ABSTRACT

MCCOY, WHITNEY NICOLE. Black Girls Accepting the Grand Challenge: A Qualitative Exploration of a Summer Engineering Program's Influence on Black Girls' Racial Identity, Engineering Identity, and STEM Self-Efficacy. (Under the direction of Dr. Jessica T. DeCuir-Gunby).

This mini-ethnographic case study investigated Black adolescent girls' perceptions of their experiences in an informal engineering education context. A girl's race and gender can influence her perception of her identity and of her potential for educational achievement. The intersections of these social dimensions such as race and gender can be especially critical for Black girls. Therefore, by utilizing Critical Race Theory, focusing on intersectionality, and Black Feminist Thought framework, this study investigated how rising 6th through 8th grade Black adolescent girls (*N*= 11) navigated and described their (a) gendered racial identity, (b) engineering identity, and (c) STEM self-efficacy while participating in summer engineering camp. Additionally, the camp leaders' perspectives regarding their role in the summer engineering camp and their influence on Black adolescent girls' multiple identities were examined. Using daily dairies, semi-structured interviews, and self-expressive art, thematic analysis revealed how Black girls' multiple identities in a predominately White environment influenced their attitudes towards achievement, their perception of engineering, and their understanding of how double bind identities contributed to success for Black women and girls in STEM fields. Resiliency, racial pride, and working harder were strategies they utilized to succeed in the camp environment. Implications will help expand or improve informal engineering experiences for Black girls in order to build bridges and dismantle the barriers that may prevent them from identifying themselves as engineers and persisting in engineering fields.

Keywords: Black girls, intersectionality, racial identity, engineering, self-efficacy, STEM

Black Girls Accepting the Grand Challenge: A Qualitative Exploration of a Summer Engineering Program's Influence on Black Girls' Racial Identity, Engineering Identity, and STEM Self-Efficacy

by
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DEDICATION

This dissertation is dedicated to:

Daddy

From a young age, you showed me what love, patience, and perseverance was. From volunteering every Wednesday for math superstars and at church, to the hugs and laughs we shared as you used your voice to bring us together, the unwavering love you showed me has never been forgotten. Your commitment to support others led me to pursue this degree. For that I am grateful. Your Love has been with me through every step of this Ph.D. journey and may you continue to watch over me through the next one.

♥*Forever your Little Girl* ♥

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I love you!

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Beautiful Black Girls in Engineering Camp

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BIOGRAPHY

Whitney Nicole McCoy was born in Asheville, North Carolina on January 6, 1988. She is the daughter of the late Michael Glynn McCoy and Sylva Renee McCoy-Young. Raised in her parents' hometown of High Point, North Carolina, she had a passion for reading and science. Growing up she prided herself on giving back to the community. She was an active member of Girl Scouts of America where she earned her Gold Award, an active track and field athlete, and the Student Body President at Southwest Guilford High School. After being awarded a STEM scholarship, she attended Winston-Salem State University where she served as the Student Body President, a member of Alpha Kappa Alpha Sorority, Inc., and was a charter member of the Beta Beta Beta Biological Honour Society. Whitney earned a Bachelor of Science in Biology from Winston-Salem State University in 2010. It was through these transformative experiences that Whitney realized she wanted to pursue a Ph.D. and career in education. After undergrad, Whitney joined Teach For America in Charlotte and earned her Master of Arts in Teaching in Elementary Education from the University of North Carolina at Charlotte in 2012. She has six years of classroom teaching experience at the elementary and middle grades levels in public and charter schools. While she was a classroom teacher, she served as the head track and field coach and was named Teacher of the Year.

Whitney began her matriculation at North Carolina State University in 2016 to pursue a Doctor of Philosophy in Teacher Education and Learning Sciences with a concentration in Educational Psychology. She is a Southern Regional Education Board Doctoral Scholar and a recipient of the prestigious National Science Foundation Graduate Research Fellowship, a highly competitive fellowship that is awarded to 2,000 students nationwide each year. During

her time at NC State, she revitalized and served as the Black Graduate Student Association President, has been a member of the Teacher Education and Learning Sciences Graduate Student Association, and a member of the College of Education Graduate Student Advisory Board. In addition, Whitney has been able to assist with several courses such as Adolescent Development and Critical Race Theory in Education. Professionally, she has spent the past four years as a part-time staff member with The Engineering Place as the Assistant Day Camp Coordinator where she works effortlessly to teach others about engineering education.

Upon graduation, Whitney will utilize her skills and talents related to Black girls in engineering at The University of Virginia in Charlottesville, Virginia. Beginning in the summer of 2020, she will serve as a Postdoctoral Research Associate on the Making Engineering Real (ME-REAL) National Science Foundation Innovative Technology Experiences for Students and Teachers Grant Program.

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#ThisIsWhatAPhDLooksLike

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CHAPTER I: INTRODUCTION

One stated goal of the National Science Foundation (NSF) is to enhance inclusion and broaden the diversity of the workforce in science, technology, engineering, and mathematics (STEM) fields over time (National Science Foundation, 2003). This goal addresses several related factors, such as minority faculty being underrepresented in United States' colleges and universities, particularly in STEM disciplines, policy-leading organizations voicing concerns about diversity, and slow integration and advancement of women and people of color (POC) in STEM workplaces (National Science Foundation, 2003). In order to achieve this mission, the NSF is deploying funds to examine the educational pipeline and the experiences that women, girls, and minorities have in science and engineering learning contexts (National Science Foundation, 2003). A better understanding of learners' experiences is critical to identifying the barriers that impact persistence and motivation for non-White, non-male students. Because middle school is a critical stage for persistence and sustaining interest in STEM disciplines, the NSF is working to maintain girls' interest in science beyond middle school, recruiting more girls into elective high school mathematics and advanced-placement science courses, and increasing young women's enrollment in STEM undergraduate studies, particularly in engineering and the computer sciences (National Science Foundation, 2003). Despite several initiatives to increase diversity and research agendas in this area, considering all women and girls as a monolithic group—as is typical of research that does not disaggregate results by demographic subgroups—makes it even harder to critically examine the multidimensional experiences that may promote or decrease participation for students from historically underrepresented populations. Thus,

despite the increased focus on understanding the experiences of women and minorities in STEM fields, educational research on Black girls is still limited.

Moreover, because male researchers and scholarship about male students have historically dominated social science research, our knowledge about Black girls' experiences remains limited (Johnson & Ginsberg, 2015). When trying to expand the narratives of Black girls in STEM, their double bind (Ong, Wright, Espinosa, & Orfield, 2011) of being Black-identified and girls in a White male-dominated field compounds the likelihood that they will not persist and makes it even more imperative that we expand our research on this subgroup. Additionally, in research on K-12 STEM education contexts, content areas are often grouped together instead of being disaggregated by science, technology, engineering, and mathematics (Fletcher, Ross, Tolbert, Holly, Cardella, Godwin, & DeBoer, 2017). With engineering being one of the fastest growing fields and one that will help us innovate, improve, and create designs to help humanity, it is essential that we take a more critical approach to researching Black girls in engineering (Fletcher et al., 2017; National Science Foundation, 2003).

Black Women and Black Girls in STEM

National reform in science and engineering has stated a goal of improving science opportunities for all Americans yet underrepresented students still receive inferior education and reduced opportunities in science (Atwater, 2000). Currently, African Americans[1] make

[1] In this dissertation, the terms "African American" and "Black" are used interchangeably to refer to U.S. citizens of African descent.

up just 5 percent of professionals in the science and engineering workforce (National Science Board, 2018). African American men make up 3 percent of employed scientists and engineers while African American women make up less than 2 percent (1.6 percent) (USDOE, 2016). The National Society of Black Engineers has also noted that STEM research often carries an implicit and explicit deficit-orientation towards African American women in engineering (Fletcher, Ross, Tolbert, Holly, Cardella, Godwin, & DeBoer, 2017). Studies typically focus on how Black girls and women have poor academic preparation, lower academic test scores, and lack familial support (Fletcher et al., 2017). Instead of focusing on individual shortcomings, researchers should examine the structural factors that contribute to systematic exclusion of women and people of color from STEM fields, as well as how these individuals' cultural experiences can enhance research and practice across STEM fields (Ireland, Freeman, Winston-Proctor, DeLaine, McDonald Lowe, & Woodson, 2018). Thus far, researchers have identified multiple systemic factors that create challenges for Black women engineers including stereotype threat, biculturalism, tokenism, feelings of isolation, and pay inequities, in addition to the lack of representation and role models in engineering fields (Fletcher et al., 2017; Ireland, Freeman, Winston-Proctor, DeLaine, McDonald Lowe, & Woodson, 2018).

These and other factors have led to low persistence among Black women in STEM professions despite the fact that they lead matriculation rates among African American students in collegiate settings (Lord, Camacho, Layton, Long, Ohland, & Wasburn, 2009; Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, & Gary, 2009). African American women have also shown a steady 27% decline in attainment of engineering degrees in recent years, with less than 1% of engineering degrees awarded to this population in 2015 (Fletcher

et al., 2017). This is often called the double bind: “the exclusion of women of color in STEM and the undermining of their career pursuits because of both racism and sexism” (Ong, Wright, Espinosa, & Orfield, 2011). Based on previous studies to test the double bind hypothesis among minority women that applied for fellowships, Brown (1995) found that being a minority woman had greater negative impact on fellowship attainment than either being a woman or a minority, even when the Black woman was ranked highly in achievement and talent. Their identities in particular contribute to conflict in the STEM workplace (Ong et al., 2011). For example, in the masculine STEM environment, they may have to redefine who they are, mask their Blackness, hide their family obligations, and find strategies to cope with being the only one. Each of these internal conflicts may deter them from working in the field and could contribute to lower confidence and increase the demand for internal motivation on the part of these individuals. These circumstances may lead to stress, and the social stigma around “who is a scientist and engineer” may impose psychological complications for these women (Johnson, 2011). Moreover, strategies for recruiting Black women to engineering fields begin in K-12 contexts. Thus, a better understanding of how Black adolescent girls access and experience formal and informal STEM education opportunities, especially engineering education, is needed.

In recent years, the Black community is being more loudly celebrated through social media movements and catch phrases such as *Black Girl Magic* (Thomas, 2015). Efforts have also been made to recognize the contributions, innovations, and resilience of Black women and girls in science and engineering fields (Allen, 2018; Thomas, 2015). Despite recent examples of Black women engineers being represented in popular U.S. (White) culture such as in Margot Shetterly’s *Hidden Figures* movie, the representation of Shuri in *Black Panther*

as a scientific engineer, and hashtags that highlight contributions by people of color and women of color such as #BlackAndSTEM, #BlackWomenSTEM, and #ThisIsWhatAnEngineerLooksLike, the fact still remains that research agendas are not substantively addressing the needs of Black girls in STEM learning contexts (Johri, Heyman-Schrum, Ruiz, Malik, Karbasian, Handa, & Purohit, 2018; Joseph, Hailu, & Boston, 2017; Shetterly, 2017). For decades, African American girls have attended American schools, and although there are programs targeted to the needs of English Language Learners and African American boys, research agendas regarding the educational disadvantages that African Americans girls encounter in STEM learning contexts are almost nonexistent (Hanson, 2008; Johnson, & Ginsberg, 2015). Furthermore, educational practices are exclusionary and create gender and racial disparities (Morris, 2016). This causes school systems to fail Black girls on a large scale, leading Black girls to have lower proficiency in science and less confidence in their mathematical abilities as early as grade 5 (Pringle, Brkich, Adams, West-Olatunii, Archer-Banks, 2012). This is directly tied to science and engineering identity outcomes, with their proficiency decreasing as they move through the system (Jones, Howe, & Rua, 2000). Research shows that that Black girls' interest in STEM often declines around grade 5 (McCann, Marek, & Falsarella, 2016), which suggests that in addition to being a pivotal phase for identity development, adolescence is also a critical time for considering how better to recruit and retain Black girls to engineering fields (Epstein, Blake, & Gonzalez, 2017; Schwartz, 2008). Black adolescent girls face stereotypes that prevent them from envisioning themselves as scientists and that may cause them to question their own potential, in turn making them reluctant to explore STEM fields and careers (Atwater, 2000; Seiler & Elmesky, 2007). Frameworks to investigate the unique cultural experiences of Black girls are

limited (Ong et al., 2011; Parsons, 2008). As many studies are focusing on disciplinary practices among Black girls (Morris, 2016), little is known about the experiences this population has in school-based and informal learning environments from the Pre-Kindergarten through twelfth-grade levels. Likewise, there is a dearth of literature on Black women in the field of engineering, so more work needs to be done regarding the intersection of race, gender, STEM self-efficacy, and career outcomes (Ong, Wright, Espinosa, Orfield, 2011).

The Nature of Engineering in Formal STEM Education

Science is a broad field of study that encompasses the interactions and interconnections of a range of physical, biological, and chemical systems; scientific observation, experimentation, design, and improvement have been essential in the development of many aspects of our daily lives (Atwater, 2000; Seiler & Elmesky, 2007). Engineering, an extension of science, is how science and mathematics are applied and implemented to innovate, design, and construct new solutions for complex problems. It is often referred to as “the missing E” because it is not a formal content area like English language arts, mathematics, science, social studies, and technology (Brophy et al., 2008). Teachers in the middle grades can often be unaware of how connected engineering is to the content they teach in science and mathematics since engineering has only recently been adopted in K-12 education through the Next Generation Science Standards (Pleasants & Olsen, 2019). Instead of integrating content standards, the focus in many mainstream schools is science (Brophy, Klein, Postmore, & Rodgers, 2008; Pleasants & Olsen, 2019). Thus, engineering is not a visible option and, with science curriculum being hegemonic in nature, Black girls encounter barriers in the engineering educational pipeline and along the pathways

to engineering careers (Ireland, Freeman, Winston-Proctor, DeLaine, McDonald Lowe, & Woodson, 2018).

Science Education for Black Girls

Science education forms the foundation for engineering education in the U.S. K-12 system, and researchers have outlined several critical issues with the potential to impact engineering identity development and career outcomes for Black girls. Decades of studies suggest that teachers in K-12 schools, beginning at the elementary level, often avoid science because they do not have the equipment to conduct experiments, they are not knowledgeable about the content, and/or they feel pressure to spend the time teaching courses that are tested by the state (i.e., English Language Arts and Mathematics) (Tilgner, 1990). Some schools may even elect to teach science for only half of the week because of national tests (Tilgner, 1990). Low persistence of Black girls in STEM classes and careers has been tied to a lack of STEM course offerings in low-income schools for children of color (Smith-Evans et al., 2014). According to a 2014 study, only 50% of predominantly Black and African American high schools offer calculus and only 63% offer physics (Smith-Evans et al., 2014). Only 57% of predominantly Black high schools offer a full range of science courses (i.e., biology, chemistry, physics), compared to 71% of predominantly White high schools. Fewer Black girls are enrolled in advanced placement courses than any other female population (National Center for Education Statistics, 2015; Smith-Evans et al., 2014). Black girls are also more likely to be enrolled in intense literature courses instead of science and mathematics courses, which sets them behind the curve when trying to pursue advanced studies in science and engineering (Smith-Evans et al., 2014). Smith-Evans found that without taking advanced

science courses in high school, Black girls are not positioned well to succeed in STEM fields later on in collegiate settings.

According to the U.S. Department of Education, the average science test scores for African American students were at least 30 points lower than those of their White peers (National Center for Education Statistics, 2015). These performances could be connected to many African American students believing that science is "only for smart kids" and/or "if we had more famous Black scientists then there would probably be more Black women and men in the science field" (Brand, Glasson, & Green, 2006). These perceptions greatly influence the stereotypes students develop and the value they hold for an activity (Collins & Lightsey, 2001). The views of science that African American children develop as they mature and interact with family, peers, school curriculum, media, and many other influences (Brand et al., 2006; Walls, 2012). Many researchers have studied Black girls' academic performance in schools. Academic performance tracking in science courses has created pressure for teachers because they, as well as students, are evaluated based on student performance, thus creating tension in social networks of Black girls because lower and higher performers feel like they have to separate themselves (Gholson & Martin, 2014; Joseph et al., 2017). Moreover, even though some Black girls have performed higher in life sciences compared to physical and earth sciences assessments, composite science scores on achievement assessments are significantly lower than the basic achievement level of White students (average 129.70 and basic is 131) (Young, Feile, & Young, 2017). Lower performance in physical and earth sciences can lead to negative attitudes regarding the subject matter, thus leading to a lack of early science achievement for Black girls that is directly related to STEM efficacy, career

outcomes, and teacher preparation (Smith-Evans, George, Graves, Kaufmann, & Frohlich, 2014).

Teacher Preparation in Science Education

The problem does not begin with the teachers; it starts with collegiate preparation of pre-service teachers. African American students represent 53% percent of students in U.S. K-12 public schools. In these schools, 20% or more of the teachers are uncertified or unlicensed. These statistics contribute to improper curriculum preparation in core subject areas such as language arts and mathematics and lack of access to quality science and social studies content (US Department of Education Office for Civil Rights, 2014). Many certification programs over the past 30 years have not required intensive coursework in multiple science courses for elementary teachers (Clotfelter, Ladd, & Vigdor, 2006). Without having a hands-on experience of how to implement inquiry-based learning and hands-on learning in the classroom, teachers may not know how to implement high-quality instruction for students (Tilgner, 1990; Walls, 2012).

Research shows that classroom teachers with negative attitudes regarding science project these feelings onto their students (Brand, Glasson, & Green, 2006). Considering that every student can be influenced by their teacher, negative attitudes can discourage students from pursuing STEM opportunities (Wieselmann, Dare, Ring-Whalen, & Roehrig, 2020). Understanding Black students' achievement in science and math requires examining cultural values and norms. From taking defensive stances regarding classroom interactions with teachers, to refusing to take advanced science courses because they lack confidence and support, Black students have expressed that teachers are the gatekeepers of capital, resources, and entry into STEM (Seiler & Elmesky, 2007). Black girls in particular are typically the last

group of students to be targeted for science opportunities because of dual academic and behavioral marginalization (Collins, 2018; Ireland et al., 2018). Additionally, many teachers hold an assumption that men are better-equipped for STEM (Brown, Henderson, Gray, Donovan, Sullivan, Patterson & Wagstaff, 2016). For some teachers, stereotypical beliefs about girls' and minorities' science skill set (e.g., math and science is a "guy thing"), name calling, and other ineffective teaching practices can deter students from becoming interested in science (Pringle, Brkich, Adams, West-Olatunji, & Archer-Banks, 2012). As most educators in the K-12 workforce are White females and often hold deficit beliefs and biases about Black girls and their capabilities in science, these patterns can greatly contribute to lower performance, interests, and expectations in STEM over time (Collins, 2018). Exclusionary practices can also lead to less flexibility for creativity and interpretation about what science is as students matriculate through the K-12 educational system (Calabrese Barton & Tan, 2018). If educators are not driving the STEM narrative and the structures place limits on Black girls, pathways cannot be created for them. By using intersectional approaches and being sensitive to the fact that we all have different backgrounds and perspectives, we can challenge and disrupt how schools are teaching science and tracking students. This will help ensure that Black girls can achieve in environments where their actions and attitudes are typically punished (e.g., longer or harsher suspensions) unequally for actions such as "being distracting because they talk a lot" or "rolling their eyes" (Ireland et al., 2018; Joseph et al., 2017; Morris, 2016).

Engineering Education

With limited access and teachers who are novices in the field of science, we cannot even scratch the surface of integrating hands-on engineering experiences broadly.

Engineering experiences involve working collaboratively, making decisions on measures and data, and persisting through design failures by using systematic approaches to improve the discipline and solve problems to help people (Mathias-Riegel, 2001; Pleasants & Olsen, 2019). Among the primary necessities for engineering education are the ability to be creative and the possession of tools, cheap or expensive, that allow students to design freely and fail (Brophy, Klein, Portsmore, & Rogers, 2008). However, many schools lack access to equipment and typical school curricula do not encourage creativity (Moore, Glancy, Tank, Kersten, Smith, & Stohlmann, 2014). Schools are more likely to teach students that failing is not good because it has a negative connotation and having a free, creative mind is only elicited in art-based classes, although this has been debated (Moore et al., 2014). Still, engineering can allow students to integrate all content areas as they work on a project (Moore et al., 2014). For example, when tasked with designing a launching tool for a country that needs medicine during an outbreak, students can use mathematics through measurement, investigate the country's geography through social studies, use scientific knowledge to look at physical science concepts, and utilize language arts by writing a narrative about their creation. The "Habits of Mind" in engineering are also life skills that all children benefit from, such as systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations (Lucas & Hanson, 2016). By using these habits, engineers solve problems that students discuss each day known as the Grand Challenges, such as: advancing personalized learning, making solar energy commercial, reverse-engineering the brain, engineering better medicines, restoring and improving urban infrastructure, securing cyberspace, providing access to clean water, and engineering the tools of scientific discovery (Vest, 2008). Teaching the Habits of Mind can allow students to collaborate and

communicate better, and seeing that failure is a reality, they will grow and improve. Thus, introducing these habits will allow more students to gain exposure and possibly pursue a career in the field to address the critical challenges we face in the world (Lottero-Perdue & Parry, 2017). With many new testing protocols being introduced into school environments, such as the Next Generation Science Standards, a critical examination of the state of STEM education is essential (Pleasants & Olsen, 2019).

Importance of Informal STEM Education

As an extension or alternative to formal teaching practices, informal learning has become an avenue for teaching students about the field and enhancing their exposure to engineering (King & Pringle, 2017; Pleasants & Olsen, 2019). Informal learning is also referred to as out-of-school learning (Eshach, 2007). Although there is a misperception that children spend most of their time in the classroom, most learning experiences occur outside of the classroom (Bell, 2009; Falk & Dierking, 1992). Informal learning environments can be instrumental in changing students' views of STEM. These experiences are categorized as *everyday experiences*, everyday learning experiences that support learning through play outside, observation in the home, etc. that may occur through interaction with the natural world and assist with the development of everyday skills and awareness. *Designed settings,* which are science centers, zoos, museums, aquariums, and parks that utilize real-world phenomena to engage students in inquiry or conversation to develop an interest in the subject matter. *Media* refers to the television, internet, podcasts, gaming devices, and other tools that make information readily available and increase access to discovery learning; and *program settings* such as summer programs that can be found on collegiate campuses and community centers (Bell, 2009; Falk & Dierking, 1992; Simpson & Parsons, 2009). These settings

provide opportunities that are different from school classroom learning environments. STEM experiences outside of school have the potential to diversify the workforce and allow students to integrate their personal heritage into learning (Falk & Dierking, 1992). These environments may require procedural and conceptual understanding, but also tend to focus more on an inquiry/discovery hands-on approach (Buck, Cook, Quigley, Prince, & Lucas, 2014).

Informal Engineering Education Programs

In engineering education, the goal is to apply real world concepts that will lead to discovery and invention of new concepts. For example, challenges might ask students to design a water filtering system in a community with dirty water or create a form of Chapstick that will last all day (Thompson, 2014). Informal programs allow African American students to investigate and design new projects as well as identify how they can create a lasting impact in their surrounding community (Denson, Lammi, White, Bottomley, 2015). Informal engineering programs such as Engineering is Elementary (EiE) have emerged with a curriculum designed to help educators and students increase engineering literacy through hands-on design activities (Mathias-Riegel, 2001). The Summer Engineering Experience for Kids (SEEK) is a program organized by the National Society of Engineers that hosts elementary and middle school African American students and gives them exposure to collegiate STEM students, hands-on projects, and the roles of engineers and African American images in STEM (Fletcher et al., 2017). Lastly, there are many programs emerging to encourage Black girls to become scientists and engineers. The most prominent program that spans across the United States is BlackGirlsCode, which “introduces programming and technology to a new generation of coders, coders who will become builders of technological

innovation and of their future" (Rockman et al., 2017). Annual reports from these programs discuss program goals, but only BlackGirlsCode includes a case study research evaluation listing themes of "mattering and belonging," "leadership and confidence," "culturally relevant programming", and "increased academic success and interest in STEM career pathways" (Rockman et al., 2017, p. 14). A BlackGirlCode alumna stated:

> It's important for programs like this to exist I think it's mainly because there's not that many African Americans or women in general in the field of STEM and engineering and technology. I feel like doing this helps people, maybe like me, who I thought I was going to be a scientist and now I'm converting more into computer science, which is what it seems like my field might be in college (qtd. in Rockman et al., 2017, p. 22). With potential for such a strong influence on Black girls' views of STEM, more research should explore Black girls' experiences in these programs. Although each of these programs exposes students to engineering, research evaluating these programs are not extensive. Typically, engineering research is conducted on collegiate engineering programs, informal computer science programs, and LEGO robotics programs for students from various backgrounds (Whitman & Witherspoon, 2003). Also, many informal education research studies do not include African American students or Black girls, because the programs are not accessible or unreasonably priced for many families in urban and rural areas (Denson et al., 2015; Simpson & Parsons, 2009). Moreover, with increased access and knowledge about these programs, a lasting impression can be created in communities that are not typically exposed to STEM experiences (Simpson & Parsons, 2009).

Problem Statement

Currently, research shows that only 7% of women in collegiate settings graduate with a STEM degree and only 28% of the science and engineering workforce are women (USDOE, 2016). Moreover, a scant 2% of women scientists and engineers in the field are African American (Ashcraft, Eger, & Friend, 2012; Lord, Camacho, Layton, Long, Ohland, & Wasburn, 2009; National Science Board, 2018). A girl's race and gender can influence her identity as well as how she perceives herself and her ability to achieve (Cole, 2009; Collins & Lightsey, 2001). Therefore, the intersection of these social dimensions can be critical for girls, especially for African American girls (Capobianco, Diefes-dux, Mena, & Weller, 2011).

Goals of the Research

The purpose of this study was to understand and examine the experiences of African American adolescent girls who were participating in an informal summer engineering program by utilizing a mini-ethnographic case study design. Critical Race Theory (CRT) and Black Feminist Thought (BFT) frameworks with an intersectionality lens (Crenshaw, 1989; Delgado and Stefancic, 2017) were used to understand the lived experiences of the African American adolescent girls who participated in the camp and in my study. Specifically, the research explored the girls' experiences using the constructs of (a) racial identity, (b) engineering identity, and (c) STEM self-efficacy. The goals were to investigate the following research questions: (1) How do African American adolescent girls describe and navigate their multiple identities while participating in the informal summer engineering camp? (2) How do African American adolescent girls view themselves in the context of a summer engineering

camp? (3) What are camp leaders' perspectives regarding their role in the summer engineering program on African American adolescent girls' multiple identities?

Theoretical and Conceptual Framework

The unique experiences and cultural backgrounds of African American girls in STEM fields are not often investigated (Parsons, 2008) and frameworks utilized to do this are limited (Ong, Wright, Espinosa, Orfield, 2011). Sixty years after *Brown v. Board of Education*, African American girls "wear the cloak of invisibility" (Johnson & Ginsberg, 2017, p. 26) in STEM, but especially in engineering (Ireland, Freeman, Winston-Proctor, DeLaine, McDonald Lowe, & Woodson, 2018). In order to explore these experiences, three major theories inform my analysis: racial identity (Sellers, Smith, Shelton, Rowley, & Chavous, 1998), engineering identity (Capobiano, 2006; Collins, 2018), and STEM self-efficacy (Bandura, 1986; Britner & Pajares, 2006). Racial identity is how one perceives her membership with a particular racial heritage group, including attributes and feelings that are developed as she interacts with family, peers, school, and media (DeCuir-Gunby, 2009; McAdoo, 2002; Tatum, 2017). Similarly, engineering identity is how closely she recognizes that she can be an engineer based on her ability and personal interest (Morelock, 2017). STEM self-efficacy is how she perceives her ability to do well in STEM. STEM self-efficacy is influenced by various experiences (i.e., vicarious learning, verbal influences, emotional and physical states) and in turn influences choices, effort, and achievement (Bandura, 1986). Thus, STEM self-efficacy is a strong predictor of future achievement in engineering and career choices (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Kier, Blanchard, Osborne, & Albert, 2014).

Looking at the intersections of these social dimensions for African American girls can

be a critical way to explore how to create pathways for them in STEM education (Capobianco, Diefes-dux, Mena, & Weller, 2011; Cole, 2009; Collins & Lightsey, 2001). Intersectionality describes Black women's and girls' multi-dimensional interconnected experiences regarding such identity categories as race, gender, sexuality, class, and others that overlap and contribute to systemic oppression and discrimination (Crenshaw, 1989). Therefore, I utilize intersectionality and Critical Race Theory to address issues of power (Delgado and Stefancic, 2017; Ladson-Billings & Tate, 1995) and Black Feminist Thought (Collins, 1990) as my theoretical framework to investigate how the informal STEM learning environment influences African American girls' STEM experiences.

Critical Race Theory

The success of Black women and Black girls in engineering is directly tied to the historical underpinnings of people of color being marginalized as White men are privileged in educational contexts (Johnson & Ginsberg, 2017; Shetterly, 2017). This is highlighted in the movie *Hidden Figures* when Mary Winston Jackson, one of the three women who helped NASA catch up in the space race, helped women and minorities advance their career potentials so they could change their titles from "mathematician" to "engineer" and increase their chances of promotion. In the movie she is asked, "If you were a White male, would you wish to be an engineer?" She replies, "I wouldn't have to, I'd already be one. Every time we have a chance to get ahead, they move the finish line" (Shetterly, 2017). This encounter illustrates how Black women have historically and still continue to face systematic power issues that deter them from being engineers and scientists (Yoder, 2016). For example, in 2005, 1,100 African American women graduated with a bachelor's degree in engineering. By 2011, 809 African American women earned the same degree, which was a 27% decrease

(Yoder, 2016). Frameworks such as Critical Race Theory (CRT) will aid in dissecting the literature on Black girls in science and engineering education.

Originated by Bell, Freeman, and Delgado, critical race theory (CRT) is a critique of the legal and civil rights movements' so-called victories, and addresses the relationship of race, racism, and power structures in U.S. society (Delgado and Stefancic, 2017; Ladson-Billings, 1998). CRT questions the foundation of our country's pride in its liberalism, apparent equality for all, and ostensibly fair and just constitutional system. Although some landmark court cases seemed to propel African Americans forward and allow them to gain opportunities (e.g. *Plessy v. Ferguson*, *Brown v. Board of Education*), their impact has been diminished over time and Whites have been the primary beneficiaries of civil rights and landmark decisions (Bell, 1992). Some scholars may caution against the use of CRT in the field of education. To improve relationships and biases, research agendas must reflect the historical experiences of people of color (Ladson-Billings, 1998). These calls to action have been stated, but those in K-12 education are hesitant to require these honest conversations about race relations and how racism affects the outcomes of minorities (Ireland et al., 2018). Additionally, research studies often group together all people of color in reporting results despite creating distinct racial and/or ethnic subgroups (e.g., African American, Latinos, Asians, and Native Americans) encounter different problems and barriers (Ladson-Billings, 1998). Within this study, there are some tenets that are more prominent than others. Therefore, in subsequent chapters I will focus on *intersectionality* (Delgado and Stefancic, 2017*)* as a methodological framework that can be used as an analytical tool, critical race theory has the potential to be transformative in expanding the current literature on Black adolescent girls in science and engineering.

The six tenets of CRT are: (1) the permanence of racism, which states that race is permanent and a constant that controls social, political, and economic mobility in our society; (2) interest convergence, which acknowledges that Blacks will only benefit from a system if Whites see something in it for themselves; (3) the critique of liberalism, which says that our neutral stance and colorblindness allow Whites to ignore how race prevents equal rights and opportunities; (4) Whiteness as property, which states that "the law's construction of Whiteness defined and affirmed critical aspects of identity; of privilege; and of property," making it easy to exclude African Americans (Harris, 1993, p. 1725); (5) intersectionality, which explores the intersection of race, class, gender, and systems of oppression (Collins & Andersen, 2007; Crenshaw, 1989); and (6) counter-storytelling, which uses narratives to give people of color a voice in a marginalized society (Delgado and Stefancic, 2017; Ladson-Billings, 1998).

CRT asserts that racism is normal in our social order. Though some believe that racism is gone with the days of the civil rights movement, CRT allows individual accounts and voices to speak to the present-day struggles that people of color and minoritized groups have with racism. African Americans today might have more opportunities, but they are still provided fewer opportunities and paid less on average than Whites, and in many ways, schools are more segregated now than they were in the 1970s (Frankenberg, Lee, & Orfield, 2003). CRT calls for people to become activists and work together to challenge educational injustice in America. Based on an understanding that every group of people is different, CRT recognizes other minoritized groups through Latino CRT, LGBTQ CRT, and Muslim CRT (Delgado and Stefancic, 2017; Ladson-Billings, 1998). I will expound upon the foundational background of the tenets of interest and discuss how they are related to Black adolescent girls

and their persistence in science and engineering as it pertains to identity.

Intersectionality

Kimberlé Crenshaw coined the term intersectionality, which describes the multi-dimensional interconnected lens of social identities that overlap with racist and oppressive encounters (Delgado & Stefancic, 2017). For Black women and girls, constructs such as race, gender, class, and other social categories overlap and contribute to systemic oppression and discrimination (Crenshaw, 1989). Within her work, Crenshaw also highlights that Black girls are often invisible compared to Black males, but are vulnerable to some of the same risks, such as expulsion, underachievement, and dropping out; all of which have long-term effects (Crenshaw, Ocen, Nanda, 2015; Morris, 2016). With historical underpinnings in Black feminism and CRT, intersectionality is a critique of feminist and antiracist movements (Carbado & Gulati, 2000) that depend on stereotypical images of who is represented (i.e., White women and Black men), as well as a framework that challenges the marginalization of women of color through power systems such as the U.S. law system. It investigates the intersections of race, class, gender and systems of oppression by looking at relationality, the scrutiny of power relations, and the advocacy of social justice (Crenshaw, 1991; Collins & Bilge, 2016). Not discipline-specific, the framework can be utilized in multiple venues, such as history, science, law, and psychology, within and outside of the United States and concentrates on "an undercurrent of anxiety around the continuing salience of Black women in a theory that reaches beyond their specific intersectional realities" (Carbado, Crenshaw, Mays, & Tomlinson, 2013, p. 305). Within research, counter stories of Black women that have faced discrimination, marginalization and privilege issues that are created by their separate, but intersecting identities, will allow us to broaden the field of literature that already exists. As an analytical methodology, intersectionality helps us look at the hidden dynamics

of the double bind, although some have challenged that researchers are "too concerned" with African Americans and have critiqued findings that focus on the lives of Black women over lives of people from different gender and sexual orientations, disabilities, nationalities, races, and ethnic groups (Collins & Bilge, 2016).

To be Black and a woman is a complex experience. It is not that this identity is just "Black" or "woman," they are a "Black-woman" (Ong, Wright, Espinosa, & Orfield, 2011). Crenshaw states that "Discourses have failed to consider intersectional identities such as women of color" (Crenshaw, 1991, p. 1242). There are three types of intersectionality: structural, political, and representational (Crenshaw, 1991). Structural intersectionality focuses on "the ways in which the location of women of color at the intersection of race and gender makes the experience of remedial reform qualitatively different from White women." Political intersectionality looks at feminist and anti-racist politics. Political agendas often look at men of color or Black men (i.e., police brutality and Black men) and White women (i.e., feminist women's march and #metoo movement (Johnson & Ginsberg, 2015). Representational intersectionality looks at the cultural construction of women of color. Intersectionality can be used not only as a framework, but a methodology to challenge the consequences that Black women and Black girls face. Their multifaceted identities of race, gender, and educational/career interests call for a critical understanding and plan of action can be created when working with this population.

Black Feminist Thought

As CRT is used to critique the legal victories that our society has had, Black Feminist Thought (BFT) was used as a framework to guide this study in further centering the Black girl in the research. In this framework, Collins (1990) situates the Black woman's

"experience at the center of analysis [to] offer fresh insights on the prevailing concepts and paradigms" (p. 560). By reconceptualizing structural systems and oppression, social relations are reframed along with ideas of resistance. The theory also provides knowledge about the truth of Black women/girls. Some of the main concept of BFT are: *outsider within,* which is the idea that identity leaves us in this position because we are neither a part of Feminism, which is centered around White women, or Black Social Thought, which is centered around Black men; *intellectual activism* within scholarly work and outside in all content areas such as music, art, literacy, etc.; *self-definition,* which is "the power to name one's own reality," *controlling images,* which focuses on the critique of stereotypical images of Black women that have oppressed the population; and *matrix of domination,* which highlights structural oppression in the hegemonic, disciplinary, structural, and interpersonal domains that lead to intersectional oppression because of race, gender, sexuality, age, and socioeconomic status (Collins & Bilge, 2016).

Collins (2002) cites BFT as an extension of feminism that "articulates the taken-for-granted knowledge of African-American women" (p. 750). It does so by encouraging Black women to self-define their standpoint, and through scholarly research rearticulating the knowledge claims that White scholars, especially men, have developed about the stories and experiences of this population (Collins, 2002). By challenging the current research methods that ask African American women to displace themselves from their own work, BFT encourages Black women scholars to center themselves in the work, make new knowledge claims, and build credibility in their work by working collectively as a community (Collins, 2002). BFT states that a specialized lens is needed to understand the collective perspective African American women have on their unique experience of being Black and a woman

(Collins, 2002). Thus, I will utilize this framework to center the voices of the Black girls that are in this study.

Dissertation Overview

By highlighting the voices of Black adolescent girls in engineering education, this study was committed to challenging the structural forces that impact informal learning in STEM education. Black women and Black girls are often ignored and silenced in engineering learning contexts, and current educational practices tend to deploy deficit orientations rather than valuing the positive cultural perspectives that Black girls bring to science and engineering. This chapter shared the current state of Black women and girls in STEM education and formal education practices in science and engineering, as well as why informal education is important. In subsequent chapters, the literature review will ground the study by explaining how informal learning has influenced Black girls. The literature will connect how Black girls' development in these programs is related to psychological theories such as racial identity, engineering identity and STEM self-efficacy. In chapter three, the research design, methodological process, and questions that guided the study are shared. Next, in chapter four, the findings are presented using thematic analysis. Lastly, chapter five discusses the findings as well as limitations, recommendations, and directions for future research.

CHAPTER II: REVIEW OF THE LITERATURE

This chapter addresses the theoretical and relevant literature that guided me in investigating Black girls' experiences in summer engineering camps and how those experiences relate to their identity development and self-efficacy. I review the current literature, focusing specifically on scholarship around Black girls in informal STEM education and the psychological constructs of racial identity, STEM self-efficacy, engineering identity, and intersectionality. Due to the limited scholarship that focuses on the current state of Black girls within engineering education, the review includes related research in the areas of science and engineering.

The STEM Pipeline

The STEM pipeline, an educational pathway that ultimately determines the number of students who will become STEM professionals, is a metaphor is often used to describe students' trajectory toward the workforce especially in conversations about representation of minorities and women in STEM fields (Allen-Ramdial & Campbell, 2014). Research studies have identified "leaks" in the pipeline through which women and minorities matriculate in K-12 and decide against pursuing STEM degrees at the collegiate level (Cannady, Greenwald, & Harris, 2014; Joseph, Hailu, & Boston, 2017). Many factors such as race, gender, ethnicity, socioeconomic status, and school experiences have been identified as contributing to attrition through the pipeline. However, the broad majority of research in this area draws attention to student academic or behavioral issues instead of structural inequity (Allen-Ramdial & Campbell, 2014). Such an approach shifts focus away from systemic gendered racism within the STEM pipeline that cause women to be the least represented in engineering

compared to science and mathematics (Lord et al., 2009) and Black women to represent only 1.6% of working professionals in science and engineering (USDOE, 2016).

Black Girls in Informal STEM Education

Children are spending vital amounts of time outside of the classroom, and researchers seeking to understand the pipeline cannot rely only on the classroom setting for understanding STEM exposure. Harvard's out-of-school time research database has stated that informal programs can increase or improve various factors for girls in STEM, such as confidence with math skills, attitudes about STEM media messages, the number of female science majors in colleges, and social support, to name a few (Chun & Harris, 2011). However, these benefits do not come without challenges. The Harvard report (Chun & Harris, 2011) describes three challenges that are connected to the Black girl informal STEM learning experience: "a limited body of existing research on out-of-school programs focused on STEM education, and therefore there is a lack of consensus on metrics," "a struggle to engage girls who do not initially express interest in STEM subject matter," and "competition for time and resources with many different curricular components" (Chun & Harris, 2011). Therefore, given the push to increase the number of Black women in the field of engineering, there is a need to expand the body of research and understanding of the experiences of Black females in these settings and focus on Black girls at a younger age—such as adolescence—to influence STEM outcomes.

As a result of the limited research on Black girls' experiences, little is known about how to assist and support them in informal environments (Thompson, 2014). Informal learning for Black girls provides them with free choice and spaces without stereotype limitations (Eshach, 2007). Using their own intrinsic motivation, the learners themselves can

lead their own exploration compared to the formal school environment (Eshach, 2007). In many of the settings that cater to the needs of Black girls, the staff members are invested in the personal outcomes of Black girls specifically (Rockman et al., 2017; Scott & White, 2013). Research studies that focus on the intersection of racial identity, being a Black girl, and/or STEM often observe high performers or girls that succeed in the field (Fordham, 1993; Ireland et al., 2018). These studies do not focus on all constructs at once (i.e., racial identity, STEM self-efficacy, and engineering identity). African American girls are bombarded with explicit and implicit messages that "being a scientist is not feminine enough," "only nerds like science," and "you are acting White if you are performing academically in science, technology, engineering and mathematics (STEM)" (Ashcraft, Eger, & Friend, 2012; Saatcioglu, 2012; Tate & Linn, 2005).

However, many informal learning programs aim to increase interest in science, mathematics, and engineering using a hands-on approach, field trips, and mentoring strategies that use efficacy, gender, and/race as constructs (Ferreira, 2002). COMPUGIRLS, a computer science engineering program, is working to increase diversity and utilize methods, such as culturally responsive practice (CRP), to increase science self-efficacy for African American girls in underserved communities (Elam, Donham, & Solomon, 2012; Scott & White, 2013). CRP allows students to make connections with what they are learning and their community, thus increasing science value and self-efficacy (Scott & White, 2013). CRP teaches students through a strengths-based approach and increases cultural competency, achievement, and racial identity. Scott and White (2013) assert that showing students that there are African American and Latina engineers engaging in activities to improve their community can make a difference. For example, in COMPUGIRLS, students built a Scratch

program (an online programming language community for children to share interactive media stories, games, and animations) to exhibit the negative effects of gentrification on urban areas (Scott & White, 2013). Using the narrative approach has been helpful because research shows that girls often have strong verbal skills (Scott & White, 2013), so girl-focused engineering activities could be more narrative-based. Doing so will aid in improving self-efficacy, or one's belief that they can accomplish a task or succeed in a situation (Brickhouse, Lowery, & Schultz, 2000; Jones, Howe, & Rua, 2000; Sammet & Kekelis, 2016).

Another program, Digital Divas, an after-school informal program with Black and Latina girls also focused on computational projects that used story narratives to expand circuitry and fabrication knowledge (Fisher, Lang, Craig, Forgasz, & McLeod, 2016). Using situational interest or the spark within an environment that allows a girl to engage or disengage with an activity as a way to develop interest in STEM, a community of Black and Brown women and girls were given scaffolded challenges to develop a computational narrative (Erete, Pinkard, Martin, & Sandherr, 2015). After reading a narrative and listening to questions related to the characters' identities and appearances, researchers noted that the girls had certain beliefs regarding people in STEM careers or students with STEM interest (Erete et al., 2015). Understanding their thoughts about identity can provide insight on how to increase girls' interest in STEM (Erete et al., 2015). Identity and race were found to be indicators that minority girls attribute to positive self-image and STEM identities (Barron, Gomez, Martin, & Pinkard, 2014). It is essential that African American girls understand how they can create a lasting impact within their surrounding community and world within STEM (Capobianco, Diefes-dux, Mena, & Weller, 2011; Chubin, May, & Babco, 2005). Programs

like these that challenge the current curriculum and discuss topics that matter to Black girls are needed to drive the STEM narrative for this population.

Similarly, using a critical race feminist lens and counterspaces as their conceptual framework and social construction epistemology, King and Pringle (2018) used the voices of Black girls to understand STEM-related informal experiences through qualitative narrative inquiry. Semi-structured interviews with photo elicitation, student work samples, reflection journals, and field notes were collected. The researchers found that field trips transformed interest, girls were autonomous of their own learning in STEM activities, and race was the main influence on their STEM perception of school. The researchers were able to see how the community-based program changed their view of STEM and how examining gendered racial experiences can construct new meanings about the identities that Black girls develop in these settings (King & Pringle, 2018).

In a sequential explanatory mixed-methods study using self-efficacy constructs, Buck et al. (2009) applied feminist theory to assess the attitudes that African American girls have about science in an urban community. The researchers found that science learning is school-based and success in the subject area drives more success (Buck et al., 2009). An integrated approach that focuses on the intersectionality, self-efficacy, and identity development, will help to more fully understand how these girls are influenced by participating in science and engineering programs.

Identity and Efficacy Theories

Along with CRT and BFT being the main frameworks utilized in this study, there are additional theories that were utilized to cover the depth of study of Black adolescent girls in science and engineering. When examining the theories that address Black girls' engineering

identity development, retention, and persistence in engineering are connected to identity and interest. Feeling like they belong in a space and value certain tasks are some of the factors that contribute to identity development. Collins (2018) mentions that Black students may ask four questions that contribute to their persistence in STEM relating to belonging, success, interest, and assimilation in the area. Furthermore, these questions are related to the psychological constructs of (a) racial identity, (b) STEM self-efficacy, and (c) engineering identity.

Racial Identity

Racial identity is a person's psychological perception that she shares the cultural and racial heritage of a particular group, including attributes and feelings (e.g., I am Black, Black people do X) (DeCuir-Gunby, 2009; McAdoo, 2002). One's individual racial identity is influenced by the attitudes and feelings about oneself, the racial group orientations that affect one's attitudes and behaviors, and the conscious affirmation and commitment one makes to their particular racial group (DeCuir-Gunby, 2009; Tatum, 2017). Working to develop a healthy racial identity is important because a person's racial identity greatly affects the value orientations they might possess (Tatum, 2017). Racial identities develop as children mature and interact with family, peers, school curriculum, media, and many other factors (McAdoo, 2002; Tatum, 2017). These may influence the stereotypes and prejudices that they develop (Tatum, 2017). Specifically, studies suggest that African American girls' self-efficacy may be a mediator of racial identity, gender identity, and STEM identity (Collins, 2018). Thus, researchers should consider incorporating the two measures together (Collins & Lightsey, 2001). Practitioners should pay attention to girls' racial identity development as it relates to their self-esteem. Thus, this construct can be an important factor and should be analyzed

when examining the experiences of Black adolescent girls to aid in understanding how race influences their perceptions of engineering.

Multidimensional Model of Racial Identity

There are many different racial identity models, such as Cross (1980; 1995) which focused on five stages transformation which lead to Nigrescence or being Black, and Parham & Helms (1981) model of racial identity attitudes. For this study, I will focus on one of the most widely used theories regarding Black students, Sellers' Multidimensional Model of Racial Identity (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). Sellers, Smith, Shelton, Rowley, and Chavous (1998) created the Multidimensional Model of Racial Identity (MMRI) to define the significance of group racial membership and individual self-perception of one's race. To determine the qualitative meaning of racial identity among African Americans, the four dimensions are: racial salience, racial centrality, racial regard, and racial ideology. *Salience* is the "extent to which one's race is a relevant part of one's self-concept at a particular moment or in a particular situation," *centrality* is the extent to which race is valued in the individual's identity, *regard* is "the feeling of positivity or negativity towards being Black," and is divided into two sub-groups, *private* and *public. Private Regard* measures the extent to which the individual feels positive towards other African Americans and being African American and *Public Regard* measures the extent to which the individual feels that other groups feel positively or negatively towards African Americans. *Ideology* subscales are generated to assess how individuals feel African Americans should act and include *Assimilationist, Humanist, Minority, and Nationalist. Assimilationist* beliefs see similarities between African American and mainstream U.S. Society. *Humanists* see similarities among all people regardless of race. *Oppressed Minority* see similarities between African American

experiences and those of other oppressed minorities. *Nationalist* views emphasize the uniqueness of being African American and show support for African American communities and African American social groups. To operationalize the MIRI, the Multidimensional Inventory of Black Identity was created (Sellers et al., 1998); but to measure the racial identity of early and middle adolescents, which are very different from adults, the multidimensional inventory of Black Identity–Teen (MIBI–T) (Scottham, Sellers, & Nguyên, 2008) was adapted from the MIBI. Regardless of what dimension of identity a child is associated with, understanding racial identity theory can support educators' understanding of student learning and academic outcomes in engineering education amongst Black girls (Chavous, Bernat, Schmeelk-Cone, Caldwell, Kohn-Wood, L., & Zimmerman, 2003). Furthermore, along with racial identity, understanding how students perform in an area can bolster their interests.

Self-Efficacy

Self-efficacy is a component of social cognitive theory which states that learning occurs in a reciprocal manner that includes observing behavior, imitating, or modeling through social interactions, experiences, and/or media (Bandura, 1989). Self-efficacy is one's perception of her own ability to be successful at a task (Bandura, 1986). In other words, self-efficacy is a personal judgment of one's own competence. Self-efficacy is developed and continuously influenced through interactions and experiences (i.e. vicarious learning, verbal influences, emotional and physical states), and varies across different domains and tasks (Bandura, 1989). Self-efficacy influences choices, effort, and achievement (Bandura, 1986). For example, a student who has high self-efficacy in science and engineering may choose to join a robotics club and design projects at home using YouTube videos. This activity may

increase science vocabulary, which increases achievement on science assessments. On the other hand, that same student may have low self-efficacy in literacy. The student might avoid sharing ideas in classroom discussions. This may limit their flexibility with literacy strategies and result in lower grades in English/Language Arts. *Performance accomplishments* are based on personal mastery through repeated success (Bandura, 1977). Failure on multiple occasions can reduce mastery expectations. Through experiences of success, self-efficacy can be transferred to similar tasks and goals as well as when a person can model the task themselves. *Vicarious experiences* come from observing other people around us. By seeing others succeed, people may form an enhanced belief that they have the same capability for mastery. This is often a result of looking to role models, because behaviors that are viewed as successful can influence other individuals to perform in the same way when they related or identify with the model individual (Bandura, 1977). *Verbal persuasions* are when influential people in our lives increase our belief that we can succeed or master a task based on their suggestions or encouragement (Bandura, 1977). Although this is one way to shape self-efficacy, it is not as strong as performance accomplishments or vicarious experiences, because it is not self-induced (Bandura, 1977). Lastly, *emotional and physiological states,* such as stress and depression, can alter how confident one is regarding mastery ability (Bandura, 1977). Negative emotions can result in decreased self-efficacy, whereas positive emotions can result in increased self-efficacy (Bandura, 1986).

STEM Self-Efficacy

STEM self-efficacy is an individual's belief that they can perform a task or be successful in science, technology, engineering, and/or mathematics Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Self-efficacy is a strong predictor of future achievement in

science and engineering and also influences career choices (Bandura et al., 2001). STEM interventions can increase self-efficacy, but without STEM interest that can be hard to attain (Bandura et al., 2001). Students who consider themselves good in the content area also believe that they can achieve well in the same area (Bandura et al., 2001). This aligns with other research showing that students with high self-efficacy will put more effort into future tasks, which will increase the opportunity for future success, and continue to promote high self-efficacy (Pajares & Schunk, 2001). Shapiro & Williams (2012) state "women can serve as a source of stereotype threats for other women" or girls when they are not as confident in their own STEM ability. For example, in classrooms, when a woman teacher is not confident in her science and math ability, girls in the classroom may fear that they are incapable of achieving in these areas too. Successful role models from similar backgrounds and the same group (e.g. African American girls meeting African American women scientists and engineers from the same community) can reduce stereotype threat, dispel myths, and relieve some of the burden for girls that may be apprehensive about STEM (Marx, Ko, & Friedman, 2009; Shapiro & Williams, 2012).

Many studies focus on STEM self-efficacy at the collegiate level. Even with undergraduate women in engineering showing positive increases in self-efficacy after participating in engineering curriculum at a Predominantly White Institution (PWI), there are significant decreases in African Americans' feelings of inclusion in these spaces (Marra, Rogers, Shen, & Bogue, 2009). This may be the result of feelings related to belonging such as peer relationships, feeling valued, and/or cultural connections. Furthermore, for Black men and women at Historically Black schools, same-race mentoring in an engineering curriculum led to higher self-efficacy (Lent, Brown, Sheu, Schmidt, Brenner, Gloster, & Treistman,

2005). Thus, the relationship between racial identity and STEM self-efficacy were connected for students who were trying to develop engineering identities. The linkages between racial identity and STEM self-efficacy have the potential to guide further understanding of STEM outcomes.

In regard to gender and race, these constructs greatly influence outcomes because expectations for a child's educational and career interests are driven by social norms and gender-appropriate standards (Brickhouse, Lowery, & Schultz, 2000). Some may view engineering as a creative space for children; however the field is often viewed as competitive and impersonal (Morelock, 2017). Girls typically follow the rules rather than break or invent them, and while girls are playing house or teacher in their rooms, boys are tearing down castles of building blocks (Brickhouse, Lowery, & Schultz, 2000). For example, girls are more likely to develop higher interest and self-efficacy for "girl-like activities/careers," such as a nurse, teacher, and artist. Boys are more likely to develop high self-efficacy for "boy-like activities/careers," such as scientists or athletes. These images of what girls do compared to boys fail to challenge hegemonic male gender norms nor do they question the diversity that we see when we challenge these homogeneous roles (Brickhouse, Lowery, & Schultz, 2000; Morrongiello & Rennie, 1998). Beliefs that Black girls may have internalized regarding their STEM self-efficacy can reveal how confident they are in pursuing specific fields. With many teachers emphasizing that engineers use mathematics and science as tools, these beliefs can guide us in understanding how STEM self-efficacy is related to engineering identity.

Engineering Identity

Science identity is described as how one views their own abilities, their sense of self and interest, and what they desire to be as it pertains to science (Carlone & Johnson, 2007). Engineering identity is how closely one recognizes or believes themselves to be an engineer based on their ability and personal interests (Morelock, 2017). Although each of these definitions are similar, what it takes to form a science identity, which entails wanting to create questions, observe, and create theories is very different from an engineering identity, where the person will be engaged in creating solutions to those questions (Morelock, 2017). There are many factors that have been associated with achieving a science or engineering identity. More specifically, these are called constructive, detractive, and directional factors (Morelock, 2017). Constructive factors are those that help positively develop these identities such as experiences in the content area, exposure in formal learning or informal learning, internships, role models or connecting with a professional network, and confidence in one's math or science skills (Morelock, 2017). Detractive factors have negative impacts on developing these identities, such as engineering related experiences (more negative or less exposure), gender marginalization, and one's identity (i.e. being female, being a minority) (Morelock, 2017). Directional factors do not negatively or positively affect professional identity, but do affect the kind of identity that is developed such as environmental factors (Morelock, 2017).

Identity or a "certain kind of person" (Gee, 2001) that is drawn to the field based on their nature is an area of increasing interest as efforts to diversify science and engineering also grow. Gee's (2001) identity framework consists of four dimensions: nature, institutions, discourse, and affinity (Gee, 2001). In reference to Black girls, the nature dimension relates

to something they cannot control (i.e., being Black and being female). The institutional dimension would be how the Black girls must behave or act based on the rules or culture of the camp setting. The discourse dimension refers to the characteristics or personality traits girls would have when interacting in a setting. Affinity refers to how the Black girls are committed to engineering based on their interests. Every dimension is thought to contribute to who an individual becomes based on various aspects of their lives (Gee, 2001). Thus, these four dimensions influence how engineering identity develops when engaging in a particular experience.

As researchers try to increase identity development in science and engineering, many interventions approach identity as a something natural and innate instead of considering how it interacts with student beliefs, interests, and values (Winston, Wall Rice Bradshaw, Lloyd, Harris, Burford, & Burrell, 2004). Researchers often ignore factors that may work against acquiring these identities (Collins, 2018). Most research studies focus on science identity, as engineering identity is less frequently considered, although there is a need for a more diverse engineering workforce. Science and engineering identity models can be used to investigate what affects STEM outcomes.

Many researchers, such as Carlone and Johnson (2007), Capobianco (2006), and Collins (2018) have expanded Gee's (2001) framework to investigate what drives STEM pursuit for women and minorities. Carlone and Johnson (2007) developed a model of science identity that focuses on undergraduate women engineers and collective and socially constructed identities. It is composed of three intersecting dimensions—competence, performance, and recognition—and is based on the assumption that "one's gender, racial, and ethnic identities affect one's science identity" (Carlone & Johnson, 2007, p. 1191).

Competence is the knowledge or understanding of the content, performance is how one utilizes tools and communicates about scientific practices, and recognition is being seen as a "science person" (Carlone & Johnson, 2007). These researchers also take into consideration that cultural influences such as social norms, historical, and political meanings can have an effect on women of color and their science identity (Carlone & Johnson, 2007).

The Capobianco (2006) framework suggests that academic, institution, gender and role models determine how young women view themselves in the field as engineers. This is the only model that focuses on gendered engineering identity (Capobianco, 2006). Academic identity is "their belief in who they are as an engineering student," institutional identity is "their connection to the respective engineering program and/or university," gendered identity is "their belief in who they are as women and how their gender is mediated in the engineering program," and a role model is "someone they aspire to be and how others encourage and support them" (Capobianco, 2006, p. 291).

Collins (2018) focuses on psychological/individual factors, STEM contextual/environmental factors, and cultural factors that influence African American STEM identity. This model was the most relevant to the current study. Collins states that critical characteristics are needed for Black students to develop high interest in STEM (Collins, 2018). For Black girls in engineering, being able to see the possibility of success or a role model through *reflective identity* (e.g., race, gender, educators, and practitioners), can give them a sense that they belong in the field. Along with this, *competence/ability* can increase participants' self-confidence when they perceive their ability through successes in informal STEM environments like an engineering camp. Lastly, connecting engineering to the girls' community through *value/interest* allows them to see how STEM can help within

their environment, which will increase their interest in engineering. After achieving each of these components, the girls can successfully adapt, be successful, and feel as though their Black racial identity is accepted in the camp setting (Collins, 2018).

The Need for a Theory of Black Adolescent Girl Engineering Identity

Most research efforts are focused on the current science agenda and increasing the population of girls in science. Many academics have hoped that as more Black women enter the academy, much of their focus will be on Black women and Black girls, but instead many research Black males (Johnson & Ginsberg, 2015). With a great need to increase scholarship and research in the area of engineering to solve the problems that we face today, Black girls' engineering identity development should be a targeted area of study. When looking at the Carlone and Johnson (2007), Capobianco (2006), and Collins (2008) models of identity, they all mention ability/efficacy, gender and race, and science/STEM identity in some form, but each STEM field is different and different experiences cater towards pursuing a career in either science, technology, engineering, or mathematics. As we are working to disaggregate gendered and racial experiences in STEM, we should look to do the same for STEM theories. Science and mathematics are the more widely researched as they pertain to Black girl trajectories compared to engineering (Ireland et al. 2018; Joseph et al. 2017). Science discovery is what leads us to engineer designs of the future; so, although it may seem like one could research the field of science to learn about engineering outcomes, the status of application, creativity, and failure in each field make them vastly different. Science research studies do not typically focus on Black girls' abilities in engineering. The complexity of engineering innovation is distinct from pure scientific experiment exploration that focuses on observation compared to creation. Current theories of science and STEM identity only

account for collegiate, secondary students, or pre-adolescent students and have not assessed the feasibility of utilizing this theory on African American adolescent girls. Most of the theories have been tested on majority White populations. Along with this, whereas Collins's (2018) model is most relevant to the study, the model does not account for the inequitable structures (e.g., costs, access, parental knowledge, schooling practices) that exist within STEM for Black girls. Instead the model suggests purely assimilating into the STEM culture and using defense mechanisms to survive in the environment.

A new model of engineering identity development for Black girls should focus on recognizing the systems and intersecting experiences that contribute to the outcomes of these girls in engineering. By recognizing the gendered racial identity (i.e., the intersection of a of Black girls' gender identity and racial identity), being aware of the contextual STEM environment (i.e., a predominantly White environment, a predominately Black environment, majority men, majority women), understanding the girls STEM self-efficacy (e.g., science and mathematics self-efficacy), knowing the girls internal environment (e.g., home and familial life), and challenging the structures that variously limit or afford opportunities in this space, we can utilize CRT and BFT with pre-developed theories (see Figure 1) to explore how Black girls are persisting in the field of engineering education. Each of these various constructs may impact one another. For example, STEM self-efficacy may be impacted by the home environment if the girl has a parent who is a mathematician. The STEM contextual environment may also impact the girls' gendered racial identity if she is the only one in the setting. Thus, in order for Black girls to gain a seat at the table in the White male-dominated field of engineering, we must examine the missed opportunities, inequitable education, and

psychological constructs that influence the invisibility of Black girls and Black women in science and engineering.

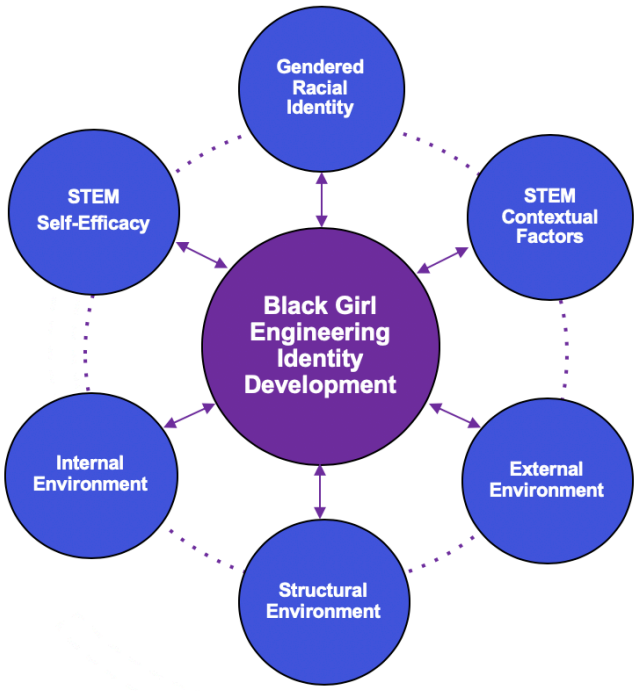

Figure 1. Intersection of Black girl identities in engineering identity development. Adapted from "Confronting color-blind STEM talent development: Toward a contextual model for Black student STEM identity" by K. H. Collins, 2018, *Journal of Advanced Academics*, 29(2), 143-168. Copyright 2018.

CHAPTER III: RESEARCH DESIGN AND METHODOLOGY

Research Questions

The purpose of this study was to understand and examine the experiences of African American adolescent girls in an informal summer engineering camp. This approach allowed me to investigate how the girls' multiple identities including racial identity, engineering identity, STEM self-efficacy, and their intersections were influenced by their experience in a field where Black girls are underrepresented. Little is known about the experiences of Black girls in informal engineering learning contexts and how these informal contexts influence their multiple identities. Therefore, the following questions guided this study:

(1) How do African American adolescent girls describe and navigate their multiple identities (i.e. racial identity, gender identity, engineering identity) while participating in an informal summer engineering camp?

(2) How do African American adolescent girls view themselves in the context of a summer engineering camp?

(3) What are camp leaders perspectives' regarding their role in the summer engineering camp on African American adolescent girls' multiple identities?

Research Design

To address my research questions, I used a mini-ethnographic case study design. Mini-ethnographic case studies focus on a narrowed view of inquiry which allow the researcher to understand the culture, norms, and roles of people in a bounded phenomenon as they are immersed within participants' lives or derive interpretation through interviews (Fusch, Fusch, & Ness, 2017; Merriam, 1998). This allowed for in-depth analysis of a within-site descriptive case study (Fusch, Fusch, & Ness, 2017). This blended design allowed

me to conduct research from an "insider's point of view" as a storyteller (Creswell & Clark, 2017; Fusch, Fusch, & Ness, 2017). Multiple sources of data were collected to ensure that I could depict a detailed understanding of the girls' lived experiences in the findings.

The use of this mini-ethnographic case study design was necessary for this study given our limited knowledge about the experiences of Black girls in the field of engineering education (Ireland et al., 2018). It also allowed me to develop a fruitful understanding of the small population of Black girls that had access to and participated in this specific informal learning setting. I utilized thematic analysis to provide a better understanding for educators in formal and informal settings, researchers, and policymakers that hope to improve engineering outcomes for Black women. Lastly, I was able to examine how teachers, camp counselors, and camp administrators viewed themselves as they contributed to the identities of Black girls through group interactions during camp.

Mini-ethnographic research can be completed over a short period of time (i.e., one week) and, through observation, the researcher is immersed in the cultural context of the participants (Fusch et al., 2017). In this approach, researchers collect interviews, artifacts, and observations to understand the culture in a meaningful way (Fusch et al., 2017; Hammersley & Atkinson, 2007; Humphreys & Watson, 2009). The researcher studies the "behavior, language, and interaction of the culture-sharing group (Fusch et al., 2017; Hammersley & Atkinson, 2007; Humphreys & Watson, 2009). Culture is a dynamic, complex, ever-changing force in human lives. Culture and ethnicity are the foundational factors that influence other expressive behaviors such as thinking, speaking, performing, relating, speaking, and teaching (Carter, 2003; Yosso, 2005). Affiliations, age, gender, social class, education, race, residence, individuality, and immigration influence these mitigating

behaviors (Yosso, 2005). Each of these factors, culture and ethnicity, expressive behaviors, and mitigating behaviors interact with one another and are multidirectional in their influence on individuals (Yosso, 2005). Therefore, understanding the behavior of Black girls in this educational setting is imperative to assessing the benefits and areas for improvement in engineering education for this population.

Program Site Context

The study took place at the Explore Engineering camp at a public university in the southeastern region, Grandover University. The campus is a predominately White land-grant institution that works to serve the state through extension, innovation, and research. Grandover University serves approximately 35,000 students. At the time of this study, Grandover University was well-known for their STEM programs and their College of Engineering was nationally ranked and recognized for many achievements. Explore Engineering was housed within the College of Engineering that served more than 10,000 students (approximately 6,900 undergraduates and 3,300 graduate students). The College of Engineering prided itself on one of the best in the nation among predominately White institutions that produced Black engineers and on being above the national average (25%) for enrollment of female undergraduates. Enrollment of minority students (e.g., African Americans, Hispanics, and Native Americans) was nine percent for undergraduates. Racial and ethnic demographics were as follows for undergraduates: 90.3% White, 3.2% African American, 4.8% Hispanic, 1.3% identified as more than one racial or ethnic group, and less than 1% Native American.

Founded as an extension of the Women in Engineering Program, Explore Engineering had a mission to educate citizens about engineering as a discipline, career opportunities in the

field, and the impact engineering has on real world applications. By utilizing informal workshops, sessions, and camps with hands-on engineering design learning, the program leaders hoped to increase students' interest in engineering, particularly for women and students from historically underrepresented groups. During the academic year, many educators utilized the program to borrow materials at no cost and used the pre-developed lesson plans to integrate engineering into their classrooms. Additionally, local schools used programs that Explore Engineering hosted throughout the year like STEM Nights, Design your Own City, and Engineering Enrichment Days to give students exposure to the field.

The Explore Engineering staff consisted of three year-round employees, one that dedicated her time to the summer day and residential camps that served over 1,000 students during a seven-week period from grades K-12. Developed approximately twelve years prior to this study, the summer day camps at Explore Engineering typically served White students from high socioeconomic backgrounds. The cost to attend the camp was $425 per week and each camper was eligible for financial assistance. Each summer, the day camps served approximately 500 students from grades K-10, hosted about 15 teachers for an engineering learning experience, and employed seven undergraduate engineers and six high school students that worked together during camp. Explore Engineering hosted two weeks of high school day camp, two weeks of middle school day camp, two weeks of upper elementary day camp, and one week of lower elementary day camp. As the grade levels of the campers increased, the percentage of females and African American students decreased. The context of the program is important because African American adolescent girls are underrepresented in the program, especially at the middle school level. In most cases, the girls in this study were the only one on their team or were one of two African American girls on their team.

Participants

Participants were selected based on enrollment in the main summer campsite, Explore Engineering. The girls were rising 6th through 8th graders in private and public schools throughout the United States. In total, there were 18 African American girls who enrolled in the camp. Out of the 18, one did not attend due to transportation issues, one did not attend because she did not know how to access the parking area, two declined to participate, and three did not complete the study. Eleven African American girls completed the study. They were enrolled in one of the two weeks of middle school day camp (five in week 1 and six in week 2). Although there was a fee of $425 associated with the camp, all of the African American adolescent girls (along with other applicants) were eligible for financial assistance to offset the camp cost. Only girls who qualified and provided proof of need through the camp application were granted financial assistance. Of the camp participants, 36% of the girls received financial assistance ranging from $100 to $425 to offset the total cost. During week one of the camp, there were a total of 76 campers, 46% girls and 54% boys; they self-identified as Asian (11%), African American (28%), White (37%), Hispanic (7%), Native American (8%), and Other (4%). An additional 5% did not identify their racial group. During week two, there were 75 campers, 59% female and 41% male; 7% Asian, 23% African American, 51% White, 7% Hispanic, 8% Native American, 3% No response, and 1% Other. As a part of normal camp activities, the African American girls were placed into six smaller groups of 12 with campers of all races/ethnicities and genders with whom they collaborated and used hands-on learning and design activities to experience engineering.

The perspectives of the camp counselors (undergraduate engineering and education majors), camp teacher team leads (K-12 educators), the camp coordinator, and the camp

director were also obtained to provide an understanding of how their role assisted the girls as they navigated through the camp. Camp staff was diverse compared to previous years: 83% of teacher team leads were African American, 17% were White, 71% were women and 29% were men. For the engineering majors, 29% identified as African American, 57% identified as White, and 14% identified as Latinx; 43% identified as women and 57% identified as men. The camp coordinator and director both identified as White females.

Engineering Summer Camp Activities

Each girl participated in one week of engineering summer day camp. Camp ran from approximately 8:45 am to 3:30 pm. As a part of the camp, the girls were assigned to one of six teams (two teams per breakout room) with one teacher team lead (current classroom teachers/educators) and one undergraduate day camp counselor (current engineering undergraduate students). All participants were introduced to the engineering design process: ask, plan, imagine, create (includes testing), and improve (Cunningham, 2009). Each day participants engaged in hands-on engineering challenges/activities in which they worked with different groups of three. Collaborations among ideas were displayed in the engineering notebook each participant was given and on the group Whiteboard where ideas were shared. After completing each engineering challenge, camp closing activities allowed for engineering design results to be judged, assessed, and then awarded based on group performance. During the intervention, I took field notes and utilized pictures of engineering design products and engineering notebooks/Whiteboards to gain a better understanding of daily interactions at camp. A sample camp schedule and challenge example are provided in Appendix A.

Engineering Challenges

During the week of camp, the girls participated in nine engineering challenges/activitities, two of which they redesigned. Each engineering challenge was introduced to all of the campers using real-world scenarios that were developed by undergraduate engineering majors with the assistance of teacher team leads, who give direction regarding camper understanding based on background knowledge for the specific age group. The challenges focus on various types of engineering disciplines such as mechanical, aerospace, industrial systems, environmental, biomedical, and civil engineering, with a focus on the problem that needs to be solved. Campers were given an hour and 15 minutes to complete each challenge. Each challenge was presented using a challenge guide (Appendix B). Descriptions of each challenge can be found in Table 1.

Table 1

Engineering Camp Challenges

Challenge	Description	Grand Challenge	STEM Connection(s)
Straw Construction	Manufacture straw structures using a budget and time constraints	Engineer tools of scientific discovery	Learn the advantages and disadvantages of effective communication
Polymer Discovery and Polymer Process	Develop a formula to create a sticky, stretchy, and leakproof polymer	Develop carbon sequestration methods	Understand solutions and how they interact/Estimate liquid volumes and masses
Heartache	Make a device that will clear clogged arteries without having to perform bypass surgery	Engineer better medicines	Explain the functions of major systems in the human body/Understand and find a percent of a quantity
Fuel-Less Flight	Create a glider that will travel the greatest distance	Develop carbon sequestration methods and manage the nitrogen cycle	Analyze motion in one dimension and systems of forces/Calculate the change in distance
Pipeline Construction	Determine the most economically and environmentally friendly path for the Atlantic Coast Pipeline	Provide access to clean water and restore/improve urban infrastructure	Evaluate human influences on freshwater availability
Water Consumption	Implement a new water infrastructure to ensure adequate water to the entire county	Provide access to clean water and restore/improve urban infrastructure	Understand ratio reasoning to solve problems/Understand the hydrosphere and the impact of humans on local systems

Table 1 (continued)

Water Filtration System	Design a water filter that will allow you to make it through the next three days	Manage the nitrogen cycle and provide access to clean water	Understand that although some populations have the capacity for exponential growth, there are limited resources
Fabric Contraption	Construct a lightweight, clean water containment device	Provide access to clean water	Explain how places are influenced modification of the engineering designs

Data Collection

Several forms of data were collected for this study. After Institutional Review Board approval (#16853), participants who chose to be in the study completed a minor assent form after parental consent was given, which detailed the research methods, time commitment, risks and benefits, and anticipated impact. Data collection took place over 14 weeks from early-July to early-October. To prepare for data collection, I practiced observing Black girls in the high school Explore Engineering camp two weeks prior to the middle school camp. This allowed me adjust to taking field notes and stepping out of my role as the assistant day camp coordinator. It should be mentioned that while I did step out of my role to collect data, at some points it was necessary to return to that role to address major camp concerns. This only occurred once during my two weeks of data collection. Before the camp began, each girl completed a demographic questionnaire electronically. During the camp, I took pictures of engineering design products and engineering notebooks and collected field notes to keep

track of observations. At the end of each day of camp, the girls completed daily diaries/reflections in which they discussed how they navigated their multiple identities within the informal engineering summer program. Also, each girl was interviewed and shared her self-expressive piece of art individually after the end of the camp regarding how she perceived her experiences in the camp as an African American girl. In addition, approximately nine camp staff members, the coordinator, and director were interviewed at the end of camp.

Demographic Questionnaire

The demographic questionnaire (see Appendix C) contained questions regarding the students' ages and current grade level. The girls completed this questionnaire before attending camp on an electronic form. Information regarding previous camp attendance, socioeconomic status, race and ethnicity, and parent/guardian career status was also obtained from camp records. Additionally, questions regarding why they enrolled in the camp, how many years they attended camp previously, their sense of STEM self-efficacy, and what their career aspirations were included.

Daily Diaries

The use of daily diaries is similar to traditional journals that allow participants to have "repeated self-reports that aim to capture events, reflections, moods, pains, or interactions near the time they occur" (Iida, Shrout, Laurenceau, & Bolger, 2012, p. 277). This methodology is used in family contexts, classrooms, and leisure activity (Iida, Shrout, Laurenceau, & Bolger, 2012). Most daily diary studies are completed using adults, but children and especially adolescents have used diaries to report and reflect on their daily experiences, express emotions, problems, self-assured, or to set goals (Iida, Shrout,

Laurenceau, & Bolger, 2012). For this study, time-based daily diary designs were utilized where participants reported on their lived experiences based on their willingness to elaborate in a written diary on a fixed-interval schedule (Iida et al., 2012). Based on the given daily dairy protocol (Appendix D), the participants responded to a series of three questions regarding their summer engineering camp experience. The girls responded to the questions after camp. When all campers were dismissed, the girls were given a personal voice recorder that was labeled with their name and three questions to reflect on her daily experience. Each girl was placed in an isolated location on the camp site where she could privately share her thoughts and opinions. Responses ranged from 30 seconds to three minutes. Reflections were related to race, gender, efficacy, and engineering identity, and responses were elicited through a question and answer format along with a discussion involving their engineering design products and engineering notebooks.

Self-expressive Art

On the last day of camp, the daily diary included a reflection response to the three questions and a picture/photo/self-expressive art that were both completed at home. The self-expressive piece art represented how they viewed themselves as a Black girl within the context of the engineering program after participating. The girls were able to create narratives, PowerPoints, poems, dances, drawings, etc. During the end of the semi-structured interviews, the girls shared a brief description of what the art meant to them and why they decided to express themselves that way.

Semi-structured interviews

Semi-structured interviews are conversational in tone and follow a pre-scripted set of questions that allow for flexibility in how the researcher addresses the participant as they

engage in open responses to the questions (Barriball & While, 1994). As questions are asked, the researcher can probe, ask further questions, or request explanation or clarification from participants (Hutchinson & Skodol-Wilson, 1992). Participants are given the opportunity to freely express themselves using this technique (Hutchinson & Skodol-Wilson, 1992). All the African American girls were asked to participate in an interview regarding their perceptions of the engineering camp (Appendix E). Questions were developed to gain an in depth understanding of the lived experience of the girls. The girls also shared their self-expressive art with me and explained what it represented. Utilizing some of the concepts of racial identity, engineering identity, and STEM self-efficacy, informal learning, and intersectionality as they relates to race and gender, open-ended responses were elicited during these hour-long interviews. In addition, nine camp staff members (i.e., teacher team leads and undergraduate engineering counselors), the coordinator, and director were interviewed at the end of camp regarding what they may have observed or how they believe their role contributed to the girls multiple identities during camp (Appendix F and G). Interviews were recorded using two voice recorders.

Engineering Design Products and Engineering Notebook/Whiteboard Pictures

Pictures were taken of engineering design products and engineering notebook/Whiteboard (i.e., drawings of engineering design planning and team interaction) during the camp intervention. Every girl was observed for three challenges. Engineering design products are the finished products that a team of three campers creates after being given an engineering challenge/problem that needs to be solved. Through planning together during open communication and by using Whiteboards with a different marker color per camper (to help decipher interaction and collaboration), a drawing was created to help

develop a plan for producing the engineering design product. Next, by using everyday materials such as scissors, tape, construction paper, pipe cleaners, cardboard, and cups, the campers worked in teams to develop their engineering design products. Based on a rubric and constraints (Mathias-Riegel, 2001) that were shared with the campers, these design products were tested and then scored. This aspect of the protocol was utilized to collect rich data and develop a deep understanding of the participants' lived experiences and engagement during the camp. Cross-analyzing pictures of finished design projects and design notebooks together with reflections from the semi-structured interviews could elicit deeper memories, emotions, and thoughts helped me develop a rich picture of participants' experiences at camp. The engineering design products and engineering notebooks/Whiteboards pictures helped elicit how each girl viewed engineering in informal environments, why she enrolled at the camp, how she perceived failure and her engineering identity, and how the experience influenced her STEM self-efficacy.

Field Notes

Field notes, memory notes, and significant behaviors were recorded during the camp to capture a deep understanding of the social situation and gain insight (Chiseri-Strater & Sunstein, 1997). During this process, date, time, place, engineering challenge activity, and participants were recorded. Along with this, l recorded specific details, personal responses, words and phrases, and questions that I may have had regarding the interaction, as well as a reflection on what was learned using an observation protocol (Appendix H) (Chiseri-Strater & Sunstein, 1997). Each observation lasted for about one hour and 15 minutes. During these observations, I served as a non-staff member of the Explore Engineering camp. Each participant was observed three times where I examined the girls in their breakout team

rooms. I sought to observe who the campers interacted with and how, track specific details about what happened during the challenges, and record observations and questions the campers had, sensory details, motivation, interest, and overall morale of each camper during the challenge work time. These field notes were detailed and a direct reflection of what happened based on my observations.

Data Analysis

A variety of techniques were used to analyze the data sources. Data analysis began with transferring multiple sources of data and organizing them systematically. All data were organized in a password protected Google Drive account. Demographic surveys were downloaded from Qualtrics and transcripts were downloaded from Rev.com. Survey information was used to guide questions during semi-structured interviews.

To guide the data analysis, frameworks from Polkinghorne's (1995) as well as Braun and Clarke (2006) were used to investigate the narratives that the girls shared. Using these techniques, the narratives were analyzed as data to "product typologies or categories" (Braun & Clarke, 2006, p. 5). Using the events that occurred at the summer engineering camp, as well as the pre-developed interview protocol for examining certain constructs, I identified common themes across the girls' stories. For this study, "concepts are derived from previous theory or logical possibilities and are applied to the data to determine whether instances of these concepts are to be found" (Braun & Clarke, 2006, p. 8). Additionally, using this form of analysis allowed me to discover relationships and differences among the girls' experiences. The themes that developed are "patterned responses or meaning within the data" (Braun & Clarke, 2006, p. 82). To do this, researchers engage in six phases: 1) engaging and familiarizing the data through reading and transcription; 2) generating initial codes which are

theory-driven or data-driven; 3) searching for themes by thinking about the relationships between code levels; 4) reviewing the themes; 5) defining the themes; and 6) producing the report (Braun & Clarke, 2006). Using this approach allowed me to systematically compare the girls' experiences, guide psychological interpretation, develop thick descriptions, and identify themes that corresponded with the frameworks used to guide this study.

Analysis of Daily Diaries and Semi-Structured Interviews

Daily diaries and semi-structured interviews were transcribed for analysis. After transcription of interviews by a transcription service (Rev.com), I listened to all transcribed interviews to confirm transcript accuracy. After uploading transcripts, pseudonyms were created for all names and identifiable people, places, etc. using an Excel spreadsheet, and added to the transcript to replace all identifiers. Finally, transcripts were uploaded using a data software program, Dedoose 8.2.

The interviews and daily diaries were analyzed using thematic content analysis (Hsieh & Shannon, 2005). Thematic analysis is an approach that "identifies, analyzes, and reports patterns within data" (Braun & Clarke, 2006, p. 79). Therefore, after becoming familiar with the data after reading the transcripts and associating artifacts with the responses that are elicited, I used open coding to form concepts and questions (Strauss & Corbin, 1990). Each girl's transcript and artifact prompted me to jot down patterns, similarities, differences, and my overall impressions on how the responses connected to the research questions. In doing so, I was attentive to how participants identified themselves racially, how they expressed their interest in engineering, their motivation during the camp, and their interpretation of their experiences with other campers. Afterwards, axial coding allowed me to relate concepts to categories while generating hypotheses (Charmaz, 2006) and identify

potential themes in a codebook. Using Google Docs, I created a table to input themes, descriptions, and examples to guide my analysis. Semantic/latent themes regarding intersectionality (race and gender), racial identity, engineering identity, and STEM self-efficacy were identified. The codebook used theoretical and literature-based concepts regarding racial identity, engineering identity, STEM self-efficacy, and intersectionality. Themes were developed within the codebook. Following the creation of the codebook in Google Drive and in Dedoose, the data were coded using multiple iterations of examining the transcripts.

Codes were developed after reading through all 11 transcripts as well as using visual analyses to interpret the self-expressive art. Initial interview/diaries and self-expressive art were then coded and the codebook was refined based on main codes and sub-codes. Transcripts were coded three times each. Code excerpts were downloaded by each girl's responses and then by each code theme application. Using code excerpts, thematic findings and subthemes were created. Using the program's features, themes that are repetitive were noted and then interpreted. Patterns and quotes that are highlighted as well as findings from the engineering design products and engineering notebooks/Whiteboards, were used to create themes for the study participants' experiences and narratives of the camp environment for the staff members. Using thematic analysis, I analyzed and organized the narratives by grouping similar quotes and patterns revealed by the data based on the research questions and using Dedoose (Braun & Clarke, 2006; Polkinghorne, 1995; Solórzano & Yosso, 2002). After reading the personal accounts from camp and connecting the similar participant accounts based on themes, primary themes as well as CRT and BFT frameworks were applied to the girls' accounts and then translated into a themes and subthemes. The focus of the themes was

to use various forms of data to explain how the Black girls experience an informal engineering learning context. Based on the selected events, how data are organized, interpreted, and focused on a specific topic are what makes it a thematic analysis (Braun & Clarke, 2006; Riesmann, 1993).

After conducting the study, I conducted thematic analysis on the interviews, engineering design products and notebooks/Whiteboards, and demographic information for each girl as a form of resistance against the norm or dominant discourse (Solórzano & Yosso, 2002). This allowed the voices of Black girls to be heard and exposed us to an experience of STEM education that many are unaware of (Solórzano & Yosso, 2002). Narratives of the camp staff were also shared to better understand the entire camp context. Thus, utilizing this methodology allowed me to develop a holistic understanding of the culture of the program and through thematic analysis reveal Black girls' experiences in the informal engineering environment that are typically ignored due to lack of awareness or biases. Using an intersectional and BFT approach, narrative analysis sought to highlight "(1) multiple inequalities and intersecting forms of oppression, (2) avoiding hierarchies of oppression, (3) experiencing of at least one form of intersectionality, and (4) centering the voices of multiply burdened" (DeCuir-Gunby, Chapman, & Schutz, 2019, p. 92-93). Thematic analysis enabled me to utilize direct quotes from the participants to find comment elements across the data sources analyses and develop meaning (Riesmann, 1993). In these narratives, participants used processes of "(1) attending, (2) telling, (3) transcribing, (4) analyzing, and (5) reading to be developed" (Clandinin & Connelly, 2000; DeCuir-Gunby, Chapman, & Schutz, 2019, p. 91). Through thematic analysis of the narrative responses of the Black girls and the camp

staff and data triangulation, I was able to share rich qualitative findings in ways that illuminate Black girls' experiences at an informal summer engineering camp.

Analysis of Self-expressive Art

Using visual analysis (Rose, 2016) and thematic content analysis (Braun & Clarke, 2006), each self-expressive piece of art was coded using the codebook mentioned above. I also examine specific colors (e.g., pink and purple for girl-related and blue for boy-related activities), word placement, and images (e.g., colorless images, depictions of Black girls/women). This allowed me to make meaning of each girl's artwork. Afterwards, each piece of art was grouped into a main theme regarding each girl's main takeaway from being a Black girl in the summer engineering camp context.

Analysis of Engineering Design Products and Engineering Notebook/Whiteboard Pictures

For each of the 9 challenges the girls participated in, engineering design products and engineering notebook/Whiteboard images were uploaded to Google Drive. A data chart was created that identifies the product engineering notebook/Whiteboard images, associated engineering challenge, and any field notes taken regarding the challenge, as well as the participant. Artifact analysis, a process used to examine the materials and interactive qualities of an object to understand the way it is used by people and the culture in which it is used (Rose, 2016), was used for engineering notebooks and design products. Using an active process, I observed the objects to see how they may have promoted engineering identity and STEM self-efficacy by examining the words in the notebook and on the Whiteboards and connecting them to the design products. Questions were recorded to probe participants about observations. Artifact analysis continued during interviews. Following artifact and thematic

analysis, I integrated both methods (Rose, 2016). Utilizing methods based on Creswell and Clark (2017), joint displays and separate findings were presented to summarize analyses. Triangulation of data allowed me to look for similarities and contradictions. Relationships or connections that the girls have with the artifacts were revealed during semi-structured interviews as they shared their understandings of how specific artifacts were associated with their camp experiences. Symbolic meanings of the artifacts and associations with the research constructs of racial identity, engineering identity, and STEM self-efficacy were revealed through the interviews.

Analysis of Field Notes

Any field notes taken were connected to engineering design products and engineering notebooks/Whiteboards during artifact analysis in the data chart. During coding of the interviews, any other connections between field notes, artifacts, and interviews were added in the notes section of the transcripts or within the questions that reference artifacts. Field notes were also coded using themes.

Analysis of Racial, Gender, Engineering, and STEM Identities

To analyze how salient the girls' racial identity, gendered identity, engineering identity, and STEM identities were while they were in the camp, I used Capobianco's (2011) engineering identity scale, Collin's (2018) Black Student STEM identity model, and Seller's (1998) racial identity scale. Based on the statements from the girls' relaying how important their race, gender, or being an engineer was to them in the camp setting, I coded their racial identity and gendered identity as highly important, moderately important, or not at all; their engineering identity as a high perception, moderate perception, or low perception; and their STEM identity as high, moderate, or low.

Credibility and Trustworthiness

A variety of steps were taken to establish credibility and trustworthiness in this study. Triangulation multiple sources of data (i.e. interviews, engineering notebooks and design products, field notes) allowed me to validate of findings (Creswell & Clark, 2017). First, a codebook was created to describe themes and peer review of the codebook assisted with coding reliability. Second, member checking, which is the process of validating findings by sharing a brief overview with them with research participants (Huberman, Miles, & Saldana, 2014), was conducted to ensure that coding and analysis reflect participants' views after interviews. In member checking, the participants (1) received their transcribed interview, (2) noted whether they wanted to change any of their comments, and (3) received sample codes that were created based on the analysis. If the participants were satisfied with their responses, they responded via email. Third, data were coded in multiple iterations in order to make sure that coding was consistent. Afterwards, the peer review (Huberman, Miles, & Saldana, 2014) of significant themes after data analyses also helped ensure the accuracy of findings. Along with this, thick descriptions were provided within the findings to accurately portray the girls' experiences. Each of these strategies was used to mitigate bias within the study based on best practices of mini-ethnographic case studies (Fusch, Fusch, & Ness 2017). Finally, I disclose relevant information about the researcher's bias and positionality.

Researcher Bias and Positionality

As a former STEM educator in Title I schools and an African American female, I have substantial experience educating students in science and mathematics. As a K-12 educator, I often struggled to engage students in science and mathematics content based on the standards and limitations that the public educational systems placed on me. Teaching to

the test and working with students who could pass state exams took priority over the modes of critical thinking and exploration that would allow students to make meaningful connections to topics and sustain their interest in engineering education. These experiences made science and mathematics discouraging both for me and for my students, who were predominantly African American and Latinx, because they could not easily make connections with concepts or apply them to real-life scenarios. I loved science and mathematics as a child, but I did not fully understand all the ways that this knowledge could be utilized in the workforce. When I enrolled in college, I focused heavily on biological sciences with intention of attending medical school. Later, after participating in a summer research program where I focused on lung biology, asthma, and environmental medicine, I realized that there were many other pathways where I could use science and mathematics such as engineering, epidemiology, and biostatistics. I believe students should know about various educational opportunities before they enroll in college. Specifically, engineering as the integration of science, technology, and mathematics can introduce students to how they can discover, create, and address some of the most pressing issues that we face in our society.

Researcher as the Storyteller

Because this is a mini-ethnographic case study, I was directly connected to the camp as the assistant day camp coordinator. Prior to taking this role, I had participated in the camps for the previous 3 summers, one as the assistant day camp coordinator and two as a teacher team lead where I assisted an undergraduate student with challenge implementation for campers in the K-2, Upper Elementary (3-5), Middle School (6-8), and High School (9-10) Day Camps. During the duration of this study, I continued to have a behind-the-scenes role with the campers (compared to a direct role when I was a teacher team lead) in that I assisted

with preparing/teaching undergraduate counselors and teacher team leads on how to implement engineering education during camp, guiding assistant camp counselors as they prepare camp materials, and monitoring day-to-day camp agenda implementation. Therefore, I did not work directly with the girls who participated in the summer engineering programs. By collaborating with the program and understanding the development of engineering challenges, as well as the systems in place to recruit campers throughout the year, I was able to create a more faithful portrayal of the camp environment that the African American girls experienced.

As a staff member and researcher in the camp setting, I know my identity as a Black woman and former educator allowed me to connect and empathize with the girls throughout the camp as they completed daily diaries, interviews, and shared their experiences with me. My robust understanding of the literature on how these experiences can impact the girls allowed me to analyze and interpret the data collected for this study. Critical Race Theory and Black Feminist Thought exemplify my positioning in this research study. As a scholar, I want to push the current boundaries of the current literature on engineering education by acknowledging that the complexity of our identities can add value to STEM fields. Thus, to address issues of power and inequity that inevitably arise in research, I remained critical of my own positionality as the researcher and checked my interpretive biases throughout this analysis. I situated myself in descriptions of the camp setting and used member checking and data triangulation to create accurate and faithful depictions of the lived experiences of study participants. Although there may be concerns regarding subjectivity and reliability in mini-ethnographic case studies, collecting multiple data types and triangulating the findings enabled me to mitigate interpretive bias. By conducting this mini-ethnographic case study, I

hope to expand our understanding of how Black girls experience STEM education in informal learning contexts and how their perceptions of engineering are influenced by their positive and negative experiences.

CHAPTER IV: FINDINGS

In this chapter I analyze the experiences of 11 African American adolescent girls who participated in the summer engineering camp. Utilizing three data sources (e.g., daily diaries, semi-structured interviews, and self-expressive pieces of art) supported by engineering design products, engineering notebooks, Whiteboard drawings, and field notes, this chapter presents a collective case analysis of unified themes and subthemes regarding how the camp environment influenced African American girls' identity development and self-efficacy in the predominately

White educational setting. Participants identified as African American, represented a variety of grade levels (rising 6th through 8th graders), and were enrolled in and attended the engineering summer camp each day for a week. Pseudonyms were used to maintain anonymity of the study participants as well as others who they referenced and interacted with at camp.

This chapter is organized into four segments beginning with an explanation of the Explore Engineering camp experience, participant profiles (see Table 2) based on demographics such as grade level, previous camp or STEM experiences, exposure to engineering, and the participant's racial identity, gendered identity, and STEM self-efficacy (see Table 3). Next, I present the themes that emerged based upon interview data analysis taken from each girls' experience. Throughout these themes, as the culminating piece of the week-long experience, I share illustrative examples of the self-expressive art that describe how the girls viewed themselves within the context of the camp after participating. To provide greater context for each case, I then provide the staff's understanding of their role in

the camp. Guided by CRT and BFT with an intersectional lens, themes were developed and utilized to guide how these Black girls made meaning of their personal camp experience.

Explore Engineering Camp Experience

Camp Environment

The camp was hosted in one of the main engineering buildings on campus, Dandy Hall. Dandy Hall was an older brick building that had been constructed in the 1920s with 16-pane windows throughout the four-floor design. During the academic year, the building was mainly utilized for many undergraduate engineering courses and the Explore Engineering program was located in a small portion of the third floor. At the conclusion of the academic year, I along with the Explore Engineering summer camp staff, transitioned the two offices and four storage rooms that we had on the square shaped floor to an exciting and whimsical camp environment that would be welcoming to all campers and appropriate for this age group. Along with these rooms, we were given three lecture style set-up classrooms that had enough tables and chairs for 30 to 40 students, arranged in rows. To ensure that the campers had plenty of space to move freely, design, and participate in an aesthetically pleasing setting during camp, we transformed these classrooms to three breakout zones. When these transformations happened, faculty and staff members would say things like, “It’s that time of year again,” “I’m getting ready for flying marshmallows and hallways full of teenagers”, and “This place feels different in the summer”. Our design elements helped to create these impressions.

As campers walked the hallways of the building, they began on the first floor and saw red arrow signage that would direct them to the third floor. They walked the stairs and when they reached the top of the stairs at the third floor, they would arrive at the camp

coordinators' office and signage that showed directional arrows for the three traditional classrooms that had been transformed to the red/blue, purple/yellow, and orange/green breakout zones, as well as the meeting zone. In the breakout zones, more than half of the tables and chairs had been removed and rearranged. The rooms had an imaginary line that divided the two teams in each room. Each breakout zone had a team of a particular color and 4 long rectangular tables with red or black chairs to help arrange the 12 campers in four groups of three. Along the walls of the rooms, cardboard taped to tables served as gluing stations. Adjacent tables included six red bins that had an assortment of newspaper, toilet paper rolls, bubble wrap, cereal boxes, scrap paper, and other materials that campers used and re-used during the engineering challenges. The rooms also included large Whiteboards lined with colored electrical tape that corresponded with each team and markers. The carpeted breakout zones made it easy for the campers to test their designs in any space, and projectors and media equipment were used to display the engineering challenges and play the most popular music of the year while they worked. The zones also included signage with outdated pictures of engineers, the habits of mind, and the engineering design process that was referenced often during camp. Before each challenge, the assistant counselors placed material kits in the rooms on the front tables for each of the eight groups of three. Throughout the week, the rooms increasingly accrued more campers' designs composed of pipe cleaners, popsicle sticks, straws, etc. that would decorate the tables. Teacher team leads draped the walls with large, colorful, hanging post-it notes with camper group names, scores, and challenge descriptions. As campers interacted with one another on the floor, at the tables, and sometimes in the hallways to develop designs, teacher team leads and counselors would circulate the rooms and hallways to assist.

Along with the breakout zones, there were several zones that campers were familiar with and that were significant to the camp. The meeting zone had six rows of tables and chairs that identified the team that should sit there by a large traffic color cone in front of the row. Every member of the camp that week would gather at these zones multiple times through the day. A team color lantern was also hung on the back wall behind each table. Team leads and undergraduate counselors would sit in a U-shape around all the tables, unless they were presenting at the front where the projector and microphone were. The resource zone, which served as a storage place, included ten silver sliding shelves that had red bins holding various materials like calculators, felt, scales, markers, stickers, marbles, plastic utensils, wire, construction paper, stop watches, magic erasers, and other materials. On the other side of the zone, you could find non-perishables that were used for camp in the cabinets, batteries, tools, a refrigerator, sink, and microwave. These materials were held in this room and then transferred to the larger open staging zone where the assistant counselors had camp materials organized on shelving by high school, middle school, upper, or lower elementary school. These materials would be prepped and prepared in the staging zone for campers, undergraduate counselors, and teacher team leads. In many instances, you could find an assistant counselor stepping out of one of these two rooms to assist campers or give them materials that they desired to have to improve their design. This also added to the community atmosphere and ensured that each camper and staff member felt welcomed and valued in the space.

A Week at Camp

The first week of the middle school Explore Engineering camp was always exciting and stressful for the staff. For this camp in particular, the first week was when the

undergraduate engineering counselors and other staff members executed all camp challenges on their own without the support of faculty mentors. Instead of working on a week-long project like they did during 9th and 10th grade camp, there were at least three different engineering challenges a day that the campers engaged in. Thus, when we began the camp introduction on the first day of camp, there were a lot of nervous faces in the room. To begin the first Monday of camp, I opened up by introducing the camp rules such as respecting others and persevering at all times before explaining the engineering design process. Many of the campers raised their hands and assisted in explaining different parts of the process since they were familiar based on previous camp experiences. As they sat at their tables in the classroom which had been transformed into the camp meet-up zone labeled by team colored lanterns of red, orange, yellow, blue, green, and purple, they became increasingly more engaged as I explained the camp schedule and smiled at the group. I shared that my name was Whitney and it was my last year of school ever as I was beginning the 22nd grade next year. Afterwards, I introduced the rest of the camp staff members and heard chuckles and gasps as the undergraduate counselors and teacher team leads stood at the back of the room and shared interesting facts about themselves.

After the opening, Naomi, one of the teacher team leads, read a book called *What to Do with an Idea?*, to encourage creativity since middle school age children often push the limits and have ideas, but this is not always encouraged in school (Mathias-Riegel, 2001). After doing this, I dismissed the campers to their breakout zones based on team colors to work on team names, chants, and signs. There were three breakout zones that were regular university classrooms during the academic year: the red/blue zone, yellow/purple zone, and green/orange zone. Two teams were placed in each zone. As I walked around to each of the

zones, the staff members were playing games like Tossing the Question Ball and Two Truths and a Lie to get to know their teammates. They were also voting on what they wanted their team names to be. As the time came to a close, many of the campers stated that they needed more time to finish their team signs, but they were still excited about carrying them to lunch as they got to shout their chants out loud.

Next, I dismissed the teams for lunch, and we walked down the three flights of stairs to the brick pathway that led us to the dining hall. In the 82-degree weather, with our Walkie Talkies, fanny packs, and emergency medical supplies attached, we lead 72 campers down the hill and under a tunnel. For the campers, lunch was one of the most exciting parts of the day. I reminded the campers that they needed to make healthy choices, clean up after themselves, and be aware of allergens related to the foods that were served. After releasing the campers, they swarmed the cafeteria, piled their plates with grapes, pepperoni pizza, and soda. The undergraduate counselors were seated at a large round table in the corner and the teachers sat together in the middle of the room so they could observe the campers. After lunch dismissal and clean-up, we trekked over to outdoor time in large green space with four separate patches of grass separated by bricks. The campers played kickball, sat on the large brick wall, shared secrets, and did cartwheels to take a break from the dim breakout zones in the main camp building. Teachers and counselors interacted with the campers during this time.

After outdoor time, campers returned to the main camp building and went into the meeting zone where we all gathered. The undergraduate counselors shared the very first engineering challenge for the day, straw construction, by describing the scenario, tools, materials, constraints, and testing rubric. After the campers asked questions about the

challenge, they returned to their classrooms and split their teams of 12 into smaller groups of 3. This same procedure was used to introduce all challenges. Campers then went through the rest of the engineering design process to decide what they were going to do to complete the challenge. They imagined their straw designs, planned them by drawing on their Whiteboards and in their notebooks, and then created the designs. During the challenge, the campers explained their design and tried to get their teammates to duplicate it without seeing it.

Next, the campers built balsa wood airplanes and tested them to see how far they would go. Everyone's design used the same prototype. Afterwards the campers were introduced to the balsa wood airplane challenge. They returned to rooms and worked on this challenge in small groups of three and when the time allotted ended, the gliders were tested. At the end of the day, the campers engaged in the daily closing meeting where the top score for each of the teams was shared. The 1st, 2nd, and 3rd place teams were given prizes and an opportunity to share their design thought process. After camp pickup, I led the staff member in a discussion regarding how the day went and any improvements we needed to make for the second week.

For the rest of the first week, campers typically engaged in three new challenges a day and the schedule remained fairly similar from day to day. On Tuesday, they completed Heartache where they created a solution for a clogged artery, and a Polymer Process Discovery challenge where they created a sealant for a damaged surface. On Wednesday, Pipeline Construction allowed them to create a water system that used pipes to retain the most water. They also completed Water Consumption where they used mathematics and a budget to deliver the most water to a town. Lastly, they redesigned the balsa wood gliders with the same group as Monday. This design would be tested on Friday during the camp

closing for parents and guardians. On Thursday, the campers completed the Fabric Bucket challenge where they designed and tested an apparatus developed to retain water, and teams competed to see whose apparatus could hold the most water after traveling a certain distance. Along with this they did the Water Filter challenge where they made their own filter and tested the water for purity. Lastly, they redesigned the Pipeline Construction challenge.

On Friday, the schedule was different than Monday through Thursday. The morning began with campers improving redesigns and preparing the rooms for the closing sessions. They also completed camp programmatic surveys at this time. After lunch, they enjoyed extended outdoor time and engaged in reflection time to look back on what they gained from the experience. Next, they walked to the presentation zone to get ready for the camp closing presentation. At this closing, I presented each team to the parents as the campers screamed and yelled their chants with enthusiasm. Parents and guardians then followed the teams as they competed in outdoor competitions and viewed indoor exhibitions of all the challenge designs that had been created all week. The red, yellow, and orange teams did outdoor competitions first while the purple, green, and blue teams looked at exhibitions. Then the teams switched and returned to the presentation zone. At this time, after calculating final scores with the undergraduate engineers, I shared final scores as well as results for the best engineering notebooks. All the winners from 1st, 2nd, and 3rd place were given university drawstring bags, water bottles, and fidget spinners. At dismissal, campers gave their friends hugs and prepared to leave camp and enjoy the rest of their summer. Schedules for weeks one and two of camp were the same. Only minor changes were made to the challenges between the two weeks. Staff members found it easier to address issues campers may have had during design time in the second week since they already facilitated challenges the

previous week. Each of the week one camp elements were developed to provide an enjoyable experience for the campers, especially for those from historically oppressed and marginalized groups such as Black girls. Campers' interactions with each other, their family backgrounds, and their individual interests contributed to their overall camp experience.

Black Girl Participant Profiles

Camp Week One

Quinne. As a timid, first-timer at the camp, Quinne was apprehensive about attending the summer engineering program. A rising 7th grader from out-of-state, she had been exposed to well-rounded experience in many outside-of-school settings geared towards sports such as track, volleyball, basketball, and gymnastics. Additionally, her involvement in many camps and outreach programs that were geared toward African American students, as well as her upbringing in a predominately Black community, contributed to her racial identity. Quinne's mother, a Black woman in a technology field, was excited to enroll her daughter in the camp when she learned it was hosted at her undergraduate alma mater. Quinne's engineering identity had been influenced prior to camp by her involvement in many organizations such as Black Girls Code and the National Society of Black Engineers' Summer Engineering Experience for Kids. At Explore Engineering camp, Quinne's sense of her gendered racial identity was highly salient in the environment. She felt more comfortable because she was one of the few girls who had another Black girl on her team. As a science lover, she challenged herself to conquer her beliefs regarding her low math self-efficacy and high science-self efficacy. Her interest in science experiments and achievement led to her heightened internal motivation to participate in engineering camp. Her participation in camp did not change her views about engineering. Quinne had a low perception regarding her

belief and interest in becoming an engineer. Her STEM self-efficacy was moderate. Her motivation was also driven by her goal of ultimately being "a pediatrician for our children or an entrepreneur because [she] want[s] to own her own business or company." Thus, when discussing how she saw herself in the context of camp, Quinne believed that "Black girls can be and do whatever they want."

Caroline. An easy-going, rising 8th grader, Caroline saw the engineering camp as a place where she could be herself. She was excited about learning new techniques in this new environment. An avid writer and Lego lover, Caroline was first introduced to engineering in the 5th grade by her teachers, participated in her school's robotics club, and played soccer. Her interest in engineering fields and her love for mathematics and science led to her high self-efficacy in STEM. Additionally, she was motivated to be an engineer for the National Aeronautics and Space Administration, which indicated that she had a strong perception of her engineering identity. Her parents, one of whom was in a STEM field, saw camp as an opportunity to expose her to something new. Caroline knew a little about engineering because she had a cousin in the field. Caroline feared making a mistake and was concerned with failure at camp, but she understood that being unaware or not knowing was also a way to learn lessons that she could grow from. Additionally, her racial identity was moderately important while her gendered identity was highly important at camp. To Caroline, the camp experience was like a "tangled path of roses" that she navigated as she met new friends and built new ideas and solutions.

Brooklyn. A rising 6th grader, Brooklyn's bubbly personality made it easy for her to make friends at camp. Brooklyn was actively involved in robotics club, tumbling, soccer, volleyball, and had a love for the outdoors. Being the daughter of an engineer, Brooklyn was

interested in attending camp for a second time so she would not be bored over the summer. This was an opportunity to see if engineering was something she wanted to do long-term. When I spoke with her, she shared that photography, astronomy, and web design were her career interests. Brooklyn's gendered identity was more salient during her experience at camp. It was also apparent that race was not a salient factor in Brooklyn's experience. She showed her love for science as she engaged in camp challenges, although her belief that she was better at mathematics contributed to her moderate STEM self-efficacy. Brooklyn indicated in her own reports about her experience and her self-expressive art that coming to the camp allowed her to challenge herself mentally and boost her self-confidence in mathematics. Moreover, Brooklyn maintained a low perception regarding her engineering identity throughout the duration of the study.

Cora. Brooklyn's older sister Cora was a second-time attendee to the camp and a rising 8th grader, and stood out from the group as a leader. Actively involved in soccer, art club, robotics club, and the Spanish Honors Society, Cora's high interest in engineering was driven by exploring it as a career path. Her father was a computer engineer. She came to camp very confident in her abilities in mathematics and science. Similar to many of the other Black girl participants, she was concerned about not being able to make friends but excited about attending and completing the engineering challenges. Her advanced understanding of career pathways led to her interest in pursuing an interdisciplinary career where she could combine her love for art, creativity, and writing with technology. Like her sister's, Cora's sense of her gendered identity was more salient during her interactions at camp. Her racial identity was not important since she maintained a colorblind approach to race. In fact, she said, "I never felt alienated, alone, and uncomfortable. I feel normal."

Summer. A creative camper, Summer, was new to the engineering experience. Her mother was a teacher team lead for the camp and thought that Summer's love for animals and interest in creating habitats for endangered animals was closely related to engineering. She wanted to be an oceanographer when she grew up. As a rising 6th grader, Summer had attended a camp related to inventions and like others, was not as confident in science and mathematics. Summer described her ability in these areas as "not great, but not bad, in the middle." Thus, her perception regarding her engineering identity was low and her STEM self-efficacy was moderate. Summer felt like her race did not influence her perception of her experience in the program while she felt her gendered identity was moderately important in the setting.

Camp Week Two

Jenesis. A courageous and creative spirit, Jenesis was a rising 7th grader who enrolled in camp for the first time. Her mother, a teacher at a STEM school, found out about the opportunity when she applied to become a teacher team lead for the program. Brooklyn was involved in art club, yearbook club, and the Mathematics and Science Education Network. She had no outside exposure to engineering. She did not like mathematics but she did enjoy engaging in science. At home she described herself as "a problem-solver, a fixer of all the things that broke." Thus, she wanted to learn new things at camp so she could be a computer animator, and had a high perception of her own engineering identity. On her demographic survey, she described Black girls as "magical queens" that can do anything they want. Thus, Jenesis had a strong sense of her gendered racial identity and this was a salient influence on her experience.

Carmen. An avid artist, Carmen was interested in learning new things at camp as a rising 6th grader. Along with this, Carmen's aunt was a STEM professor at the campsite location. This drove Carmen's interest in the field although her engineering identity was low even after participating. Carmen was actively involved in golf and karate. Her lack of confidence in her mathematics and science abilities mixed with her love for drawing allowed her to engage in the camp atmosphere easily because of the hands-on nature of its activities. Like many girls, she mentioned that she wanted to help people and become a doctor or a lawyer when she grew up. For Carmen, her sense of her gendered identity was more salient than of her racial identity. Ironically, although she stated that she felt race did not matter, she spent every moment she could with Jenesis. In her self-expressive art, Carmen drew a small beaker to exhibit that the camp was just an added piece of the experiences that made her the Black girl she was becoming.

Imani. Imani was always wearing a smile on her face; I had worked with her at camp for the previous three summers. Now a rising 6th grader, Imani was actively involved in orchestra and swimming. With her mom and dad being computer engineers, she really enjoyed the creative aspect of the field. At camp Imani's dyslexia (that she learned about two years prior to participating in this study) did not limit her abilities. She was able to contribute to her groups in an effective way through art. Along with this, Imani felt really comfortable about her mathematics and science abilities. During my interview with Imani, she shared that "Black girl magic means that Black girls have the power to do whatever they put their mind to" which contributed to her high sense of gendered identity. Imani's racial identity was moderately important to her. At camp she felt like she had girl power and through art she could express her emotions.

Ezinne. A courageous and focused camper, Ezinne, came to camp for the first time during the summer in which this study was conducted. Her mother was a nurse, and signed Ezinne up for camp so she could have a new experience and gain exposure to STEM. As a rising 8th grader, mathematics and science were Ezinne's favorite subjects. When interviewing Ezinne, she shared many of her perspectives on politics and social issues. What stood out the most was her understanding of how politics influences the outcomes of minoritized populations, especially African Americans. Thus, her gendered and racial identity was very salient in her experiences at camp. She used her internal drive and resilience to keep her motivated as she worked to succeed during the engineering challenges. Her strong self-perception in identifying herself as an engineer was related to her interest in developing new tools for the future. In Ezinne's self-expressive art and in her interview, she shared how constant battles with White boys at camp encouraged her to work harder and be successful at camp.

Elise. An opinionated and strong-willed camper, Elise was coming to camp for the second summer at the time of this study. As a rising 7th grader, she was actively involved in dance outside of school. Elise's grandmother enrolled her in camp as a way to provide Elise with access to STEM concepts and education. Elise saw camp as a way to open her eyes to new things, especially since mathematics and science were her strongest subjects in school. Thus, she had strong STEM self-efficacy. She knew that she wanted to "help make our nation's next generation be better at math" by becoming a math teacher, a social media blogger, or a chemical engineer because she liked make-up and explosions. Being the only Black girl on her team influenced Elise to work harder and prove other campers wrong regarding her engineering ability. This contributed to her low sense of engineering identity

and her very salient gendered racial identity. Black Girl Magic made her believe that “Black women can do anything they put their minds to; they are powerful and the future is theirs”.

Layla. A rising 6th grader at the time of this study, Layla had participated in camp for four years in a row. Her mom, a former university employee, wanted to expose Layla to a STEM area in which African Americans were underrepresented. Layla was actively involved in tennis and swimming. Layla’s reading collection kept her motivated as a Black girl who loved STEM. She spent a lot of time at her neighborhood library reading *Moon Girl* Magazines and other books that featured Black girls fixing, improving, creating, and challenging the current narratives of what they could achieve, which led to her strong sense of her own gendered racial identity. Layla never said that she did not like or could not do mathematics. Instead she said, “Mathematics is good; I just need to keep practicing and reading. I’m really good at science and coding,” which contributed to her moderate STEM self-efficacy and drove her interest in being a chemist who could deal with liquids and substances or a veterinarian. Layla’s racial identity and gendered identity proved to be salient to her experiences during cam

Table 2

Black Girl Summer Camp Participant Demographics

Camp	Name	Team	Grade Level	Racial Identification	Years at Camp	Family Socioeconomic Status	Financial Assistance
Week 1: July 8th – July 12th	**Quinne**	Purple	7th	Black	1	More than $150,000	No
	Caroline	Yellow	8th	Black	1	More than $150,000	No
	Brooklyn	Purple	6th	Black Filipino	2	More than $150,000	No
	Cora	Red	8th	Black Filipino	2	More than $150,000	No
	Summer	Green	6th	Black/White	1	$50,000 - $74,999	No
Week 2: July 15th – July 19th	**Jenesis**	Red	7th	Black	1	$50,000 - $74,999	Yes
	Carmen	Red	6th	Black	1	$75,000 - $99,999	No
	Imani	Blue	6th	Black	4	Did Not Report	No
	Ezinne	Blue	8th	Black/African	1	$125,000 - $150,000	Yes
	Elise	Green	7th	Black	2	$35,000 - $49,999	Yes
	Layla	Orange	6th	Black	4	$25,000 -$34,999	Yes

Table 3

Black Girls' Racial, Gender, Engineering, and STEM Identities

Camp	Name	Racial Identity	Gendered Identity	Engineering Identity	STEM Self-Efficacy
Week 1: July 8th – July 12th	**Quinne**	Highly Important	Highly Important	High Perception	Moderate
	Caroline	Moderately Important	Highly Important	High Perception	High
	Brooklyn	Not Important	Highly Important	Low Perception	Moderate
	Cora	Not Important	Moderately Important	High Perception	High
	Summer	Not Important	Moderately Important	Low Perception	Moderate
Week 2: July 15th – July 19th	**Jenesis**	Highly Important	Highly Important	High Perception	Moderate
	Carmen	Not Important	Moderately Important	Low Perception	Moderate
	Imani	Moderately Important	Highly Important	Low Perception	Moderate
	Ezinne	Highly Important	Highly Important	Moderate Perception	High
	Elise	Highly Important	Highly Important	Low Perception	High
	Layla	Moderately Important	Highly Important	Moderate Perception	Moderate

Table 4

Black Girls' Self-Expressive Art Inventory

Camp	Name	Artifact	Title
Week 1: July 8th – July 12th	**Quinne**	PowerPoint Collage (Fig. 4)	A Black Girl Can Do Anything
	Caroline	Poem (Fig. 8)	Failing to the Finish Line
	Brooklyn	Drawing (Fig. 6)	Imagine the Possibilities
	Cora	Poem (Fig. 9)	I'm Me
	Summer	Drawing (Fig. 17)	n/a
Week 2: July 15th – July 19th	**Jenesis**	Drawing (Fig. 3)	My Vision of Explore Engineering Camp
	Carmen	Drawing (Fig. 15)	n/a
	Imani	Poem (Fig. 2)	I am a Strong Girl
	Ezinne	Narrative (Fig. 14)	n/a
	Elise	Poem (Fig. 11)	How I Felt at Camp
	Layla	Poem (Fig. 5)	Engineering Camp

Staff Participants

A diverse group of teacher team leads and undergraduate counselors were selected by the camp coordinator and director to participate in the camp. The teachers came from varying content areas (e.g., English, social studies, physical education, art, technology, mathematics, science) and grade levels (see Table 5). Teachers were chosen based on their desire to learn about engineering integration in their classroom. To prepare for camp, teachers participated in a two-day workshop; one day focused on what engineering is and the second day focused on implementing the camp challenges guided by the undergraduate counselors. The engineering design process, how to ensure campers engaged in positive communication, and

how to design effective challenges that would interest campers were the focus of the teacher professional development. The undergraduate counselors participated in a month-long training session where they experienced the same two-day workshop as the teachers. Undergraduate counselors also spent this time planning, testing, and finalizing the camp schedule. During the camp, undergraduate counselors led the challenges and testing while teacher team leads assisted with challenges, managed camper behavior, and supervised interactions.

It is important to note that as the Assistant Day Camp Coordinator, I engaged and assisted with preparing all of the teacher team leads and the undergrads. The professional development remained the same as previous years despite my research being introduced to the context. Only teacher team leads and undergraduate counselors that gave consent to participate in the study completed the semi-structured interview at the conclusion of the camp. The staff was aware of my role as a researcher during the two weeks of camp, but their behavior was not influenced by my role as a participant-observer. The camp coordinator and camp director were supportive of the study and aware that the camp context and Black girls' experiences should remain consistent with the practices of previous years.

Table 5

Staff Summer Camp Participant Demographics

Staff Member	Position	K-12 Content Area/Major	Team	Racial Identity	Years at Camp
Sarah	Coordinator of Explore Engineering Outreach Center	n/a	n/a	White	10
Lucy	Director of Women in Engineering and Explore Engineering Outreach Center	n/a	n/a	White	13
Carla	Teacher Team Lead	6th – 8th Project Lead the Way	Green	Black	3
Stella	Teacher Team Lead	5th Grade	Blue	Black	1
Chase	Undergraduate Counselor	Computer Science Engineering	Blue	Black and Latinx	1
Weston	Undergraduate Counselor	Mechanical and Aerospace Engineering	Purple	Black/African	1
Todd	Teacher Team Lead	4th Grade	Yellow	White	1
Melissa	Undergraduate Counselor	Biomedical Engineering	Red	White	1
Misty	Undergraduate Counselor	Biomedical Engineering	Orange	White	1

Presentation of Findings

Analysis of the girls' interactions at the camp revealed three themes (see Table 6) that were most salient to their interactions. The first theme was *I Can Do Anything* with two sub-themes of *Girl Power* and *Black Girl Magic*. The second theme, *#AmIWhatAnEngineerLooksLike*, had four sub-themes including *Accepting the Grand Challenge*, *They Won't Let Me Help*, *A Love Hate Relationship with Mathematics*, and *Accessing a White Space.* The third major theme, *"I Could Be a Person in History": Racial Pride and Colorblindness in Engineering*, had three sub-themes that consisted of *Disregarded, but Encouraged: Black Girls and Women in STEM*, *Changing the World by Becoming a Black Woman in STEM*, and *Colorblind Realities*.

Table 6

Themes and Subthemes

Theme	Subtheme
I Can Do Anything	● Girl Power ● Black Girl Magic
#AmIWhatAnEngineerLooksLike	● Accepting the Grand Challenge ○ Learning from Epic Failure ○ The Pressure of Competition ○ Tools for Success ● They Won't Let Me Help, but Silencing Won't Stop Me ○ Relating to Gendered Groups ○ Culturally Relevant Connections ● A Love Hate Relationship with Mathematics ● Accessing a White Space ○ Affordable Opportunities ○ Being the Only One ○ Role Models and Black Visibility ○ Support Structures for Comfortability
"I Could Be a Person in History": Racial Pride and Colorblindness in Engineering	● Disregarded, but Encouraged: Black Girls and Women in STEM ● Changing the World by Becoming a Black Woman in STEM ● Colorblind Realities

I Can Do Anything

For each of the study participants, their intersecting identities of being Black and a girl influenced their overall experience. This double bind identity led to personal empowerment as they dealt with campers during collaboration and as their personal competency was challenged when they created engineering designs. Thus, the first theme, "*I Can Do Anything,*" emerged from the data. The intersectional nature of the girls' various overlapping identities (regarding race, gender, class, education, cultural influences, etc.) and

the positive messages that the girls had internalized regarding their racial identity, engineering identity, and STEM self-efficacy contributed to their beliefs about their potential for success in the engineering camp and their pursuit of STEM education. Additionally, the sub-themes that emerged through analysis of the interview data are *Girl Power,* the idea that females have the ability to succeed in engineering, and *Black Girl Magic,* celebrating the perseverance of Black girls through adversity.

Often the girls reflected on societal norms and being *silenced and marginalized,* or struggling to be respected in the camp setting. Aligned with *Intersectionality,* the girls in my study were able to draw on their backgrounds and prior experiences to cultivate a strong sense of self-appreciation and cultural awareness in the face of their oppression based on two or more identities and the unique oppression that Black girls face. This was developed in spite of *racial permanence,* knowing that race is a part of our society, and sexism that existed and served as an opportunity to discredit and attack their ability to succeed in engineering. When trying to gain respect in the engineering camp, they recognized that there were times when they were shut down because they were girls and/or because they were Black. Thus, the girls mentioned that dreaming big about the possibilities and not allowing others to discourage them would ensure that they could be successful and resilient in that space.

Girl Power

With the environment dominated by men, motivation often came in the form of being girl-focused compared to race-focused. Thus, the girls' intersectional identities created space for them to be stereotyped which led to collectivism in navigating the environment. The gendered aspect of their intersectional identity allowed them to connect with other White girls in the setting. Furthermore, Collins (1990) mentions that the "interlocking oppression"

of being Black and women pressures Black girls to negotiate between identifying as either. Along with negotiating these intersectional identities, I noticed that in most cases, the girls from high socioeconomic backgrounds found their gendered identity to be more salient that their racial identity, thus subsuming their racial perspective as a Black girl. This viewpoint—whether intentional or not—contributes to ongoing patterns that devalue the Black experience and position *Whiteness as property,* or the higher social value of being White and not identifying as of color. Out of the study participants, 5 of the 11 girls mentioned a sense of Girl Power that pushed them to work hard during the camp. When I observed the girls at camp daily I found that they often communicated and gathered to separate themselves from the boys, outside of when they were the only girl in a challenge team of three. In most cases, the race or ethnicity of the other girl did not matter. As long as the girls found another girl to connect with, they felt comfortable. For example, there were many instances in camp where the girls encouraged each other because they noticed that there were few women in the space. Girls often high fived each other when they worked in all-girl groups. They said things like "girls are just as good as boys," and when an all-girl group won at camp, girls would congratulate and gather around them in a way that was not typical when an all boy group won. Additionally, there were a few instances when two girls would be working with one boy, and the boy would seem disinterested because he was the only one. I observed one of these instances where a boy named Aiden was apathetic about completing a challenge because he mentioned that he was the only boy. He was working with Ezinne and another girl, Jill. The teacher team lead, Stella, approached him and discussed why girls' opinions should be valued while Ezinne said to Jill, "We can win; that way we can show him working with girls is cool." Aiden began to work with the girls, but was not as engaged as he usually

was in the challenges. The team did not win, but they did have one of the top scores for their group. Similar occurrences were common at camp. Along with this, many of the girls shared during their interview the reasons why they were motivated based on their gender identity.

Cora, a rising 8th grader, typically thrived and was a leader in any group at camp. When I watched her work with all girl teams, she was more confident and comfortable communicating her thoughts. During interactions with all boys, I noticed that she thought strategically about when to insert herself into the conversation and reflected more on what was needed compared to spending more time talking through her thoughts when working with mostly girls. Her constant effort to silence herself spoke to her gendered identity, or how cultural expectations about girls meant that she should be the one that did the coloring for the project, be passive, or make little contributions to the group because females are not typically engineers. Cora was also maintained a *colorblind* belief, that all people are/should be treated equally regardless of their background. This view ignores the *permanence of racism* that controls social, political, and economic mobility in our society. Cora mentioned her current support systems and how being around people that encouraged her in STEM made her feel like she could be successful in the field, therefore, she would not allow people to get in her way. When asked her about being the only African American in her group and how she enjoyed her camp experience, Cora said:

> I like who I had around. Again, I know that I am like Filipino, Caucasian, and African American, but I don't like putting myself into a group, and then look at other people from the eyes with that group I disliked. I really am just a great female. It's just because of the people around me so far. They've never treated me differently and

> I feel confident in the way that I am, and if I were to be disregarded, it's onto the next person. If you can't treat me right, then I'll find someone else who will.

This belief could have a negative influence on Cora in engineering settings as she grows older due to her inability to see how much her double bind identity influences others actions. However, it did allow her to develop a strong sense of gendered identity where she could challenge oppressive encounters with boys at camp.

Girls were also able to share their self-expressive art that represented how they felt as Black girls in the engineering camp context. Ranging from poems to PowerPoint presentations, each of these artifacts centered around a specific theme. Imani, a rising 6th grader, was very excited at camp when I shared with her that she would get a chance to create a piece of art for me. During camp, Imani's team lead would ask them to reflect daily by writing in a notebook similar to what students may do in a typical school classroom. Imani hated this because of her dyslexia and would pretend like she was writing during this time after a challenge. Her team lead fussed at her one time for pretending because the lead felt everyone should reflect in writing even though she was aware of Imani's dyslexia. Her team lead often said engineering identity was connected to good notes in your notebook, which made Imani feel even worse about her ability to write and create as an engineer. At one point, Imani approached me and asked, "Ms. Whitney, do I have to reflect in my notebook? We never did this at camp before, not even when you were my teacher, and no one else is doing it." I approached the team lead and told her this could not be mandatory, and that students should be able to reflect in any way that they wanted to. Thus, Imani began to draw various pictures in her notebook like flowers or her engineering designs during reflection time. Imani's encounter with her teacher team lead, Stella, is an example of how

CRT challenges the hegemonic nature of education based on dominant ideology. For Stella, writing reflections in notebooks was beneficial for every student, but this approach imposes beliefs without critically examining what is needed for every student. During my conversation with Stella, she could not understand why Imani could not complete the reflection. After explaining that this experience disadvantaged Imani because it lacked critical discourse or scaffolding—which was not what we intended to do at camp—Stella was more open to finding ways to promote Imani's success going forward.

Along with this, Imani was always the first to pick up multiple colored dry erase board markers to use her imagination and create a design during challenge time and down time during transitions. Her images typically had multiple colors infused in them and she created her own along with adding to a group design. Imani's love for art and her connection of feeling empowered by it was described later in her interview. For Imani, art was a way overcome the oppressive *matrix of domination* that existed in structural domains such as school or camp because of the hegemonic nature of education. Using art as a form of power, creativity, and to express her individuality, Imani used this representation as a way to produce *intellectual activism,* or a way to reclaim who holds knowledge and what knowledge looks like. With many forms of expression such as music, poetry, and art, being silenced and devalued, Imani was able to reclaim her right to be valued in the space as a Black girl by centering her voice and art in a field like engineering where ideas and creativity are valued. During my interview with Imani, she originally shared a drawing that listed the six team names, challenge projects, and parts of the engineering design process. In Imani's room that was decorated with pictures of her success in swimming, medals, and a host of colorful paintings and drawings, her mother shared with me that Imani had created a poem (see

Figure 2) first, but was apprehensive about sharing since it was not engineering-related. As a camper who had been battling a journey with dyslexia for the past two years, she proudly shared and highlighted how her week at camp reminded her that she was a strong girl, that her art was connected to engineering, and that she had a purpose:

I Am a Strong Girl

I am a strong girl who likes to do art.

I wonder what I'm going to become. I hear my amazing future as a woman.

I see my painting as extraordinary.

I want to succeed in life as a girl.

I am a strong girl who likes to do art.

I pretend that I am the strongest girl in the world.

I feel the power of a real artist. I touched my art like my heart.

I worry about the weak power of a girl.

I cry after I have seen the success of my art work.

I am a strong girl who likes to do art.

I understand the strength and power of a strong girl.

I say that you are powerful.

I dream to travel around the world to see all of the art.

I try to reach weak girls, and make them strong.

I hope that my art will be stronger than now.

I'm a strong girl who likes to do art.

Figure 2. Imani's Poem - I Am a Strong Girl

Black Girl Magic

The girls showed their overall resilience daily as they encountered challenges from their peers and battles internally with themselves. To capture the universal beauty and power that they exude when living in their Blackness and girlhood, the term Black Girl Magic was used. *Intersectionality* and some of the girls' understanding that *racial permanence* exists in society allowed the girls to use this colloquialism as a way to state that they were going to overcome and celebrate their accomplishment in the setting. Girls described this as being "strong" and "powerful." With there being one and sometimes two Black girls per team, Black girls that were connected to their racial and/or gender identity would encourage one another and discuss their successes at times where all campers were together like lunch and during outdoor time, especially at the end of the day during daily diary time. During these meet-ups, I would ask the girls to stay behind in the meeting zone, grab their personal voice recorders that had team color tape with their names labeled on them, and use guided questions to reflect on their day for two to five minutes. Ironically, the girls found this a time to connect with others that may have had similar experiences as them. During the first day of daily diaries during week one, Quinne mentioned, "I was so glad to see other girls that look like me, I wish more of y'all were on my team." Other girls had conversations about how happy they were when "another Black girl won." Along with this, when I announced winners during the camp closings, girls like Elise would nod to Cora when their work was rewarded to show solidarity, or they would bump fists when they walked past their long group tables. I also noticed Jenesis do this when Carmen and Ezinne won. Nonetheless, the inherent sense of gendered racial pride was captured at times when the Black girls could collectively talk to one another.

These encounters between the girls highlight evidence of BFT and CRT. Unbeknownst to them, the girls were developing their own narratives regarding their experience in the camp setting. By recognizing what Collins (1990) calls the *matrix of domination,* systemic oppression, as being marginalized or powerless in the camp setting, they *self-defined,* or empowered their own reality. They affirmed their own identities through collectivism and by drawing on the success of other successful Black women that they knew of in engineering or other STEM fields. Their desire to show the boys that they could in fact succeed and the positive messages they internalized regarding their engineering identity and STEM self-efficacy made evident that the girls' gendered racial pride served as resistance to gendered and racial bias.

Jenesis was one of the girls who loved talking and interacting with me during camp. She often asked me questions about my research and what I knew about successful Black women in engineering. In her interview, Jenesis shared how people had *controlling images* and viewpoints regarding Black women and girls. Her awareness of this type of oppression, often perpetuated in the field of engineering, drove her to work alone or only with those who seemed to be like her. When working with boys and sometimes girls whose backgrounds were different from her own, Jenesis often felt like she could not get her point across; I noticed her shut down, create her own designs, and be proud that hers was just as successful or better than her group members. Instead of being in groups with people who were different, a certain type of comfort came from being around other Black girls since she felt an inherent pride in Black girls achieving. Similar to Collins' (1990) concept of *self-definition,* Jenesis used this as a way to create her own safe space and refute further silencing or disregard for her work that she felt was valuable. During challenge time, she always ran back to Carmen

and whispered in her ear after something happened that she did not like during challenges. In some cases, she spent as much time with Carmen as she did with her challenge team. Her self-expressive art reflected this. Out of all the people she encountered, it displayed all the Black girls and women she encountered during camp. Jenesis centered herself in her self-expressive piece of art with a rainbow over her head. She said this about the symbolic meaning of the rainbow: "The rainbow in the middle is me as a Black girl in engineering. I felt that I had something special in me which was Black Girl Magic…it really empowered me a lot." Within Jenesis' art (see Figure 3), she chose to highlight her friends who identified as Black girls as well as me, the assistant camp coordinator. Vibrant colors usually associated with the feminine like pink and purple were used to display her interactions with others who had the same double bind identity as her. Blue, which is typically associated with boys and masculinity, was used in conjunction with the engineering challenges and "rude male teammates", and green, a more neutral color, was used for lunch. Jenesis expressed how important it was to be surrounded by girls and women that reflected her own identity, as she was still being influenced by engineering and the experiences where she had to interact with others who were not as accepting of her ideas and vision for the challenges.

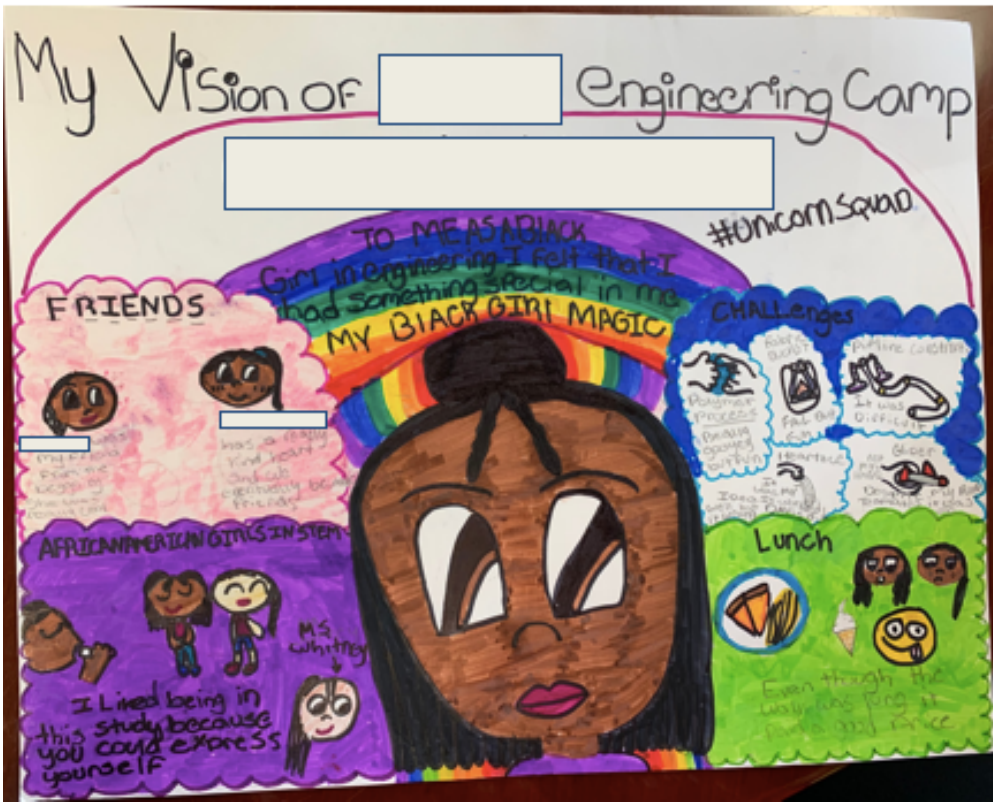

Figure 3. Jenesis' Drawing – My Vision of Explore Engineering Camp

Jenesis's form of expression in Figure 3 explains that for her, being a Black girl in the camp setting was a way for her to celebrate her inherent love for all things engineering and technology while promoting Blackness and being a girl. Despite the setting making her feel invisible because of *the racial permanence* and *Whiteness as property* that she encountered based on her interactions with some campers, she decided to challenge the feeling that she needed to assimilate to the dominant culture, and found a way to gain freedom and acceptance by celebrating who she was and others that looked like her. Quinne, a rising 6th grader, felt similarly regarding her gendered racial pride.

When I first met Quinne, she refused to participate in the study because she thought it was "too much to deal with" along with being in a new camp. It was not until her mom explained reasons why her participation was so vital that she signed up. When Quinne

arrived at camp, I greeted her on a hot, sunny day in a gravel parking lot and thanked her for agreeing to participate. She shared with me that she was excited to “help get more Black girls in engineering.” When I assigned Quinne to her team lead, Jada, who was a Black woman, she smiled back at her mom, pointed at Jada, and waved goodbye. Her mom told me that was a signal that being on a team with a Black woman made Quinne feel better about her new environment. Being in a world with many Black women and girls that are role models was important to Quinne. To her, gender and race were especially salient to her experience. Camp was another space where Black Girls were Magical. Thus, her self-expressive art included many powerful Black female figures such as: Michelle Obama, who was then the First Lady of the United States, Simone Biles, award-winning Olympic gymnast, and Mae Jemison, the first Black woman to travel to space (see Figure 4). When I asked why she created this to represent how she viewed herself in the camp she said:

> I just had to do that because I'm Black. I can do anything. You can do sports; you can do academics. I can be the President's wife. She could judge. She does coding. She can do anything she wants to do because she's a person. She can do whatever she wants, or a Black girl can do whatever she wants.

Figure 4. Quinne's PowerPoint Collage- A Black Girl Can Do Anything

Quinne's collage was coded and examined to interpret its meaning based on her experience and her cultural background (Rose, 2016) in my artifact analysis. This analysis revealed that Quinne was proud of who she was a Black girl. Depictions of her natural hair, brown skin, and educational goals make it clear that Blackness and success were important in her self-representation. Quinne made it clear that she would not allow people to get in the way of her goals and success, although she was aware that barriers exist. Quinne's personal background in coming from a community full of successful African Americans that are doctors, engineers, lawyers, etc., and her point about how much she values having Black role models and teachers speaks to the need to have more Black engineers or people of color in the setting. Collins (2018) describes the pressure to assimilate in these settings, but as shown

by Quinne's expression of happiness and feeling like she belonged in that space, it is essential that role models within engineering education represent a range of identities and backgrounds. Expressions focused on the relative scarcity of Black female engineers highlights *racial permanence* in the field of engineering and the infrequent efforts on the part of these units to diversify their departments and organizations. Additionally, Quinne discussed how she heard a counselor mention that White male engineering students may try to discourage women and minorities:

> I mean, I can do STEM because that's what I want to do. I can do well. Unless they say that people are not permitted, if it's not like a professor or the owner saying that and it's just an engineering student saying that, I'm not going to listen to them.

Many of the participants described Black Girl Magic as a way to stay encouraged despite what others may believe about them as African Americans. When I met Layla at the library for her interview after camp, she was excited to show me all of the books that had Black girls doing science and engineering. This made me reminisce about her first day of camp when she opened up her bag that had Shuri collectible items in it. Her mom constantly exposed Layla to science experiments at home although her STEM self-efficacy was lowered by her classroom performance. At camp, Layla never allowed others to discourage her. During challenges, even when campers like Ashir shut her down because she was a female, she continued to motivate her teammates and worked to validate others' opinions by saying things like "that's a great idea" or "that could work if we tried to add both ideas." Layla's interest at camp never died and it was books and other images with Black girls as scientists and engineers that drove her interest in the field. Layla's reading collection of strong Black female characters kept her motivated and interested in STEM. She cited these books as the

reason she has stayed interested in engineering and discussed why she is motivated to keep working hard at engineering camp. Layla mentioned:

> I love to do science, coding, testing, and it was something I keep reading. A [comic book] series I keep reading that is like about a Black girl who likes to engineer and code, *Moon Girl and Devil Dinosaur* and also Shuri from *Black Panther*. Moon Girl's a different person. She's just a comic, but I kept reading her and she come up with pretty amazing stuff to save the world and like gadgets, weapons, different types of electricity, and science liquids. She always just tested tests that I always love to do to test my stuff and that's it. My mom kept finding the stuff on the internet about stuff she think I might like, and I did, like *Moon Girl*. My first time reading the first comic, I was in awe. I was amazed. So, I just kept wanting to read it. And with Shuri, I went and saw *Black Panther.* I wanted to collect everything she had in the store. Camp is great it's amazing because it feels like I stand out and I know, I always keep telling myself I am a smart Black girl and I even have my book [about being Black in STEM] which say I'm a pretty Black girl. I keep reading because it's true. With being a Black girl at an engineering camp, I can find something different and discover something new I have never learned. But I also know that other people, not even my same skin color can also be a scientist. They just need to put their mind to it. And with me and other Black girls out there, they can just put their mind to it. They can be like scientists... if they want to be a scientist or chemist, just dream big, and that's it".

At camp each year, one book was selected to be shared with the middle school level campers. I and the camp coordinator, Sharon, typically spent weeks trying to find books for the lower elementary camp and a book for the upper level camp that would guide campers'

understanding that people from all backgrounds, especially those that are historically marginalized and underrepresented, can be engineers. Although books were not a focus of the middle school camp, we understood the value of the message that one book could send. In searching for books with Layla at the library and with Sharon earlier in the year, I recognized that even as Layla was empowered by culturally affirming her identity as a Black girl who loved STEM by the books she chose, books that were representative of engineers and scientists mostly had White boys on the covers and as characters in them. This highlights CRT tenets such as *racial permanence* and *Whiteness as property* regarding who holds science and engineering knowledge. Furthermore, Layla's constant drive to resist the notion that Black women cannot be engineers and her belief in redefining the narrative for Black girls in the camp setting speaks to her STEM self-efficacy and her ability to *self-define* her experience outside of the controlling images she may encounter as a result of others' views at camp or the lack of books about Black girls in STEM.

For Elise, a rising 7th grader, being the only Black girl on her team influenced her view of the environment. In her interview, Elise often discussed the current treatment of Black women in the news and racial profiling, as well as her belief that people think Black women's "minds aren't strong enough." So, when she saw a Black girl, Melody, and a Native American girl, Gia, succeed during camp, she was encouraged. This sense of collectivism shows that Elise too found ways to *self-define* her space in the camp through witnessing other Black and Brown girls' achievement. As the assistant camp coordinator, I gave Melody, Seth, and Todd first place during the polymer process challenge. Interestingly, this challenge was frustrating for Melody. Her group was working with the borax, glue, and detergent; the rooms were covered with green tarps and the tabletops were lined with brown paper to help

reduce the amount of cleanup. She kept telling her teammates to “stop messing around with the slime” because they were wasting time and not figuring out the recipes that were needed to make the different substances. Although Elise did not win an engineering challenge and she was unaware of what Melody encountered during this challenge, seeing Melody win kept her motivated:

> We didn't talk very much because Gia was quiet and then Melody, me, and Gia, we started doing the group at lunch. We actually spoke every day when we first started. I would be like, “How did your day go?” and Melody would tell me everything that had happened and when she had won I was like rooting for her. I saw [Melody] go up there and she was so happy. I was like, this is going to be happy. She was [a Black girl] on purple. When [Melody] went up there and she was so proud of herself. I was like, this is something that makes people happy. She was glad and me and her, we had a mutual friend at camp, Gia. I feel like that was showing people what Black girls are mostly, I'm not going to say above but kind of above other people. We have very strong mindsets. We are very driven because of people and the way they treat us.

Elise’s ability to foster community among others Black and Brown girls as well as her ability to champion the success of others speaks to BFT. Regardless of her understanding of how structural bias spoke to gendered racism through the devaluing of Black women’s and girls’ minds and forms of knowledge-making, she was able to see from a personal perspective how magical their interactions and capabilities were in engineering.

For Ezinne, being one of the first in her family to do something pushed her not to give up. During one of her daily diaries, her experience with a White boy camper led her to say, “Engineering is very important to our society and today we learned how those activities

meant stuff in real life. And I like to add that even though I'm Black and a girl, it doesn't mean that I cannot become anything I want." Ezinne's encounter was with Josh. During the balsa wood plane challenge, we laid down tape for the starting point as well as a long measuring tape to see how far groups threw the planes in meters throughout three different hallways on the third floor. It was during this time that the initial problems began to form between Ezinne, an African girl, and Josh, a White boy. After Josh would not allow his team to put the parts of the plane together, the counselor tried to coach the team and get everyone to participate. When I asked her about this encounter and what made her keep going after she encountered this on the first day of camp she stated:

> So basically, neuroscience and then biomedical engineering interest me because I still want to be in the medical field. Nobody in my family is a doctor. I want to be the first. All of [the campers] encouraged me. And especially Josh because he made it feel like I couldn't do it, and I can do it, just because I'm a girl and I'm Black doesn't mean I can't do it. I'm still going to try my hardest and not let them push me down just because of my gender and my ethnicity. If people try and put you down then you have to speak up or you tell a counselor because they can't just keep you quiet just because of your skin color.

Unlike many of the other girls, Ezinne decided to speak up and confront gendered racial bias that she encountered at camp. She refused to allow a White man to privilege his own prior experiences in aerospace engineering over her knowledge and abilities. This encounter and the difference between White and Black campers' experiences in this setting displays how *racial permanence* and *Whiteness as property* can discredit and deny the collaborative nature and valuing of everyone's experiences that help propel the field of engineering forward.

Furthermore, the Black girls collectively utilized their gendered and racial pride as well as their past experiences and knowledge about what it takes to be successful in the camp to use *Girl Power* and *Black Girl Magic* constantly. Whether the girls wanted to be engineers, or were trying to figure out their career options internally, they would not allow others to discourage them during camp. From personal goals, wanting to prove others wrong, or being a positive image for the Black culture or girlhood, they continued to motivate themselves.

#AmIWhatAnEngineerLooksLike

Adolescence is a time when exploration is guided by active learning, interacting with peers, and guidance from role models, all of which can shape and define who individuals are. Whether they were returning to camp or newcomers, the girls in the study explored what it was like to be an engineer. Although many of the girls were familiar with the STEM acronym, they had a very limited and generalized understanding of each sub-area within STEM and an even more narrow view of the field of engineering. Hence, the theme of #AmIWhatAnEngineerLooksLike allows me to examine how Black girls perceive their individual engineering identity, what they believe engineering is, and the benefits and drawbacks of their experiences at the Explore Engineering camp. This theme was inspired by the 2015 social media campaign #ILookLikeAnEngineer which aimed to fight gender stereotypes, enhance visibility, encourage diversity and inclusion in the field, and inspire people who may not have considered being an engineer (Johri, Heyman-Schrum, Ruiz, Malik, Karbasian, Handa, 2018). This hashtag is evidence that within the field, *racial permanence* and *Intersectionality* must be addressed as there are very few Black girls that are in the program. Furthermore, as many girls realized that they were one of a few in the program, they realized how engineering is rooted in *Whiteness* as it limited their options for

authenticity in the setting, and inequitable experiences in schools influenced their beliefs in their own mathematical ability. Additionally, constant battles against being *silenced* contributed to their ability to find respect and personal value in the camp. Within this theme, the first sub-theme, *Accepting the Grand Challenge*, explores how the girls handled the camp challenges, coped with failure, and worked under pressure. The second sub-theme, *They Won't Let Me Help, But Silencing Won't Stop Me*, is representative of the Black girls being *silenced and marginalized* by White males in the engineering camp where the girls felt unheard and voiceless. The third sub-theme, *A Love-Hate Relationship with Mathematics*, explains the exploration of mathematics self-efficacy during camp engineering challenges. Last, *Accessing a White Space*, describes the structural support girls noticed within the program as well as how girls navigated this space when interacting with other campers.

When enrolling in the camp, the participants chose Explore Engineering for various reasons (i.e., hands-on, fun, making new friends, acquiring new knowledge, parent interest, career exploration). They each arrived with different understandings of what engineering was that were based on other informal experiences, parental background, or school experiences in STEM. Quite often, their understanding of STEM gained through school experiences was used to convey what they believed engineering was. Thus, when I asked each of the girls why they loved engineering or if it was their favorite STEM subject, all of them replied "no." The girls enjoyed science and technology most because they loved experimenting, discovery, coding, and social media. Layla shared that she loved technology because, "I can figure out how to code, put something together, and make something work and move, and I love that." For Jenesis, she enjoyed Xbox, YouTube, computer science, and technology. Caroline enjoyed "technology a lot because like now, we're communicating, and it's led to power, it's

led to a water getting clean." Some of the other girls found interest in science because of their prior experiences. Elise's love for science had grown from her ability to get her hands dirty. She shared, "I like makeup, but then also explosions. And just simple projects like vinegar and baking soda, I love those. If I find it in the cabinet, I go outside, and I blow it up." Within this theme, I will share how the girls' personal interests, interactions, and understanding of inequity at the camp contributed to their multifaceted sense of their own identity. Layla, who was at the camp for the fourth time, used the challenges to motivate herself. Accepting the grand challenge of creating engineering designs, coping with failure, and navigating the space with a positive attitude kept Layla interested in the field and camp itself. While other participants were questioning if they fit or envisioned themselves as engineers, Layla already felt like one. Camp was a way to reconnect and continually motivate her. When I asked her to share how her experience was with me, she read this poem:

Engineering Camp

Roses are Red

Violets are Blue

I love engineering camp as much as you!

We asked, we planned and designed too.

But the best part was when we improved

To make it better for me and you.

Figure 5. Layla's Poem – Engineering Camp

Accepting the Grand Challenge

The Grand Challenge in the camp setting was more than conquering the tests and trials of the engineering education experience. In addition, the girls had to navigate a

community rooted in *Whiteness as Property* as they were challenged to find their place and purpose in the environment. While engineering is a field that claims to be neutral and welcoming to all, gender and racial disparities suggest that anyone who is non-White or not a man does not belong in this field or discipline. This positions engineering as the intellectual domain of White men. Furthermore, many studies have found that Black women are made to feel unwanted and unwelcomed when persisting in the field, which in turn drives them to leave (Fletcher et al., 2017). In my encounters with men in this role, I remember women engineers making mention of the "Wall of White Men" that honors those that have been successful in the field. On the wall, not a single Black woman is represented, but that does not mean that Black women have not been successful in the field. Additionally, while Black parents do often want their children to participate in engineering opportunities, STEM schools and STEM resources are slanted toward selective schools that have ample resources and highly certified teachers whereas schools that serve majority-Black students often lack access to engineering resources (Elam, Donham, & Solomon, 2012). These practices make engineering highly racialized and sexist, thus further eliding our understanding of Black girls' experiences in the field and discrediting their unique contributions.

The Black girls in my study experienced engineering identity development through self-interest, performance, and cultural connections in the space. Through innovation, creativity, and recognition in the environment, the girls developed their own perceptions of who can be an engineer and whether or not they fit that constructed image. When I asked the girls what an engineer was, their responses included similar traits and characteristics across respondents. They described engineers as "a person who fails sometimes," "creates something," "goes under cars," "helps people by building new things and making sure the

world is better," "they explain things well and give details when they talk," "they are creative and really smart," "they know math and science," "hardworking," "trustworthy," "passionate about their work," "they never give up," "they use a lot of math and make plans for new buildings," "focused," "confident," and "have high self-esteem." Unlike many of the other girls who said anyone can be an engineer, Ezinne mentioned, "People who are leaders that are strong, they persevere, and they don't really listen to what other people say. They are also men, White men." Ezinne was aware of the privilege that allowed that was afforded to White men and that would only promote the interests of African Americans when their interests converged. Similar to these descriptions, Caroline added:

> An engineer is a person who can make simple solutions for things that other people might not think of. They're like the creative side of problem solving really since they think about things in ways other people wouldn't and then they show it to other people and they let people modify things and change it, so it's easier for other people.

These descriptions showed that the girls had some understanding of engineering, but they had no idea of how vast the opportunities were or how interdisciplinary engineering was. Brooklyn was still exploring how much she enjoyed or wanted to be an engineer, and valued certain traits that she felt engineers had, one of which was "they think outside the box." While engineers do think innovatively, limited opportunities for Black girls and women have led to limited design development in our racialized society because Black women's viewpoints are not considered. This contributes to an overall culture in engineering in which White knowledge is positioned as better than Black knowledge. As a participant who had accepted the grand challenge of engineering before, camp was a chance for Brooklyn to be exposed to new ideas and imagine and explore the possibilities (see Figure 6).

Figure 6. Brooklyn's Drawing – Imagining the Possibilities in Engineering Camp

Two girls also mentioned that engineers "need patience," "but that does not mean that they are nice or kind people." These traits and characteristics were developed based on the girls' understanding of engineering. I followed up with a question asking if they thought other African American women or they themselves could be engineers. Many said things like, "If I put my mind to it and work hard enough," "it's an open option," and "yes I do, I can do whatever I want to do." Along with possibly being an engineer, girls made mention of being graphic designers, pediatricians, veterinarians, and coders. Caroline said:

> Depending if I continue this path of learning about engineering, yeah, I think I might be able to be an engineer. I say might because I do tend to sometimes fall more on the medical side of things, I explore that more because I get grasped by it or I'll sometimes be looking up engineering more and learn more about that one day. Medical sometimes grasps me more because they would get to work on like the heart and lungs and operate on people, sometimes take a diagnosis, stuff like that.

For most of the girls, a deep connection with the medical field was developed from their past interactions and knowledge about doctors. This also spoke to gendered expectations of women compared to men for career paths and exposure to the field. Without being fully exposed to engineering, girls may have a misunderstanding of what engineering careers entail. Moreover, these discussions were the beginning of my investigation into what contributed to their engineering identity development and the roles that male domination, racial and gender bias, mathematics self-efficacy, and collaboration with other campers play in their identity development.

Learning from Epic Failure

Perceptions that girls had about engineers and the broader discipline of engineering were challenged in the space. Using their conceptual knowledge of science and mathematics as well as collaboration skills, the girls worked in groups with others of a wide range backgrounds to complete the challenges. The girls learned that challenging work, competition, and failure are primary parts of engineering. Unlike in school, failure was an experience that every camper had to cope with. In my role at camp, I worked with the counselors and teacher team leads to make sure that they gave all the campers the autonomy to learn on their own, develop and build knowledge though their interactions, and learn from

failure. As I walked and observed the teachers on all six teams within the three breakout zones, it was not unusual for me to walk past a team of campers that were arguing about why their design was not working. Sometimes, I encountered teams that were crying or had given up on improving their design. For example, I noticed that Carmen was working in a team with two boys. She began to suggest changes, but after seeing that their design did not work the group began to play around with all of the materials like pipe cleaners, paper towel rolls, and other reused materials instead of trying to redesign and improve their idea. It was not until the teacher team lead redirected them by saying, "Let's go back and reflect on what we can do to make changes" that the team began to work on the challenge again. Knowing that failure was hard for campers to deal with, giving awards at the end of the day was tough for me at times. When many of the campers would suggest that every participant should get a prize, I would focus on what we can learn from failure, have campers tell me in front of all 72 campers and the staff what they would do if they got redesign time, and discuss engineers that failed and have been successful. In the meeting zone in the middle of the week when challenges had gotten tough, I asked campers to describe some of the best engineered designs. One boy from camp raised his hand and mentioned, "You told us about the 409 cleaning spray last year, they tried that many times." I could hear the room rattling with talking and statements like, "I would never try that many times" or "I would if I was going to be rich." These discussions continued throughout the week and helped to instill a belief that working hard pays off over time and that benefits come from failure. Instead of looking at failure in a negative way, failure was seen as an opportunity to learn and improve. Layla, who was at camp for the fourth year, indicated that her positive experience kept her coming back:

> The friends I made there because they were fun and funny and also to try and think of something different so I can always put my mind to discover different things. So, like I can put my notebook so I can write it down and always plan it out before I design it. And also improve with the best parts because I could always add onto it. Even though it failed, it was fine because every time I failed, I said, "At least we win the epic fail award".

This push to overcome failure served as a way to recognize success and was proof that the campers had the competence or ability to be an engineer. This led to increased self-confidence and a growing engineering identity. Carmen, a first timer, enjoyed camp and had the most fun as she was completing the fabric bucket challenge. As I observed her working with Jenesis and Cam, a Black boy, they laughed loudly at the way their makeshift fabric bucket looked. It was lined with rainbow colored kite material, and cardboard was placed around it (see Figure 7). Carmen chuckled and said, “Working with y’all is so much fun.” The group could barely complete the challenge because they were laughing and joking around so much. They added a straw and plastic bag to the design to “help with leaking and water collection.” For the next 15 minutes as they waited to test outside, they had Cam practice acting like he was walking fast back and forth outside to transport water from one end of the grass to the other. He practiced skipping, walking on the sides of his feet, and other strategies that would possibly help. This interaction showed how many positive interactions occurred during challenge time. This group in particular was also one of the few all-Black groups that I encountered, further highlighting the importance of reaffirming the campers’ racial identity in the space. Seeing camaraderie and collective growth added to their

reflective identity and feelings of relatedness, which in turn increased their engineering identity. For Carmen the new experience was full of fun:

I thought it was a fun experience and I think I'd maybe like to see new activities and just like seeing the same people. Maybe meeting more new people and just seeing some people that I might already know and just having background knowledge with the camp.

Figure 7. Carmen, Jenesis, and Cam's Fabric Bucket

For others like Imani who was at camp for the fourth time, returning to camp allowed her to explore new ideas without the reminder that her dyslexia was a disability for her in the formal school setting. She saw how she could add value to the environment even despite her disability, which further reinforced a sense of relatedness at camp. Informal learning empowered her: "The projects, the friends, you meet new friends that go to your school. The

experience in camp. The projects really encourage me to come, because I love the projects, they were so much fun."

Being able to collaborate with others was helpful at times. Especially when one of the girls was not as confident about her STEM self-efficacy, teamwork pushed them to communicate effectively and learn from others. As I watched Summer, I noticed that she took the role of the artist in the group. A lot of her teammates would suggest: "Tell her because she could draw a prototype well," or they would do the mathematics and she would watch and write notes in her notebook. As a newcomer, this made her feel more comfortable. When she did not understand certain ideas, she would ask other campers on her team or her teacher team lead to clarify ideas as they were observing interactions. Through *vicarious experiences*, watching others around her, she had developed the belief that as a younger camper, she would one day be able to complete the mathematics that was used for some of the engineering challenges. Summer shared how working with others made her feel like she could be successful in STEM fields:

> I think working with the groups, I think having a group help you with the activities that like, it's like reassuring that there's always people there. Like if you don't know something you can like ask them and just asking questions and figuring out as a whole.

The water consumption challenge was the lowest rated challenge during both weeks of camp. Using a Styrofoam board and a printed piece of paper with a city on it called Thirsty County they had budget of $15,000 to develop a water infrastructure to supply water throughout a county. The different materials with varying costs allowed campers to choose the amount of different materials (e.g., washers for treated water, toothpicks for water

treatment facilities, and string for piping) to distribute the most gallons of water across the county without going over budget. In doing so, there was a lot of multiplication, division, addition, and subtraction throughout the challenge. This became frustrating to many of the girls even though they enjoyed discussing how water scarcity was a national concern, especially since Flint, Michigan's water crisis had been a recent discussion. As I observed the yellow and purple zone at this time, most campers got off task and felt overwhelmed by the math in the challenge. Quinne's group in particular ended up putting their heads down on the desks at one point and wanted to stop. The counselor Weston came over, helped them dissect the numbers, and aided them in deciphering how to use the washer and string effectively during calculations. When I asked Quinne about the water consumption challenge, she mentioned getting the epic failure award. This award was given to campers that persisted through their failure and communicated effectively to ensure that they still learned from their mistakes. This was a hard concept to understand for some campers, but some of the best-engineered designs were created through failure. Quinne shared with me:

> Oh, I kind of felt happy that I got an award and I kinda felt weird that they even have an epic failure award. I mean, I don't think you're supposed to get an award there for failing. And for the things that people built on accident.

Although success increases STEM self-efficacy, these *performance accomplishments,* based on mastery through repeated success, can also lower expectations for success. By failing over and over, Quinne was discouraged by the challenge. Brooklyn, who had been at camp before, felt differently about getting the epic failure award than her teammate Quinne. Brooklyn had a positive view of failing which led to her increased STEM self-efficacy compared to Quinne. While Quinne was apprehensive and walked up slowly at the camp closing for her

prize, Brooklyn excitedly came to the front of the meeting zone to share why she felt failure was vital and how much she gained from the challenge. Brooklyn also shared with me how she felt about her group getting the epic failure award:

> I think it's fine. I failed like big time on one of them. I mean it wasn't too bad because like our team was really encouraging and we were just like, eh, it's fine. Whatever. Basically, the reason we got the epic failure award was because we went bankrupt and like right off the bat, we didn't think about how many washers we would need ahead of time. Throughout the time we had to like just wait for everybody else to finish, we like still kept a smile on our face and we were thinking about ways that we could've done it differently.

One of the hardest interactions for me to watch during the week was between Elise and her teammates. On the first day of camp, she talked to many of the girls on her team, but seemed to be looking for commonalities between her and the others. Her desire to relate to others and identify with others with the same gendered and racial identities was essential. When a Black boy, Sadiq, arrived at camp late she tried to interact with him on an engineering challenge, but he would not talk to her or the other camper. When I asked Elise about working with her teammates, she said, “I was being judged by both groups, boys and girls” because of her race and gender. Elise was the only Black girl on her team for the entire week of camp. She refused to let this get in her way, but it also pushed her to isolate herself when the environment became too much. This was a common for Black women in the field of engineering too. By being on a team where she felt misunderstood, the social isolation she experienced may have contributed to personal self-doubt because Black girls were absent from the camp. Through personal observation, the girls stood out based on their hair and skin

color alone, and this may have been enough to make them feel like they were not fit to be engineers. Once again, their *intersectional* identity made interactions for girls like Elise unpleasant at times. The girls expressed wanting to confront some of the White boys that were disrespectful to them, and with their racial and gendered identities making them anomalous in the camp, some of the girls acted different so as not to misrepresent their own personal backgrounds. So instead of embracing who they were, they assimilated to the environment to prevent stereotyping from overshadowing their accomplishments and interactions with others. The staff members noticed this and usually pulled Elise to the side to ask her what was wrong. Her response was often, "I don't feel included." For Elise, failing was not just related to the challenges, but corresponded with the interactions she had with her teammates because she was unsuccessful in fostering positive interactions with them through collaboration. Elise felt defeated by the third day of camp. In her daily diaries she shared:

> Today in my opinion was on the better side, even though I didn't give up, I got tired of like trying to, I would go somewhere, sit down, get back up and try again. Today in my opinion, was like the best day because I was able to have that time to myself. Everybody needs their own space.

So while the environment was supposed to be a space that promoted diverse backgrounds and perspectives, the *Whiteness* of the space led Elise to find more comfort in working on her own. On the fourth day she was encouraged to work harder, and on the fifth day she truly understood why learning to fail was an important life lesson. Elise had a good understanding of the camp purpose:

> Engineering helps a lot of people throughout the world and that it takes more than one. Like you can't do a project all on your own. You got you . . . but you have to

> work with somebody. We don't have to but, you have to work with a team to be able to accomplish what you're looking for because not everybody can do everything on their own. And then adding onto that, nobody has the exact same idea. You could think alike, but there's always going to be something different. So, having other people contribute to that and like saying, "Oh well we could add this or maybe we should stick with this, so this and this can happen." Like having multiple ideas and combining them. So always working with another person or even just asking for help helps. Even though we couldn't retry it, I knew what I would want to do with the alterations. I'd want to do everything. That probably pushed me harder. When I was tired, or I didn't want to finish it. We had lost and I didn't know what else to do. We were like, "oh you could do this and then I would add onto it and then we wouldn't become the best but at least we tried, and we gave it our all." [On day five], the thing that I didn't enjoy was when we did lose, but it was okay. I'm happy because that's what engineering is. It's about basically getting back up, trying again and innovating and creating new things. I learned that it's okay to fail, that not every time has to be perfect or correct. We have to make mistakes too. You have to have a wrong to make a right in my opinion. You do learn from your mistakes. And if you didn't fail the first time, I feel like you're not getting it right. You're already making something that's already been made, if that makes sense.

The concept of failure, here crystallized in Elise's response, was often related to school. Failure in school also speaks to a neoliberal paradigm that often places the responsibility of failing Black and Brown students on achievement gaps without acknowledging the role of structural racism in precluding access to these resources, thus

failing students from historically oppressed backgrounds. Considering that certain designs like the cellular phone have transformed from the original brick cell phone to today's more advanced iPhone with multiple applications on it, several redesigns, tests, and trials were necessary for the campers to learn what engineers do. For the girl campers, failure typically came harder than it did for the boys. Girls often cried or compared their work and themselves to other designs and designers that were more successful. Boys usually found humor in their failures. A few girls compared failing in camp to how failing in school was unacceptable. For Ezinne, she had accepted failure and had a different perspective. As a more mature camper, she communicated to many of the teams that she worked with that failing would making them better. Ezinne said that failing at camp and redesign encouraged her. In her words:

> In school you might not get that many opportunities to fail. When we fail at the camp, we can do it again and we learn from our failure. But when we fail in school, like if we fail a test sometimes, like this year in eighth grade they said we can't retake any tests. It's just going to be one final grade. I don't really retake tests, but if I get like a C on a test and I'm not happy with it because it was a big test that's like 50% of our grade, then obviously I'm going to retake it. And they won't let you and you don't. I mean like you learn because you have to study harder, but then you're also like, why did I get this grade? Like I studied all night. I think sometimes we need to just keep on trying again. And that's how life should be.

Thus some of the lessons that were being taught at the camp conflicted with the school environments where students spent most of their time. Ezinne's ability to recognize that you were not always given the chance to work harder or try again reflects the *myth of meritocracy.* So while at camp success could be gained from working harder, this was not a

reality of her experiences in school. When I asked Caroline how she felt about failing at camp, she began to laugh loudly. When I asked her why she was laughing she replied:

> Because we failed so many times, it's like it's a new learning experience for something else, so just opens up new doors if you fail. I've just felt a little bit ashamed that we failed, but like after realizing where we went wrong, it was like, oh, it was that simple? It was like, if we only added one more thing or if we only had this much more time, we could have fixed it, or it wouldn't have failed. In the future, I probably won't be so hard on myself when I fail. I'll probably be like, "Oh, let's see what can go . . . what could I have done here?" or like what if you had this much more time and just think what would've been the outcome of that?

Caroline's overall feeling was that camp was a positive influence on her as a Black girl interested in STEM, despite being a person of color, since her race was not salient to her experience. When reflecting on the competition, challenges, and failure she encountered, she mentioned:

> I feel like there's more positive because while we did fail some challenges, our ideas proved others wrong about what we could do. When I gave ideas, they usually helped us get further, so that means it doesn't really matter what your skin color is. It just means that we just have to try harder to get our ideas through and then they end up working a little bit more or they don't.

Caroline's self-expressive art was representative of how many of the girls left camp feeling about failure. Failure was a hard concept to accept, especially when dealing with competition and working with others, but it was a beneficial learning experience, as shown in her poem:

Failing to the Finish Line

The failures we faced were doors to new solutions.

We go to make new friends and show each other our ideas,

building off of each other to get to the goal.

Finding an answer through a different mindset each time,

Like a path through a tangle of roses.

Through we faced bumps and setbacks,

We reach a finish line so we can begin a new race and get something better.

Figure 8. Caroline's Poem – Failing to the Finish Line

The Pressure of Competition

One aspect of the camp structure that was discussed often during the planning phases was developing challenges as competitions or more exploratory activities. This was where campers would examine and carry out trials to see how materials and substances worked versus having them develop and test designs that would end in a contest. The camp coordinator Sarah felt like the competition was "healthy" and I agreed with her. I felt like the camp should be as similar to real-world interactions in engineering as possible. Especially being a Black woman, there were no short cuts or participation awards that were given in our society, so why should be falsely send that message to students at camp. Typically, these discussions happened before camp among the Explore Engineering year-round team to make sure that camp provided the best experience for campers. The main argument was that "not all campers thrive based on competition; for some it's discouraging." Despite discussions that competition may have not been good for girls, the Black girls shared reasons why they enjoyed the constant battle between groups. By constantly testing their designs, and

benchmarking (or checking in with other groups), making improvements, taking meticulous notes, a pressure-driven environment was created. Cora thought the challenges were tough, but she enjoyed them:

> Well, I think it encouraged me because the competition, yeah it's tough. People around us were having great ideas, but also with those ideas you can bounce off of them as well. You could see how they succeed and think, "Okay, so that's how they did it. How can we do that as well, but with what we've got?" And it's good to be competitive, too. It also kept the drive going because if someone else is doing that thing and they're about to win, you want to win. The whole point is to try and win and be better than. Improve your engineering skills and just have fun, too. I like competition. The pipeline I felt the most successful, because we got 100% even though we failed the first day. And we had to use what everyone was complaining about but, and the first time, you fail miserably, but we tried it again and we managed to get both of them, and it worked.

The challenge scenarios were always related to real-life problems. For Carmen, this encouraged her to try her best:

> I think it made everyone just want to push and try to do their best and like try to come out on top. Because if you succeed, you get that feeling of success, like you actually like helped someone or did something that could help a person in real life.

Brooklyn loved the competition also. For her, winning was the ultimate goal as she improved her designs:

> I'm a very competitive person when it comes to certain things. So, if I'm driven to do it then like if we do something good, I'll be like really excited about it and want to

> improve on it and keep going. I feel like you could always try again and there is like a design process. There is always a [time to improve your designs] and you just go in and around and round and round, so you'll be fine. It encouraged me. I really wanted to like win.

By contrast, some girls did not enjoy the competitions. As some of the campers bragged about their success and refused to let their teammates give input, competition took away from team efforts. This usually happened during transitions, lunch, outdoor time, or after I gave out awards during camp closing. Campers would ask others what their scores were because they were not shared with the group until the end of the day at the camp closing. When campers' performances were lower, they did not always want to share their results for various reasons like being frustrated with the process or upset that their idea was not utilized. Additionally, in some instances, certain teams thought they would place and did not. In response, others would sometimes brag to those teams about having won. Elise shared how these encounters negatively impacted her interest in the competition:

> It discouraged me. Well not to say I didn't like it. People were worried about how good they did. But for me, I kind of got discouraged. I was just sitting there and oh I am not doing anything; I'm not going to do anything. Oh well. Yeah, it kind of discouraged me. Not praised but people would say good job depending on what they did and the other people who didn't get first place, they were not. In my head the way that I think is, oh you didn't do good enough. You didn't get first. You didn't try your best. Don't always gloat about it.

Jenesis did not enjoy the competitions at first. Yet when she started winning, her attitude changed:

> It was okay. It was like, I mean first the competitions were like, wow, I don't feel like doing this, because we weren't winning. Then as we started to win, it was more exciting. I just don't like losing. If you lose, it will just improve [sic] you to do better. We started out losing, and then when we started winning it made us feel better.

For the girls and the other campers, while competition encouraged them to not give up and work through difficulties, it also highlighted who had cultural capital or intellectual property in science and engineering. Campers mentioned that their experiences in Science Olympiad or engineering clubs, that their parents were engineers, or that they had an experience in aerodynamics. In most cases these were not a part of the Black girls' experiences, and their presence was implicitly disregarded. They had to work to help others see value in their work because campers would sometimes choose teams based on who was successful. These issues were again things that the camp leadership was unaware of.

Tools for Success

During the engineering challenges, one of the materials that guided the designs of the engineering products was notebooks and Whiteboards. Each of the campers had notebooks where they recorded notes and kept drawings to provide information on how to improve their designs, although these were not required. Campers carried the 3" x 5" spiral notebooks lined with graph paper to record their results, ideas, and engineering measurements throughout the day (see Figure 9). All campers carried these with them from their breakout zones to the meeting zone throughout the day. Some campers' notebooks were filled with images whereas others may have had three pages worth of written details.

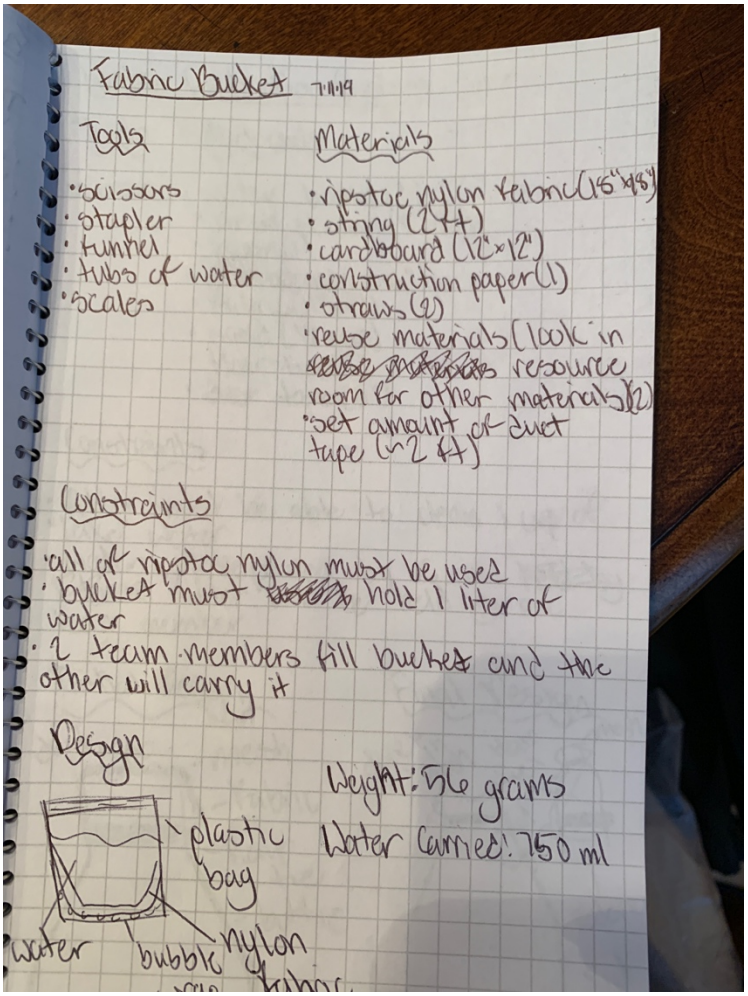

Figure 9. Cora's Engineering Notebook

The Whiteboards were large plastic sheet board that had been cut into 4 ft x 4 ft squares that would allow all campers to see the design easily. When observing groups at the beginning of a challenge, they would all grab a different color marker to see each other's contributions easily. The boards would typically have numerical equations, labeled parts such as a straight line labeled as a straw, a curly line to symbolize a rolled up pipe cleaner, and various images that had been interpreted differently based on the team (see Figure 10).

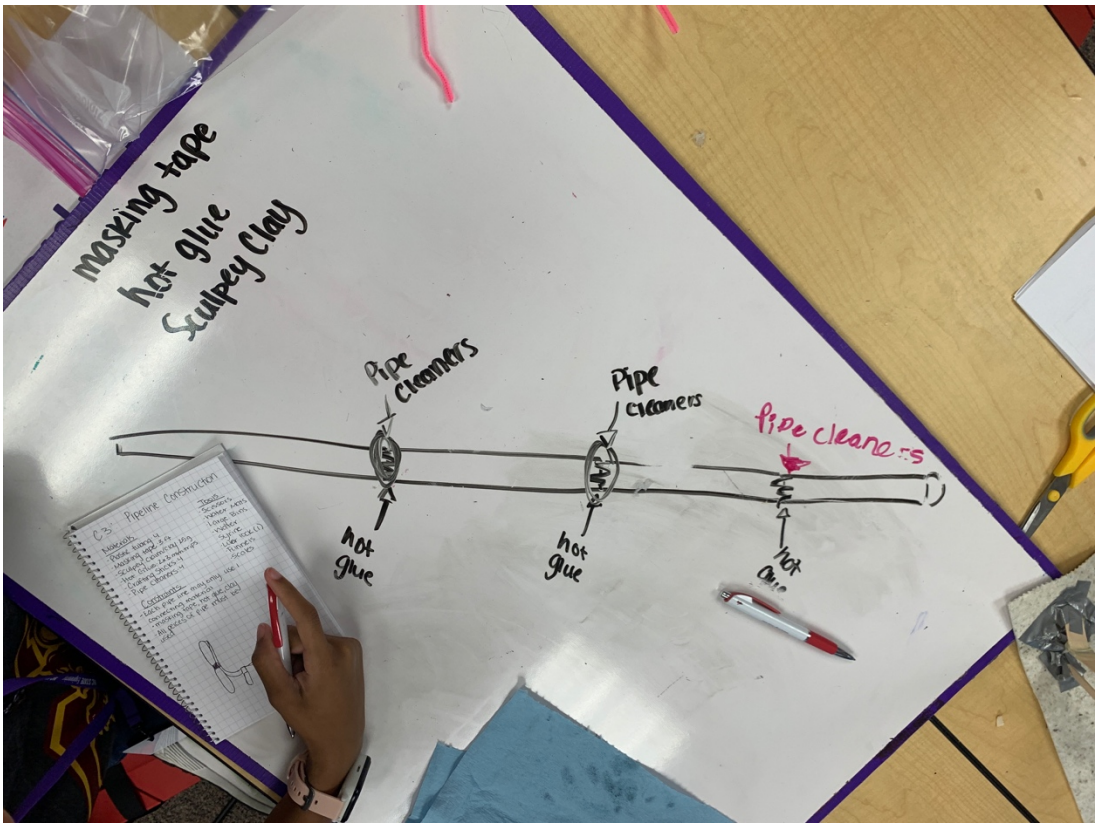

Figure 10. Engineering Whiteboards

I watched campers get excited about drawing their ideas on the Whiteboard and suggesting, “maybe we should add part of his ideas to hers” or in some cases groups would argue and campers’ designs would be erased in anger. Each individual camper kept a notebook with their own individual doodles, inventions, and ideas. Four of the eleven Black girls that participated won the camp Note booking Award that was chosen by teacher team leads and undergraduate counselors. I was very excited when I noticed that these awards would reaffirm the girls’ gendered racial identities and show that someone saw value in their perspectives and contributions. Cora, who won that award, shared the reason she took good notes during camp:

> Keeping notes is very important for engineering, but also on top of the things that I did not enjoy, I didn't have a lot of time to look at what we needed to see, including

> the notes that we needed to take and the materials that we needed. And they kept changing on top of that. So again, adding to the stress.

Summer, who also won the Note booking Award, had many drawings. Her love for art guided her strong desire to record her designs. Summer shared:

> Because when you're doing something by yourself, you take your time. Sometimes you may slack a little bit, but when you know you're going against someone, that means you have to work harder. My drawings helped decide what we wanted and how we wanted it to look.

Layla also used drawing to foster her success at camp. Even when her teammates were not open to her opinions, she recorded her ideas in her notebook:

> I love free-drawing. You got your tools and materials. I see some designs; I see some math. I write down stuff. I can design what I'm thinking in my mind, planning, and always labeling so I know which one is which, so I won't forget. And I always put down my tools right above it if I can. Because sometimes I might not just have one idea. I can have two, three, or four. Like with the pipeline construction, I had different ideas or different ways to showing it.

Overall the girls shared that they enjoyed their camp experience, learning from failure, and aspects of collaboration. While *Accepting the Grand Challenge* included multiple obstacles for them, they felt as though the camp was a good space for them to grow and develop their engineering identity and STEM self-efficacy.

They Won’t Let Me Help, but Silencing Won’t Stop Me

Participants in the study were all very excited to collaborate with other campers and use their creativity to design what could be some of the world’s new inventions. In doing so,

the camp demographics were overwhelmingly White- and male-identified, which reflects the overall makeup of professional engineering fields. As the girls shared their stories with me, repeatedly the word "they" was used. As I asked them who "they" was, in every instance it was White boys. Study participants shared a perception that White boys dominated conversations and collaborations and disrespected Black girls' opinions during the challenge work time, trial tests, and competitions. This consistent battle reflects broader patterns of Black girls being *silenced and marginalized* in the field of engineering. Along with this, *the critique of liberalism* allows us to address the equitable playing field that is supposed to be created in informal settings like this one. During the teacher team lead and counselor training, we talked to the teachers about how to facilitate healthy interactions between the boys and girls at camp. While this was something that could be hard to observe, girls would disassociate from their group because their viewpoints would be ignored or because the boys would play around a lot. For some of the Black girls, this was tough. Many of them were more outspoken that the other girls in the group. So, when they were ignored, they would call the boys out by saying "you aren't listening to anything I'm saying" or by making remarks that "your design is going to fail anyway" because they were not allowed to participate. Other Black girls that were silent and exhibited avoidance as a way to cope resorted to walking around and observing the eight different designs created by other teams. During one observation, I noticed Melody get angry and turn red. During this challenge, she mentioned "y'all are buying things we don't need to buy and when I pitched my part you just shut down all my opinions." Even after her team lead tried to address the issue, the other teammates had gotten so far into the design that the girl was no longer invested. Within the breakout rooms, I could see girls walk up or go get suggestions from other girls that were on different teams

when they were working alone. Sometimes they would even share ideas and work to get their boy teammates to listen to them. Elise discussed an encounter with two White boys, Seth and Jim, who ignored her and a Black boy, Sadiq, who was disengaged with the camp challenges and left after one day:

> Seth was like, we don't need that. I just sat there, walked out with a piece of hot glue in my hand. And the part that really bothered me is when we didn't do a good job, I understand that was trial and error but still, Seth was like it would've worked if it would have an engine. I was like, but you know it didn't have these things. You could've did other things instead of this. Does that make sense? [Sadiq] was quiet. At first I was frustrated, but I learned I get mad or sad about things too easily. I just let them do whatever they want to do. Like today in class, this boy kept trying to talk over me. I said, you got it. I sat in the corner. Well, not in the corner. I just sat in my table. I was like you got it, I'm good. I don't need anything. I'm listening, I'm doing my work.

Elise's stigmatized understanding that she "gets mad too easy" was reflective of the *assumptions of style and beauty* of how Black girls or "good girls" should communicate. So instead of combating gendered racial encounters, she avoided being "disruptive" which perpetuated the myths that the White boys' behavior was acceptable and reinforced the stigma against outspoken Blackness.

Campers that attended were usually involved in various camps throughout the summer. Some were in one camp per week. I often heard whispers about going to golf camp, horseback riding camp, and space camp that focused on aerodynamics. Campers like Elise did not have this experience, which speaks to issues of access that Black girl campers had

based on family socioeconomic status. Elise attended one camp each year and that was Explore Engineering. As I watched Elise interact with one of her groups, a boy boasted about his mathematical ability. He shared that he “had the top score in math in his school” and that he was going to “get a scholarship to the best aerospace engineering program.” When he asked Elise what other camps she attended she said, “just this one, but I have a lot of other experiences.” He looked at her and discredited her comment, value, and worth just by the way he looked at her. When I asked Elise what she disliked the most about camp, her was response was:

> Some of the males. A lot of the males. He was older. His name was Aidan or something. I understand yeah, he was really smart. He was doing college math in the seventh grade. And I was like oh, that's really good. He took aerodynamics and everything. But I feel like he took that stuff and gloated about it. And then there was Jeff. We were doing the balsa wood glider planes and kept taking it from me. Or if he didn't take it from me, it was like oh, let me see it. And I would be like okay. Because we're supposed to be working together. And then he took it and he did something. He had cut some things. I was so confused. And then he said he needed something to help and I knew he had a hot glue gun. And then he was like oh, we don't need that. And I was like I just spent five minutes in here trying to reconstruct this. I usually work, I don't work better but I work pretty good on my own. In another challenge, I had met—I forgot his name but it was one boy—you could tell he was rude. He was really antisocial. Me and him had worked in a team. We were going back and forth, and we were adding on top of each other’s ideas and that bonding really helped me and him.

While Ezinne definitely had preconceived views of *White privilege* and how some White males thought they were better than Black people, she was still open to working with them and tried to give them an opportunity to treat her fairly before she judged them.

Recruitment for girls in the camp became harder as the campers got older. While some camps were first-come-first-served, we prided ourselves on selecting who was able to attend. One particular focus was on recruiting girls and minorities. Even with this intention, more boys than girls enrolled in the camp. Whereas the enrollment was roughly 50% boys and 50% girls for Kindergarten through second grade camp, there were fewer girls that registered for the opportunity in middle school. Early exposure has been shown to cultivate engineering identity development (Collins, Joseph, & Ford, 2020; Schwartz, 2008), but as girls get older there are fewer opportunities for them to engage in informal learning opportunities despite that this is a crucial time at which to increase interest and engineering identity. In interacting with the boys and girls in groups, Elise felt that her viewpoints were not valued because of her gendered racial identity. In this environment, she felt controlled by the boys' views and their dominant perspectives during collaboration, thus silencing her and as she stated, making her "voiceless." Elise also shared how she recognized that the group sizes and small proportion of girls to boys may have contributed to her feeling voiceless in the camp challenges:

> A lot of the girls here were actually a lot like me, surprisingly, Black and White. Well, because I haven't worked with any females yet and I've only worked with males, I don't really know how they act differently. So, I guess it'd be just a different experience if I were with a female. I had to work with a lot of males and each time it was I quote "what you did was stupid or that didn't make any sense." "No, I got it, I'm

> good." "I don't really need your help." And when we were doing the plane, this one boy, he was like, I messed up when we only had like five more minutes left. But maybe if I was able to help him, I could've helped him more because he wouldn't really let me do anything. And I understand like I probably should have spoken up for myself, but still it's like hard. We probably should work not like small groups, like bigger groups as a team together because it does get harder when you work for small groups cause you don't really have a voice. It's either you have a leader and you have sidekicks I guess. And it's hard because usually when we do a group, I do have to work with boys but they're not as outspoken. They are more outspoken here than they are at my school where it's like if you don't take the lead you won't get the project done. But here if you tried to take the lead, you're going to get pushed back or like push down and say no. And I feel like it's not just because of like my race or anything or that I'm a female. It's just how people are naturally does not understand that. But so, I should have a voice too. And I don't understand that because males always think that they're better than me, and I feel like that's a real problem.

Some staff members did address campers by saying, "she is just as capable as you," or "listen to her opinion," but the larger issue is that through collaboration campers saw this as acceptable and did not change their behavior until instructed to do so. How gender norms relate to career aspirations is problematic and can contribute to the boys believing that they are the best engineers, in turn leading them to privilege their knowledge over the girls'. Over time, these gendered racial negative comments can have a devastating effect on the matriculation of Black girls in this setting and in other engineering context and professions. As seen by Table 2, there were many first-timers in the camp. Thus there are many factors

that many contribute to the persistence of the girls in the program and that deserve more extensive investigation and analysis beyond the present study. When Elise shared herself expressive art with me, it was disappointing to see that these experiences of feeling *silenced and marginalized* took a major toll on her experience at camp. She described herself as someone that typically thrived when working with others, but for some reason, she was never able to truly overcome these encounters with boys at camp. Elise shared:

How I Felt at Camp

We all go through trial and error, we all make mistakes.

Throughout that week, I did all of those.

At the same time, I also felt disappointment with myself, knowing I could do better.

But not only better, I felt as if I was never given the opportunity sometime,

usual getting shut down by a male and sometimes females.

Having to go through that every day was like a never stopping revolving door.

The conversations were, "that's not right" or "I took the class", "I know what I'm doing."

I respected their ideas and heard them out.

I just guess they don't understand or did not care that what they say has an effect.

And that effect can either drive someone or simply stop them in motion.

Quite frankly, I like to think that I'm a driven person,

If there is a question, I want to be the first to answer. I thrive under pressure.

Maybe I was just scared to meet new people

knowing I would only know them for a week.

Figure 11. Elise's Poem- How I Felt at Camp

Figure 11 (continued). Elise's Poem- How I Felt at Camp

After someone would say something negative towards me I would either thrive or sink.

As a matter of fact, when I sink I come back harder than ever.

Trying my best and that's exactly what I did.

To sum it up, the week had its ups and downs. I met new people that I still talk to.

Also, that every people you meet in life won't like you and/or be your friend.

In camp, listening and communication were some of the primary ways campers shared their engineering ideas. Campers often used a large Whiteboard to draw and share ideas, and used individual notebooks to record and store information for reflection. In particular, Caroline had many ideas drawn in her notebook that were not always shared on the Whiteboard. When I asked her about her ideas being valued at camp she shared:

> I did have to try a little bit harder sometimes to get my ideas listened to, but I'm a quiet-spoken person, so that's normal. Sometimes it did have to do with who I was working with because sometimes they would listen more to my ideas and sometimes depending if I was working with certain people, my ideas weren't heard as much. I won't really say names, but most of the time, it was when I was working with mostly boys. I think that was when I was in a group of four and then they were people of different color. Mostly when I was working with White people my ideas didn't get heard as much, but, yeah, that's normal.

Caroline mentioning that it was normal for her ideas being ignored is representative of *racial permanence* in our society. It expresses the entitlement of White boys and White students compared to Black girls who have to work harder and overexert themselves to be heard.

Similar to school, when the teachers at camp praised or suggested that a design was good, it would influence what other campers chose to create. Thus I reminded teacher team leads and counselors not to do this at camp. This was hard for teachers since they were so used to giving feedback in their classrooms. Feedback in the camp setting resulted in teachers inserting themselves into the group. When girls were ignored, I noticed that if a teacher said their design was nice or showed interest in its features, the students would change their ideas because they thought teachers knew the best way to create a winning design. Jenesis also shared in her daily diary and in her interview how her opinion in a group was devalued until a teacher team lead praised her design:

> I didn't enjoy the group of White boys I was working with [on the balsa wood plane]. They were really making me frustrated and upset because I was trying to help work on the airplane with them, but they were kind of just leaving me out. They were very, very, I guess I would say rude, not very wise with their choices they were making. They were all White boys too. They were like, “Oh my gosh, we can do this, and nah, nah, nah.” I'm like, “Okay, let's do this and this.” They were like, “No, because it's wrong. Dah, dah, dah.” I was paired up with them. I came up with this idea. They were like, nah, nah. They decided to do the other idea. And then when Ms. Naomi walked by and she was all like, Oh, I liked this idea, which was my idea. And they, and she was, she thought it was the whole group's idea then they wanted to do my idea just because Ms. Naomi said it was nice. Then I just left. Then I went to Megan, and she was like, “You can make your own.” And I did, and it was actually successful, and theirs was not. Then they came crying back to me, wanting my help.

Ezinne worked with Josh during most of the week on the fuel-less flight balsa wood challenge and the redesign. In her daily diary, she shared how he tried to do the challenge alone:

> Today at camp I enjoyed rebuilding airplanes because it made it better so that we could test them again on Friday. And the reason I liked that is because we can see what we can improve and what we can remove. I didn't like when Josh kept on taking over everything. And then I finally had to step in and tell him that everyone has to do something. So, he finally let people do stuff.

I was unable to see Ezinne during all of this two-part challenge, but one of the counselors, Melissa, shared information about Ezinne's team with me. After camp, Melissa came to me excited and said, "I do not know what you are looking for in your study, but I have to tell you this. Ezinne went off on one of the boys and he deserved it. He is a typical spoiled White boy and he would not let anyone help. Finally, Ezinne said, 'Let me do this, I can do it!' really loud and he gave her the plane." When I asked Ezinne during the interview about Josh and how it made her feel when he wouldn't allow her to give input, she said:

> Basically, when there was just one person who thought that I would break everything. Josh thought that he could, um, controlling everything and one of the pieces broke off and he thought that I broke it. I told him that I wanted to manage a plane also and it was like, no, you can't do it. I didn't help a lot. All I did was throw at once and didn't even get to put it together. We didn't add anything the first time, but the second time, which was the redesign, we added the washers at the bottom, which it made it go farther. Josh claimed he knew everything about aerodynamics and everything about flight and planes. And I told him that I didn't do anything the first time. So, I wanted

> to do something, and Megan came and said, yeah, you should let her fix the, to put the plane together. He finally let me put it together, but then he was like, no, they should go there, and we shouldn't put that there. And I was like, can you just like breathe and chill because I haven't finished putting it together. And then it ended up working and going pretty far.
>
> And then the last day of camp when he decided to throw the plane, it didn't go far, but when I threw it, it went really far. So, it was like, well, we can show who did the better job. He didn't discourage me because when you're, when you're just in, you know, doing engineering, some people might discourage you and tell you that you can't do it, but you don't always have to listen to them because there's gonna be people in your life like that. And some of them just try and do it. So, you might give up, but sometimes you just have to try hard and persevere.

Imani, who was also on Ezinne's team, took a different approach than Ezinne. When she was shut down, she did not stand up for herself. She drew in her notebook and on the Whiteboard until the next challenge began. When a teacher team lead approached the table and asked why Imani was not working, the boys would say, "She does not want to help; she's playing around." The boys' effort to criminalize Imani speaks to the *controlling images* of Black girls. With her team lead being a Black woman, she too was unaware of what was going on and allowed the boys to dominate the situation. Even with this being untrue, the team lead was unaware of what was happening so Imani was pulled to the side of the classroom and had a discussion about her behavior. When I interviewed Imani, she discussed how Josh and Noah doubted her ability to grasp the camp challenge concepts and think critically about engineering:

> I think Josh just took over everything, he just wanted to do his idea. Because out of everybody else idea, but he think this one's the best, and like, "I have more experience. I have all A's in this." He treated everybody like that, because he thought his idea was better and he had the best. I feel like that he wanted to do it all his way. I did not help that much, because he just did it. But, at the end we had a good project, it was up for so long.

Working with others also took away from the camp experience. Boys in the space were often seen roughhousing, making swords out of the materials, or making mixtures with the borax, glue, and detergent. This caused bigger messes. At one point, I had to have a group meeting with the red/blue zone to talk about how their messes were causing cleanup to take a lot longer. The carpet in their room had glue on it that could not be removed. The smell of the borax, glue, and detergent substance was much stronger in their room because the teacher team leads and counselors gave them refills when they made a mess. Girls were the ones that usually cleaned up these large messes even though they were not the ones to make them. When I asked Layla what she did not enjoy she said:

> The boys acting kook a little. Not really behaving good. Making so many loud noises I can barely focus, but I always kept my eye on the work. And some of them, they were rude and not believing me. But when it comes to the other teams they believe me. I was like, "That is interesting."

This speaks to the society's acceptance of White boys misbehaving and judgment of Black girls and when they confront issues or want to have fun. When they do this, they are said to be "acting up."

Caroline was shy, but her ideas and designs were very advanced because of her ability to draw designs that looked similar to the materials. In a very mature way, Caroline would try to resolve conflict when it arose. During the straw construction challenge, Logan explained to her partners how to make her design. After they created it, her partners called her design "basic." The proud look she had on her face immediately changed. She asked them why they think it is basic and the girls say because it is plain and does not have a lot of detail or creativity. When working with others, I also saw her suggest, "Let's find common ground" and "this should benefit everyone, not just one person." Caroline would draw a picture connecting various members' ideas and share why she felt like a collaborative effort would work. When these tactics failed, she also became distant from her groups. Caroline regretted being silenced at camp. She had this advice for Black girls that decided to come to camp:

> I would tell them to come but I would tell them that if they get ignored just tell the people that they are working with that their ideas should be heard and what they have to say should be heard. Because that's one thing I regret doing is not telling my ideas louder. And I'd also tell them to speak to more people because I also regret not doing that. I should have spoken more to other people even when we're doing challenges.

The fear of being judged incorrectly for speaking up was a reason why the girls avoided being their true selves in the camp. This too was representative of Black women in engineering. With camp being situated in a collegiate setting where engineering majors were mostly White males from the "good old boy" south, what the girls experienced at camp was reminiscent of what studies have shown Black women deal with at the collegiate level. Elise also cited the gender stereotypes and bias she encountered at camps as a reason why there are

so few women in the field. At the end of the first day of camp, Elise wrote this in her daily diary:

> I learned that there's multiple types of engineering and something bad or I guess I shouldn't say that, was that engineering is male predominantly, there are some female engineers, but like at the camp in my group there's like five, six females and it's mostly males. That was something like I didn't really want to learn. A lot of people put [women] down and say oh you're a girl, you couldn't do this, and they don't see as many people, many women in STEM. Meaning that less [sic] women are going to be in STEM as time progresses unless we do something about it and start doing more STEM.

This encounter shows that Black girls' potential is often ignored in informal engineering education. When I spoke with many of the girls, they shared that they were not sure that the White boys or other teammates were aware of the negative repercussions their comments had on their individual identities. Although many of the teacher team leads and undergraduate engineering counselors were trying to address problems and mitigate conflicts in groups, I noticed in my observations many covert actions like scratching out or erasing a girl's design, passing the design between two boys, or ignoring the comments or suggestions of the Black girls. Although no overt comments were made at camp, many of the girls wondered if the messages that related to their gendered ability were also connected to race or the *racial permanence* in engineering. Adolescent-age campers know overtly disrespectful comments related to your ability and race are not acceptable, yet in our society sexist and racist comments and actions are more systemic. These and other factors contributed to the girls' feeling that they did not belong in the community of prospective engineers. Elise also shared

how she felt other males in the program were treating her different because of her gendered racial identity. When I asked her why she thought a White boy may have been disrespectful of her and devalued her opinion, she shared:

> I think it was my gender and my race. I felt like he didn't think that I knew that he knew. And I even asked him, when we first started. You were there. I was like oh, you know a lot about planes? And he was like, yeah I guess. And I was telling him I don't know anything about planes. Honestly, I don't but I would at least like to try. I think it was my gender and maybe what I said, might've said she didn't know anything about this.

Different from the other girls' perspectives, Carmen felt like camp provided an equal playing field for everyone. During her interactions with campers, she was typically reserved and went along with what other suggested. She was more likely to give input when she worked work with girls compared to boys. This may not have been something she realized however. Boys and girls that were all competing for the same thing in various groups was equality for her, just as the *critique of liberalism* does not acknowledge how equality is impossible in a society with entrenched racial bias and White privilege. Carmen felt as though camp was different from the real world when thinking about fair treatment of girls and boys in the field. Carmen said:

> I think it's a little bit of a challenge and I feel like it's just harder for some people. If we keep working, it'll work out for like everyone. There was a time when men would be over everyone, so women would be equal, but women had to try and be equal. But like thought [women] need to work a little bit harder to be equal. Camp is not like that, but the real world is.

As is evident in Carmen's statement, some girls felt that things were equal at camp, although this was not the experience of the majority of the girls, many of whom felt ignored and unheard. Furthermore, educational cultures that require Black girls to work harder have become normalized and can be a stressor for them. Thus in many cases, Black girls resorted to working with all girls to limit the need for conforming completely or assimilating at camp.

Relating to Gendered Groups

Throughout most of the camp, study participants were typically the only girl in their group of three or four. In rare circumstances, they would be on a challenge team with one or two other girls. Most of the Black girls mentioned how much easier it was to communicate and share their ideas in mixed-gender settings compared to when they worked with all boys. I noticed the girls code switching, a practice connected to devaluing Black language and privileging *Whiteness*, when they talked among themselves during daily diary recordings at the end of the day, more so than when they interacted with their teams and saw their ideas ignored. One girl, Elise, even encountered a White boy who refused to say her name correctly after she pronounced it multiple times. It was not until I approached the group and said her name that he corrected himself. From that point forward, when groups were picked, she tried not to work with boys. In her daily diary, Elise discussed the first time she was able to work with other girls on day three:

> I worked with two other females today in a group and it was actually a lot easier than it normally is. So, I just feel like there should be more females at this camp. So, it's just one girl. She seems very, very nice, but when you're doing something she takes over. She basically says, no, you can't do this. I'm going to do it to make sure it's right. And I thought that's a little harsh, a little rude but that's how you feel. Can't

> really stop you. The other girl I was working with, she was very like optimistic and she kept trying and that was already good in my opinion of her, cause me, I was ready to give up honestly because even though like we tried our best. Also, the ladies in the study that are with me, I'm not in a group with any of them, but still it's like we've always finished is either we talk about something, like if anything happened, like we basically talk about what we put on the recording and how we felt about it. And I feel like that's really cool.

The collective bond that Elise formed with the other Black girls and some of the other girl campers was helpful in bolstering her engineering identity, and her response suggests that participating in my research also helped her to build community with other Black girls. However, ratios in camper gender demographics meant that these interactions were limited. After Ezinne's experience of working with some of the boys, she said she had preferences about gender of the groups she worked with at camp: "Mostly girls. Because girls either want to know what you think, or they weren't trying to take over the project." Considering that the campers were all adolescents, it was not surprising when Quinne shared how she felt about boys:

> The boys were just annoying. They always got us in trouble. They were talking loudly while the teacher was talking and so then she'll be talking, and they know she will be talking and still keep talking. And then when she talks about them, which then when she's calling their name, they will still be talking and, well they didn't get us in trouble. And so, it was yelling.

Quinne's point that boys in her group ignored another Black woman, Jada, shows how White boys may be disrespectful or resistant to authority figures that they see as inferior such as

African Americans or more so women. Black women's *intersectional identity* makes it harder to address this issue. When asked who she preferred working with, Jenesis also said: "Girls. Because they were just like, they were more calm and not doing too much. Not leaving the group. Not sneaking out. Not yelling at Melissa and Jonas. They were doing too much." For Elise, working with girls had not effect on her because she still felt like if it wasn't her gender, it was her race they were looking at:

> Not all the girls were bad but not all of them were good. I feel like with the girls, it wasn't that I was a female, it was the coloring of my skin. I'm Black too and she's White, so she can do better than me, I feel that's how she felt. I didn't really enjoy working with boys or girls. Yeah but then some of the guys, I would do really good with. And Sadiq, he was the only Black boy and he didn't talk.

Brooklyn initially said she didn't mind working with either gender, but suddenly remembered how hard it was working with boys and mentioned: "I didn't really mind. I mean boys are always a little bit more stubborn than girls. I always like working with girls more just because they, I feel like they listened more often than boys do".

Layla discussed how she tried working with boys at camp, but they did not want to include her. I shared with her an observation I conducted as part of this study. During one challenge, Layla walked up to Ike a few times and tried to contribute to the project. From a teacher's perspective, it may have looked like the group was getting along well. It was not until you moved closer to them that you realized that Layla and Ike were arguing. She brought him a piece of string to discuss how it could be used for the Heartache challenge. Arish kept telling her how they were going to clean the artery. They collaboratively developed a design on the Whiteboard, then when Layla tried to touch the materials, Arish

said, “I got it.” For about 20 minutes Layla stood over him and tried to help, but he pulled the materials away from her. He finally passed it to her when the counselor said they had ten minutes left before testing. Layla shared this when talking about working with boys and/or girls:

> It was good. The people I worked with best was the girls. It was good. This kid kept saying I didn't do much work, but I knew that. Ike. But I said like, "What are you talking about? I keep asking you if you need my help." He'd never respond to me. Yes. I tried to ask like, "I asked you twice." Like, "No, you only asked once." But I still asked. The girls. Yeah. It was mainly the girls, like Faith and Marilyn and Emily and Natalie. They were fun to work with, but only if they cooperate correctly and treat others how they want to be treated. The girls are fine. Yes, I was the youngest of the bunch, going into sixth grade. The woman in the blue tee, she said I was acting really mature around the kids going into seventh and eighth grade, and me being one of the good ones.

Layla often had to be the bigger person in situations with the boys on her team. Girls finding camaraderie with other girls still had to navigate their racial identity and typically had to be the bigger person, resulting in *White supremacy* or the disallowance of Black girls from being able to show emotion because they would be seen as inferior or looked down upon. Although they did not always find emotional support at camp, they were connected to challenges that they felt addressed issues relevant to their own communities.

Culturally Relevant Connections

The girls’ engagement in the challenges reflected their personal connection to the scenarios shared during the engineering challenge introductions. Many of the girls enjoyed

certain ones more than others, and challenges that reflected their interests also had a positive effect on their engineering identity development and STEM self-efficacy. The water challenges reminded them of the Flint water crisis, the heartache challenge was connected to high blood pressure and heart attacks, and the polymer process challenge enabled them to use their vast scientific knowledge to create what they recognized as slime. These challenges grasped their attention. From these experiences, the girls were able to recognize that there were problems in engineering that they may want to solve in their careers. They saw value in developing inventions and "becoming a person in history" like the *Hidden Figures* women that were role models in their own community. Without connecting challenges to the girls, their reflective identity would not have been ignited, but by using this approach, the camp was making strides towards cultural consciousness, expanding understanding of the culture as they connected this to the Black girls in the specific context of the engineering camp. By making relevant cultural connections, the program can make the campers and girls more aware of engineering and drive their interest in engineering careers that might address the specific needs of their communities while building their engineering identity and STEM self-efficacy. Caroline shared how she was motivated to learn more about engineering because of personal reasons:

> There were things that encouraged me, especially like the water consumption and then the heartache one. Those were very encouraging for me to do more STEM because there are a lot of White people in those areas. It's just that Black people don't get water for the water consumption. When we do get flood warnings, or we have to be scarce on water, if we just figure out a way to help with that, that would be good. Then with the heartache, in general, and with a different part of the body, like with

> my brain. But that's not for my community. That's more personal as in with my epilepsy. There's a lot of people in doctoring, but it would be nice to have more color in that section.

For Elise, the challenge related to water was also very salient to her experience in her community. Elise lived in a predominately Black community in a home with her grandmother, mother, brother, and soon to be stepfather. She said:

> So, where I used to live, it wasn't bad, it was crowded, and I felt like the water couldn't have been as clean. We had a little river flowing through, you could see things in the water and stuff. So, for that challenge it was like real life's happening. Being able to get cleaner water, and for us to be able to pay for these things, if they can take so much money for taxes, how come they can't use that money for good. There are Black people who are successful, but still Black people are like lower classes. So, we live in less fortunate places with cleaner water and everything. I feel like that one was kind of built for Black women to show there are things that can help your community.

This was one of the few times where Elise felt connect to camp, and her reports about her experiences indicated that she also realized how engineering highlighted inequitable practices in our society and how Black girls in engineering could disrupt this through representation in the field. For Quinne, the water filter challenge reminded her of her home. Quinne was from a northern state and also lived in a prominent predominantly-Black community. In her neighborhood, Quinne mentioned seeing a pond that had dirty water. She believed this was a source of the city’s water. In her words:

> I related to the water filter because down my street there's a little pond and it's kind of dirty. I haven't really seen it, seen it, but it looks dirty and you can have a little water filter in the pond, where it filters the water. Maybe the grass is dry or something and it has been wet and it'll go to the water. We'll take dirty water; we'll filter the water and like take the dirty water out and have a bucket that gets changed. I would think that you have a filter connected to a tube that goes to the drain, right? The Hills will go into the bay and help with clean water.

In one of the challenges that all of the girls enjoyed, polymer process, they were tasked with creating a polymer that was sticky, able to stretch, and leak proof. Using spoons, bowls, gloves, and their estimation skills, the girls poured various mixtures of borax, glue, and detergent in bowls to create the polymers. Many of them placed their sticky fingers on the tables, picked up the stretchy substance and stretched in two feet across the room. They also tested the sticky substance for reliability by throwing it on the plaster wall multiple times. At the end of this challenge, there were roughly eight bowls on each table. The campers raved about taking some of the slime they created home. We provided bags for them to do so after testing. For Carmen, this activity reminded her of using materials to fix damaged walls after a major storm:

> I related to polymer process because like having to fix a crack in the wall that could help maybe like after our tornado. I think that was an example for that one. Like if someone has a tornado and I like crack their wall, like they could put a substance down to at least hold it before they can like save up money and like pay for reconstruction on their wall for them . . . . If I know it can help myself, it can

definitely help other people who might need it much more than I do because if I can relate to it, I might be more determined to fix it.

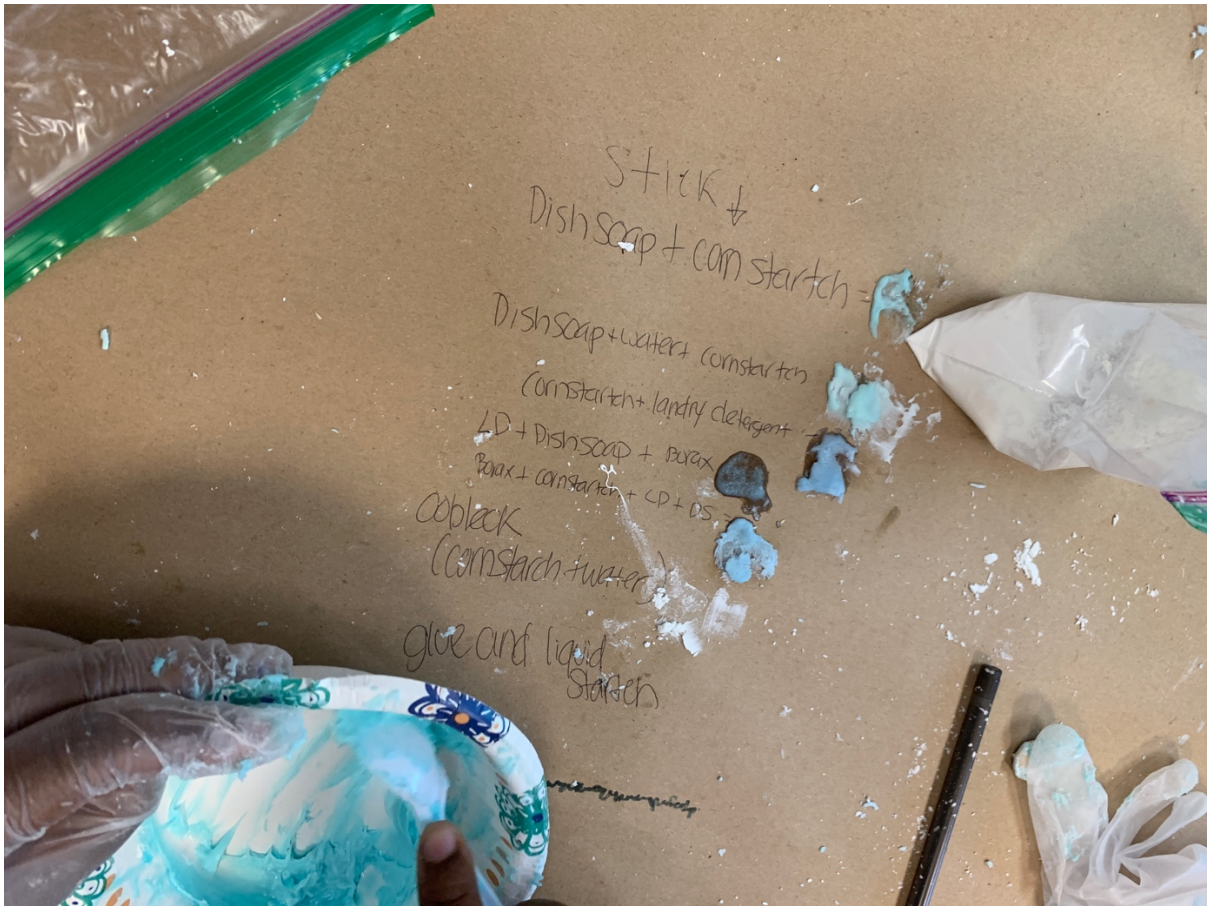

Figure 12. Polymer Process Challenge

The creation and curriculum development of the camp was based around everyday problems. When planning the challenges that the girls completed, our aim was to create challenges that would attract any child's interest. This was important, especially when trying to enhance a sense of engineering identity. When girls could see the purpose in the work they were doing, they became more interested in camp. Connections between movies, books, or issues in certain countries drew girls like Brooklyn into completing the challenges. She stated:

> I'm into this cause it relates to me. This is a problem I want to solve. I liked the water filter one because like I would watch movies where like they were sending like Africa

> and they'd have like trouble finding water. And like they would have to like go to a pipeline that burst to get water and it still wasn't clean. And especially because of like global warming and stuff, water is melting, just getting even more dirty. So, I feel like it could help people out.

After thinking about current events, Imani was drawn to challenges because she knew that arteries being clogged could lead to death. During our interview she shared how she had family members that had heart problems. She also mentioned that a lot of Black people have these problems like high blood pressure. These connections would increase her sense of engineering identity because she saw a way to impact the field directly through her role in the challenge. She discussed this in her daily diary:

> My experience at camp today was we did heart arteries project and we had a tube that had clay in it like a real heart artery that was clogged. We had to get that Playdough out and unclog it. When we did that, we had a short bit of time. Then they had to test for certain amount water, and it had to go all the way through, and they were timing us. It was how long it takes for the two liters to go through. And whoever had the least time in like, increased their amount of time won. I learned today is how the heart arteries are. They, it's the important thing in life. Cause people have had a lot of surgeries. Because people have clogged arteries, and I don't want people to have that and they can die, so I think I want to help with that, and build something that can help with the heart arteries.

At camp, during the pipeline construction challenge, a camper made mention of the pipeline that burst and killed someone in a city near the camp location. When this was shared, many campers' heads perked up because this issue happened not far from their homes. This

resulted in the teacher team leads and counselors talking about what types of materials are in pipes, what travels through them, and what type of engineers are a part of the reconstructing process when these systems fail. During her interview, Imani talked about how pipe damage could lead to explosions or water damage:

> The water construction, I think, "This really happens in real life, because people actually run out of water, and people have to use money to get our water fixed and get water there." So, I think that really impacted my community. And the pipeline construction, because you had to get the water through the pipes without it blowing up or leaking, and I think that really impacted, too because people have had leaks in their pipes. You had to get it cleaned up, and not get rusty.

Caroline worked with two girls on the water consumption challenge. They made a plan of how to utilize their budget and they laid out how much water and pipe they would need to fill five water facilities using a calculator. Caroline worked easily with this group and they relied on her strong math skills to solve the problems. On day three of her daily diary, Caroline shared how she enjoyed the water consumption challenge where she was tasked with getting water to the entire county:

> Today I liked the whole entire pipeline thing where we had to figure out how to move the pipeline and we're the, we had to do the money for the towns. That was good cause then that I had to strategize more on how we should plan out and what we should do first. The money because we had to plan out what we should do first, how we should carry it out. And it was more of let's see what we can distribute here and there is more of who gets this and who doesn't get this. And it was a harder decision. Yes. But it was a good experience to like learn because that is something that happens

> as my counselor, Ted said, it is scarcity where some people don't get something. Sometimes in my house we do run out of water, but it's not necessarily a big problem. It's just I have experienced sometimes when we do get flood warnings, or we have to be scarce on water.

These personal connections reignited the girls' interest in the camp because of their ability to see that their experiences could provide knowledge about the problem that needed to be solved. It was only when mathematics was involved that some girls were discouraged.

A Love Hate Relationship with Mathematics

The interdisciplinary nature of engineering required students to use creativity along with their knowledge of mathematics and science at camp. Science was guided by experimentation and applying content knowledge such as what kind of materials best filter water. Mathematics knowledge was needed when measuring or estimating to solve real-world problems. Thus, the girls' use of mathematics and science in the engineering setting influenced their STEM self-efficacy. This was problematic considering that mathematics instruction and preparation for Black girls is exclusionary which is aligned with *Whiteness as Property* in our educational systems. Joseph (2017) and Joseph, Hailu, & Matthews (2019) pointed out that Black girls' low participation and achievement in mathematics makes it far from a universal language. Limited resources, teachers' beliefs, and low tracking of Black girls in mathematics systems exclude Black girls from mathematical pathways, and the stark reality is that this leads to disengagement and low STEM self-efficacy for Black girls. Considering that many researchers have connected mathematical knowledge to engineering identity (Johnson, 2011; Thompson, & Lyons, 2008), it is important to consider how this relationship played into the girls' experiences at camp.

Most girls at the Explore Engineering camp raved about their interest in science and suggested that math was hard or less fun for them. During the water consumption challenge, campers had to design a solution using a $15,000 budget to disperse water treatment facilities, kilometers of piping, and gallons of water to Thirsty County. This required campers to use their mathematical skills, especially estimation, which was more the focus of the challenge compared to other challenges requiring much more creativity and design. Most of the girls in the study complained about this engineering challenge. Quinne, who had lower self-efficacy regarding mathematics, said this about the water consumption challenge and why it was frustrating at camp:

> [It was frustrating] because I didn't understand it...I mean it made sense. It made sense, but the way we, so we had eight washers and we already had like 16 Million, so we went over like $26 million instead of 15 and was like, I had to do the math and my group like worked on that like actual box thing. Yes. And I was like, I got it right. But it's just, I didn't want to do that…[I don't like math] because sometimes it's boring. I like it sometimes. It's just when I can't figure stuff out I get frustrated. I never gave up on the engineering stuff, but I did say I didn't want to do the math and they still gave me the math part. You have to divide by a hundred weight divided by itself, divided by a hundred. Yeah. And I didn't want to do that. So, my other teammates did it".

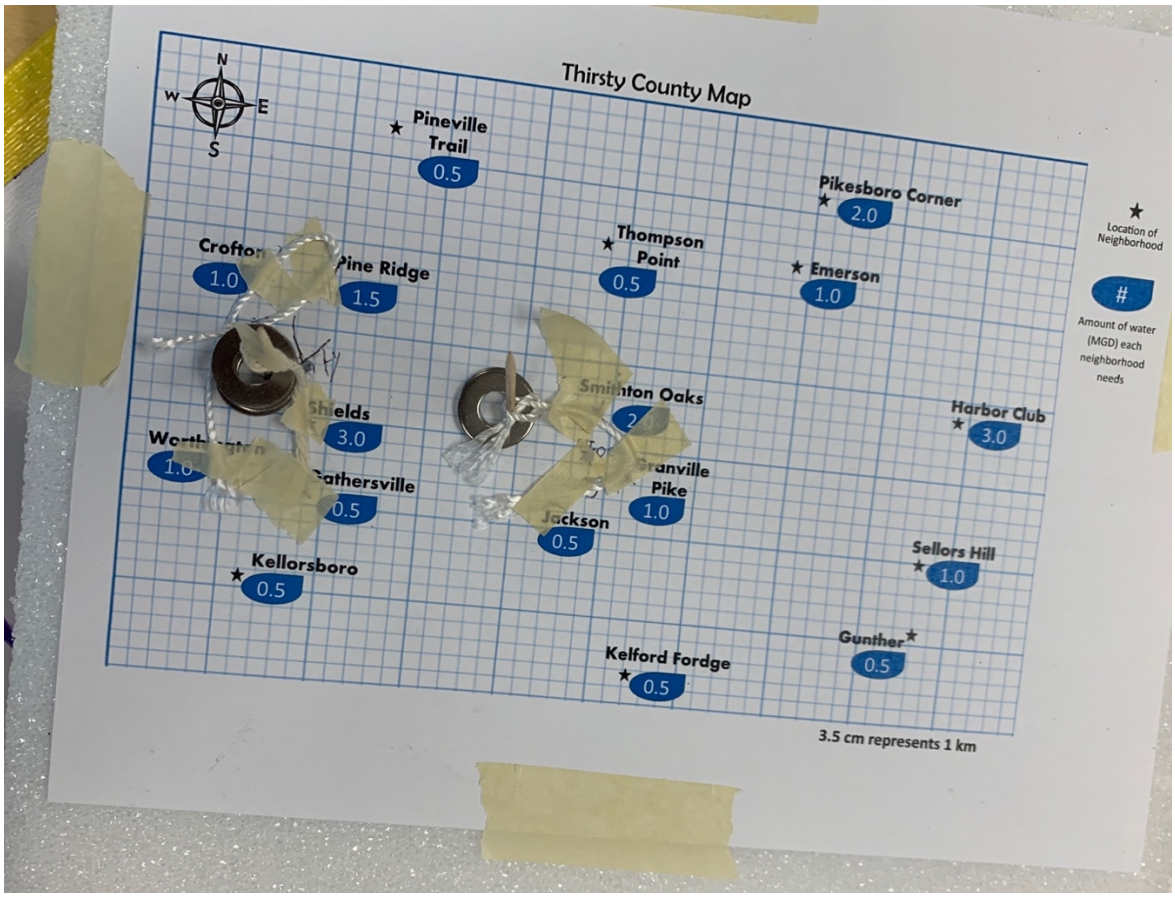

Figure 13. Water Consumption Challenge

Brooklyn, Quinne's teammate on the water consumption challenge, said about her performance on the challenge, "I probably felt most failure in water consumption because obviously we went bankrupt. I'm not the biggest fan of math." This challenge was completed during week 1, and at the end-of-the-day meeting that I had with the staff members afterwards, we spent a lot of time looking over the challenge to make it more feasible for the campers. With an original budget of $150,000 during week one of camp, during week two we reduced it to $15,000. We also provided calculators for the campers and reduced the costs for the washers and the pipes. I gave additional support to the high school assistant camp counselor as needed to make sure groups could work one-on-one with a staff member to reduce their frustration during this challenge. With mathematics being an important skill for

many engineers, the math skills required for this task could limit the extent to which the girls developed an engineering identity. Cora mentioned how the water consumption challenge and mathematics in general required a lot of focus. During this challenge Cora felt the most unsuccessful. Cora stated,

> I think it was the one with the money and having to put the [water treatment facilities on the county]. Yeah, that one, there was a lot of calculations. I mean I'm comfortable with math. Math definitely isn't my favorite thing to do. Like . . . It's a lot of brain power, and I'd rather be doing something else, just on my phone or just drawing or something. It's a lot of focus that's required and I get very distracted easily, so . . . I didn't like the time we were given like on the water consumption. There was a lot of math to do and the calculators were a little bit difficult to work with. And with that fact it was difficult to do all that math in that little bit of time. My group ended up having only like three minutes to fix what we needed to be fixed and like work around our problems there.

Caroline not only struggled in this challenge, but her real life application of what failing meant—not being able to help Thirsty County get enough water because she couldn’t figure out the calculations contributed to her attitude towards mathematics. When asked why she did not enjoy the same challenge, she said, “We couldn't get the people the water they needed and when we did, we would overflood it. That was iffy and then, we messed up the map, so that was kind of rough.”

Overall, the girls came to consensus that mathematics was not of interest to them collectively. These comments were very familiar to me. Many engineering majors at the collegiate level, especially women, would drop out of programs because the math was not

engaging to their experience or they lacked confidence in their math abilities (Cass, Hazari, Cribbs, Sadler & Sonnert, 2011). This literature also shares that even when attaining a grade of a "C" in a course, which men may accept, could make many women feel like failures and want to change majors. So, the thought that the girls in the study were experiencing this early was concerning when they wanted to be engineers. Jenesis was very blunt in talking about which STEM topic was the least appealing to her:

> I mean, working with numbers is a little bit easy, but then it gets harder and harder. It's just like, wow. I just hate math. I'm not the best at math. Even though my grades are pretty high, I just don't like it. Throughout the activities they kind of taught you, but it was fun. Actually, my grades are improving in math.

Layla mentioned how the math in the water consumption challenge made it less appealing to her, but even when she encountered some of the hardest challenges at camp, her positive self-efficacy kept her striving to learn from her interactions. She said,

> The water consumption has got like lots of math and I was thinking, and I still need more practice on my math for middle school because it was only math for sixth grade. I haven't even got to sixth grade yet. And with the big math I kinda need more practice on. I tell myself, "Layla you can do it. Just put your mind to it and you can do it."

The low sense of math self-efficacy that some of the girls had weighed on their engineering identity development. Imani said there were times when she felt like she was not capable of being an engineer, times when she had to do intense math:

> I think the water consumption, it was really hard, and you really had to choose the right choices, and you had a budget limit, and it was really hard because you didn't

> know which ones to pick, and all the money you had to spend to try and get the least, the least of money, and track the most cities. So that was really like mathematics, but still it was a little challenging. It was challenging for me. It felt like, it was a lot.

Although some girls found math challenging, others found that they loved the logical nature of the subject when applying it to engineering. Elise described herself as a big math nerd. Elise was interested in being a math teacher because she desired to help other student with a challenging subject matter. She said:

> It's not like they succeeded, but I thought they were [more fun]. It was a lot of math and I felt like I can see this in the real world. [This camp made me feel different] about math. I feel different personally because I'm younger, and there's some things for sixth grade, some things for eighth grade. So, you need to learn some about this, or you need to learn some—you have to go back and forth. So, I feel it made me feel a little bit better that I learned something from eighth grade math and also helped me feel better and more confident.

Summer's math self-efficacy was increased by the connection to other campers who could assist her. She stated:

> I don't know how many there were that had mathematics in it, but, um, the ones that did have mathematics in it, if you couldn't figure out a problem or something, your partners would help you until you, how you would figure it out or something.

Cora on the other hand entered camp confident in her math ability because of support she received in school. The thought of struggling in math was very similar to learning from failure for her. She said:

> Yeah, I'm pretty confident with [math courses]. I get good grades in them at school, and science has been one of my better subjects. It's challenged me at some points, but I always feel confident in it, and my math, I also feel confident in. Of course, it's difficult. I'm doing an accelerated course if any, but it's meant to challenge me, and I'm glad that it is because I never really experienced that through elementary school, but now that is a challenge. My math teacher last year, was telling us that mistakes are important for learning, and I took that and ran with it, and now I feel comfortable in all my subjects because of it. When I go there, I sometimes feel the people ... I feel like I can take on a leadership role. It's something that I don't normally feel when I'm away from people, but then I meet the people, and I hang out with them for a while, and I feel a leadership role around them, and that gives me a sense of hope, I guess? I can do that when I grow up as well, have even more confidence to have that feeling all the time and be able to do that.

Ezinne found math to be her favorite subject area. In her groups she was often intrigued by the math portion of the challenges. She said:

> I like to do math for fun. Because it's just easy and it's really fun and I watch videos and do study skills about it during the school year and sometimes I can help my friends do it because not everyone likes math. Everything has to do with math. My sister doesn’t believe that because she hates math. It’s just been easy for me.

Caroline found the challenge to be relevant to her life and her love of math allowed her to engage in the challenge. She said:

> I liked the where we had to do the money for the towns. That was good cause then that I had to strategize more on how we should plan out and what we should do first.

> Like especially with the money one, the money, more than the pipeline because the towns one we had to plan out what we should do first, how we should carry it out. And it was more of let's see what we can distribute here and there is more of who gets this and who doesn't get this. And it was a harder decision. Yes. But it was a good experience to like learn because that is something that happens as my counselor, Todd said, it is scarcity where some people don't get something.

Accessing a White Space

As stated in chapter two, access to informal camp settings involves being able to pay to participate, having transportation, and knowing that the opportunity even exists. Out of the 11 participants, six of the girls were first-timers at the camp and four of the girls received financial assistance. The girls had to navigate being the only one on their team when a lot of the campers were returners or had a friend that attended camp with them. Access also begins with knowledge. When speaking to the camp leaders about how recruitment and retention of Black girls is handled, I learned that the program relies mostly on word of mouth. With schools neglecting to include engineering in their curriculum and many communities uninformed about the possibilities of the field, many Black girls are simply unaware the camp exists, which poses an initial barrier to access. The attendees typically had parents that worked at the university, attended a school connected with the camps' STEM nights, or had a parent who was in a STEM field and was an advocate for increasing the amount of Black girls in the area. Similar to collegiate access, factors like affordability, transportation, and awareness contributed to the pervasive privileging of Whiteness and masculinity in the space. Thus, we discussed how role models and support systems within the camp aided them in adjusting to the setting and what was needed to remove barriers (if any) and increase the

amount of Black girls in the program. Below are the results of my analysis of barriers to access.

Affordable Opportunities

Participation in the camp cost of $425 for the week, and campers may be unable to attend based on affordability. Applicants could request financial assistance during the registration process by completing an optional form that indicated the parent/guardian salary, occupation, number of adults and children in the household, and projected family contribution. At times, families would reach out and request more aid because what they were granted was not enough for them to cover the remaining costs. If extra funds were available, they could be awarded at the camp coordinator's discretion. When some families noticed the cost of the one-week camp, it was only our mention of financial assistance that encouraged them to apply. Furthermore, the participants shared how *Whiteness as property* provided Whites with more privileges then Blacks. Within politics, in schools, and in the community, girls recognized that they were typically the last to be recognized as capable or worthy of being afforded an opportunity. As I was privy to other information regarding the camp because of my role as Assistant Camp Coordinator, I knew that there were two girls that could not attend due to transportation issues and that many other Black families had called to inquire about offsetting the cost or changing the timing of the program because it started during work hours and ended before the workday was over. Along with race being a focus, class also played a major role in who attended the camp. Many of the families of the Black girls had salaries well over $100,000. So, although the program directors mentioned a mission of getting more women and minorities into engineering, without the available income, or increased financial assistance streams, this dream was far from a reality.

Some of the Black girls that participated mentioned receiving financial aid as a way to offset cost and still be afforded the opportunity. Elise mentioned financial aid as a way to get other Black girls to come to camp. She described the price of camp as:

> Something crazy . . . They have scholarships, first of all, that's how I got in, they have scholarships. And if you are given the opportunity to go take it, you might not like it, and you don't have to come back, but at least give it a chance. Because it might be like, am I opening a brand new door that you never knew you could walk through without going through this camp?

At the end of the first day of camp, Ezinne spoke about her how thankful she was to have the opportunity to come to camp in her daily diary. This was the second time that Ezinne received financial assistance to come to camp:

> I like learning about new things and I'm very grateful that I get attend to attend the engineering camp because some people can't afford to come to the camp and I'm very grateful. But if it were me, I would really like for those who want to be future engineers, I would really want them to come and at least have a free program.

Interestingly enough, some girls were aware of the privilege they had in being able to come to camp. Imani was one of the few Black girls that had been at camp more than two years. Imani, who had two parents that were engineers recognized that it was unusual to have a lot of Black campers because of affordability. When asked what it feels like to be a Black girl in the camp space and how she knew Black people could or could not afford the camp, she said:

> I think it feels good, because usually Black girls usually don't do this. They can't afford it, so it really feels good that I can do this, and my parents can afford it. It's really fun and I really learn a lot from it. [I know we cannot afford it because] I went

> to my school, I learned all these different camps, and they are a lot [of money]. We had backpack buddies, so backpack buddies help people when they can't eat food and a lot of Black girls got [backpacks]. So, I learned that, wow, I really am fortunate that I can do it.

Understanding that Black women were not always allowed to attend college or get the jobs that men had stuck with the girls. When asked about being at camp and pursing engineering, many of them mentioned women and Black people sneaking to read or not being recognized for their efforts. Caroline stated that there are so few Black women in engineering because:

> We do get those opportunities, it's just depending on where you're from, you might not have [that camp opportunity]. When you're a Black woman and do it, it's just harder to get there. What makes it hard? Well, like I said, we do sometimes face racism still, but like it's not as much, like I said, but it does still happen. Then, also, sometimes even with a lot of people, ideas do get ignored. Depending on where they're at in their life, they might not have enough money to continue on with that career. Simple things like money, water, food, all that could factor in, too.

More specifically, Caroline was referring to the door being open for anyone to come, but structural inequity may prevent more Black girls from attending camp. Imani made mention of structural inequity at the collegiate level and the knowledge that Black women may or may not have about the opportunities in the field of engineering. She said, "Some people don't know about it, or some people can't afford [college]."

Being the Only One

Within the study, five of the eleven Black girls were the only ones on their team. The other six girls each had one Black girl with them on their team. Thus, many of them may

have been subjected to feelings of isolation and alienation. Quinne, who came from a community where she was surrounded by successful African Americans, was very aware of her racial identity. During camp, being in the presence of other Black girls and Black staff members made her feel comfortable in the setting. Quinne shared:

> I liked working with Brooklyn cause she was the only Black person. I probably would been like not sad, but I don't know if I was the only Black person. But Taylor was the other Black person. So, it kind of made me feel happy that it wasn't the only Black person. If it was just me and two other Black boys, no, I wouldn't have felt as [comfortable]. Brooklyn and me got along together. My counselors were Black. So, Black girls can do engineering or Black people can do engineering. It made me feel the same. It made me feel fine. Either way there was still some other Black [counselors] there . . . even if they weren't on my team, seeing other black counselors made me feel good.

The feeling of otherness and isolation pushed Quinne to want to work harder to pursue the field of engineering and STEM in general:

> It wasn't really many Black folks that were girls and so it was like you had to not let the other people like make you feel like really bad. It's like they might've thought that we shouldn't be doing STEM and that it wasn't meant for us. I kind of feel like more girls should be in STEM. Black girl should be in STEM.

Some of the girls were not influenced by being the only one. For them, being one of the few girls in the program was more salient to their gendered identity and a motivating factor compared to their racial identity. Seeing less girls in the camp setting, or hearing from undergraduates that there were not that many female engineering majors, pushed the girls to

compete even harder against the boys. Racial discrimination was hard to identify in camp, but sexism was more overt. Boys in the camp had no problem ignoring or telling girls that they were incapable of achieving. Thus, despite many of the Black girls being unsure that they wanted to be engineers, they were not afraid to show that they could indeed be engineers just like or even better than boys. When I asked Carmen how she would have felt if Jenesis was not on her team, she said, “I don't think I'd feel any different. No one there was judging. So, everyone was like equal. I don't think it would have made any difference.” For Imani, another Black girl on the same team, being the only one was not a concern. This was Imani’s fourth year at camp, so she mentioned that she felt fine in the setting. When I asked Imani about working with Ezinne on her team her response was:

> I worked with her, but I . . . I didn't really work with her that much. We were all in different [groups of three]. Working with her was fun, because the redesign, she helped us really good. I think I felt the same way as when I worked with other girls with her. If I was the only Black girl I would have felt like . . . I didn't really care; I would just do the project.

Brooklyn’s gendered racial identity was not something she was concerned about during camp. When we spoke about being lonely in her group because she was one of two Black girls, she shared:

> I feel like there were enough to the point where it's like you can relate to them and it's fine. I mean like once again, I don't really mind being in a certain space with like different people. It doesn't really bother me.

Ezinne thought that Josh was targeting her because she was Black. She shared how he allowed others in the group to participate, but kept her from giving input on their engineering design:

> Because he thought he knew everything. Probably because I was the only Black girl in that group. In that group. I was thinking, why is he going to let other people do stuff and then let me just sit there and do nothing. My other teammates didn't say anything. Anthony was like, yeah, stop breaking it. And so, he fed into what James was saying but his was a joke. Here's a joke. What about Josh was like, yeah, you need to stop breaking in because the first time you broke it and now it won't go far. And I was like, okay, but you didn't break it.

Role Models and Black Visibility

Within the camp staff, four of the six teacher team leads were Black women. None of the undergraduate counselors were minoritized women. Collins (2018) mentions reflective identity, the ability to recognize people that look like you in the STEM field, as a way to enhance STEM identity development for Black students. Thus, although these teachers were not engineers, the girls saw them as competent in the area. This provided the girls with role models in the camp setting that had the same double bind identity as them. Caroline was the only one on the yellow team, but in the same breakout room the purple team teacher team lead was a Black woman. Caroline saw this teacher as a role model that positively influenced her racial identity, engineering identity, and STEM self-efficacy at camp. Caroline said:

> I liked how she communicated with her teammates even when they weren't on the competition, on like the challenge, and really did get the challenge. How should I phrase this? She did start brainstorming with people who might not even be on her

> team a little bit. It was more encouraging. I feel like it's encouraging because it's kind of not encouraging for me personally to be the only [one]. If I was the only Black person, I would be fine with it, yeah, but I liked to have other people who like me to help me a little bit and show me because I learn from watching others sometimes.

In addition, Jenesis felt like camp staff members like myself were role models to her, even with my behind-the-scenes role. She walked beside me to lunch most days and we talked about why I was interested in Black girl research, why I loved engineering, and she talked to me about why she was working so hard to be an engineer. For her it was about succeeding for her family and helping her mom because she had done so much for her. Jenesis's mom also worked at camp and was using STEM education in her class daily. She explained why I was encouraging to her: "I saw you. You're like a role model to me because you kind of got everybody together. You were like the head besides [the camp coordinator]."

For girls like Imani, her parents served as her role models because they were actual engineers. This encouraged her to believe that she was fully capable of achieving what may have seemed like a dream to others:

> Not a lot of black girls that do engineering. And I wanted to be, I want more people to come in engineering. I like having fun, and it's really inspiring to me because you learn all these new things that you didn't even know in school, they didn't really teach you, so it's really inspiring. I have seen stuff. I was saying like, "Who did that?" And my mom says, "Engineers." And I was like, "Wow." Because I didn't know engineers did that. So that's really inspiring me, what they do.

Ironically, as many of the girls were mentioning that there was a large representation of Black women at camp in the field, these women were the teacher team leads. Brooklyn also

mentioned that she knew she could pursue her dream of being a web designer through coding because of Black women in the setting. Brooklyn said, “The counselors a lot because like there are lots of African American women being counselors. So, I mean it kind of like, I can do that, you know.” Carmen also mentioned her counselor: “I think Ms. Naomi was a role model, like her helping as a Black woman and being our, like our group leader and like her being a black woman and like helping us figure activities out. That stuck out to me personally.”

Support Structures for Comfortability

The camp environment had many structures in place to assist the girls during the camp. Between rules and procedures, to a 1:4 ratio of staff to campers, the program was set up to ensure that campers had support and all of their needs could be addressed at any given time. Most of the spring semester before camp began was spent interviewing staff members. The camp coordinator believed staffing was one of the main reasons the setting was so successful in providing great opportunities to kids. Additionally, many aspects of the environment were the best of the best since the camp was the only one on campus that was American Camp Association accredited. Support from a counselor ensured that Ezinne was able to succeed and her ideas were valued at camp. She shared:

> No matter, no matter what the people thought I was going to keep going. Probably when people don’t encourage them or they put them down instead of like saying, you can do this, you're capable of this. They're like, Oh, okay. So, you broke it and you messed it up. Now I'll have to start all over again. Encouragement from Josh and the counselors helped me. I didn't feel discouraged. Sharon, my team lead, was encouraging me, “Oh, that's a really good, like I hope you guys, his idea works”. And

> I felt encouraged because I thought one of our challenges wasn't gonna work because the first time we tried it, it failed. But we tried it again and altered it and it worked. And it, um, won that challenge which one? It was the polymer. There was also a time with the balsa wood gliders.

Brooklyn mentioned that Black girls should always feel welcomed in the camp:

> [Black girls] should at least try it. I mean you might not like it but then again you could be missing out on one of the greatest opportunities in your life. They don't feel like they fit in when they really should feel like they fit in. Cause like I feel like kids don't understand and they won't treat other kids different. It's like they don't like, they won't be mean about it. [A support system is] the counselors. Counselors would be like, come on, do it. And like the kids would be like, yeah, you can do this cause . . . if you were like not participating as much as you could have, they'd be like, Hey, do you want to do this? Maybe add more challenges that they would like, try to find out their interests when they send in the survey.

Teacher team leads at the camp played rock, paper, scissors with the campers and they would do things like toilet paper the opposing rooms in friendly competition. For many of the girls, this was not their experience at school. The teachers were hired with the understanding that they would manage their groups effectively, learn about engineering, and have fun because that is what camp is about. When you walked into the breakout rooms, you would hear the year's latest music playing as the campers worked. One of the popular songs was Lil Nas X's "Old Town Road." Teachers would dance with campers as they pretended to be cowboys as they worked on their designs. Another facet of the camp was that staff members went by their first names. There was still a sense of respect, but this removed the school vibe from the

setting. Additionally, campers made engaging camp chants. One green team composed a jingle telling other teams to “Be Careful” when competing against them because they were the best. The song was to the tune of rapper Cardi B’s popular song by the same name. Jenesis compared the teacher team leads to the teachers at her school. At camp, she found the teachers to be more enjoyable: “The teachers are not as annoying as the ones at our school. They were nicer, and the undergrads you could relate to them more . . . the counselors, they were nice and funny.”

Bridges for Increasing Black Girls in Engineering

Lastly, the girls were interested in having more Black girls come to camp. Therefore, they shared with me some suggestions on how to increase that population in the camp or why there may not be many Black girls attending camp as well as various things that helped them feel connected to and like they belonged in the space. These bridges had positive effects on their experiences. However, it is important to mention that all of the girls stated there were no specific barriers that prevented them from coming to camp. For Elise, making new friends made her feel welcomed. For many campers in general, survey results showed this was one of the most exciting parts of camp. Elise mentioned that sharing the information in your community would be helpful in increasing access to more Black girls, but nothing would have stopped her from coming. She stated:

> Get advertisements on Instagram or Twitter to let more girls now. It was just one moment at my grandma's shop, she didn't know about the camp, so I told her about it and she's like, “Oh yeah!” Because the camp was going on the same week that she was in summer camp that she had already paid for. And I was like, “Hey, you should check it out.” Word of mouth also really well too. I feel like it's more trustworthy

> than seeing an ad." Honestly, if something prevented me from coming, it would have been a fire. I don't care what other people say, if I'm coming to this camp, I'm coming; I don't care what you say. If I have to work by myself, I will, it's something that I will try my best, but it doesn't mean I'm going to succeed, or fail. It just means that it's opening new doors. It's showing me what I can do and what I can learn more.

Quinne mentioned being able to give daily feedback through the diaries made her feel like she was valued in the camp. This was not the first time I heard this. Jenesis also drew a voice recorder in her piece of art. This showed me that the girls were finally able to feel like their stories and viewpoints were valued by someone. Quinne's response and many of the other girls' suggestions on getting more Black girls to participate and advice they would give to new potential participants was connected to her adolescent identity of wanting to feel welcomed and valued as an African American. Quinne said:

> It's a friendly environment and then No Bullying zone. Go because if you want to be an engineer and even if you don't want to be an engineer, it's a good opportunity. An opportunity or I don't know how to, a good career option that you can have. There probably won't be a lot of Black people and well they probably will if they make friends, they'd probably be mostly White people or different cultural people. They might not be so nice to them because they probably think why a Black girl should be doing engineering in the first place.

On most of the programmatic surveys for the camp, campers indicated that the best part of coming to camp was meeting new people and making friends. During camp staffing and hiring, the camp coordinator worked hard to create a diverse and inclusive environment where all of the campers could feel like they belonged and could identify with being an

engineer. In doing so, half of the middle school camp staff that worked directly with campers were Black. This was not typical, but it suggested that by hiring a staff that looked like the girls, they could then envision themselves as engineers in the STEM context. Although they were not engineers, the girls mentioned that the teacher team leads encouraged them and this made them feel like if these teachers could guide engineering education, they could surely become engineers as well. With that, I often checked to make sure no camper was eating alone at lunchtime. If this occurred, I would have them join other campers, me, or another staff member. Just as social communities are important during the school year, this is just as important at camp. Feeling connected and in a supportive environment is a significant emotional need for adolescents. During outdoor time, staff members would split up and have indoor board games, outdoor activities like freeze tag, jump rope, or invite campers to gather on the brick wall and talk. Belonging was important to many of the campers. In Layla's opinion this is why many Black girls may not feel comfortable coming to camp:

> She might decide not to come to, maybe she doesn't think she might fit in because she's black, because she's a different race. [I can feel like I fit in] because I know, just because I'm a different race, it doesn't mean I'm different to other people. They treat me like I just go along with the group. Just work together. Just because you're a different color skin, you could still be a part as long as you put your mind to it. You can show them there's different people of all races, but if they all work together, they can just treat each other like how they want to be treated. Always communicate with your team and if somebody is not cooperating, just keep . . . but if somebody is being loud or noisy just focus on your work. Don't worry about them as long as you get your stuff done.

Carmen usually played the group outdoor activity at camp, or she hung out with Jenesis and talked. For her, being accepted by others was important to Black girls and may be why they do not attend:

> Maybe just past bullying, confidence issues about work, or self-conscious about what their skin color. Their skin color doesn't have anything to do with engineering, but other people like they might have an issue with that. People might not come because they don't have it and maybe they don't have a good education. Okay. And so, they might not think they're smart enough or able to do things like that, they might not be determined to try, and they might give up before they have the chance to do that.

Cora on the other hand mentioned how a Black girls public regard would discourage her from coming to camp: “People who have a prejudice against how African-Americans behave like they think that they're going to do something wrong when really that's just like on them and their views.” For the girls, when I walked with them to the pick-up area of camp each day, they described how the counselors and teacher team leads would sometimes catch another camper treating them unfairly and address it. During the middle of the week, Jenesis shared with Carmen, “He was just making me so mad and there was nothing I could do about it.” I was unsure who she was talking about, but she referenced a boy on her team during a challenge that day. Jenesis thought that more girls would be encouraged if they knew there was support and if they knew the benefits of coming to camp:

> I would tell them about how it would help you. It could also get you a scholarship the more you go to [Grandover University]. If you grow up and you decide to be an engineer, and if you decide to work there as a college person, you can get money.

Coming to camp consistently over a number of years seemed to help campers adjust to being the only one. Campers like Layla and Imani felt comfortable coming each year even though their input was not always valued. Imani mentioned how she believed other campers treated Black girls. She said:

> If you're the only African American girl, people looking at you may make you not want to come. Money also may make them not come. We need to make them feel at home, comfortable, and they need to have fun. Don't really care about what color you are. Just have fun at camp, and enjoy yourself. You are who you are and can't change that, so if you like doing it, then you go do it, even if you're a girl. We treat girls nice, and all with the respect equally, and boys and girls.

Developing culturally relevant engineering challenges was a focus during the planning stages of the camp. Culturally relevant teaching allows students to experience academic success and develop cultural competence by utilizing the strengths and unique backgrounds of everyone in the group. The semester before camp, the staff looked at problems that may be of interest to the campers based on their various backgrounds to guide the curriculum. For Summer, culturally relevant experiences would engage more Black girls. She recommended, "Maybe do activities that relate to other Black like astronauts, doctors, and assigning scientists that make you more connected to them." Similarly, Caroline said find a challenge they are interested in and that there were not any real barriers that prevent Black girls from participating:

> Something that they're connected to would be good. They could solve that problem and show them how problem-solving thinking they could help that. And then if they wanted to explore more in that, that could be an open door. Maybe they wouldn't

> [participate] unless they're not into it, maybe if they're too shy and introverted, because that's what I kind of am. But it kind of helps open up a little bit. Being the only one definitely showed that the mix of people in that area, which I like, so it shows the different mindsets that they might have. It didn't negatively impact me necessarily unless like they would just ignore me completely. That happened once when I was working with two girls, Carol and Tinley. That is fine because like it ended up working out anyway, but other than, the rest of it was a positive impact because we got to see other people's ideas and all. I wouldn't say I felt uncomfortable. I felt like, usually when I'm the only person of anything, I'll usually feel more pressure generally. I want to represent the women of color good and I don't want to misrepresent it badly, so yeah, that was the only reason I felt a little bit more pressure. Usually one of the things where I feel that pressure, I usually just say if something doesn't work, then that means I'm doing it right or if I make a mistake, I just pretend that it was supposed to happen because I have like, for example, one time I was at school during a game and I made a really bad mistake. I was the only Black kid, so I was like, “That was supposed to happen,” but it wasn't just on me, so it was good. I didn't do it by myself.

Ezinne felt like it was the camps responsibility to go and find more Black girls to participate. In her opinion, there are plenty of Black girls that are interested in the topic:

> Well, I think there should be like a lot of them because they might want to do it. So, we should go find some and give them a day to test out some challenges. And if they like it then they can come next summer. So, one day where it's just like Brown girls,

Black girls in this space and we're just going to say, Hey, tell them and then visit camp and see what it's like. And then they would like get exposure to it early on.

As we ended her interview, Ezinne shared a narrative as her self-expressive art. With a focus on being the only one, support systems within the camp, being silenced and marginalized, and then using discouragement to empower herself, Ezinne exuded what it meant to access a White space and navigate through it as best as she could:

I attended the Explore Engineering camp on the week of July 15th to the 19th. It was very fun and experimental, but one thing I had noticed was that there weren't as many Black girls as the White girls. Usually people who are Black, especially females, don't get recognized as much as White men or White women. When I get older and I know I'm financially stable and I don't need my parents paying for my things, I will try and find as many girls as I can who really wanted to do the engineering and let them have the experience of what an engineering campus like. I would like to share my experiences in the engineering camp. During the balsa wood would challenge I was paired with James Anthony and Sasha and Avery. My teammate, James, was saying how he knew everything about aerospace and aerodynamics, but I told him that we would have been using aerodynamics because we would have to diminish the drag from the current air going past it, but he said that I was still incorrect. The next challenge was the polymer. My teammates were Neha and James. Neha was a very sharp and eager to use ingredients and make the slime, sometimes when I wanted to touch it to see how the consistency was she would pull it away and say, "It's not ready." It was getting annoying, so I had to experiment to

Figure 14. Ezinne's Narrative

Figure 14 (continued). Ezinne's Narrative

make my own polymer and only I knew the ingredients. When I finished making the polymer, we decided to use it for the stretch test. Later we found out someone tampered with our polymer, so we had to remake it, and like I said, only I knew the ingredients, but when I wanted to make it, Neha started pulling the bowl away from me. But thanks to James he said that it was my polymer so only I knew how to make it. The last time so one got me annoyed was when we did our balsa wood redesign. I worked with the same people. James, Sasha Anthony and Avery. My teammate James had already had an approach for how we could modify the plan. When we got out new planes, I wanted to put it together, but James said that I would probably break something if I put it together and that it would be better if he did it himself, but I didn't see that as fair because I hadn't done anything but sit and watch them the first time so I wasn't going to let that happen again. Luckily Melissa came over and told James that he should let me put the new plane together later. Later, I did a lot more than I did last time and I was really happy because I have to stand up for myself and not be pushed around. In conclusion, I had some ups and downs, but at the end, all that matters is that I had fun, made some new friends, and learned more about engineering.

Being given the opportunity to attend camp was very rewarding for many of the girls, but the environment did not come without challenges. Despite this, many of the girls used resilience, internal support systems, role models, and internal motivation to succeed when they faced opposition. Moreover, by being exposed to engineering, allows each girl to be aware of the field of engineering. Carmen drew herself as a Gotcha Life character and added a beaker to

represent engineering camp. For her, all her experiences added to who she was becoming. When I asked her what her drawing represented she expressed:

> I just drew a picture with a lot of my interests on it. If I didn't have gotcha life, I wouldn't have started watching YouTube. I feel like if I didn't have one of these things, I might not have another one . . . And that might influence not having another one. I feel like engineering camp influence made me put a beaker on the shirt and I did that as a little symbol to represent that I went to engineering camp. I put just put this mark on her face to represent like a difference that she has from other people. The beaker just represents that I went to engineering camp and that it is now an open option that it created, and it just opened a lot of opportunities that might get me into engineering in the future.

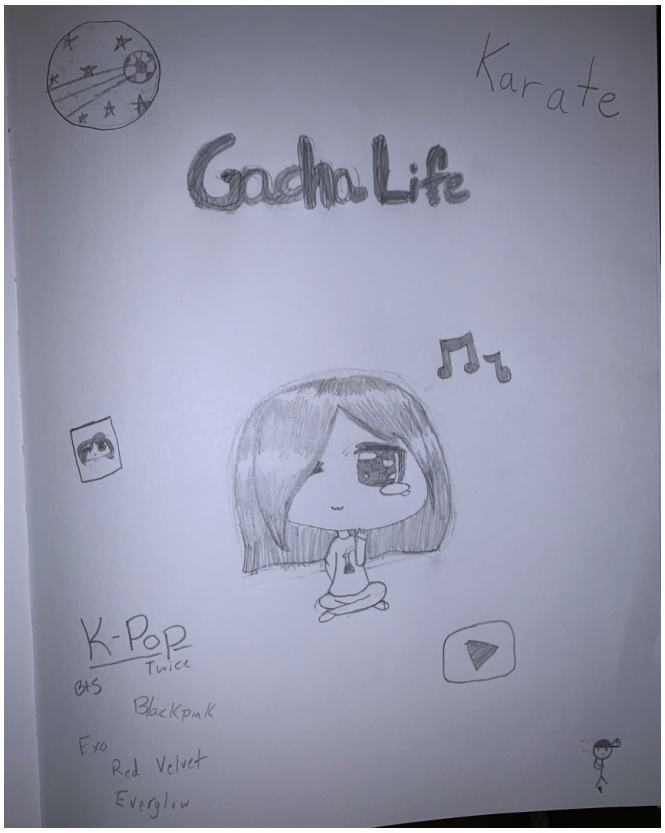

Figure 15. Carmen's Drawing

As the Black girls navigated their identities in the camp, there were various aspects that drove them to question #AmIWhatAnEngineerLooksLike. Using their knowledge of how to cope with disrespect and invalidation, their STEM self-efficacy, and engineering identity, they were able to come to camp and enjoy their overall experience. These sentiments contributed to their interest in taking their passion for engineering outside of camp and their personal lives by giving back to larger communities and the world just as other Black women had done in the field.

"I Could Be a Person in History": Racial Pride and Colorblindness in Engineering

As the girls navigated camp and discussed with me what their experience was like as a Black girl in an area where they were underrepresented, they indicated that racial pride allowed them to overcome inequity at camp and refuse to allow racism or sexism to stand in the way of their achievement. Although they were aware that Black women, like the *Hidden Figures* of NASA, had been victims of *racial permanence*, being *silenced and marginalized,* and *Whiteness as property* when it came to educational rights; the girls refused to allow these same powers that existed in their lives to deter their dreams. These feelings were expressed through the sub themes I developed. *Disregarded, but Encouraged: Black Girls and Women in STEM,* where the girls shared their understanding of the public regard, or judgments that others had about them as African Americans, and how they coped with it. *Changing the World by Becoming a Black Woman in STEM,* which focused on the private regard, or ways in which the girls felt negatively or positively about being a member of the Black STEM community. The girls' racial identity and gendered identity contributed to the pride that they had for Black women who had overcome barriers before them in STEM. Lastly, *Colorblind Realities,* highlights colorblind ideologies, or the idea that racial classification will not limit

one's opportunities. Moreover, some of the girls shared that race was not a concern for them regarding success in STEM. These girls felt that people just needed to see them for who they were, strong girls that had interests in engineering and who would achieve at all costs. They desired to be change makers, leaders of transformation in the engineering field, and a person in history that Black girls could look up to in the future.

Disregarded, but Encouraged: Black Girls and Women in STEM

During interviews with the girls, their understanding of what it was like to be a Black girl in today's society was often connected to public regard, or whether they believed other people viewed the African American community positively or negatively. To be a Black girl in today's society as well as a Black woman meant that they would be disregarded and ignored. Many girls made mention of historic incidents where this had happened in our society. Stemming from the *Whiteness as property tenant* and knowing that *racial permanence* may require them to work harder or prove others wrong to achieve, the girls' heightened awareness and sensitivity to the current climate of how Black women and girls are viewed is reflective of the girls' knowledge and understanding that *Whiteness* is valued more than Blackness. Nonetheless, the girls were encouraged by this. They refused to allow this to deter them. Ezinne also mentioned that being an African American girl can be hard. She said:

> Well there's some people that might not like us just because of our skin color and they don't think that we can do things that they can. Like usually the White people because they might be racist, and they don't like us because we can't do things. I really feel encouraged by them, although they might not like us.

While she could not recall any specific examples other than being judged because she was the "smart Black girl," Caroline made mention of racial microaggressions, verbal or nonverbal exchanges that "communicate hostile, derogatory, or negative racial slights and insults toward people of color" (Sue et al., 2007). These assertions are exclusionary based on her racial identity. Caroline noted the covert, disguised nature of racism today. She made mention of the treatment of Black girls by saying:

> Being Black girl in society, so that means that I will face some racism, but I don't show it as much now, but I have seen it discreetly done to me even while I'm at school. That means I just have to prove them wrong and just try harder than the others to get what I want to achieve.

Reflecting on aspects of *racial permanence* and *intersectionality,* Elise mentioned how the social and political nature of our society makes gendered and racial equity a myth. For her, working harder would help, but it would not eliminate the difficulties that Black girls faced, especially when White systems and individuals continuously criminalize Black girls and women. Elise made mention of the numerous challenges that Black girls and Black people have based on inequity in our political, racist society. Elise shared:

> To me it means that we'll have a lot more challenges than other people. We were talking about this actually the other day in my house. My brother had said something and I'm a really big feminist, and it had just got me mad and he says it all the time. But in today's society it's like Black women are pressured not to say anything because of the color of their skin. People say oh, we're equal today. But we really aren't. People are still racially profiled just because of the color of their skin. I was watching

> this show the other day and this girl had got stopped because of the color of her skin. She did not do one thing wrong.

Each of the girls had constructed meaning behind why there was not a large representation of Black women in the engineering and STEM fields in general. The girls described gendered and racial stereotypes that people had regarding Black women. Quinne's mother who was an engineer served as a role model to her. Furthermore, Quinne was disheartened by forms of racial and sexual discrimination that led to *controlling images,* or gendered racial stereotypes that determined that Black girls should be housewives or fashion models. Quinne mentioned that the reason there were not a lot of Black women in STEM was:

> Because the other people that are not Black probably thought that we weren't educated or something. And that we couldn't do it because we were Black and that we were girls. And people think that men should be doing everything. This makes you be doing engineering. Oh, and girls should be like doing fashion and stuff like that.

For Cora, there was a constant battle and tug-of-war that Black women had to face at work, especially in STEM. Although these outdated views had been deemed inappropriate, based on historical background as domestic workers and child bearers, they were still viewed negatively in the workplace. Cora was aware of how the Black woman experience was often overlooked, ignored, and negated compared to others. She said:

> They don't want to be disregarded. No one likes to be felt forgotten or looked over, and no one wants to be . . . . It felt like they know that they are better than a different person, but they also know and can see that it's obvious because of the way that they look, that they're being segregated.

Jenesis's public regard of how others saw her as a Black female influenced her perception of the field. Everything related to STEM success and how other White students viewed her when she was underrepresented in engineering settings was related to her racial identity. Jenesis believed that people judged her skin color because of stereotypical perceptions that Black people are less fortunate and that all Black father figures are in jail. For her, White students felt like *Whiteness* was better based on the opportunities they received. Misperceptions about her ability to succeed only reminded her that she too could be successful as a Black woman in engineering. This is how she believed people in society and White girls at school viewed her double bind identity and interest in STEM:

> People these days, they care about race. All they do is care about race, and they determine who you are based on your race. People come up to a White person and be like, "Oh my gosh, she's probably rich." There's different people out there who are just like, "Well, you can't do this because you're Black," Then people would go to a Black person, and probably would be like, "Oh, she's probably poor." She probably has no money. Her dad's probably in jail. Dah, dah, dah, dah. Sometimes I think about how people would think about me like, "Oh, I don't like her, because she's Black, and she doesn't want to work, and dah, dah, dah, dah." It's just like, wow. But then on the other hand, it's just like, Wow, I'm really good at this. I'm a Black person. I could be a person in history.

Ezinne, whose mother was a nurse and whose father worked in the medical field, shared why she felt African Americans have been denied many opportunities in STEM fields, how we are viewed in society, and how Black women's experiences in STEM were different. First Ezinne mentioned financial resources because access to engineering is typically acquired

through wealth and money. Along with financial support, if Black girls are unaware of how engineering can influence their own communities, they may not be interested. Thus, she shares how the nature of engineering and informal education are problematic due to the lack of knowledge and access, who is granted cultural capital in STEM, and the inherent racism and criminalization of Black people in White spaces. With a greater risk of being targeted, harassed, profiled, of accused for offenses involved in the *intersectional* status of being Black and a woman made *White* men feel more comfortable talking advantage of them because in our society, "White was right." Ezinne indicated that White supremacy only made it easier to ignore the gendered racial experiences of Black women. I asked her to explain and tell me how she became aware of this. She mentioned that:

> Some are not financially stable, or they usually say, well what does that have to do with that? When you look at an African American, usually they don't have like the biggest homes, like White people because White people have all the good stuff. But that's one of the reasons why. And another reason why is they probably been to [a good STEM job], but like they've been discouraged by someone, and they just don't want to go back because they're afraid they might get pushed down and that they might not have anyone to tell that because they're scared. There's not a lot of Black girls or women in STEM and usually men try and push them down because they're usually seen as the superior ones. Usually the White men mostly because they have the good jobs and usually they don't have to work for things. My dad works in medicine and so usually they try and make you lose your license and they easily have access to all these things because you're seen as the bad person because you're Black or they just go, you're just different.

Despite these realities, Ezinne, along with the other girls were determined to push through the gendered and racial bias they encountered to influence the greater world through their work in engineering and other STEM fields.

Changing the World by Becoming a Black Woman in STEM

Since the girls were able to work in teams as engineers for the week, I asked what their experience would be if they were a Black woman in the actual engineering field. Throughout the girls' experiences in camp, and based on their knowledge on the current climate of Black women in the field, they too had resilient attitudes regarding their personal success in the future. The thought of working harder and proving others wrong was just a part of the Black female narrative and was worth it if they could help someone else along the way. Thus, their STEM self-efficacy and engineering identity were guided by their gendered and racial identities. This *intersectional* experience shows that while Black girls constantly have to fight to achieve, similar to the livelihood of Black women, helping them cope with the negative aspects of this battle is essential to retaining Black girls in engineering. Along with it being tough and challenging, the girls were driven by the ability to change the world and be successful Black women in STEM. Cora said:

> I feel like they could be better than the person of a different color who's next to them. They would be looked over because of the history of our country, and how they had been treated before, and the prejudice against their color.

Caroline felt like she would be more successful, but she would still be perceived the same:

> I feel like I don't think much would change other than if I had that, I would just be like every other person except when we walk in, someone [Black] can think they can have the opportunity. I just feel a little bit more accomplished. I can see how it can

> be different, because they do get ignored sometimes, like with the Hidden Figures, they got ignored. That sometimes still does happen in the world we live in.

Being Black and a girl influenced how Elise thought about STEM. Her perception of how Black women were stereotyped because of media images and other incidences played a major role in how she would be viewed as a successful Black woman in the field:

> I know for a fact that there are not that many Black women in STEM. If I do something small, it doesn't have to be that big. I feel like it's going to put an influence on somebody. I don't know who, it'll be somebody in the world. I feel like yeah, it puts pressure on me to want to do things like that.

Elise also shared how media images made it hard for her to navigate and form community amongst Black women because of how they were negatively portrayed as disruptive, loud, and constantly relying on men. In her opinion, instead of working together collectively as Collins shares regarding BFT, she felt as though competition amongst Black women only made if harder as we worked against ourselves and the dominant culture of the field. When I asked if the experiences of Black females in STEM was different from others, she said:

> We as black women, I feel like we're always competing with somebody else. Black women today, they fight over men for no reason. They’re always trying to compete for something. Yeah crazy but it’s really cool and it's surprising because people will be like oh, they live in their hood. And most people think that's where a bunch of Black people live. That's not true. Most Blacks don't like doing [engineering] because they don't [know] what that looks like or hasn't seen color in STEM. [Being a Black woman in STEM would be] amazing, but also tough because people would judge you on the color of your skin. Then it would be amazing when you do get recognized and

> people are proud of you because of what you did and it's not just Black people, but you're praised by Black and White and it shows to little girls that you can do anything.

Many of the girls mentioned that because there are more Black women in the field, working harder would allow them to be productive in engineering. This belief is a part of the *dominant ideology* that challenges meritocracy, or the illusion that working hard and your personal IQ will allow you to gain social mobility through wealth and power. Jenesis felt as though African American women had made strides towards overcoming some inequity in engineering, but still had a long way to go:

> Actually, everybody has a chance of doing something. Since African American females, back in the days we didn't get to do a lot more stuff than the African American males. But now, there's more African American females, and we can all work harder, and we can be really good engineers.

As one of the girls that had come to camp four years in a row, seeing an increasing amount of Black girls in the program made Imani feel as though she would not have to worry about being the only one in the field. Her view of the current reality of Black women in engineering and being disconnected from how her gendered and racial identity may lead to her being underrepresented in the field were concerning to me. Imani felt like as time went on, there were no reasons for more Black people not to be in engineering fields because of the privileges we had gained. In her words:

> I think it would be interesting and it would be different. You are in control of the projects and getting it done on time. I think I want to work with a team, but it's like you have to really work with them to get it all done. Unless you want to do it yourself

> and take over. It would be more Black women by then because I think more people are interested in Black engineering, and more Black people are coming, so I think there will be more, and I won't be the only one.

Imani also shared how *White privilege* had once made her want to be White since White people were afforded more opportunities than Black people:

> I think [being in STEM as a Black girl] looks the same thing as a White person because you're doing the same thing as a White person does, so it really doesn't change my experience or way I look at it. I think the color of my skin [influences how I feel about myself in engineering] because I think sometimes I wish I was White. Then I feel like this is me, and this is who I am. I think it was a different experience in how [White people] are, and they're just different in general. It feels like they get more than Black women do, so yeah. But [White] men and [White] women are equal.

Girls like Carmen also worked to validate their own opinion in the field futuristically, instead of being *silenced and marginalized.* Carmen too had the perception that if you work harder, you can be successful, and people will value you. She said:

> Black women in STEM, it'll be like working with other Black females that'll like help everyone, like stay together more. If I'm the only one, I'll just have to try and get my opinion across and try to get everyone to hear it before just throwing it away. Maybe [Black women] in engineering get discouraged because of what they look like and maybe they have troubles with other people, like discouraging them.

For Layla, her STEM self-efficacy that was driven by her love of science and developing engineering identity drove her interest. For her, similar to her interactions at camp, just thinking positively and being the person that tried to balance situations would make being a

Black woman engineer interesting. This too exhibited how Black girls and women making concessions for their thoughts, views, and worth because of their *intersectional* identity. Layla shared that being a Black woman in STEM seemed fun because she would get to explore new things:

> It would probably be pretty cool to try different things. Discover something new, like maybe find a different element for the periodic table. Like maybe find something out in space or in the bottom of the sea. It'll be pretty fun. It might be a little hard to try like figure out different equations. Like, what would this be and figure out. Yeah, it'll be mainly fun. So, I can discover new places like go into the sea, maybe go into space, but I have to try and just keep thinking good thoughts. Just think stuff through first.

As Collins (2018) model mentions reflective identity for Black students in STEM, being an example for others that were Black and women would be important for girls like Quinne. This was reminiscent of how she was influenced by her teacher team lead, Jada. For Quinne, if she changed career interests and pursued engineering it would be surprising, but it would have a great impact on others that looked like her:

> It probably would be good because if people want to look up to me, they will and their black girls, they will probably want to do engineering when their older. I would be a role model for everyone, for multiple people, little girls.

To conclude our conversations regarding their camp experience, I asked the girls if they believed people judged them based on their race and/or their gender. Layla thought that it was because they were Black, and after thinking for a moment she also spoke of inequity because of her gender since females were underrepresented:

> There might be less because they're Black, maybe because I've saw some people not allowed. Girls just because they were black. And I knew that was just not right. That's wrong. Sometimes maybe because I was a girl, because men do lots of work.

Ezinne spoke of how gender stereotypes place limits on Black women and girls in STEM:

> Black and female because women are supposed to stay at home and feed their children instead of working. And then it's more that you're a Black woman because we're usually frowned upon.

Lastly, Jenesis said she thought that people at camp saw her as normal person, except when she was working with boys:

> They saw me as just a normal person. There was so many girls in there. There was nothing to think about. The boys weren't listening to me probably because of my race and maybe because I'm a girl too. They did that to Carmen too.

Gendered and racial bias was a hapless reality for the girls, their various interests, and futuristic engineering goals. Between them understanding the stark reality of how Black women have come to succeed to their beliefs that there personal worth would be valued if they stood up for themselves, they all had admirable objectives to overcome inequitable systems that existed.

Colorblind Realities

Counter to some of their fellow campers, some of the girls felt like their race was not a major concern. Cora and Summer in particular identified as Black girls, but when I talked to each of them, they both stated that they did not belong to a particular group. This is reflective of *colorblind ideology,* or the idea that because of laws there are equal opportunities that do now preclude you because of race. Furthermore, colorism which is

prejudice based on skin tones or Black girls' hair textures may have contributed to these feelings since most girls that resonated with this ideology had a lighter skin tone and the texture of their hair was more similar with the White girls they associated with. Cora and Summer navigated camp by hanging with girls from various background throughout the week. They were less likely to just hang out with all Black girls or all White girls during the week. Their colorblind mentality made them feel like they were not limited in society because of their appearance nor did they identify with a certain race. Gender was more salient to their identity. Cora, who identified as Filipino, White, and African America, had a humanist view of her racial identity. She felt very similar everyone despite their racial identity and her African American identity:

> I don't feel different being African American. I'm okay with being that. I've never had a problem, but I've never fit into a certain category because of the three different like races that make up me. I never have run with a certain group or color or anything. So I just feel like myself, like just me. I'm in my own category, you know? And I'm fine with that. I've never felt because I'm African-American, I've never felt set aside or looked upon differently. Every place that I go, people around me have like accepted me and they don't see me in any different light.

Additionally, Cora's self-expressive art described how she viewed herself as a Black girl in the context of the camp. Before sharing her poem, Cora said, "Again, I know that I'm African American and I'm coming in different when I'm put in the engineering field. I just feel like me. I've never really . . . I identify with the groups, but I don't identify with the groups. I don't place myself in categories."

I'm Me

I know what I am,

Where I come from,

I'm different when put in the engineering field.

I never feel

Alienated

Alone

Uncomfortable.

In fact

I feel

Normal

No different than everyone else.

I feel like I have a fair chance.

I feel comfortable

I feel welcomed

Just like everyone else

But still

I know I'm different

Of course I am

I'm me.

Figure 16. Cora's Poem- I'm Me

Cora's younger sister Brooklyn could not describe what it was like to be a Black girl. Being Black and female did not influence her determination or discourage her interest in

STEM either. Her innocence and unawareness of how her double bind identity could influence her opportunities was shown by her response:

> I don't know, to be honest. I mean, I guess it's good because people like sort of look up to you. If you think about it, they're doing like a good job continuing to do what they're doing. So, I mean, yeah, it's, I don't know . . . . You shouldn't be treated different [because of your race] so I feel like it isn't.

Summer, who identified as African American and White, felt similarly to Brooklyn. For her, being Black did not influence her actions, the world and outcomes around her, or her ideas regarding Black women in STEM. Gender was more salient for her in camp. In her words:

> It’s not race and gender. I think it would be female for the most. A lot because a lot of people don't see me as biracial. They see me as White because they don't know who my parents are. That’s it, basically it.

Additionally, when I reached out to Summer to get her self-expressive art, I was unable to get in touch with her at first. After a few months, her mom reached out and shared a picture that Summer drew (see Figure 12). Summer was unable to provide me with an interpretation, therefore I will use visual analysis to provide one. Throughout camp, I noticed that Summer, unlike many of the other girls, floated in between interacting with the White campers and the Black campers. Her picture is a depiction of how she is navigated her White and Black identity in the camp. With one side representing her father’s White background and the other representing her mother’s Black background, similar to abstract art, her world was not a definitive reality based on what she looked like. For Summer, her identity was based on the internalized characteristics of her personality, not her race, as it was something she was trying to understand and navigate currently.

Figure 17. Summer's Drawing

When I asked her to explain how identity would influence her or her outcomes in STEM, she said, "Not really [and] I wouldn't think so." These girls disregard for their racial identity minimizes the effects of racism, or *racial permanece* and encourages the liberalistic society that ignores how race prevents us from attaining equal access and rights. This realization futher complicates the pursuit of Black girls attaining engineering education and degrees because of their disconnection from realities of the field. Furthermore, to help ensure that we work towards more equitable understandings in engineering education, the staff or leaders of these organizations play a vital role in changing the narrative for Black girls.

The Staff Perspective: Increasing Equity in STEM for Women and Minorities

This study focuses on Black girls' perspectives in order to highlight voices and experiences that are often silenced. Along with centering the girls' voices, it is important to understand how the staff believed their role could influence the girls' multifaceted identity and what their goals were when working with campers who are underrepresented in the program. The staff members' interviews allowed me to understand how aware they were of the girls' multiple identities, how they looked to foster identity development for the girls, and how they sought to understand the culture of the camp based on camp leaders' perspectives. After interviewing the staff members, I discovered four themes across their responses: *Recruiting and Retaining Black Girls*, *Developing Engineering Identity, Role Models and Reflective Identity*, and *Building Resilience and Confidence in Black Girls*.

When speaking with the staff, it is important to note what the staff members' overarching goal for the camp was as we consider how their role may have influenced the Black girls.

The camp director, Lucy, who also served as the director of Women in Engineering, shared how the purpose of the camp was to diversify the engineering workforce. Camp served as a great pathway for this:

> I really want to help empower more and more diverse kids to know what engineering is to be technologically literate. And for some of them to become engineers, making them into engineers is not really the first goal, although I'm really highly interested in getting them into STEM.

For Sandra, the camp coordinator, the purpose was to teach campers about the breadth and depth of the field. With each of us having problems we need to solve, we should teach campers how they can do that in real life. Sandra said:

> The purpose is to introduce kids to the whole concept of engineering and what engineering entails. There are so many different aspects of engineering. It's solving problems to help people and it's something that everybody should be able to find some kind of interest, something that would inspire them to help someone cause you can make a connection to every single thing that is in this world to something an engineer is involved with.

Some of the undergraduate counselors and teacher team leads had similar intentions and goals for the camp. Most of them had an underlying personal connection as to why they wanted to work with campers in the setting. For example, Melissa was a biomedical engineering major with a spunky attitude who was often ready to show the girls that they could compete or outdo the boys at any given time. Increasing the gendered and engineering identity of the girls in the camp was essential to her. Her purpose for working with camp was connected to who she was. Melissa said, “I just hope they are more passionate about engineering and that the field in the future will not be so male dominated and it'll be more diverse.”

Along with building resiliency, which was an aptitude that Weston, a mechanical and aerospace engineering major, needed as a Black male, he was also interested in developing a safe space for campers, especially Black campers and girls since he knew what it was like to be underrepresented in groups. Weston was committed to valuing the campers and letting the

girls know that their ideas were respected. He also felt that getting campers to collaborate effectively was essential to engineering design and a lifelong skill that could be useful:

> I would really work on the importance of everyone contributing somehow, but also making sure they don't get frustrated or they don't give up too soon if they don't get it to work right away. I want everyone to come into the room and be genuinely excited to be with their counselor and their teacher. Know that no matter how it turns out, whether they come out on top or like come on bottom, they don't feel like their time was wasted and they realized they came to camp to have fun. My goal is to make sure that it was a safe space and I have the space for them to try to get to ideas flowing.

Additionally, Carla, a third-year teacher team lead who taught engineering related courses at her school, wanted to connect with campers, share her passion for engineering, and be a role model to others. As a Black woman she knew how important building the reflective identity was for girls and minoritized individuals:

> My goal was just to connect with them and get them to like understand my love for engineering and let them see like how engineering can be really fun and exciting. So that's why I went around and would ask them questions and stuff like that.

Recruiting and Retaining Black Girls

One of the Black girls, Layla, mentioned during her interview that number of Black girls in the program had increased compared to three years ago when she first came. Although there were more Black girls in the program, the tactics used to achieve this were not clear. Staff members saw recruiting and retaining these girls as a part of their responsibility. In my role throughout the year, I noticed that recruiting and retaining Black and Brown campers was a major concern for the program. Centered around the *critique of*

liberalism, various aspects of the camp structure prevented Black girls and Black families from gaining access to the engineering camp. While the camp was open to everyone, race as well as socioeconomic status prevented people from diverse backgrounds from attending the camp, and impacted recruitment as knowledge of the camp was only available to certain groups of people. Without a large year-round staff to focus on this, there was not much success in having a cycle of Black families that would learn about the program. While the coordinator wanted to work with community organizations that targeted Black and Brown students, she had little time outside of her normal responsibilities to do this. Sharon discussed the approaches she was using for recruitment and retaining the girls. Community efforts and hiring a staff that was supportive of diverse background was essential:

> We don't do a ton of advertising as a whole. We do go to STEM Nights at elementary and middle schools, and do hands on activities because I do think that the best way to attract children to engineering camp. We reach out to special communities for homeless kids and kids who are in lower socioeconomic areas. We do programming with Jack and Jill. There's always room for improvement. Girls in general, my numbers this year are down for females. They're down for Black kids compared to the last year. I think the most important thing is leveling the playing field as much as we can. By trying to do programming that's inclusive as possible. My strength in a camp is through the people and their ownership, and their feeling of commitment to it keeping an eye on the kids. It's the teacher team leads and the undergrad counselors. They're in the trenches and helping to make sure they should be listening. They should have like ears, like elephants and you know, eyes like owls, looking and making sure that things are going well. That's not to say there won't be frustrations.

Along with creating a supportive environment, providing financial assistance to get Black girls to attend was a concern for the camp director and coordinator. Many of the girls believed that working hard would help them succeed in STEM, but opportunities were still limited for those that were unaware of the field of engineering and did not have access to the camp. Moreover, diversifying the field had as much to do with the K-12 level as it did higher education. Additionally, one aspect of Explore Engineering that was important to remember was that it was an outreach program. Therefore, the same type of work for grant funding was not put in place for this as it was for collegiate efforts. So, developing partnerships and fundraising was also a major concern for Sharon: "African-American by far have more requests. 90% is mostly African American. Partnering with organizations that have good connections to the community is important." Additionally, the effort to positively portray Black girls on flyers was also a form on tokenism, or making a symbolic effort to display gendered racial equity in engineering. Tokenism masks the issues that exist within our structures and falsely represent organizations to outside audiences, which may contribute to discouragement among those that sign up because of false advertisements. Lucy added how she intended to get more Black girls to come to camp:

> Talking about the camps at their church, collaborating with other researchers that already have inroads into the African American community, and we want to show pictures that show variety of kids. And if there's only one person in the picture, then I would like it to be an African American girl. Cause that hits as many different groups as I can hit. It's, come learn how to do something that's gonna make a difference in your own community type thing, not the newest tech thing.

While these interests and efforts were great, the real issue came down to staffing and purpose. The program only had one full time staff member dedicated to camps, retention and recruitment, and more staff and structures would enhance efforts to address low camp enrollment among Black girls. Without focusing on this, access and information could not be provided to families that might be willing to participate if they were aware of the possibilities that engineering could bring to them.

Developing Engineering Identity

Because the camp focused on engineering, building and developing that engineering identity was important to most of the staff. Training did not focus on engineering identity development; instead the focus was on how to implement engineering education and how to facilitate activities. The purpose of camp was to expose the campers to the field. Therefore, staff members may not have been aware of factors that contribute to positive or negative experiences regarding engineering identity development. If I or the camp coordinator noticed teaching practices that could negatively impact a camper's experience, we would discuss it with them one-on-one to ensure all campers had a good experience. Similar to what some of the girls mentioned in their narratives, staff members were already aware of the masculine environment where confidence in science, mathematics, and positive collaboration are very valuable. One of the counselors, Melissa, saw her role as a way to build a strong sense of purpose and cultivate engineering identity for Black girls. She shared how too often the girls were *silenced and marginalized*, but for her this only taught the girls what the field was like and what they would need to do to succeed in the field. However, this puts more pressure on Black girls because of their identity and neglects to address the gendered and racial bias that exists. Melissa shared:

> I think that the girls just want to be treated equally, but they also need to know that it's a male-dominated field and people are always going to be trampling one another to get ahead. So, you just have to keep positively reinforcing them so that they feel good about engineering and they want to keep doing it. No one thinks that women have as good ideas as men, which is so untrue. But that was definitely one of the barriers that the girls felt that they couldn't speak up or their ideas wouldn't be appreciated as much as one of the boys in the groups. I just tried to make sure everyone was included and doing what they're saying, so if one camper likes drawing more, they would do the drawing or if some of them were very good at managing, they would help manage the group. So, they all had roles and they could all, um, have like an equal say in what was going on. No one was just facilitating everything. The boys are definitely a lot more outgoing and dominant and the girls had to like interject and say, Hey, I have ideas too. Like I could do this too. I think that it just made the girls realize that there needs to be more women in the engineering field. Like an equal representation isn't going to be shown because men are so dominant in the field. And I think the camp shows that and the girls not being listened to shows that as well.

Sharon often turned to me as a Black woman to ask my perspective on ideas that may be of interest to Black campers. She was also read books about equity in engineering, STEM education, and among women and underrepresented minorities. She read these books because she was interested in addressing the *racial permanence, intersectionality,* and *White privilege* that existed in the field, but she knew it would take much more than her efforts to do this. Being able to experience what an engineer does and building a curriculum where Black girls could do this in a safe environment was important to Sharon:

> You get excited out of, “Hey, I'm really good at that math.” I want them to have an understanding of what an engineer does. It was not all just about wanting them to want to be an engineering. They're okay if they leave not wanting to be an engineer. It's not for everybody. But at least they understand a little bit more about, you know, what engineers do and how they solve problems and you know, that it works with people and you're not sitting alone.

For one of the undergraduate counselors, Misty, she too wanted to encourage the girls to be confident in their abilities. For her, pushing the girls limits when it came to their STEM self-efficacy and engineering identity were the most important,

> I encouraged them. I would go around say like, “Don't worry, like you guys are on the right track.” So, I just tried to be as positive as I could if they were getting discouraged and thought their design wasn't working and I would talk to them about different things. How different products have failed in the past, but people have worked on it and come back with an even better product. It gave them a little bit of motivation so they can also work through their failure.

Weston wanted the campers to feel comfortable in the environment. He felt like this aided the campers in building a strong sense engineering identity. As an African American male, his deep connection to the campus and feeling like he belonged contributed to his own personal successes. He wanted the Black girls that came to camp to feel like this was a space for them as well rather than feeling isolated. Isolation often occurs for underrepresented individuals in exclusionary structures and environments, in this case based on the Black girls’ gendered racial identities. Furthermore, Weston shared what he would do to help campers feel a part of the community:

> I would try to stress that it is good to be comfortable and have people that you know are going to work well with. But also, it's good to branch out and see what other ideas he might be able to listen to or add to your own.

Carla made sure the campers developed a stronger sense of self-efficacy and hoped that valuing each girls idea would help them feel like they could be engineers. She understood how their *intersectional* identity may make them feel *silenced and marginalized,* or hyper visible. She hoped that her presence brought them comfort in the camp:

> I would hope that they would see that entering into a STEM field, whether it be engineering or any other field, that is a viable option for them. That it's not just something that you have to be. I would sit down with the groups and discuss how to express your ideas and how to talk to each other. I would have each of them writing their own ideas and then I would go through with them and give them each a certain amount of time to talk and to respond. I think a lot of the females really saw a lot of success in the camp and so I do think that they will have a stronger sense of their STEM ability after doing something like this. One way I assisted in doing that was an indirect way by myself being female and Black. It's a very indirect way and also somebody who does teach engineering. I've just got to teach at the middle school level, but I think that that does have an influence cause I talked with some of the girls about that. I'm thinking like why can't I do this, cause a lot of kids don't have that ability. Not even just the girls, but a lot of students in general. Girls specifically, I certainly think it influences their ability to say that they can do it.

A first-year team lead, Todd, used his sarcasm to motivate the girls in the camp. He joked about what the girls were not capable of which motivated them to prove him and other boys

wrong. While this tactic seemed to work for him, it also reminded and reinforced some of the negative gendered bias that the girls could not escape when they were interacting with some of the boys:

> The obnoxious me would say why don't you let one of the boys do that because that's too hard for girls or girls can't be engineers, so why not you do something else. This feeling of I can do that. What are you talking about? The boys can do it and I can, or what do you mean the girls can't do this, or a roll of the eyes. What I was saying was clearly so ridiculous because they are proving right before my eyes that girls are absolutely capable. It was kind of fun to play with that stereotype and that kind of lowered expectation type of thing. It just put girls into a position where they felt like they had to defend their spot to be at the table and not be so quick to yield it. I hope that all the kids walked away feeling like I was with a lot of different people, but together we created a great project, or I had my doubts about working with this group, but I realize that we are all kind of engineering oriented and that really didn't play into our design unless I allowed it to.

Developing an engineering identity was connected to various aspects of the staff identities and values. Therefore, the staff utilized aspects of gender, failure, and Blackness, to help the girls navigate their intersectional identities. Although many may have been unaware of how systemic and structural factors such as *racial permanence* and *Whiteness* impacted the girls' views of engineering outside of camp, they did work to make them feel welcomed and valued in the setting.

Role Models and Reflective Identity

As mentioned in chapter two, role models and being able to see themselves as engineers is vital for identity development. Thus, hiring practices for staff members were connected to the need for role models for Black girls and other minoritized populations at the camp. Even though this was a priority, most applicants were White women because the camp did not pay undergraduate engineers as much as internships and the focus was on children. While we were aware that there were plenty of Black women and women of color in engineering, *racial permanence* prevents Black women from having easy access to the field, thus making it even harder for Black girls to see themselves represented in other engineers. So, as the girls looked across the rooms to recognize their *intersectional* identity in someone else, they had to find that in a White woman, negating their own racial identity. Thus, Sharon and I usually spent three months out of the year working with engineering programs that served women and minorities to recruit those students for camp. In a given year, we were lucky if we had two undergraduate engineers from underrepresented backgrounds. Often, staff members were interested in sharing their stories on how they got into the field of engineering as a way to motivate and allow girls to see that anything is possible. Misty served as a great role model, especially to Ezinne during the challenge when Josh would not allow her to contribute. Misty saw her role as a way to motivate females:

> I hope just by them seeing that I've made it through half an engineering school as a female would encourage them enough to know that as a girl that can do it and that they should do it if they're really interested in it. As far as racial, I'm White. I hope hey saw Weston being an African American student in engineering. I hope they just saw that, and you, and everyone that was a female there, and were just encouraged.

Carla talked about being a role model because she was Black, a woman, and fully capable of teaching engineering in the classroom. She had transformed her teaching career to be focused on engineering education. She also hosted her own camp focused on developing hair products through chemical engineering. This cultural connection seemed to get more girls interested since they could relate and understand why engineering was important to their own lives. It made the girls see they too had cultural capital in science and engineering. Carla shared:

> Maybe a Black girl isn't comfortable. So, having staff and me, myself being Black and female, I think that's one of the greatest ways that I influenced their racial identity. Not just being Black, but being someone who is comfortable with it, comfortable talking about it, and working through the challenges. I'm also a Black person who clearly identifies with Black culture. So, it's not like I'm giving up a part of my whole cultural identity to sort of progress into a STEM field, you know.

Sharon discussed how she worked fervently throughout the year to recruit a staff that was representative of all campers. From minoritized populations to campers with disabilities, she wanted campers to see themselves in the staff members:

> I'm hoping that they saw the same thing. Especially because they have two identities and so it's not just one. But I think because we have a good mix of staff being able to see all those different things. I think was really helpful for them. So, we tried to make sure we have three female counselors and three male ones. I use as many diverse and female images as possible from camp. The White males already know they can be anything and do anything. So, I would much rather select a female of color, I'll reach out to the engineering program for minorities and women.

In her experience, Lucy felt like diversity in staff was what made recruitment get better from year to year. This was true, but due to the low campus enrollment of Black and Brown engineers, which was connected to *Whiteness as property* with the school being a PWI and engineering education catering to White men, recruiting these students was hard since they typically took internships first and were heavily recruited because of their racial identity. Lucy shared that undergraduates from underrepresented populations often wanted to give back:

> I've found over the years that that diverse engineering students, and by diverse I mean girls or people of color or both, seem to be more interested in sort of giving back in certain ways. And this is a way that they can do that. So, it's actually easier to recruit a really diverse set. And so, um, that's one of the things that we do. And then we also really, we try to put pictures of engineers around.

Chase too wanted the girls to feel like they could be successful. During camp, he would spend just as much or more time with the girls than boys to make sure they felt confident in their skills. He took particular interest in eating with the Black campers at lunchtime, listening to their conversations, and allowing them to ask questions about his experience as an engineering major. By forming a collective community of possible future engineers, Chase affirmed the girls' racial identity by appealing to their interests, having open conversation, and showing them that he had succeeded at the university as a Black student. As a Black man, similar to Weston, being valued was important to Chase:

> So, I really hope that I tried to help them see their ideas are valuable. Don't listen to what anybody might say. Anyone can do it. So, diversity is really important. Any

> minorities, they should all be respected for that and they should understand that themselves.

Weston and his teacher team lead were both Black. During camp, he came to me and stated that this grouping made him feel empowered because it would show other campers that Black people are just as capable as others in the field. As his colleague Chase did, Weston wanted the girls to know that they could create their own narrative. By collaborating with Jada, his teacher team lead, Weston tried to get the girls to see that they were in control of their *self-definition* of who they were in the informal engineering space. He felt like this allowed him to positively influence the girls' racial identity development because they saw two successful leaders:

> Well, I hope one because it was um, my teacher team lead. She was also African American, so I hope just like seeing they are on a team where it was two African American leaders. We are very involved in engineering. We were having so much fun. It's a challenge, but it's not a challenge that we're just gonna turn our backs to. I'd want to encourage them to want to do this one day. I think it's really helpful, especially the younger, they are seeing people like them in positions of leadership very hands on, engaged with them. It helps them to be more confident in themselves and realize that the opportunities are endless really. I do feel like they were able to form a connection and understand the importance of why they were doing such a challenge.

While the staff worked to be role models and reflect the identities of the Black girls, they were very clear that outside of camp, the girls needed to find ways to maintain these interests

in engineering themselves. Thus, they tried to instill values of resiliency through the engineering habits of mind so they could utilize these skills as they moved forward.

Building Resilience for Women and Minorities

Lastly, the staff saw building resilient Black girls as part of their responsibilities. It was not enough for the girls to work to succeed or overcome a challenge during one session. Resilience was something they needed to develop and take with them beyond the informal engineering setting. The habit of minds that were used at camp reinforced the idea of resiliency through persistence. Thus, on a daily basis, plastic bands were given out to campers that displayed this characteristic. By the end of the week, some campers had three or four of these bands on their arms showing that they displayed many engineering habits of mind. Stella, a teacher team lead, mentioned how *projected stereotypes,* or ways in which the girls were presumed to communicate as the Angry Black woman figure, would overshadow the girls' abilities. She worked to make sure they knew how to communicate effectively. Furthermore, Stella's idea of communication also pushed back against the idea that the girls could not be themselves and that they needed to assimilate to the dominant culture and work harder instead of addressing issues of concern. She also mentioned how the girls' *intersectional* identities led them to work harder. Stella talked about how she wanted the girls to feel like they were just as good, or better than anyone else:

> I want them to know they're just as intelligent as everybody else. They will have to walk work harder unfortunately. I want them to know they don't have to prove themselves that often. We do have to prove ourselves as women of color; it sucks. I had to learn that the hard way, do it in a tactful, nice way. I mean, they don't have to get frustrated and upset. Show don't tell or argue about how smart you are.

Although this may have been hard to acquire because of being *silenced and marginalized* in the setting, Sharon wanted them to leave with increased confidence that was gained through camp interactions. This trait could be used throughout their lives:

> I think a lot of it is a sense of confidence in skills. I want them to leave with some collaboration skills. Especially females are suffering from a lack of confidence in so many ways and times. The males just seem to have a stronger identity of being an engineer and it's because of the images they see.

Although she recognized that she was not African American, Lucy wanted the girls to have cultural connections to engineering which would drive their interest. Although her efforts were in the best interest of the girls, she did not fully understand that culturally-relevant did not always mean activities related to Black culture. Through the activity that Lucy shared with me, she did cater to the girls' racial and gendered identities, but again this was not the norm in engineering contexts and not typical of the camp. Lucy often reached out to colleagues that identified as Black women to get ideas about activities:

> I'm not an expert in that. I wasn't raised in an African American community. So we hope to find people who will help us to pick out the challenges. I'll pin down my colleague, shut the door, I've got to run this past you, I've been thinking about this, and you gotta tell me where this strikes you. I know this is stereotypical White woman behavior, but we did a thing on hair, right? I said you guys have got to level set me on the hair and I'm sorry, but I need to understand what's so special about hair and Black women. They explained it to me, and natural hair versus treated hair. I guess that's the opposite of natural. I made up a presentation. I went to South Berry High school and I was talking with a group of all African American girls. I said I'm

> very interested in hair because mine always looks awful. So, I said I found these kinds of curls and they're classified by this. And we showed pictures and then I said can you identify them. Let me say every African American girl in the camp should have a good time and connect to something we do. She should see herself as really good at this.

Melissa loved that the girls became more vocal. Speaking up and standing up for themselves was something that she had to do often as an engineering major. She too noticed that the girls were *silenced* in the setting. Helping the girls learn how to do this was special to her:

> Middle school girls are pretty shy. I noticed a lot of them would hold back and then when they would have ideas, they would interject. The girls weren't as dominant as, as the middle school boys. They would say my ideas are good too. They would try and contribute as much as they could. As the week progressed, they got a lot more vocal. When they realize that their ideas weren't being heard as much as others, they weren't happy about that. So, they would start speaking up and adding their ideas more than they were.

Lastly, Todd wanted the girls to see that when you are given an opportunity, take advantage of it, and own your seat at the table. For him, each of the girls earned their right to be in the space based on their abilities, interests, and endless efforts towards success in engineering:

> I hope girls in general walked away from that summer feeling much more empowered and much more in touch with that voice of, let's try this and let's experiment with that. They had a very natural and valuable place at the table. Summer camps like the one

> that you all are providing and the opportunity to do engineering, hands-on based things is very limited, especially with a poorer community which does tend to be minority kids. So I'm hoping that the experience allowed them to discover and feel much more curious and empowered about things related to science and engineering and hopefully opened up a couple of avenues of curiosity for them.

The staff members were aware of some of the barriers the girls' may face, thus, they wanted the girls to carry these values within them. Using their understandings of what was needed to address this, the staff members tried to connect culturally and by discussing how important work ethic was. However, again these tactics did not address the ever-present *intersectional* nature, negotiating, and coping that the girls had to do at camp.

Chapter Overview

In this chapter, I analyzed common themes among the experiences of the Black adolescent girls that participated in the camp and in my study. Data sources illustrate that these girls' experiences were shaped by the following: (1) motivational messages and the belief that *I Can Do Anything* which pushed them to have a sense of Black Girl Magic or Girl Power in the camp; (2) competition, being silenced and marginalized, struggles around mathematics self-efficacy, and the camp being a predominately White space led them to question *#AmIWhatAnEngineerLooksLike;* and (3) their awareness that Black women have historically been overlooked in engineering contexts guided their understanding of how they themselves may encounter this field as well. Nonetheless, this led them to be encouraged by the possibility that *"I Could Be a Person in History"* although some girls believed their racial identity should not be a factor in their success. In addition, the staff members shared how they believed their roles focused on: (1) *Recruiting and Retaining Black Girls*, (2)

Developing Engineering Identity, (3) being *Role Models and Reflective Identity*, and (4) *Building Resilience and Confidence in Black Girls*. With Black women significantly underrepresented in engineering fields, these findings sought illuminate how Black girls' multifaceted identities are influenced by the current structures within a summer engineering camp.

CHAPTER V: DISCUSSION

The purpose of this study was to investigate the experiences of Black adolescent girls in a summer engineering program at a PWI. This research used CRT and BFT to analyze how the camp influenced the girls' perception of their own racial identity, engineering identity, and STEM self-efficacy. Moreover, by attending camp, the girls were able to challenge negative messages regarding Black girls in engineering, face their perceptions of individual STEM self-efficacy, and build resiliency. Through the use of a mini-ethnographic case study, I highlighted the girls' voices and shared meaningful accounts in order to give power to their often invisible experience. Within this chapter, I will present a discussion of the findings, share limitations, describe the implications for future research, and provide recommendations for stakeholders.

There are three major takeaways from this study. First, the data revealed that we should develop an *Awareness of the Intersecting Identities of Black Girls* in STEM learning contexts, given that participants' identities influenced their experiences and peer group interactions at camp demonstrated how being unaware of the double bind of gendered racial oppression can be detrimental to these girls. Next, the data showed how *Structural Inequity in Informal Engineering and STEM Education* operates to produce practices that are exclusionary of Black girls. Last, the data demonstrated *Resiliency and Protective Factors among Black Girls* by sharing how the participants developed internal motivation to challenge inequity and achieve success in the camp environment.

Awareness of the Intersecting Identities of Black Girls

The *matrix of domination*, or the paradigm that conceptualizes multiple identities such as race, gender, class, and age in an interlocking system that leads to oppression in a

hegemonic society calls us to be more aware of the worlds that Black girls navigate on a daily basis (Collins, 1990). Through the narratives in chapter four, the girls shared their *self-definition* of what camp was like for them (Collins, 1990). In education research, we often speak for students, but in this study, the girls' voices defined their own reality. The challenge in this study was interpreting how all these identities influenced the girls' experiences in the camp context. Along with the girls' sense of their gendered racial identity, engineering identity, and STEM self-efficacy, their socioeconomic status, personal interests, family backgrounds, past experiences, and interactions in the space all contributed to who they were. These experiences are representative of the *Intersectional* experiences of Black girls in engineering.

Ireland et al. (2018) calls for research to "conceptualize the evolving nature of identity, address the multidimensional psychological nature of racial identity, and attend to other key psychology constructs of intersectional experiences such as self-efficacy" (p. 229). In chapter one, I shared an adapted model of engineering identity development for Black girls. Based on an understanding that all STEM fields are not the same and different factors contribute to engineering identity compared to science, technology, or mathematics identity, this study looked to recognize the systems and intersecting experiences that contribute to the outcomes of these girls in engineering education. Collins (2018) and Collins, Joseph, and Ford (2019) address the challenges and complexity of Black students and Black girls in science, technology, engineering, and mathematics. The researchers explain that STEM identity and STEM talent are underdeveloped, and STEM climates and dual marginalization are the reasons why Black girls are not persisting in these fields. Additionally, the framework articulated in Collins (2018) posits that four questions influence STEM self-concept based on

interest and persistence, reflective identity, competence and ability, value and interest, and assimilation. While this framework is useful, my analysis in this study suggests that we need to extend the model to include how CRT tenets such as *racial permanence and Whiteness as property* impact identity development. Collins (2018) suggests that considering issues among Black women and redressing racial and gender inequity in STEM development can aid us in understanding how this influences STEM self-concept. Other forces such as *structural environments* may also influence Black girls in engineering. This may include systemic forces such as culturally relevant curriculum, polices and systems that address underrepresentation (i.e., financial aid and hours of the program), or availability of teachers or counselors that look like the participants and have a strong knowledge of how to meet the needs of those students based on their identity and interest in engineering (Joseph et al., 2017). Moreover, while Collins (2018) does mention that assimilation is a way for students to see what is needed for them to succeed in the field, it is problematic to compel the student to conform to the environment rather than addressing the structural problems that dissuade or prevent Black girls from feeling like they can succeed in the space. This statement positions the White experience as more valuable that the Black one, which is central to the tenant of *Whiteness as property.* Thus, we must attend to structural and gendered racial inequities that cater to disparaging STEM experiences for Black girls intersectional identities.

When Black girls are placed in a space where they are the only one, it makes them question whether they belong, as the girls did in this study, and look for role models that reflect their own identities and experiences. With the girls' gendered racial identity being instrumental during the camp, girls like Elise, Ezinne, and Jenesis negotiated who they were in the STEM setting to succeed and prevent being stigmatized. Similar to many studies that

investigate the identities of Black women in STEM, many of the participants in this study felt their personal identity as a Black person or as a girl was much more salient than their engineering identity. As some girls shared negative aspects of engineering and stereotypical perceptions of what engineering is, their ability to negotiate who they were, use strategies to succeed, and overcome gendered racial stereotypes served as a form of resistance to hegemonic notions of who can be an engineer. While this form of resistance can help girls achieve strong engineering identity and self-concept, addressing structural issues in these settings can help mitigate the work that Black girls have to take on when navigating these settings.

Along with gendered racial inequity, other factors that hindered Black girls in the setting may have been attributed to structural factors related to socioeconomic status and/or gendered racial background. K-12 STEM learning experiences were found to be directly connected to social success and monetary access (Burrows, Lockwood, Broroczah, Janak, & Barber, 2018). The fact that a small percentage of Black girls in the program came from middle- and low-socioeconomic backgrounds invites us to question who has access to and information about these programs. Historically, race has not been considered when maximizing engagement of STEM knowledge for Black children. While Black children are not always privy to modes for accessing informal engineering education, the same issue arises for girls when stereotypes lead more boys into STEM education compared to them. Monetary access has a trickle-down effect as structural racism creates conditions in which predominately White schools getting more funding and access to STEM resources such as science labs, materials, computers, hands-on experiences, and teachers that have better training for higher academic achievement in science and mathematics. Furthermore, Black

girls that may be interested or who need their interest in engineering sparked may not be afforded the opportunity based on underdeveloped resources.

Moreover, similar challenges exist in informal educational opportunities; who has knowledge about programs, who has the financial ability, who has flexibility to bring their girls to camp at the given hours are considerations directly tied to race and socioeconomic status. In addition, gendered racialized experiences contribute to individuals' feelings that they are valued—or not—in engineering education settings. For example, Elise was aware that she would be one of the only Black girls in the setting. While having to navigate being silenced and marginalized because she was underrepresented as an African American and a woman, she struggled to find community and connections to other campers. In sharing how she learned about the camp and gained financial assistance to attend through her grandmother, she mentioned that she valued the experience but did not know if engineering was the right fit for her based on how she was treated in the setting and how connected she was to the curriculum. Along with this, her sense that Black women in educational and professional engineering contexts are frequently devalued also impacted her sense of her own engineering identity. Thus, various aspects of her gendered racial identity, engineering identity, and STEM self-efficacy were impacted by who was given access to the program. Outside of camp, various factors such as Elise's school experience, access to STEM resources, and STEM role models may have impacted her interests. Thus while she had a strong sense of STEM self-efficacy, contextual factors in STEM and her knowledge of how the structural environment negates the Black woman's experience greatly influenced her development of an engineering identity.

To gain cultural capital in engineering education, equitable structural and systemic factors must be provided. The following structural and systemic elements should be addressed to cater to the needs of Black girls' engineering identity development in informal settings: (1) gender and racial isolation, (2) role models, (3) STEM education resources, (4) financial support, (5) transportation, and (6) programmatic knowledge. Gender and racial isolation in engineering can lead to a negative environment that perpetuates racism and sexism. This can lead to Other-ing and Other-ness, or minoritized individuals feeling invisible in the setting. While it may be hard to find Black women role models in engineering fields, intentionally seeking out women of color to form positive relationships with can give Black girls an opportunity to build their reflective identity and experience a more equity-based curriculum that may affirm their identities and purpose in the field. STEM educational resources such as STEM Nights and engineering education training should be provided for all schools, especially those with less access to these informal resources. Given the growing need and the NSF's interest in diversifying the field of engineering (see chapter one), reaching students in rural areas or Title I schools can expand the availability of STEM learning programs to underrepresented demographics. Additionally, as informal programs look to provided equitable access, they should seek more outside support such as grant funding and outside donors, similar to university departments, to provide more Black girls and families the opportunity to learn about and attend the programs. This funding can also serve as a way to provide transportation to some students that wish to attend, but cannot due to timing constraints or distance of the program. Lastly, for social mobility to increase among Black girls in engineering, spreading knowledge of the program to families that are unaware of how engineering can aid their communities and our society at large.

While engineering identity is influenced by interest, performance/competence, and recognition; the interconnected aspects of other structural psychological factors greatly impacted how Black girls in this study formed this identity. Without acknowledging how various aspects of intersectionality, *racial permanence,* and *Whiteness as property* impact engineering identity development and intersect with the girls' experiences, we cannot understand how best to promote persistence. Addressing specific structural inequities that influence the *intersectional* identities of Black girls as they navigated the camp can allow us to address specific programmatic issues in engineering identity development. Collins (2018) describes her model as a "cyclic attitude towards one's STEM self-concept, sense of belonging in STEM fields of study or discipline, and the perception of one's own STEM cognitive ability" (p. 163-164). By dismissing the structural influences that weigh on Black girls' self-concept, we perpetuate the problematic nature of engineering education.

Structural Inequity in Informal Engineering and STEM Education

Embedded in the tenets of *permanence of racism*, the *critique of liberalism, Whiteness as property,* the programmatic structure of the Explore Engineering camp allowed for the girls to be *silenced and marginalized* as they completed the challenges, gained interest in scientific concepts, and utilized teamwork to cope with complex mathematics skills that were needed. Gholson & Martin (2014) and Joseph, Hailu, & Boston (2017) identify structural inequity (i.e., access, deficit thinking, unevenly distributed resources) as the main source of gaps in the STEM pipeline for Black girls. By adopting an assets-based and challenging a deficit approach to Black girls' persistence in engineering—like challenging systemic issues—we can evaluate processes that create obstacles rather than situating a lack of persistence as the result of individual flaws. Thus, within educational practices, concepts

such as addressing gender and racial bias, equitable pedagogy and cultural relevance in science and mathematics education, and examining programmatic accessibility for all students is necessary to provide Black girls more opportunities in the field.

Addressing Gendered Racial Messages

The Black girls in this study shared how they were impacted psychologically when they were the only ones in the camp setting, as well as how they may have been discouraged by males that doubted their ability to contribute to the challenges. This finding is connected to the *racial permanence* as well as *intersectionality* when it comes to *assumptions of style and beauty*. The standards for gender norms within career aspirations in engineering are problematic and exclude Black girls.

Collegiate women that are interested in STEM have mentioned that the environment is isolating, competitive, and unsupportive, and they have little interaction with other members of their gender (Bystydzienski & Bird, 2006). Leslie et al. (1998) mention, "Most post adolescent behaviors in regard to science and engineering can be understood clearly only by reference to earlier life experiences" (p. 2). Research shows that the experiences of collegiate women in science and engineering are comparable to those at the high school and middle school levels (Rockman et al., 2017). When compared to White girls, the Black girl experience is said to be more debilitating, because of racial and gender inequity (Smith-Evans, George, Graves, Kaufmann, & Frohlich). Rosser (1998) mentions that group work in science, engineering, and mathematics can allow for increased achievement through communication, but there are negative repercussions that may inhibit learning when we ignore dynamics of race and gender. Moreover, over time these negative gendered racial comments can have a devastating effect on the matriculation of Black girls in this setting.

While an educator may think that dividing Black girls up equally amongst a large group so they are evenly distributed is appropriate, this practice could lead to the minoritized girl quitting or not liking the program. Instead, grouping at least two Black girls in the same group can lead to less isolation and a better sense of belonging (Lord et al., 2009).

Additionally, although the campers were at the early age of adolescence, discussing equity and inclusion in engineering is vital. In a field where there are few women and minorities, addressing the negative messages that youth send to each other can be a way to prevent negative racist and sexist ideologies from becoming sedimented at an early age. Furthermore, in settings that are predominately White like collegiate settings, *the critique of liberalism* indicates that we have forgotten how these environments still in fact cater to White men simply because Black girls have access to them. Research on addressing racism at the K-12 level suggests that studies still neglect the role that racism has in shaping in-school and out-of-school experiences. While teachers may be aware of the issues, they are not equipped to address these concerns. Black girls are also poorly prepared when it comes to confronting or coping with these issues (Kohli, Pizarro, & Nevarez, 2017). Additionally, studies in engineering education typically highlight feminist perspectives that focus on how sexism is detrimental in classroom settings as White women experience implicit bias from their men peers. Along with women being underestimated, gender is continuously noticed and highlighted by men in the field, therefore girls try to become less identifiable by wearing less make-up, or reducing "girly behavior" (Smith & Gaston Gayles, 2018). Moreover, the literature neglects to address the *Intersectional* gendered and racialized experiences that Black girls may face in these settings. A report on women engineers facing racial and gender bias found that women experienced "tightrope bias" or pressure to reduce feminine behavior,

while also being called out as “too masculine” (Williams, Li, Rincon, & Finn, 2016). Engineers of color have reported being asked to prove themselves more (Williams, Li, Rincon, & Finn, 2016). These findings are consistent with my research on Black girls in engineering camp. Thus, just as engineering workplaces have challenged these communities to address bias and critically consider the climate in formal school environments, we must take the same actions and considerations in regard to informal settings.

Mathematics Education

With engineering being connected to mathematical concepts, the nature of mathematics education contributed to the girls’ lack of interest in the subject matter. Joseph (2017) states that mathematics education is exclusionary, embedded in White supremacy, and contributes to gatekeeping. Tracking in mathematics, or separating students by academic ability, has adverse effects on Black students. Most schools that utilize this method serve minoritized populations and have shortages of high-performing mathematics teachers. Thus, if a Black girl is in a low track in elementary school, these trends typically continue throughout high school. This literature is aligned with the study’s findings related to Black girls feeling apathy for challenges that were more connected to mathematics than scientific knowledge. Studies regarding Black girls and mathematics often utilize CRT as a way to deconstruct embedded assumptions about the meritocratic environment that neglect race and gender as contributing factors. So, as we continue to push for more Black girls to pursue engineering, the ways in which Whiteness and gender regulate achievement in this area should be considered.

Programmatic Accessibility

Based on the tenets *of racial permanence* and *Whiteness as property*, engineering education research currently focuses on a more holistic approach to addressing gaps and concerns. It is well-known that Black girls are underrepresented in STEM fields and that they face stereotypes that prevent them from visualizing themselves as engineers and may question their own potential, which makes them reluctant to explore STEM areas (Atwater, 2000; Seiler & Elmesky, 2007), but their unique experiences and cultural backgrounds are not investigated or considered (Parsons, 2008). The Black student experience is once again silenced in the educational system as well as in educational research, just as the Black experience has been silenced throughout history in the U.S. Teachers and researchers alike frequently assume that Black students do not have cultural capital, or the knowledge and skills to be socially mobile. But Yosso (2005) argues that Black students have community cultural wealth that has been developed over centuries of oppression. How Blacks cope, communicate, dream, and resist can be recognized as capital because they use those strategies daily to resist hegemonic systems of oppression in society. When Black students use communal interactions and social relationships to learn, their engagement with engineering education is higher (Seiler & Elmesky, 2007).

Teachers often take a deficit approach and believe that Black students come in with a deficient understanding of science and engineering, but when teachers help students utilize their cultural capital regarding personal experiences, there are many connections they can make with engineering (Seiler & Elmesky, 2007; Yosso, 2005). With the vast majority of educators being White, teachers must become a part of their students' communities to understand how to connect home life to educational aspects of learning. By using critical

approaches and being sensitive to the fact that we all have different backgrounds and perspectives, students can easily connect engineering to their own personal lives and see how they can use it to improve their communities (Atwater, 2000; Yosso, 2005; Seiler & Elmesky, 2007).

Although these girls were able to come to the program, *the critique of liberalism* demonstrates that these programs neglect to acknowledge how the structure of the camp itself precludes target populations from participating. STEM programming has a stated interest in combating negative stereotypes that girls and minorities may develop regarding their experiences in STEM fields with hopes of addressing issues such as ability, confidence, and belonging (Ireland et al., 2018). Although an increasing body of literature focuses on informal education, these studies ignore ease of access related to location, travel time, transportation, and costs (Bullock, 2017). Informal programs typically target students from middle- and high-socioeconomic backgrounds and enroll on a first-come-first-served basis. Studies suggest that community collaborations between universities, schools, and neighborhoods would broaden participation (Burrows, Lockwood, Broroczah, Janak, & Barber, 2018). Furthermore, while the programs that should be leading these efforts often have an explicit mission to target specific populations, they lack the resources needed to recruit these participants because of the small amount of staff members they have.

Protective Factors and Resiliency among Black Girls

The Black girls in this study coped with adversity through resilience and other protective factors that helped them mitigate stressful encounters during their *Intersectional* experiences. Similar to the research of Black women engineers, being *silenced and marginalized* leads to isolation as these women use ideals such as girl power as a collective

body or affirming themselves through resiliency, growth in performance, and recognition to overcome challenges in engineering.

Highlighting the voices of Black girls allows them share how their gendered racial identity aids them in overcoming opposition. Morton & Parsons (2018) share how the *Intersectional* aspects of Black women's experiences in STEM contribute to empowerment as well as isolation. Like the women in this study, instead of assimilating, the girls with strong racial and gender pride in the camp found ways to adapt themselves in the engineering environment to succeed. As research has shown that resiliency is rooted in mentorship, role models serve as a way to build strong reflective identity in engineering (Collins et al., 2019; Joseph et al., 2017). Along with this, critical consciousness and culturally relevant teaching in engineering can advance understanding and interests as Black girls see connections and commitment to their own communities through activity development (King & Pringle, 2018). These efforts along with community-based informal opportunities can shift self-perception in engineering (Scott & White, 2013). Developing resiliency along with gendered racial pride as a protective factor can directly contribute to positive achievement beliefs (Butler-Barnes, Williams, Leath, Byrd, Carter & Chavous, 2018). Therefore, Black girls for whom racial identity is highly salient have a better chance at succeeding academically in positive educational climates because of their motivation (Neblett, Philip, Cogburn, & Sellers, 2006). Moreover, research has not yet sufficiently considered how gendered racial identity may influence motivation in engineering education at the K-12 level.

Although I have shared that resiliency was a positive way to navigate the camp, this also encouraged girls to cope through *avoidance* and tolerating disrespect, responses that have been interpreted as negative ways to deal with opposition (Joseph et al., 2017). For

Black girls, these responses can have negative effects on their mental and physical health as they try to overcome perceptions that they are not good enough. Just as some girls were focused on winning challenges, the more resilient response to strive for success and assert strong identities has been recognized as a potential stressor (Evans-Winters, 2014). This stress can deter girls from engineering or any of their interests because they tend to overwork themselves. In this way, the strength of resiliency can become a weakness. Reflecting on the *myth of meritocracy* that success is gained through individual hard work (McNamee & Miller, 2009), once they realize that the effects are detrimental they may decide to continue on which can lead to false hopes about what is possible, or they may leave the field and pick another interest where they feel more supported.

Furthermore, some fail to acknowledge racial and gender bias in learning to navigate fields like engineering where Black girls are underrepresented. As **c**olorblind perceptions influence girls' identity development, it is important to note that race or gender should not preclude you from certain opportunities. However, r*acial permanence* shows us that within today's society, racism and sexism and are guiding factors for hiring practices which shortchanges people with these underrepresented identities, especially Black girls and women. As these girls have positive perceptions about acceptance, their viewpoints can also contribute to culture shock in spaces where they are overtly judged and dismissed because of their race and gender (Johnson, 2011). Homogeneity invalidates individuals' culture, lived experiences, and identities. It also perpetuates the *myth of meritocracy* in that believing everyone is equal and that we can all succeed through hard work neglects how other factors such as privilege, class, gender, or race influence opportunity and achievement. This phenomenon is one that has occurred for many women and Black students that enter the field

of engineering in predominately White settings as their ability to succeed is challenged by White classmates. Black girls have learned to survive by constructing a “race-less” identity and refusing to adopt certain characteristics that are associated with Black girls while assimilating to majority culture or becoming invisible. It is far better for girls to recognize that valuing differences among all individuals can help us learn from one another as diversity enhances innovation. Furthermore, having a colorblind ideology can lead Black girls to infer that their racial identity is disgraceful and dissuade them from accepting their racial backgrounds.

Limitations

This study set out to impact the interdisciplinary field of research regarding Black girls in engineering education contexts, and my analysis revealed several critical factors that impact Black girls’ experiences and deserve more sustained scholarly attention. However, I also acknowledge several limitations in this research design that impact broad generalizability of the results. In future research the following areas could be addressed to improve this research:

1. Small sample size. In order to obtain rich data for this study, qualitative methods were used. Although this can be viewed as a limitation, having fewer participants allowed me to focus deeply on all of the girls in the study and develop a rich understanding of their experience compared to spending a short amount of time with more participants. By collecting data about each girl for at least six hours and through triangulation, data saturation occurred through thematic analysis. In future research studies, I plan to expand my sample size and age ranges of participants to look more deeply at the experiences of Black adolescents in various grade levels such as middle school and high school. Additionally, in

an effort to examine more informal experiences of Black girls, I can look at their experiences in predominately Black settings.

2. Convenience sample and SES variation. The participants were selected based on who enrolled in the camp. Using the demographics of the last five years of camp registration, the sample size utilized in the qualitative data analyses was small. The convenience sample also allowed for students to self-select and participants came from particular backgrounds that were aware of the program. Most of the girls came from higher SES backgrounds, thus, not much can be determined regarding Black girls from low SES backgrounds and how they would perceive engineering in informal settings. Recruitment efforts for future studies should be expanded to reach low SES participants so we can understand their experiences. Additionally, I could target a camp that is low-cost or no-cost and is focused on reaching Black and Brown girls.

3. Study completion. This study had multiple parts (e.g., daily diary, semi-structured interviews, self-expressive art, engineering design products, etc.). Therefore, it was hard to get every initial participant to complete the study in its entirety. To assist with collecting data and retaining participants, future efforts in this area should utilize a larger research team and offer more incentive to encourage girls to complete the interviews and art. The financial incentive of $25 that I offered in this study was good, but may not have been enough to encourage everyone to complete the study.

4. Length of the camp. The camp also occurred over a week; this may not have been enough time to truly study identity development. Also, I was not able to control who attended camp each day although none of the girls missed a day. Ideally, within the study, all the girls would attend camp and participate in every session each day.

5. Teacher team leads and undergraduate counselors that interact with the participants of the study and other campers are selected by the Explore Engineering staff. With that being said, even within interviewing it is hard to recognize biases that these teachers and counselors may have held regarding the Black girls that were in the camp. These biases may or may not account for how the girls interpreted their experiences.

6. Researcher's Relationship. As the researcher and assistant camp coordinator, I had a strong relationship with various members of the staff such as the teacher team leads, the undergraduate counselors, parents, girls, coordinator, and the director of the program. The girls and staff members were aware of my role and that the details shared would be used for my dissertation, thus, they may have been apprehensive to share certain details with me about their feelings toward the program. On the other hand, my relationship and rapport with the girls in this study may have contributed to an increased sense of trust and encouraged them to be more open with me about their experiences of the program. In any case, my role as participant-observer necessarily influenced to some extent the data that were collected through interviews.

Implications for Future Research

Without addressing the issues within engineering and STEM education with a CRT and BFT lens, the field may be equal, but equity will never be reached. Previous literature has shown that the lived experiences of Black girls in engineering and STEM contexts are greatly influenced by their identity development. Future research should investigate: *(1) intersectionality and its influence on engineering identity, (2) pre-adolescent identity development among Black girls, (3) the influence of informal engineering experiences in*

predominately Black and rural settings, and (4) the use of mixed methodologies in Black girl studies.

Intersectionality and its Influence on Engineering Identity

Through the examination of prior research, we know there are few studies regarding intersectional identities in relation to Black girls persisting in engineering compared to studies that focus on science education. With the steady increase of engineering and other STEM-related opportunities in the workforce, and knowing that race and gender have a convergent effect on career advancement, examining constructs like racial identity, gendered identity, and class can aid in revealing how systemic factors contribute to poor outcomes and address the invisibility of Black girls and Black women in this field. Studies rarely discuss race, racism, and systems of oppression that lead to low STEM persistence for this population. Especially with many Black girls having lower mathematics self-efficacy, which is necessary for engineering pursuits, studies push for culturally- and content-competent teachers in the classroom. Few studies address unequal resources for STEM in schools, deficit perceptions that teachers may have regarding Black girls, the lack of science and engineering curriculum being taught, and the psychological factors that contribute to inequitable practices. Moreover, utilizing frameworks like CRT and BFT when understanding engineering identity will allow us to address inequities within engineering talent development and interest that begin to develop at early ages. For example, gifted and high achieving Black students are more likely to pursue this area, but little is known about the effects that structural and contextual factors such as teachers, universities, and policies have on these outcomes. Thus, an in-depth look at how these multifaceted aspects of identity

contribute to development, interest, and pursuit of engineering can lead to more opportunities for Black girls.

Pre-Adolescent Identity Development

For the Black girls in the study, different aspects of their identity were more salient such as their gender, race, mathematics identity, engineering identity, etc. Additionally, for some girls, colorblind ideologies allowed them to disassociate dominant racial views from their influence on outcomes. For each girl their personal identity development can have positive or negative effects on the interactions they have with others. When faced with opposition, the girls in the study began to work harder and pushed to prove others wrong about their own abilities. Engaging in these coping mechanisms can lead to negatives effects on the mental health of Black girls, therefore we must attend to the mental health needs that arise from navigating Black girls' identities in predominantly White spaces. When racial realities are not confronted or recognized, this can have devastating effects on Black girls in different settings such as college or the workplace where race still defines access and opportunity. With a range of factors that influence identity such as social media, video sharing services, applications, and books, exploring pre-adolescent identity development among Black girls could help us understand how multiple identities contribute to life decisions and reveal how to improve interactions that contribute to development at home and in schools.

Informal Engineering in Predominately Black and Rural Settings

The current study focused on Black girls in a predominately White setting and many of them were from middle- or high-SES backgrounds. Because Collins (2018) states that reflective identity in STEM settings encourages Black students to pursue this field, it is vital

that we explore the informal engineering experiences of Black girls in predominately Black and rural settings. In some cases, these year-long programs also enroll more students from low-SES backgrounds and do not have a cost for participation, like #BlackGirlsCode. Because these programs are often more culturally conscious and relevant, provide access to girls from areas with limited resources, and include many participants that go on to pursue the fields of engineering and technology, investigating these programs could provide guidance for other informal programs and educators that are looking to meet the needs of Black girls from various backgrounds.

Using Mixed Methodologies

Using a mixed-methods approach can expand our understanding of how these girls persist as they inhabit multiple intersecting identities in our society. Through the use of a CRT framework with an intersectional lens, we can make meaning of psychological constructs involving identity. This will allow an in-depth construction of knowledge and challenge power systems articulated in CRT when one methodology may be limited. Mixed-method approaches allow the researcher to collect, analyze, and integrate quantitative and qualitative data and can be used to address issues of power (Creswell & Clark, 2017; DeCuir-Gunby & Schutz, 2017). In future research that examines Black girls in engineering, qualitative researchers should try to recruit larger samples of African American girls to assist with the validity of generalizations in coding (Strauss & Corbin, 1990) and work to triangulate results with other forms of data such as counter stories, student artifacts, or field notes (Golafshani, 2003). Quantitative data collection should consider racial identity measures along with efficacy, engineering identity, and mathematics identity to examine correlations and relationships that may arise in Black girls' experiences in science and

engineering as they pertain to their identities in the applied education setting (Cohen, 1988; Gliner, Morgan, & Leech, 2011) or use regressions to make predictions regarding outcomes (Hayes & Darlington, 2017). These methods as well as narrative exploration and statistical analyses could help us understand the quality of Black girls' experiences in more depth. Implications should guide researchers in improving our understanding of how Black girls are influenced by engineering education. Furthermore, by leveraging research and applying it to practical application among families, higher education outreach programs and departments, educator preparation and development, and policy, we can improve educational outcomes for Black girls and other underrepresented populations.

Recommendations

Recommendations for Black Girls and Parents

There is growing need for parents to be advocates for their children regarding STEM education, especially for Black girls who are interested in engineering. To ensure that Black girls maintain interest in the topic, parents must continue to use racial pride at home as way to build confidence and allow girls to see the possibilities they can have in STEM-related fields. Racial pride can help children from underrepresented groups resist negative stereotypes and messages that make Black girls feel that they are "nerdy" because of their STEM interests. Moreover, understanding how racial identity, gender identity, other identities, and their intersections influence girls in informal settings is important so parents can discuss and instill values that their girls can use to navigate these spaces when they are the only one. For parents that are seeking to encourage girls at home, using books that showcase Black girls and Black women in STEM, completing engineering projects at home, and talking about real world application of engineering concepts will allow girls to build

strong reflective identities to make them feel like they can be engineers. Seeking support from community organizations, museums, and programs that recognize the needs of Black girls in engineering and provide networks of Black women STEM mentors can also lead to positive racial identity, engineering identity, and STEM self-efficacy, when facing the challenge of being the only Black girl in predominately White environments.

Recommendations for Informal Outreach Programs and Engineering Departments

Researchers, teachers, and practitioners alike must challenge oppressive structures and resource gaps that fail to support Black girls in informal engineering education contexts. Many informal engineering education programs exist within predominately White institutions. With there being a need to provide more opportunities in this area to Black girls, Latinx, and Native American populations along with other underserved populations, we must address the constructs in the U.S. system that prevent these populations from gaining access to these opportunities (Simpson & Parsons, 2009). With this recommendation, I will highlight some of the suggestions that were provided by the participants in the study. First and foremost, these programs have embedded access issues such as affordability, transportation, and scheduling limits, as well as uneven distribution of information about the program to certain populations and not others. Attendees of these camps typically come from higher socioeconomic backgrounds and have parents or guardians that attended college and have a STEM degree. Thus, to provide more access to Black girls, there should be a larger focus on obtaining grants to offset programmatic costs, which can lead to more financial assistance. Camp organizers should consider scheduling camps to begin before and end after normal workday hours to assist with transportation needs of participants or provide transportation support. For recruitment efforts, program should be advertised in schools that

are Title I, rural, and have higher populations of underrepresented students, and with community organizations such as churches and recreation centers. If informal camps provide year-round programs, these schools should be targeted to increase interest in summer camp and engineering. Additionally, awareness of intersectional identity and the double bind of oppression, as well as how racism, sexism, and classism influence the underrepresented students' experiences in these settings will help us provide the best environment for these children. Providing training to staff members and increasing the number of staff role models from underrepresented groups can lead to more culturally conscious curricula within the programs. Lastly, as these programs are housed within departments of engineering and with K-12 outreach programs receiving less funding and support, educators and administrators in higher education should provide more assistance and manpower for outreach in order to meet the needs of more students and diversify the field.

Recommendations for Educators and Teacher Preparation Programs

Current and prospective educators must focus on how to address deficit ideologies in science and math education, utilize critical discourse integration in engineering education, confront personal biases against Black girls, and provide equitable opportunities for students in STEM education at the K-12 level. Equity in education begins with teacher preparation programs and professional development. With the majority of teachers being White and female, it is imperative that teachers feel confident about their own science and mathematics abilities when translating knowledge to girls. If teachers are not confident in the subject matter, it will be difficult for girls to believe that they are capable of achieving in those areas when they see teachers as role models. Thus, better training and resources regarding engineering education, STEM integration, understanding of the pedagogy and content

knowledge is vital for Black girls in classrooms. Moreover, predominately Black schools should be provided more funding and access to STEM courses, science equipment, and field trips, in addition to increasing representation of Black girls in advanced science and mathematics courses. As we look to build students' self-efficacy in this area, schools still emphasize achievement and not failing, which is a focus in engineering. Teachers should also encourage students that making mistakes is a part of the journey towards success; mistakes are proof that you are trying. Along with this, we must strive to understand the psychological factors that influence Black girls and encourage teachers to pay attention to how these factors and pedagogical practices affect students' identity and self-efficacy. Deficit ideologies and biases that teachers have about Black girls and their abilities can be detrimental to these girls' development. By adapting instruction to meet the learning needs of Black girls that are placed at risk for failure in science and mathematics, teachers can provide equitable experiences that can lead to higher achievement, positive identity, and greater self-efficacy.

Within the current K-12 curriculum, engineering is not a main content area, integrating engineering content and creating clubs at school to increase exposure to the field can increase interest among Black girls. For example, using an integrated content approach, students reading about water access can discuss scientific properties of water as they design an infrastructure to transport water to multiple areas of a city, complete calculations related to the budget that is feasible for parts and gallons of water, and then discuss how water crisis can lead to scarcity in a community. This will allow teachers to connect content to English language arts, mathematics, science, and social studies. Teachers with broad content knowledge will have more opportunities to deliver innovative instruction to students in formats such as inquiry-based learning, interactive notebooks, and hands-on experiments and

engineering challenges; rather than focusing on learning only the content that will be tested. As we continue to acknowledge the inequity in K-12 education, we must challenge curricula that cater to Whiteness and use culturally-relevant techniques in the classroom that can assist all students. Without doing so, there cannot be a direct push to increase the number of Black women in the field of engineering because they may not learn about the topic early enough.

Recommendations for Policymakers

Policymakers must address the invisibility of Black girls, engineering education, and oppressive systems that limit educational opportunities. Current policies neglect to focus on Black girls, engineering education, and acknowledging the oppressive systems in formal and informal settings based on race, gender, and class. More initiatives should be created to focus on the needs of Black girls, as they are doubly oppressed based on race and gender and impacted by deficit ideologies that interfere with their success. Additionally, policymakers should look to expand educational standards and funding for schools to include engineering, not only science, as an integral part of the K-12 curriculum. By partnering with higher education institutions, a broader group of students can be reached, funding, and resources can be maximized so that new innovative techniques can be shared with schools and other informal settings.

Significance and Broader Impacts of the Study

This study focused on a topic that is typically only explored among African American collegiate women in STEM (Buck, Cook, Quigley, Prince, Lucas, 2014). Through this study, I explored how African American girls in informal engineering learning environments view engineering as relevant to their lives and communities. There are racial, social, and economic barriers to Black girls accessing STEM which in turn impact the development of their racial

identity, gender identity, engineering identity, and the intersections of these (Ireland et al., 2018). Thus, structural barriers lead to unequal resources for informal education and a deficit orientation toward the abilities of Black girls in STEM (Simpson & Parsons, 2007). This system contributes to how African American girls achieve and perceive themselves in STEM education (Ireland et al., 2018). There is an urgent need to address these issues in and outside of the classroom to increase STEM pursuits (King & Pringle, 2017). Using a mini-ethnographic case study approach allowed me to expand the narrative around the current findings regarding intersectionality, racial identity, engineering identity, and STEM self-efficacy for young Black girls. Furthermore, in many aspects of this research area, racial identity and intersectionality are the main constructs that are omitted or ignored, and researchers do not often discuss how race and systems of oppression result in limited opportunities for African Americans, especially Black girls. Understanding the informal experiences of Black girls as well as how they perceive their interactions with others in these settings can guide us toward improving and expanding programs in all settings. Results provided a better understanding of the critical role that racial identity, engineering identity, and self-efficacy play in engineering education. Through a critical race analysis of informal engineering education, this work will inform the development of new pedagogical tools to provide equitable opportunities for Black girls, thus creating bridges and challenging barriers to more advanced engineering innovations that consider race and gender as we build and diversify the of Black women engineers and the STEM pipeline.

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APPENDICES

Appendix A

Middle School Summer Engineering Day Camp Agenda

	Monday	Tuesday	Wednesday	Thursday	Friday	Time
8:45-9:00	Drop Off *(Bass Hall)*	Drop Off *(Bass Hall)*	Drop Off *(Bass Hall)*	Drop Off *(Bass Hall)*	Drop Off *(Bass Hall)*	8:45-9:00
9:00-9:15	Camp Introduction	Challenge Introduction	Challenge Introduction	Challenge Introduction	Challenge Introduction	9:00-9:15
9:15-9:30		Challenge: Heartache	Challenge: Pipeline Construction	Challenge: Fabric Contraption	Redesign: Fabric Bucket/General Improvements	9:15-9:30
9:30-9:45	*What Do You Do With An Idea?*					9:30-9:45
9:45-10:00	Teacher Group Introduction/Activity					9:45-10:00
10:00-10:15						10:00-10:15
10:15-10:30						10:15-10:30
10:30-10:45						10:30-10:45
10:45-11:00	Fire Drill/Walk to Dining Hall	Walk to Dining Hall				10:45-11:00
11:00-11:15	Lunch	Lunch	Lunch	Lunch	Lunch	11:00-11:15
11:15-11:30						11:15-11:30
11:30-11:45	Walk to Outdoor Area					11:30-11:45
11:45-12:00	Outdoor Time ***Kickball***	Outdoor Time ***Dodgeball***	Outdoor Time ***Wiffle Ball and Bubbles***	Outdoor Time ***Ultimate Frisbee***	Outdoor Time *Free Day/* Surveys	11:45-12:00
12:00-12:15	Challenge Introduction		Challenge Introduction	Challenge Introduction		12:00-12:15
12:15-12:30	Challenge: Straw Construction	Challenge Introduction	Challenge: Water Consumption	Challenge: Water Filter		12:15-12:30
12:30-12:45		Discovery: Polymer Process				12:30-12:45
12:45-1:00					Set Up for Exhibitions/ Week Reflection (Breakout Rooms)	12:45-1:00
1:00-1:15	Balsa building and initial test	Challenge Introduction				1:00-1:15
1:15-1:30		Challenge: Polymer Process			Walk to Bass Hall	1:15-1:30
1:30-1:45	Challenge Introduction			Challenge Introduction	Closing Presentation *(Bass Hall)*	1:30-1:45
1:45-2:00	Challenge: Balsa Wood Gliders		Challenge Introduction	Redesign: Pipeline Construction		1:45-2:00
2:00-2:15		Test Polymer Process	Redesign: Balsa Wood Gliders		Walk to Main Building or Outdoor Area	2:00-2:15
2:15-2:30					Exhibitions/ Competititions *(Bass Hall and Outdoor Area)*	2:15-2:30
2:30-2:45						2:30-2:45
2:45-3:00	Daily Closing Meeting	Daily Closing Meeting	Daily Closing Meeting	Daily Closing Meeting		2:45-3:00
3:00-3:15					Final Results *(Bass Hall)*	3:00-3:15
3:15-3:30	Depart *(Main Building)*	Depart *(Main Building)*	Depart *(Main Building)*	Depart *(Main Building)*	Depart *(Main Building)*	3:15-3:30
3:30-3:45	Pick Up *(Bass Hall)*	Pick Up *(Bass Hall)*	Pick Up *(Bass Hall)*	Pick Up *(Bass Hall)*	Pick Up *(Bass Hall)*	3:30-3:45
3:50-4:30	Team Meeting	Team Meeting	Team Meeting	Team Meeting	Team Meeting	3:50-4:30

Appendix B

Engineering Challenge Guides

Challenge Guide: Straw Construction

Scenario

The Head Engineer of your company has called in sick. They have drawn a design for a new building that has already been approved and you need to build the model before they get back. Because they cannot be at work, the head engineer must talk you through the design they have drawn in order to finish the model.

Engineering Grand Challenge: Engineer the Tools of Scientific Discovery

Tools

- Scissors
- Pen
- Paper

Materials

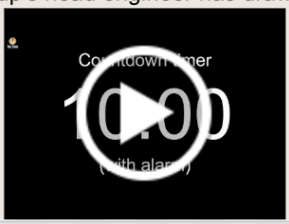
- Bendy Straws (multicolored) (10 per person)
- Rubber Bands (5 per person)
- Paper Clips (5 per person)

Constraints

1. No one besides the Head Engineer may see the pre-made structures.
2. Builders may not see what the Head Engineer has drawn and they must build the structure solely by communicating with the Head Engineer.
3. No one may touch the construction materials besides the Builders.
4. The same structure cannot be made multiple times.

Testing Rubric

1. Groups will decide which of the structures gets presented.
2. The structure that most closely resembles what that group's head engineer has drawn is the winner



Challenge Guide: Polymer Process Discovery

Scenario

A hurricane came through the city. A company needs your creative expertise as a chemical engineer to design three polymers, which are a material made of many repeating units, for various uses, that is not toxic to consumers. Design one polymer to stretch along the base of a door, one to stop a leak in a pipe, and one to patch a crack in the wall.

Tools

- Cups
- Spoons
- Ziploc Bags
- Paper Bowls
- Gloves

Materials

- Elmer's Glue (3 cups)
- Borax Powder (1 cup)
(half of the bag)
- Water (1 cup)
- Laundry Detergent (1 cup)
- Dish Soap (3 cups)
- Liquid Starch (1 cup)
- Cornstarch (1 cup)

Product Formulation

Each team will receive an ingredient list from which the polymer must be formulated.

Procedure

1. Based on the initial process, change one variable to determine how it impacts the final product.
2. Record your results and your process so that the information can be shared with other groups.
3. Continue formulating new processes until you have a solid understanding of the impact of each component.

Challenge Guide: Polymer Process Challenge (carbon)

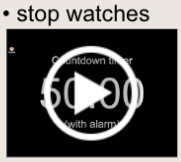
Scenario

The company has now asked your engineering team to utilize your knowledge of the polymer-making process to create final products that address the problems the company is facing.

Engineering Grand Challenge: Develop Carbon Sequestration Methods

Tools

- Paper Bowls
- Gloves
- Rulers
- stop watches



Materials

- Borax Powder (1 cup)
- Water (1 cup)
- Elmer's Glue (3 cups)
- Dish Soap (3 cups)
- Liquid Starch (1 cup)
- Laundry Detergent (1 cup)
- Corn Starch (1 cup)
- Waste Container

Constraints

1. Polymer must be the only component of your final product.
2. Each problem must be addressed with a different polymer
3. If a polymer is tested for a specification and fails, the test may be performed again with a new polymer up to three times.

Specifications

1. Polymer Stickiness Test
   a. Many consumers want a product that can hang pictures and other memorabilia without damaging the walls or the memorabilia.
2. Polymer Stretch Test
   a. The company wants to ensure their product maintains its quality even when encountering various forces.
3. Leakproof Polymer Test
   a. The company needs a product that will repair pipes and drains without causing additional leaks.

Challenge Guide: Heartache

Scenario

As doctors begin to see more and more clogged arteries in their operating rooms, they need an alternative to bypass surgery. As a biomedical engineer, you are tasked with making a device that will clear clogged arteries without having to perform an invasive bypass surgery.

Engineering Grand Challenge: Engineer Better Medicines

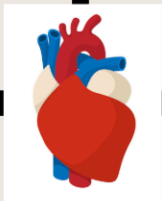
Tools

- Scissors
- Clogged Arteries
- Funnel

airpump

Materials

- Clown Balloons (1)
- Straws (2)
- Paper Clips (3)
- Rubber Bands (5)
- String (1 ft.)
- Pipe Cleaner (2)
- Wire (6")
- Craft Sticks (2)



Constraints

1. Device can be operated by more than one team member.
2. Team members cannot put any of their fingers or other body parts in the artery.
3. Once device has entered the artery it cannot be **removed** until the end of the procedure
4. The artery clearing procedure should last no more 2 minutes.
5. The device must work for 1 test.
6. Team leads or UCs will be responsible for pouring water through the artery.

Testing Rubric

1. Campers will test the time it takes for 2 liters of water to passed through the clogged artery.
2. Campers will then test the time it takes for the same amount of water to pass through the cleared artery.
3. Success will be based on your **% Decrease in time**:
   a. (Initial time-final time)/(initial time) x 100%
4. Each team will perform the procedure once.

Challenge Guide: Fuel-Less Flight

Scenario

An airline company has come to your team of aerospace engineers seeking a way to reduce fuel usage during commercial flights. They need to create a design that will allow for the engines to be turned off as the aircraft glides through the air. Create a glider that will travel the greatest distance.

Engineering Grand Challenge: Develop Carbon Sequestration Method and Manage the Nitrogen Cycle

Tools

- Scissors
- Hot Glue Gun
- Box Cutter
- Measuring Tape
- Ruler

Materials

- Balsa Wood Planes (2)
- Masking Tape (1 foot)
- Cardboard (6”x6”)
- Washers (5)
- Craft Sticks (5)
- Construction Paper (1)

Constraints

1. A group member will launch each glider.
2. The original balsa wood plane must be incorporated into the design.

Safety

1. Any cutting of the balsa wood must be performed by a UC or team lead.

Testing Rubric

1. Each group will choose a group member to toss the glider. Distance will be where the glider first hits the ground.
2. After modifications have been made, the group will launch their new glider.
3. Finals scores will be determined by the following: (modified distance-initial distance)/initial distance

Challenge Guide: Pipeline Construction

Scenario

Working with an interdisciplinary group of policymakers, lobbyists, scientists and engineers, you need to determine the most environmentally friendly path for the Atlantic Coast Pipeline. First, you must find a way to connect the pipeline itself.

Engineering Grand Challenge: Provide Access to Clean Water and Restore and Improve Urban Infrastructure

Tools

- Scissors
- Water Mats
- Duct Tape
- Large Bins
- Water
- Syringe
- Luer Lock (1)
- Funnels
- Scales

Materials

- Plastic Tubing (4)
- Masking Tape (3 ft)
- Sculpey Clay (50 g)
- Hot Glue (2x 3 min. trips)
- Craft Sticks (4)
- Pipe Cleaners (4)

Constraints

1. **Each pipeline may only use one connecting material**: masking tape, hot glue, sculpey clay
2. All pieces of pipe must be used.

Testing Rubric

1. 2 ounces of water will be sent through the piping with a syringe. The winning team will have transported the most water, by volume, without any leaks.
   a. Judge by the amount of water successfully transported (percent transported).
2. If every team's pipeline leaks, then the team with the greatest percentage of water transported wins.

Challenge Guide: Water Consumption

Scenario

As the city continues to grow rapidly, there will not be adequate infrastructure to meet the demand for water in the County. As a civil engineer, you are tasked with planning and implementing an entirely new water infrastructure system to ensure adequate water is supplied to the entire county.

Engineering Grand Challenge: Restore and Improve Urban Infrastructure and Provide Access to Clean Water

Tools

- Clear Tape
- Scissors
- Ruler
- Money

Materials

- String
- Toothpicks
- Washers
- Map/Styrofoam board

Constraints

1. The county has allocated your engineering firm a budget of $15,000
2. Water Treatment Facility (toothpick)= $1,500
3. 1 km of Piping (3 cm of string) = $250
4. 1 Million Gallons of Treated Water (Washer)= $750
5. Water Treatment Facilities have no limit on the amount of water they can treat.

Testing Rubric

1. Teams will be judged based on the number of gallons supplied
2. Ratio used to determine score (the biggest ratio wins):

   Demand Satisfied (in millions)/Total Cost (in thousands)

Challenge Guide: Water Filtration System

Scenario

While on a camping trip, your water filter breaks and you are at least a three day hike from the nearest camp outpost. Using only the materials that you brought with you, design a new water filter that will clean water found in a lake.

Engineering Grand Challenge: Manage the Nitrogen Cycle and Provide Access to Clean Water

Tools

- Scissors

Materials

- Water bottle (1)
- Mesh Screen (4”x2”)
- Foam (1)
- Cardboard (6”x6”)
- Fabric (4”x4”)
- Sand (½ cup)
- Hair-ties (2)
- Duct Tape (6”)

Constraints

1. The filter must be able to clean 1 cup of lake water with the given materials.
2. Water will be added to the filter by the UC, while one team member holds the filter.

Testing Rubric

1. Each group will use their filter to clean 1 cup of lake water in **2 minutes**.
2. The quality of the filter will be based on the following criteria **in order of importance**:
   a. Clarity and overall quality of the water (Compare to samples for scoring) (Up to **5** points)
   b. Amount of water recovered (oz) (All the water is worth **3** points)
   c. Amount of time it takes to filter the water (s) (Tiebreaker)

Challenge Guide: Fabric Contraption

Scenario

A solution to the water shortage problem in many areas is to build communal wells. Unfortunately these wells are often far from homes, requiring long journeys with heavy water containment devices that ultimately end with contaminated water. Your task is to construct a lightweight, clean water containment device that could provide a solution to this important issue.

Engineering Grand Challenge: Provide Access to Clean Water

Tools

- Scissors
- Funnel
- Tubs of water
- Scales
- Measuring Cups

Materials

- Ripstop Nylon Fabric (18”x18”)
- Yarn (2 feet)
- Cardboard (12”x12”)
- Construction Paper (1)
- Straws (2)
- Reuse Material (2)
- Duct Tape (2 feet)

Constraints

1. **All of the ripstop nylon fabric must be used.**
2. **No Boxes, Bags, Bowls, or Bups!**
3. The device must be able to hold 1 liter of water and not spill the water.
4. Two team members may fill their water containment device, the third member will be responsible for walking the device the required distance.

Testing Rubric

1. The mass of the device will be recorded prior to testing.
2. Campers will add 1 liter of water to the device in a slow and controlled fashion.
3. A team member must walk their contraption a distance of 25 ft and back in less than 120 seconds. The amount of remaining water will be measured after your trial.
4. In the case of multiple groups completing the task, the tiebreaker will be the device with the lowest original mass

Appendix C

Demographics/Background Questions

1. Tell me a little bit about yourself ?
    a. How old are you?
    b. What grade are you in?
    c. What school do you attend?
    d. How do you feel about your ability to do math and science?
    e. Do you participate in any clubs or sports?
    f. Is anyone in your family an engineer?
    g. What does Black girl magic mean to you?
2. What made you enroll in the engineering summer camp?
    a. How many years have you been at this camp?
    b. What excites you about the camp? What are you worried about?
3. Have you participated in any other informal (outside of school) experiences?
4. What do you want to be when you grow up?

Appendix D

Daily Dairy Protocol for African American Adolescent Girls

1. Tell me about your experience at camp today? What did you enjoy and why? What did you not enjoy? (i.e. schedule, challenges, counselors)
2. What did you learn about engineering today?
3. Is there anything else you would like to add?

Appendix E

Interview Protocol for African American Adolescent Girls

1. Tell me a little bit about yourself.
    a. How old are you?
    b. What grade are you in?
    c. What school do you attend?
    d. How do you feel about your ability to do math and science?
    e. Do you participate in any clubs or sports?
    f. Is anyone in your family an engineer?
2. Have you participated in any other informal (outside of school) experiences?
3. What do you want to be when you grow up?
4. When you think about science, technology, engineering, and mathematics, which topic is most appealing to you?
5. In your own words, what is an engineer?
6. What made you enroll in the engineering summer camp?
7. How many years have you been at this camp?
8. Tell me a little bit about your camp experience.
9. When you were in camp, were there things that you saw that encouraged you to be a Black girl in Science, Technology, Engineering and Mathematics?
10. After participating in camp, what STEM careers interest you?
11. During camp, was there a time that you thought you were not capable of being an engineer?
12. How did the competition influence your thoughts about engineering?

13. How did working with other boys/girls/races influence your thoughts about engineering?
14. Who did you feel more comfortable working with?
15. What are your thoughts on failure, is it okay to fail?
16. When did you feel the most successful/unsuccessful?
17. Take a look at your engineering design notebook, how did that guide your process as an engineer?
18. What engineering design project (show project pictures) did you enjoy the most, explain why?
19. Based on your experience in the program as an African American female, do you believe the activities relate to you and your community? Explain.
    a. Can these activities improve the world that you live in or your own community?
20. What types of activities were most appealing/least appealing?
21. What did you like about the camp and what changes would you make to the camp?
22. How is this engineering program different from STEM in school?
23. Do you believe the activities are designed for Black females and why?
24. What advice would you give to other Black girls that are considering coming to camp?
25. What are some of the barriers you faced as an African American female in the program? How did you address those challenges?

    What are some of the barriers that prevent Black girls from participating in STEM?

26. What are some of the bridges that helped you participate in the program?
27. What are some ways to encourage Black girls want to participate in STEM?
28. What does it mean to be a Black girl in today's society?
29. Does being a Black female influence how you think about STEM?
30. What do you think it would be like to be a Black female in a STEM career after camp? Why do you think so few Black women are in the STEM career field?
31. Are African American females capable of being engineers? Do you consider yourself to be someone that can be an engineer? What types of people are engineers?
32. Is there anything else that you'd like to add?

Appendix F

Interview Protocol for Engineering Camp Staff (Counselors and Teacher Team Leads)

1. What is your role as a camp counselor/teacher team lead/assistant counselor?
2. How is this engineering program different from STEM in school?
3. How many years of experience do you have teaching engineering?
4. How do you help facilitate learning during camp challenges? (i.e. using the engineering design process)
5. How do you engage campers in the engineering challenges?
6. What do you do to help campers cope with failure?
7. What was your goal when working with campers?
8. How did you facilitate healthy competition to influence thoughts about engineering?
9. How did you assist in influencing their engineering identity and STEM self-efficacy?
10. What advice would you give to other counselors that are considering working at the camp?
11. Do you believe that the girls have stronger beliefs about them being engineers and their STEM ability after participating?
12. How did you encourage collaboration with other boys/girls/races during challenges? Do you think these groups influenced beliefs about engineering?
13. Who did the Black girls feel more comfortable working with?
14. During camp, what experiences influenced the Black girls that participated?
15. Based on your experience in the program, do you believe the activities related to the Black girls and their communities? What types of activities were most appealing to them?

16. How do you think Black girls in the camp are influenced by being Black and females in STEM setting?
17. What are some of the barriers that the African American females in the program faced? How did they address those challenges? How did you facilitate this?
18. What improvements can the camp make to encourage more Black girls to participate?
19. How do you hope your role influenced the Black girls' racial identity, engineering identity and STEM self-efficacy?
20. Is there anything else that you'd like to add?

Appendix G

Interview Protocol for Engineering Camp Staff (Director and Coordinator)

1. What is your role as a camp director/coordinator and what are the goals of this camp?
2. In what ways do you want competition and failure to influence their thoughts about engineering?
3. How does the camp ensure that working with other boys/girls/races positively influences thoughts about engineering?
4. How do you think the girls engineering identity, racial identity, and STEM self-efficacy are influenced during camp?
5. How is this engineering program different from STEM in school?
6. What efforts does your program utilize to recruit Black girls to the camps?
7. What tactics do you use to retain Black girls in the camp from year to year?
8. How do you think Black girls in the camp are influenced by being Black and female in this STEM setting?
9. How does this camp hope to influence their STEM career interests as a Black girl?
10. What efforts do you take to make sure Black female undergraduate engineering role models or current Black women engineers can be seen by the Black girls that participate?
11. Do you believe the activities related to the Black girls and their communities?
12. What advice would you give to other Black girls that are considering coming to camp?
13. What are some of the barriers that the African American females in the program faced? How did you address those challenges?

14. What improvements can the camp make to encourage more Black girls to participate?

15. Is there anything else that you'd like to add?

Appendix H

Observation Protocol

Week:		Camper and Team:	Physical Characteristics (smell, sight, sounds):			
Date/Time Challenge	Teammates	Camper Engagement (Camper Interest)	Interaction (What happened?)	Engineering Notebook	Whiteboard Images	Engineering Design