may also show how the males in GEC felt being in a space where girls expressed their femininity while completing STEM task. Acknowledging the male's presence in this space is a key component of this study, which was not addressed and is therefore a limitation. Second, there was no extension of how the girls' identities were expressed during the formal school day, which may have shown their STEM identities in a different light. For example, the girls' STEM identity may have been influenced by school science activities, which would have engaged them more in GEC. Or the counter, the girls' STEM identity may have been negatively influenced which caused them to disengage at school but use GEC as an outlet to explore STEM practices. Last, not investigating the effects of my presence in this space is a limitation. I am an AA female who has a STEM background and has been engaged with the community, community club, and GEC since its inception. I went to the same schools that many of the girls attended and I wonder how my engagement being an AA woman in this space contributed or did not contribute to the girls' sisterhood and STEM identity. I worked with the girls for years, I learned about their lives, and I wonder what impact this had on their participation and perseverance in this space. More research needs to be done on how a "big sister" affects her "little sisters" and what that sisterhood looks like.

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APPENDIX A

FIELD NOTE PROTOCOL

1. How are students engaged in the activity of the day/engineering design?
2. What funds of knowledge and practices matter today? How?
3. What science/engineering knowledge/practices matter today? How?
4. What tools (human, material, digital, other) matter in how they bring different knowledge & practices together towards engineering design (i.e., hybrid problems/solutions/practices)?
5. Did the adult facilitator use a STEM mini lesson?
6. What pictures or other artifacts did the adult facilitator get today? And what is notable about the picture? Describe the interaction in detail that the picture capture.

APPENDIX B

OBSERVATION MEMO/CODES

Field Note Focus Question	Evidence
1. How are students engaged in the activity of the day/engineering design?	
2. What funds of knowledge and practices matter today?	
3. What sci/eng knowledge/practices matter today?	
4. What tools (human, material, digital, other) matter in how they bring different knowledge & practices together towards engineering design (e.g., hybrid problems/solutions/practices)?	
5. Did you use a Just-in-Time? If so, what was the result of it?	
6. What pictures or other artifacts of practice do you get today? And what is notable about the picture? Describe the interaction in detail that the picture captures	

APPENDIX C

BACKGROUND INTERVIEW PROTOCOL

1. Could you draw a scientist?
2. Can you describe your picture?
3. Could you draw me a engineer?
4. Can you describe your picture?
5. Why did you join GEC?
6. What do you like about GEC?
7. What do you like about science?
8. What do you like about engineering?
9. How did you hear about GEC?
10. How is your science experience at school?
11. How would you rate yourself in science? On a scale from 1-7, 1 being the lowest and 7 being the highest.

APPENDIX D

JUDGMENT INTERVIEW PROTOCOL

1. What knowledge did you use when doing this project?
2. What past or current experiences did you draw from or think about in order to come up with the idea for your invention?
3. Is there a difference in how you engage in projects in GEC compared to school? How is it different? How is it not different?
4. What does the GEC space look like?
5. What is the difference between your feelings toward science in school compared to your feeling toward science in GEC? Why?
6. Who do you feel you can be in GEC? Who do feel you can be in school? Are your feeling the same or different? How?
7. You all have said the teachers in GEC are “funner” and “happier” than those at school, why do you believe this is important to your learning?
8. When making your invention did you feel as though you could share your ideas without anyone judging you? Can you give me an example? How did this make you feel? Do you feel this way in school?
9. Tell me a story of someone being judged at school and add how that makes them feel.

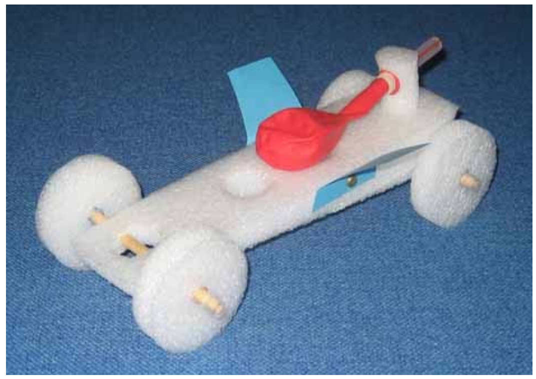
APPENDIX E

ARTIFACT INTERVIEW PROTOCOL

1. What is the name of your invention? How did you come up with that name?
2. What was the problem you were trying to solve?
3. How would your invention help people?
4. How did you come up with the idea for your invention?
5. Is there anything you want me to know about the invention?
6. What are some other things you need to figure about your invention?
7. What are some changes you would make to your invention? Could you draw them out and label them on a picture?
8. What other new ideas do you have to add to your invention?
9. Who are you making this for?
10. Tell me a story of someone using and enjoying your prototype.
11. What materials are planning to use to make your changes to your invention?
12. How does your invention make you feel as learner? Science/Engineering learner?
13. Where did you get the information to come up with the idea for your invention? Did you get any information/ideas from your friends, community, or school that helped you come up with your innovation?

APPENDIX F

TOY CAR MAKING HANDOUT



Car Name: ________________________________

Styrofoam Car Race Data Sheet

Draw a picture of your car in the box below.

Now it's time to RACE!!!

You will race your car three times making improvements after each trial.

Record the distance and the time it took for your car to reach the finish line.

Trial	Distance	Time (seconds)
Trial #1		

1. Describe how your car ran during the first trial run.
____
____

2. Find a way to change and improve your car. Describe how you will change and improve your car.
____
____

Draw a picture of your car with the changes in the box below.

Time to test your change. Record the distance and the time it took for your car to reach the finish line.

Trial	Distance	Time (seconds)
Trial #2		

3. Describe how your car ran during the second trail run.

____

____

4. Find a way to change and improve your car. Describe how you will change and improve your car.

____

____

5. Draw a picture of your car with the changes in the box below.

Time to test your change. Record the distance and the time it took for your car to reach the finish line.

Trial	Distance	Time (seconds)
Trial #3		

6. Describe how your car ran during the third trail run.

____

____

7. During which trial did your car run the best? Why?

____

____

____

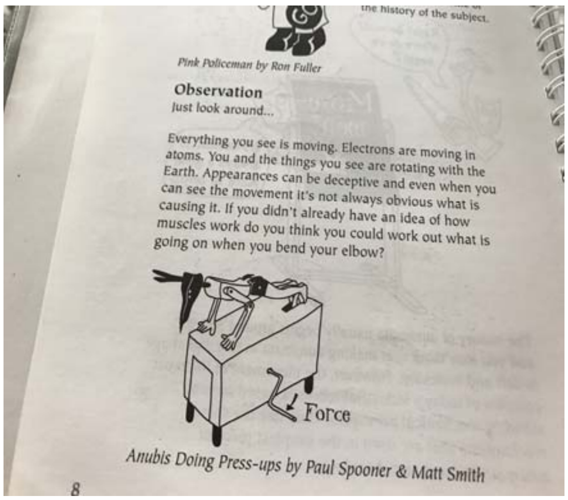
____

APPENDIX G

AUTOMATION HANDOUT

Making Automatons

1. Intro to Automatons:



the history of the subject.

Pink Policeman by Ron Fuller

Observation
Just look around...

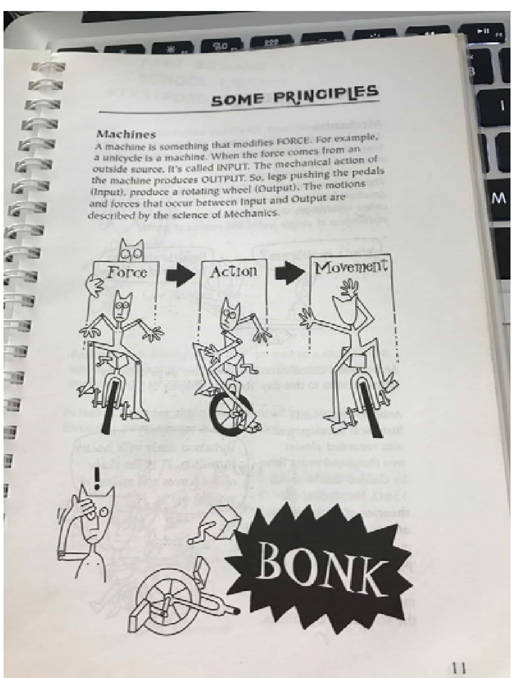
Everything you see is moving. Electrons are moving in atoms. You and the things you see are rotating with the Earth. Appearances can be deceptive and even when you can see the movement it's not always obvious what is causing it. If you didn't already have an idea of how muscles work do you think you could work out what is going on when you bend your elbow?

Anubis Doing Press-ups by Paul Spooner & Matt Smith

8

Youth explore what is happening in order for things to move. Exploration on the how electrons are related to movement in objects.

2.



SOME PRINCIPLES

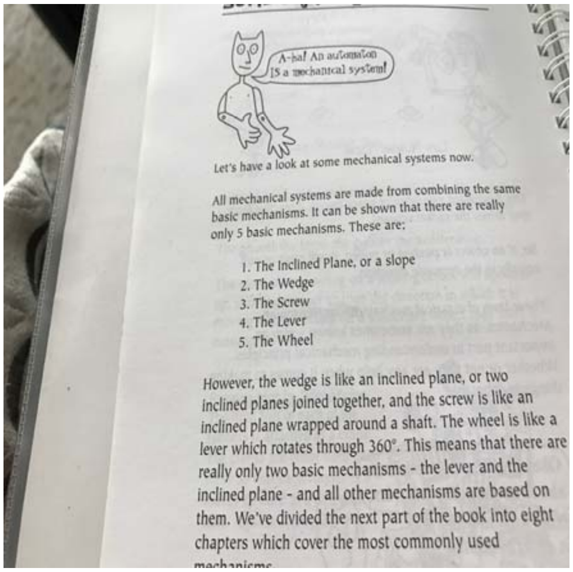
Machines
A machine is something that modifies FORCE. For example, a unicycle is a machine. When the force comes from an outside source, it's called INPUT. The mechanical action of the machine produces OUTPUT. So, legs pushing the pedals (Input), produce a rotating wheel (Output). The motions and forces that occur between Input and Output are described by the science of Mechanics.

11

One important principle for youth to explore is how machine work:
Force-Action-Movement

This concept is imperative for youth to explore how machines work in order to create their own innovation

3.



Let's have a look at some mechanical systems now.

All mechanical systems are made from combining the same basic mechanisms. It can be shown that there are really only 5 basic mechanisms. These are:

1. The Inclined Plane, or a slope
2. The Wedge
3. The Screw
4. The Lever
5. The Wheel

However, the wedge is like an inclined plane, or two inclined planes joined together, and the screw is like an inclined plane wrapped around a shaft. The wheel is like a lever which rotates through 360°. This means that there are really only two basic mechanisms - the lever and the inclined plane - and all other mechanisms are based on them. We've divided the next part of the book into eight chapters which cover the most commonly used

I suggest here that youth explore how the 5 basic mechanisms work and how they are related to machines. How these five mechanisms can be combined to make an automata.

4. Types of Mechanisms that can make an Automata move (while exploring Newton's laws):
   a. Levers
   b. Shafts
   c. Cams
   d. Cranks
   e. Springs
   f. Linkages
   g. Ratchets
   h. Drives & gearing
5. Control-is used to describe the parts of a system which accept the input and instigate the output
6. Checklist in order to build an Automata:
   a. Stage One
      - Observation
      - Discussion
      - Inspiration
      - Drawing
      - Prototyping
      - Prototype Evaluation
   b. Stage two
      - Planning
      - Construction
      - Test
      - Critical Evaluation

7. Four main uses of machines: Transform energy, transfer energy, multiple and/or change force, multiple speed (JiT discussion)
8. Combination of simple machines and circuitry—Looking how circuits can make a motor work, adding on gears
9. Youth can explore the concept of power using a multi meter and how to power an automata

APPENDIX H

TOY UNIT MAKING HANDOUT

How I Made my Toy Innovations

Toy
Group Members:

Draw a picture of your finished Innovation in the box.

What materials did you use to make your innovation?

How did you come up with the idea for your innovation?

What does your innovation say about you (use adjectives like smart, persistent, hard-working, colorful)?

Toy Car
Group Members:

Draw a picture of your finished Innovation in the box.

What materials did you use to make your innovation?

How did you come up with the idea for your innovation?

What does your innovation say about you (use adjectives like smart, persistent, hard-working, colorful)?

Automaton
Group Members:

Draw a picture of your finished Innovation in the box.

What materials did you use to make your innovation?

How did you come up with the idea for your innovation?

What does your innovation say about you (use adjectives like smart, persistent, hard-working, colorful)?

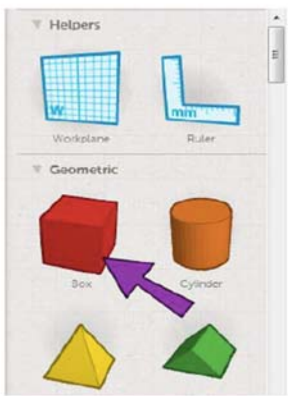
APPENDIX I

TINKERCAD HANDOUT

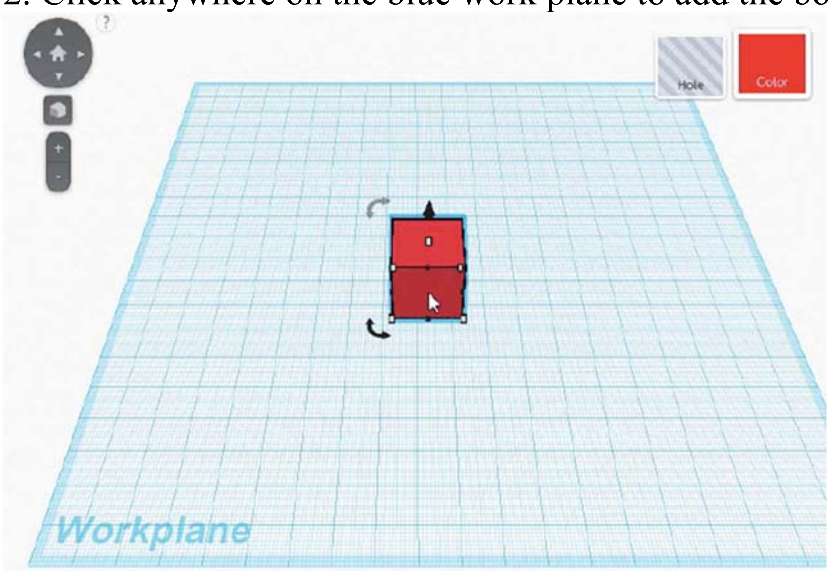
Introduction to 3D Printing
Learning How to Use Tinkercad

You will begin by creating a boat attached using the computer program called Tinkercad. Please see example below and follow the directions below.

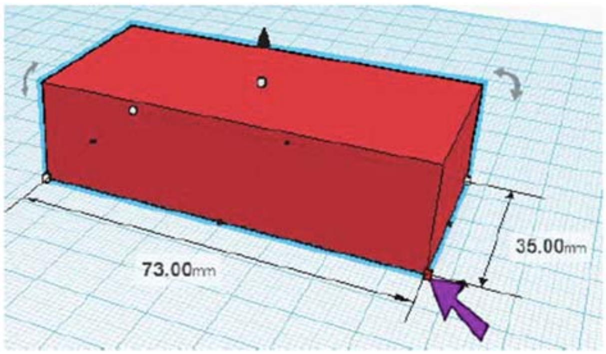
1. Click on Box tool, which is the first icon in the Geometric tool group.



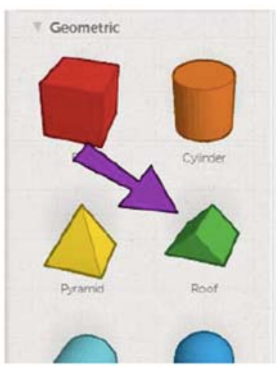
2. Click anywhere on the blue work plane to add the box to the model.



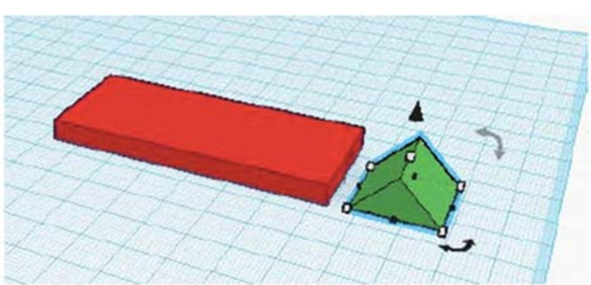
3. To make the box larger (but not taller), drag the white corner squares; by dragging a corner square you will be able to change both the width and length of the box. Put your picture in the box.



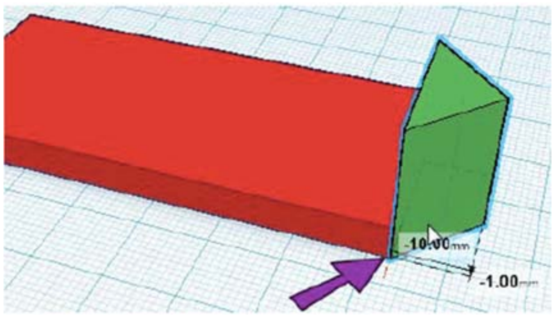
4. Now let's add a sharp corner on the front of the boat. From the geometric tools, click on the roof tool.



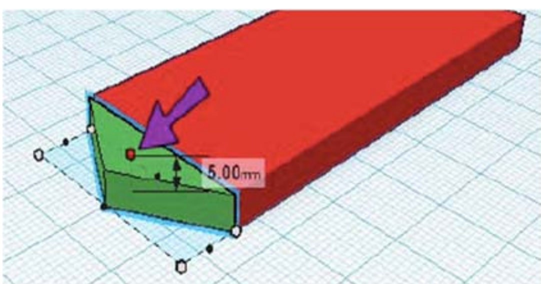
5. Place the roof in front of the narrow part of the box. Play around with the rotating tool which are is the line with the double-sided arrows, to explore how to rotate you roof. Put your picture in the box.



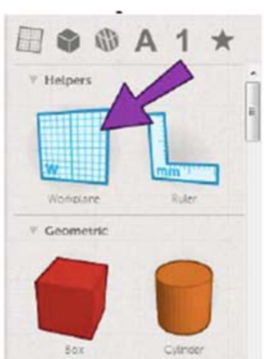
6. Click the rotate tool and rotate the roof 90 degrees (as seen in the picture below) and place in the roof in front of the rectangle so that the two objects are touching. Put your picture in the box.



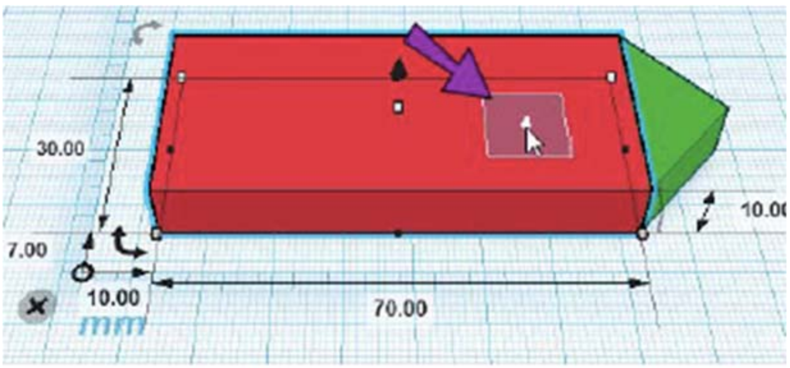
7. Resize the roof so that it has the same dimensions as your triangle. Put your picture in the box.



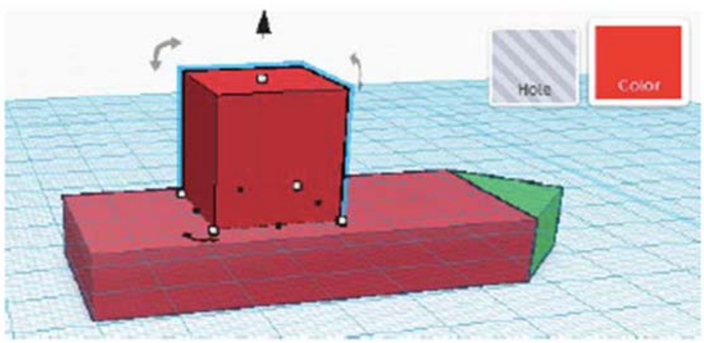
8. Now you are going to build a cabin for your boat. Click on the workplane tool.



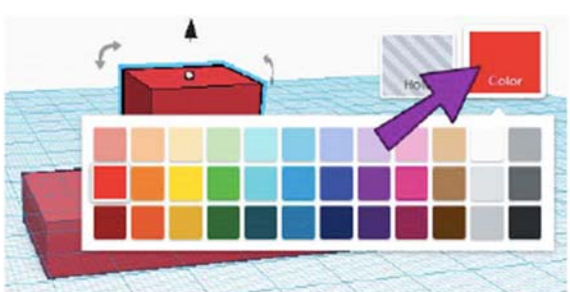
9. Move your mouse to the top of the red box, and you will see a gray square appear, showing you where the workplane will go.



10. Click the box tool and place the new box on the work plane. Put your picture in the box.



11. Now change the color of the box on top of the boat by using the color tool. Put your finished product in the box.



Create your own!!!!
Create your own 3D shape using sketch up. You must have at 3-4 features that you have added to the base.

1. What features are going to add to your base figure?

a.

b.

c.

By holding down the control, shift and 4 buttons at the same time take a screen shot of your creation and place in the box below.

Now Let's Try Making a 3D Image with your name.
By holding down the control, shift and 4 buttons at the same time take a screen shot of your creation and place in the box below.