Girls' Experiences with Gender-Inclusive Curriculum:
Effects on Perception, Confidence, and Belief in Ability to do Science

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Submitted in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
under the Executive Committee
of the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2021

ABSTRACT

Girls' Experiences with Gender-Inclusive Curriculum:
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This study explores how an afterschool science program for girls that uses a curriculum written by female scientists/science educators and highlights the contributions of women in science, technology, engineering, and mathematics (STEM) fields affects girls' perception of scientists, confidence in their science skills, belief in their ability to do science, and helps them construct a positive science identity. Using self-efficacy, identity, feminist, gender, and learning theories as theoretical frameworks, this study investigates how strengthening girls' belief in their ability to do science and confidence in their science skills and content knowledge can increase girls' curiosity and generate a sustained interest in science that may eventually lead to STEM degrees and careers later in life. By providing girls with hands-on science experiences that emphasize leadership, cooperative learning, critical thinking, and creativity, as well as female role models and stories of successful women in STEM fields, the study provides evidence of a successful intervention format that leads to a sustained interest in science both in and outside of school. Data were collected in this qualitative case study via a survey (with Likert scale and open-ended questions), an interview, and artifacts (student work), and analyzed using open and axial coding to look for themes in the data around participants' changing perceptions of science and scientists, increasing confidence in their science skills and content knowledge, enhanced belief in their ability to do science, and positive identity construction. The results of this study provide information about how to format a successful after-school program with a curriculum and methodology that nurtures learning, and by proxy, generates

greater achievement and participation in STEM among girls that could extend through secondary school and possibly into post-secondary education and career choices.

HYPOTHESISters was an afterschool STEAM program for upper elementary-aged girls (4^{th} and 5^{th} grades) based in West Harlem. The program was conducted on twelve consecutive Saturdays, for two hours per session, in the fall of 2019 (September 21^{st} through December 7^{th}) at The Forum at Columbia University. The curriculum, developed by the primary researcher in conjunction with another educator (Trisha Barton), consisted of one 12-lesson outer space-themed unit. The program participants consisted of twenty girls - ten 4^{th} grade girls and ten 5^{th} grade girls, between the ages of eight and ten. Most of the participants reside in West Harlem or the surrounding area. Except for four girls who identify as Caucasian, most identify themselves as members of communities of color, with seven participants being Latina, eight being Black or African American, and one being Asian (from India).

Table of Contents

LIST OF TABLES

LIST OF FIGURES

DEDICATION

To my mother, who instilled in me from a very young age the value of a good education and made me feel like I could do anything I put my mind to. I would never have made it as far as I have in academia or life without your guidance, support in every step of my educational and professional journey, and unwavering belief in my ability to succeed. This degree is as much yours as it is mine, and I am forever grateful for all of the sacrifices you made in your life to get me to this level of success. All of our hard work has paid off – we did it! I love you more than words could ever say.

To my godfather, Dr. M. Alfred Haynes, and my godmother Mrs. Hazel Haynes, the people who ignited my interest in science and demonstrated for me the rewards of working in service to others. I never would have seen myself as a doctor or an educator without your prominent examples of excellence in both these areas, your success in higher education, and your staunch commitment to bettering your communities and the world at large. Dr. Haynes, even though you are not here to see me reach this ultimate goal, I know that you have been watching over me, guiding me to the finish line. I am thankful every day that my mother chose you and Mrs. Haynes to be my godparents. I couldn't have asked for a better support system.

ACKNOWLEDGEMENTS

Thank you to my mother and father for supporting me throughout my academic and professional careers – I would not have made it this far without them. From helping me decorate my very first classroom (and each one after that) to helping me move across the country to embark on my doctoral journey, you have always been there to help me in any way you could. Mommy, thank you for keeping me focused when my resolve wavered, and I began to doubt myself. You have always helped me keep my eye on the prize and encouraged me to work hard for the things I am passionate about, no matter how hard things get or how insurmountable the obstacles may seem.

Thank you to my brother, Collin, my partner in crime. When I decided to uproot my life and move to New York to begin my doctoral program, I knew I could do it, because you had done it first. I watched you relocate and take your life in a different direction to make your dreams come true, and it inspired me to do the same. You have been a constant source of support and motivation for me throughout these five years, and I am so fortunate to always have you in my corner.

I thank my advisors Dr. Felicia Mensah and Dr. Christopher Emdin for the guidance and support they provided for me as I found my way through this journey. Dr. Emdin you taught me to think big, to believe in my capabilities, and to always be true to myself and the things that I am passionate about. Dr. Mensah, you have been my mentor and an exemplar of the kind of professional I want to be. You inspired me to focus on elementary science education when it wasn't even on my radar, and there I found a new home and a new drive to help teachers and students become better scientists. I am forever grateful for all of your help and handholding, and I know that you will make sure that I keep moving forward! I would also like to thank my committee members Dr. Victoria Marsick, Dr. Dirck Roosevelt, and Dr. Diane Jammula for their thoughtful questions and comments during my final oral defense.

I thank my friends Dora Kastel and Ava Javid for being a source of comfort and support throughout this doctoral journey. Dora, thank you for always being willing to talk through things, read my papers and listen to my presentations – your knowledge and astute observations were immensely helpful; and Ava, you are the best study buddy – always keeping me on track and providing an ear when I needed to vent. Thank you both for your friendship.

I thank my best friend Karla Saenz for venturing all the way to New York to see me, and for rooting me on when things got tough and I doubted myself. You are a true and loving friend.

Thank you Trisha Barton for helping me create HYPOTHESISters and for being such a wonderful colleague in general. I could not have completed this work without you working hard alongside me, sharing your wealth of knowledge and expertise.

Thank you to all the girls who participated in my study and their families for allowing me the privilege of working with your children. - RMR

Chapter I

INTRODUCTION

My Positionality

I am a black, female biologist, and middle school science teacher, and I decided to focus on a gender-inclusive curriculum due in part to my personal K-12 educational experiences and in part to my experiences teaching middle school science for over a decade. As a young girl, I loved learning and always knew that I excelled in the classroom. I thought of myself as a good student and felt that I fit in with everyone else in my classes.

I first experienced a shift in this thinking around the sixth grade when I had my first overt encounter with racism at the hands of a teacher. That was the first time I really started to think of myself as different from my peers, especially since I was the only black student in my class. From that point on, I was always on the lookout for racial discrimination from my teachers and school administrators. However, I failed to consider that I might face discrimination based on my gender as well. It was not until eighth grade, when I began to struggle with the mathematics, that gender became an additional factor coloring my experiences.

My eighth-grade math teacher recommended that I get a peer tutor who was doing well in math and gave me a few suggestions of other students I should work with who were doing exceptionally well in the class. All of her suggestions were boys. I found this odd because I knew for a fact that a girl had the highest grade in our math class, so I asked the teacher if she could be my tutor. My teacher condescendingly explained that one of the boys would be able to explain the math to me better because it "came more easily for them since boys are naturally good at math" and because "you're going to need a lot of help". Her comments definitely didn't make me feel good, but at the time, I brushed them off.

As a high school freshman, I distinctly remember that my earth/physical science teacher always called on the boys and let them lead our activities and discussions, often overlooking girls when they volunteered to answer questions or be leaders. It didn't even matter that girls had some of the highest grades in the class; he seemed to always defer to the boys. I found this disturbing because I sometimes noticed that the boys being held up as exemplars in the class did not have adequate content knowledge or great behavior. The teacher simply thought they knew more because they were boys.

As a science teacher, I found that if I was not paying particular attention to my teaching, I too enacted this biased behavior. Early in my career, I found myself overlooking girls' raised hands to call on the boys, but I believe for different reasons than my teachers in the past. I always assumed that girls were more studious and would ask for help or attention if they really needed it – an ideology that I quickly realized was false. It also seemed that many girls were not interested in science in middle school. I heard many of them say that they did not like science or that they thought it was too hard.

A few years into my teaching career, I was able to have a frank conversation with a group of seventh-grade girls that I had grown close. I asked them how they felt about science and they said that even though they did not think science was boring, they found it difficult sometimes and felt that it was "for boys". They also mentioned that they were better at other subjects and that their teachers and parents always encouraged them to read and write and do more artistic things, like dance, outside of school, but they never really focused on math and science. I found this to be upsetting, and it really made me focus on getting the girls in my classes interested in science and supporting them more, and I began to alter my teaching accordingly. I had to re-work the curriculum to include more women and refine labs and activities to make them more relatable to girls so that they could feel connected to the content. In the process of revamping my curriculum and methodology, I found that the boys in the class excelled and enjoyed the class more as well. That's when I realized, gender-inclusive curriculum and teaching methods are really just good teaching, plain and simple.

While earning my doctorate, I became aware of and began to examine my positionality as it related to my role as both a student and an educator. Realizing that positionality is the social and political context that creates your identity and that positionality describes how your identity influences and potentially biases your understanding of and outlook on the world (Stapleton, 2015), I was forced to reflect not only on my educational experiences with science but to also think about those of my students. Just like me, other women and girls' personal histories, experiences with social stereotyping, and control by authority shape their positionality (Teo, 2015), impacting their identity as females, as students, and as scientists. Thus, part of my mission as an educator is to construct alternative curriculum spaces that empower marginalized students (whether it be due to race, gender, or sexuality) to transcend perceived limitations and have a voice (Teo, 2015). By embracing feminist science education ideals in this manner, I believe that social change is possible through interrogating power inequalities and decentering science to balance out power (Roychoudhury, Tippins, & Nichols, 1995).

Underrepresentation of Women in STEM

Over the past 50 years, women in the United States have made great strides in education and entry into the workforce (Girl Scout Research Institute, 2012). However, despite these advances and the promise of jobs in science, technology, engineering, and math (STEM), women continue to be underrepresented in the STEM fields. STEM jobs are projected to increase at a rapid pace, and the United States will need to fill these jobs. Regardless of whether women are not being encouraged or nurtured to pursue STEM studies, or whether they are opting out of STEM education, the gender gap in the field does not bode well for the future. Although women are increasingly prominent in medicine (biological sciences) (Hill, Corbett, & St. Rose, 2010), their representation is low in other STEM areas at all levels of the STEM career pipeline, from interest starting at a young age to majoring in STEM fields in college to having a career in a STEM field in adulthood. As a result, few women are becoming scientists and engineers. In fact, according to Hill et al. (2010), women currently hold only one-quarter or fewer positions in engineering- and computer-related fields, even though some of the largest increases in future occupations are predicted to be in these two STEM areas.

What is Happening to the Girls?

Studies show that girls lose interest in math and science during upper elementary/middle school, and once their interest is lost, it does not appear that they ever completely bounce back (Barmby, Kind, Per, & Jones, 2008; Potvin & Hasni, 2014; Smith, Pasero, & McKenna, 2014; Unfried, Faber, & Wiebe, 2011). Even girls who excel in science and math in school often do not pursue careers in STEM fields. They are more likely to pursue degrees in the humanities, life sciences, and social sciences rather than math, computer science, engineering, or the physical sciences.

Declining interest in science. According to research, many students, particularly those disadvantaged by race, gender, and socioeconomic status, experience science as a subject that is boring, confusing, frustrating, and disconnected from their interests and experiences (Basu and Calabrese-Barton, 2007; King & Pringle, 2019; Mensah, 2013). Several reasons have been given for girls' declining interest in science and math, ranging from peer pressure to a lack of role models and support from parents and teachers, to a general misperception of what STEM careers look like in the real world (Choney, 2018). Beginning in middle school, girls display less confidence than boys in their math and science ability and develop the belief that they cannot pursue some occupations because they perceive them as inappropriate for their gender. For young girls of color, this equates to a loss of interest in science resulting in consistently low proficiency scores and ultimately leading to the exclusion of advanced science courses in high school and college (Pringle et al., 2012). It is also well-documented that gender differences exist in the value that women and men place on doing work that contributes to society, with women more likely than men to prefer work with a clear social purpose. Most people do not view STEM occupations (except for the biological sciences) as directly benefiting society or individuals and, therefore, STEM careers often do not appeal to women who place a high value on making a social contribution.

Societal Influence. Girls' perception of their ability to achieve in math and science is also influenced by outdated stereotypes and feelings of inadequacy in science and math (Carli et al., 2016). The subtleties of society and culture imply that girls are not good at or suited for math and science, and unconsciously discourage girls. Girls may be internalizing these stereotypes and talking themselves out of achieving in math and science when, in reality, they are doing just as well or better than boys in these content areas. These ideas are also perpetuated by parents and teachers, causing girls who are interested in STEM to feel unsupported in these subject areas. Compared with boys, girls with the same abilities are more likely to give up when the material is difficult and stop pursuing the field.

The Influence of Gender-Science Stereotypes. It is well known that most scientific fields (biological sciences begin the exception) are culturally gendered. Gender-science stereotypes are generally endorsed cultural beliefs that boys are naturally more talented in science than girls, and these beliefs are related to weaker science identification among girls (Steegh, Hoffler, Hoft, & Parchmann, 2020). These gender-science stereotypes negatively affect female students because they are associated with female science and mathematics achievement, predicting gender differences in science performance in favor of boys (Nosek et al., 2009). They also explain the gender gap in students' intentions to pursue science and mathematics careers. Women are generally thought to possess fewer of the qualities needed to be successful scientists, especially if they are more feminine in appearance (Miller, Nolla, Eagly, & Uttal, 2018). Additionally, according to Cheryan, Ziegler, Montoya, & Jiang (2017), a lower sense of belonging, lack of early hands-on experience with "hard science", and lower self-belief stemming from gender stereotypes are the main factors associated with low female participation in the sciences.

The Need for Gender-Inclusive Curriculum

The traditional science curriculum fails to reflect the experiences and contributions of women throughout history and in contemporary society. Often, the science that students are required to learn in school has little to do with who they are as people, especially for girls and people of color, and there are structural and institutional constraints that pose barriers to their successful participation in science (Brickhouse, 1994). Due to women's persistent underrepresentation in science careers, girls have been cited as a marginalized group in science education (National Science Foundation (NSF), 2015; NGSS Lead States, 2013). In response to this lack of representation, a variety of research-based best practices for supporting girls in STEM have been suggested, including instructional strategies that increase girl's achievement in science, the promotion of successful female role models in science, and afterschool and mentoring programs that encourage girls in science (Baker, 2013; NGSS Lead States, 2013; Scantlebury, 2014). All of these methods, as well as educators addressing their own gendered biases, are included in the gender-inclusive curriculum, which is designed so that: text, illustrations, and graphics emphasize historical and current inequities; culturally diverse role models, representing all expressions of gender identity, working in all disciplines and at all levels of science are promoted; emphasis is placed on diverse groups of people in positive and contributing roles across all disciplines; and varied assessments are implemented so that all students can be evaluated fairly in science (National Science Teaching Association (NSTA), n.d.). When these inclusive practices are put in place, science educators can capitalize on the rich and diverse strengths and experiences of all students. The deliberate implementation of a gender-inclusive curriculum is concerned with emphasizing the context of science so that all students can readily perceive its relevance, student experiences, varied forms of assessment, learning and teaching methods, and a supportive, collaborative learning environment (Mills, Ayre, & Gill, 2010). As such, a gender-inclusive curriculum provides all students with the tools they need to succeed in science and has been shown to make significant differences that benefit all students, regardless of gender or ability level (Margolis & Fisher, 2002).

The Role of Informal Science Education

Informal or out-of-school-time (OST) settings can play an important role in promoting science learning for pre-K-12 students and beyond by sparking student interest in science and providing opportunities to broaden and deepen students' engagement, reinforcing scientific concepts and practices introduced during the school day, and promoting an appreciation for the pursuit of science in school and daily life (NSTA, n.d.). Research shows that learning science is a rich, complex, ongoing process and that opportunities to learn science occur throughout the day and year, in a wide variety of settings and through a range of experiences (National Research Council (NRC), 2008; Sawyer, 2006). Recent reports emphasize the importance of learning in informal environments and determine that these experiences can promote science learning and strengthen and enrich school science (Bevan et al., 2010; NRC, 2009; Phillips, Finkelstein, & Wever-Frerichs, 2007).

Informal learning environments can encompass a wide variety of contexts and settings, including everyday experiences, experiences in designed settings (i.e., museums, zoos, etc.), experiences in structured OST programs (i.e., after school youth programs and clubs, and experiences through science media (i.e., gaming, television, the internet, etc.) (NRC, 2009), and promote an interdisciplinary approach to learning STEM (King, 2017). These diverse opportunities can help learners see the relevance of science to their lives and what it might be like to choose to do science in the real world, as a hobby, or as a career. In fact, a recent study shows that exposure to science in settings other than school, particularly structured science-focused OST programs in late elementary and middle school makes students more likely to aspire to and choose a STEM major in college (Chan et al., 2020). Informal learning experiences also provide important and unique opportunities to engage students that come from communities that are historically underrepresented in STEM professions, like people of color and girls, in powerful ways (Banks et al., 2007; Honey, Pearson, & Schweingruber, 2014). As such, informal, OST spaces have the potential to address educational inequities and broaden the participation of underserved and underrepresented populations in STEM careers (King, 2017).

Purpose of the Study

While there has been a substantial amount of research done around girls' declining interest, motivation, and attitudes towards science, most of that study has focused on what happens within the classroom context at the various levels of schooling – from primary through post-secondary education – that may prevent girls and women from studying STEM and entering the related fields. As such, these studies have investigated how girls' interest in science is affected by their relationships and interactions with their teachers (George, 2000; Raved & Assaraf, 2011); teaching methodology, and classroom environment – including interactions with peers (Hacieminoglu, 2016; Hacieminoglu, Yilmaz-Tuzun, & Ertepinar, 2011); the transition from primary to secondary school (Braund & Driver, 2005; Ferguson & Fraser, 1998; Speering & Rennie, 1996); expectations for secondary school science (Braund & Driver, 2005; Campbell, 2001; Speering & Rennie, 1996); and to a lesser extent, how race, culture, and socioeconomic status contribute to girls' overall perceptions of their role in STEM (Hill, Atwater, & Wiggins, 1995; Ornek, 2015; Unfried, Faber, & Wiebe, 2011).

There is less research that examines how out-of-school time (OST) science programs could better connect to science learning within the school and address girls' disinterest and lack of engagement with science classes. Afterschool or weekend programs that fortify girls' confidence and spark or increase their interest in science, could help them create a positive science identity and provide educators with insights on ways to relieve gender disparities in science education (Mosatche, Matloff-Nieves, Kekelis, & Lawner, 2013; Rahm, 2008). However, for OST science experiences to have a lasting connection to school science, an effective and replicable model for such programs must be created.

Looking back on my trajectory in science education from elementary school through college, my experience was a unique one. A good portion of my science teachers were women. Even though very few of them were women of color, I still had exemplar proof that women could excel in science and thus belonged in STEM fields. I also have a supportive family that indulged my interest in STEM by allowing me to participate in extracurricular activities that gave me exposure to a variety of STEM fields, rather than subjecting me to the stereotypes of girls in science and math.

Reflecting on my own teaching experience through my graduate work, it has become clear that I missed opportunities to practice gender equity and encourage girls in my teaching role, sometimes unconsciously perpetuating the status quo. Although the education community acknowledges that a gender disparity problem exists, our current methods of investigating gender disparities in STEM and coming up with solutions for the classroom are not entirely successful (Marshman et al., 2018). Therefore, it is time to shift the focus toward understanding and developing solutions for girls' lack of interest and engagement by providing girls with the support they may not be getting in school and doing so in a way that gives them tools for success that manifest themselves as improvement in participation and achievement in school.

Research Questions

Gender biases continue to permeate most education institutions in the United States. Gendered stereotypes about learning and leadership deficiencies often prevent females from having equity of opportunity, which generally limits their social and economic mobility (Clauset, Arbesman, & Larremore, 2015). A vicious cycle is perpetuated because young females (especially young girls of color) see few role models in prominent positions and are less likely to believe that they are capable of success at school and beyond. Racial identity, gender, and cultural context are at the core of understanding STEM self-concept and STEM identity is undergirded by how the preservation of male whiteness in STEM creates exclusion and unwelcoming environments for girls/women of color (Collins et al., 2019). Girls need the support and example of teachers and staff to encourage their learning through effective practices that cater to individual needs while reconstructing negative messages that society has engrained in children of color to infuse positive ideas about who they are and who they will become (King, 2017).

According to Carnevale, Smith, & Melton (2011), increasing demand for scholars and professionals in the STEM fields is motivating K-12 schools to increase graduates with STEM competencies. However, secondary and postsecondary students, in general, diverge from STEM pathways into other fields, with females participating in the STEM workforce at lower rates than males. Therefore, educators need to increase the number of students, especially women, students of color, and those from low socioeconomic backgrounds pursuing STEM careers (National Research Council, 2011). To increase participation and retention rates of Black girls and women in STEM disciplines, the culture of science and mathematics, as well as the accessibility, must change in a way that values girls, students of color, and those from low-income households (King, 2017), and one approach to enacting this change is through informal science learning and STEM education programs.

For schools to be places where science learning occurs for everyone, the education community has to not only think about the content of the curriculum and pedagogies but also consider how learning science can change students' identities by enhancing their ability to participate in the world as both local and global citizens (Wenger, 1998). This is especially true for girls. As such, curricula and pedagogies must be reframed, while simultaneously fostering critical consciousness and an understanding of what all students, and girls in particular need to succeed in school science. This includes adequately addressing any racial and gender disregard that is present in STEM curriculum, instructional approaches, and learning environments (Collins et al., 2019). To accomplish these goals, it is important to understand how girls learn science and how they experience science courses and be able to positively impact girls' feelings about science, their role in the science classroom, and their view of who can be a scientist. To examine the relationship between curricular and pedagogical approaches to teaching science and girls' interest in and connection to school science, this study asks the following questions:

1) What is girls' experience working with a gender-inclusive curriculum that focuses on the contributions of black women to science?
2) How does participation in an informal science program that employs a gender-inclusive curriculum impact young girls' perception of who can be a scientist?
3) To what extent does participation in a gender-inclusive science program grounded in stories of women in science affect girls' perception of their ability to do science?

Organization of the Chapters

In chapter 1, the introduction addresses the purpose of the study and the need for the study by examining how outside-of-school-time (OST) programs that use a gender-inclusive curriculum enhance girls' interest in science and confidence in their ability to do science. There is also a section on the researcher's positionality and personal experiences with science education, both as a student and a classroom teacher because these experiences of being the "other" and "bearing witness to othering" concerning issues of equity (Foote & Bartell, 2011, p. 45) are linked to the researcher's particular interest in and concern for issues of equity and diversity.

Chapter II provides a review of literature about the cause of the gender gap in STEM education and achievement and the role of extracurricular programs in reducing the gender gap in education. This chapter outlines the theoretical frameworks applied to this study as well. Chapter III describes the methodology of the study, including the research approach, the setting and participants, the data collection methods, the procedures for collecting data, and the data analysis methods. The findings are presented in chapter IV, chapter V discusses the major findings of the study, and chapter VI provides the conclusions and implications for further studies.

Chapter II

LITERATURE REVIEW

The gender gap in STEM education, participation, and achievement has been the subject of research over many decades. While gender differences in science and mathematics achievement appear to have decreased in recent years in many countries, they have not been eliminated. Moreover, while more women are entering the STEM workforce than ever before, women are still significantly underrepresented in STEM occupations in many countries, including the United States.

Elementary Science Education

According to the National Science Teaching Association (NSTA) (2018), high-quality elementary science education is essential for establishing a sound foundation for learning in later grades, instilling in children a long-lasting enthusiasm for science that helps address the critical need for a well-informed citizenry and society. Children are innately curious about the world and how it works, and often develop basic forms of scientific investigation and design activities to find answers to the questions and solutions to their problems long before they enter formal education (National Research Council (NRC), 2007). Effective elementary education recognizes and capitalizes on children's intrinsic interest in science and builds on knowledge they have previously acquired, providing an educational environment that allows this knowledge to expand and deepen.

Research suggests that the earliest years of elementary school are critical for the development of scientific knowledge and skills and a point of divergence in performance between subgroups of students (Curran & Kitchin, 2019). According to Morgan, Farkas, Hillemeir, & Maczuga (2016), performance on a first-grade general knowledge exam that includes science was more predictive of science achievement through eighth grade than achievement measures in other subjects or students backgrounds. It has also been documented that science achievement gaps by race/ethnicity exist as early as kindergarten and persist through elementary school (Curran & Kellogg, 2016; Quinn & Cooc, 2015). In addition to race and ethnicity, early disparities in science by income emerge in kindergarten, and differences by gender emerge by first grade (Curran, 2017).

Despite the fundamental importance of elementary science for later academic achievement, in many schools and districts, elementary science instruction often takes a back seat to math and reading and receives little time during the school day. This may be partially due to a decreased allocation of time to science as a result of accountability efforts such as No Child Left Behind (NCLB) that put an exaggerated focus on math and reading (Marx & Harris, 2006), and partially because many elementary educators do not receive an adequate amount of professional learning to gain the confidence needed to teach science (McClure et al., 2017). The breadth of content coverage in elementary science instruction has also been a point of debate for researchers and practitioners as they explore the merits of standards that cover a broad set of science topics compared to those that focus more deeply on a limited set of topics. Work that focuses on upper-grade levels and higher education has shown advantages to instruction that provides more depth as opposed to breadth of content coverage in science (Schwartz, Sadler, Sonnert, & Tai, 2009; Sadler & Tai, 2001), and as a result, there has been an increased emphasis on the need for more depth in science instruction as evidenced most recently by the Next Generation Science Standards. Evidence suggests that many early elementary students have limited exposure to several science content areas, implying that even though the total time spent on science did not decrease significantly, the breadth of science content covered may have changed dramatically. This points to a shift toward more depth rather than breadth with fewer content areas being covered for longer periods of time (Bassok, Latham, & Rorem, 2016).

Gender Differences in Science Education

Gender differences in science education at the expense of girls are already visible in early childhood education (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2017), and become more apparent at higher levels of education. Girls appear to lose interest in STEM subjects as they age, and lower levels of participation are already seen at the secondary level. By post-secondary education, women represent only 35% of all students enrolled in STEM-related fields of study (UNESCO, 2017), with the lowest female enrollment observed in information, communication, and technology (ICT), engineering, manufacturing and construction, and natural science, mathematics, and statistics (UNESCO, 2017). Women leave STEM disciplines in disproportionate numbers during higher education studies, the transition to the workforce, and even during the career cycle.

Studies suggest that girls' disadvantage in STEM is the result of the interaction of a range of factors embedded in both the socialization and learning processes (Brotman & Moore, 2008). These include social, cultural, and gender norms which influence the way girls and boys are raised, learn, and interact with parents, family, friends, teachers, and the larger community, and which shape their identity, beliefs, behavior, and choices. Self-selection bias – when girls and women choose not to pursue STEM studies or careers (UNESCO, 2017) – appears to play a key role. However, this "choice" is the outcome of the socialization process and stereotypes that are both explicitly and implicitly passed on to girls from a young age. Girls are often brought up to believe that STEM subjects are "masculine" topics and that their ability to succeed in these topics is innately inferior to that of boys. This can undermine girls' confidence, interest, and willingness to engage in STEM subjects.

Lack of Confidence

Girls' confidence in their academic abilities drops dramatically from elementary to high school, particularly in math and science. The "confidence gap" - gender differences in belief in math and science abilities (Sadker & Sadker, 1994) - is partly responsible for the gender gap, a sizeable difference in the number of women and men pursuing study or careers in STEM fields (Eccles, 1994). The gender gap widens with advanced high school math and science course enrollment and grows at each successive stage.

STEM Self-Efficacy

STEM self-efficacy predicts academic performance beyond one's ability or previous achievement because confident individuals are motivated to succeed. Students with high science self-efficacy set more challenging goals and work harder to accomplish those goals than students with low science self-efficacy. High self-efficacy is associated with greater self-regulation, including more efficient use of problem-solving strategies and management of working time (Zimmerman, 2000). Efficacious individuals also persist longer to complete a task, particularly in the face of obstacles and adversity (Zimmerman, 2000). STEM self-efficacy is positively related to STEM task performance, i.e., science self-efficacy is related to students' grades in science class (Britner & Pajares, 2006).

The relationship between self-efficacy and performance is reciprocal and continuous--successful performance enhances self-efficacy leading to the adoption of more difficult goals. The adoption of more difficult goals requires greater effort, which affects performance. Successful performance with a more difficult goal will lead to even greater self-efficacy, thus perpetuating the cycle (Bandura, 1997). The reciprocity between self-efficacy and performance makes it important that beliefs about one's capabilities are accurate (Bandura, 1997; Pintrich, 2003). Being over- or under-confident can undermine performance.

Research shows that interest is more highly related to self-efficacy than actual ability (Bandura, 1997). This explains why many girls and young women lose interest in STEM even though they do not lack STEM abilities. They lack the belief that they are capable of attaining STEM goals, such as certain grades, majors, or professions, which leads to decreased interest in pursuing STEM (Eccles, 1994; Seymour, 1995).

Parental encouragement and expectations have also proven to be an important predictor of a child's self-efficacy. Research also suggests that teachers' and practitioners' belief in students' STEM abilities can influence students' interests, as well as educational and professional pursuits (Vekiri & Chronaki, 2008). Research has also found that positive feedback from others (social persuasion) is particularly important for girls and young women (Zeldin & Pajares, 2000), and yet frequently not provided in STEM fields (Seymour, 1995).

Gender Inequities in Science

Research studies documenting the inequities that girls face in science describe situations where girls and boys are treated differently in the science classroom and learning materials (i.e., textbooks) are gender-biased. As a consequence of these inequities, girls and boys have different attitudes toward and levels of participation in science, and these patterns have contributed to women's persistent underrepresentation in the science work force (Brotman & Moore, 2008). Studies examining issues of gender bias and discrimination, as they relate to the teachers and texts in the classroom, continually find evidence that girls manipulate laboratory equipment and lead activities less frequently than boys, even in classrooms with experienced teachers concerned with gender equity (Guzzetti & Williams, 1996; Jovanovic & Steinbach King, 1998).

Girls' Attitude Toward Science

Regarding disparities in science attitudes, a widely studied topic, several studies show that girls' overall attitudes toward science are either less positive than boys' or decline more rapidly with age (George, 2000; Greenfield, 1997; Hacieminoglu, 2016; Neathery, 1997; Reid, 2003; Sorge, 2007). Other studies have shown that girls often perceive science as difficult, uninteresting, or leading to an unattractive lifestyle (Jones, Howe, & Rua, 2000; Miller, Blessings, & Schwartz, 2006). Even when girls enjoy and are involved in science class, girls' perception of their competence in the subject is lower than boys' (Jovanovic & Stenbach-King, 1998). The fact that parents have higher expectations of boys and perceive science to be more important for boys than for girls may contribute to this disparity (Andre, Whigham, Hendrickson, & Chambers, 1999).

Context also seems to play a role in girls' attitude towards and participation in science. Girls across ages choose fewer science courses than boys (Farenga & Joyce, 1999), and girls are underrepresented in upper-level physics, math, and chemistry classes (Jones, Porter, & Young, 1996). Influences on girls' choice of science courses and career plans also include factors such as peer and parental support, previous science experiences, teachers, course selection processes, and guidance counselors' career advice (Roger & Duffield, 2000; van Langen, Rekers-Mombarg, & Dekkers, 2006).

According to the research, girls prefer and choose to participate more frequently in the biological sciences, whereas boys prefer and choose the physical sciences (Dawson, 2000; Jones et al., 2000; Miller et al., 2006). Also, girls have less exposure to extracurricular science experiences than boys, especially in the physical sciences (Greenfield, 1997; Jones et al., 2000).

Addressing Gender Inequities in Science

Strategies highlighted in the research for addressing gender inequities and disparities include teacher education and extracurricular programs for girls. Scantlebury (1995) maintains that schools of education can address preservice science teachers' "gender blindness" (p. 134) by including gender issues in course discussions, holding teachers accountable for their understanding of gender equity issues, and educating teachers in both the theory and practice of a gender-sensitive education.

Researchers have also indicated that partnerships involving mentor/collaborating teachers attuned to gender equity issues inspire student teachers to have more equitable classroom interactions with students (Bailey, Scantlebury, & Johnson, 1999; Scantlebury et al., 1996). According to Bullock (1997), there is a need for effective teacher education models that motivate teachers to prioritize issues of gender and equity consistently, even when they are faced with day-to-day classroom challenges.

Classroom Curriculum and Pedagogy

Curriculum and pedagogy in science classrooms must also be adjusted to acknowledge the experiences, interests, and learning styles of girls. Brotman and Moore's (2008) findings indicate that girls learn and experience the world differently from boys, calling for changes or an expansion of the curriculum to accommodate both genders. Studies provide evidence that girls are more relational and cooperative, and less competitive than boys (Ferguson & Fraser, 1998; Zohar & Sela, 2003), striving for a deeper conceptual understanding of concepts and rejecting more formulaic, rote learning (Zohar & Sela, 2003). Many studies have also alluded to the possibility that girls in particular profit from hands-on or inquiry-based learning (Burkam, Lee, & Smerdon, 1997; Cavallo & Laubach, 2001; Heard, Divall, & Johnson, 2000), and that broadening and negotiating ways of doing science that allows for multiple and differing subjectives may encourage boys and girls to connect more in STEM subjects (Jammula & Mensah, 2020). Students negotiate their gender, race, ethnicity, and class to align with or disengage from their views of science, and populations marginalized in science, like girls/women and minorities, may form positive science identities by connecting with their views of the subject matter (Jammula & Mensah, 2020).

The current science curriculum in most classrooms does not adequately address the needs and interests of most students (boys and girls). It privileges middle-class white masculinity and associated attributes (i.e., entitlement, confidence, assertiveness, independence, etc.) and excludes alternative modes of engagement, like collaboration, caring, and inclusion (Jammula and Mensah, 2020), which are more often employed by females and people of color. Curriculum and pedagogy that attend to the learning styles, experiences, and interests of both genders incorporates ideas about equity.

Gender-Inclusive Science Curriculum

A gender-inclusive science curriculum draws on both girls' and boys' experiences, interests, and preconceptions; prioritizes active participation; incorporates long-term self-directed projects; includes open-ended assessments that take on diverse forms; emphasizes collaboration and communication; provides a supportive environment; uses real-life contexts; addresses the social and societal relevance of science; pays attention to issues of sexism and gender bias in curriculum materials; and includes the "her story" and the "lost women of science" (Parker & Rennie, 2002, p. 884). A curriculum that incorporates gender-inclusive features can have a positive effect on students - prompting them to take ownership of their work by giving them freedom of choice, which has been deemed especially important for those who have been marginalized in some way (Roychoudhury et al., 1995). According to the National Research Council (NRC) (1996), gender-inclusive science curricula are consistent in a lot of ways with general science education reform recommendations that attempt to improve science education for all students through constructivist approaches, which is why these curricula have proven beneficial for both boys and girls.

Studies have shown that teachers have limited knowledge and experience with gender-inclusive practices, and thus express resistance to focusing explicitly on gender inclusivity (Plucker, 1996; Zohar & Bronshtein, 2005). In light of these partial understandings and the unwillingness to pay specific attention to gender inclusivity, there is a need to find effective models of teacher education and professional development that better inform teachers of gender-inclusive practices and articulate the rationale for and the research behind these practices (Brotman & Moore, 2008).

To engage girls and other marginalized groups in science, the nature and culture of science in the classroom and in society at large need to be challenged. Science is often portrayed as being difficult, masculine, and completely objective and unbiased, which deters girls and other marginalized groups from participating in science (Hodson, 1999). This portrayal of science is inaccurate because both scientific knowledge and practices are impacted by the people who do science, and therefore, by the societal and cultural values that influence their actions and thought. These personal and societal views naturally incorporate ideas about gender, so it is virtually impossible for scientific knowledge to be gender-neutral (Brickhouse & Potter, 2001). The view of science as objective and unbiased has given it a powerful position in society that has been continually used to oppress women and other groups (Richmond, Howes, Kurth, & Hazelwood, 1998). According to Howes (2002), feminist critiques of science charge that because men historically have been recognized as the ones who do science, there is an automatic association between masculinity and the practice of science, which has negatively affected the understandings that we as a society possess.

Science-Technology-Society (STS)

The incorporation of Science-Technology-Society (STS) issues into the curriculum is often associated with gender-inclusive curriculum and pedagogy. However, these socioscientific aspects of science are sometimes given less importance compared to more traditional scientific content. Hughes (2000) states that STS concerns are frequently linked to feminine concerns, marginalizing and diminishing the value of these social components which reinforces a central, dominant place for masculinity in science. To work against gender binaries that associate males with "hard" science and females with issues of the social and societal implications of science, teachers must make STS components of the curriculum central, increasing their value (Hughes, 2000).

Vicarious STEM Experiences

Vicarious STEM-related experiences are especially influential for girls and young women under certain conditions (Zeldin & Pajares, 2000). They are more effective when employed in conjunction with other interventions and when the role model is similar (in race, gender, culture, background, etc.) to the observer (Bandura, 1997). Vicarious experiences such as inviting STEM professionals to give field- or career-specific lectures or to work on projects with students, and shadowing STEM professionals at work have been incorporated into the curriculum as a means of increasing interest in STEM.

Interventions and Enrichment Programs

Both short-term interventions during school and informal enrichment programs outside of school have been investigated as supplemental science programs that could address the inequities that lead to an underrepresentation of girls and women in science. A study conducted by Riedinger and Taylor (2016) on the Coastal Ecology program at the Chincoteague Bay Field Station on the Eastern Shore of Virginia concluded that the program helped the girls to see themselves as scientists and fostered positive science identities through fieldwork, engaging them in authentic science practices, and the use of actual science tools. Gonsalves, Rahm, & Carvalho (2013) reported that a meaningful introduction of science into an OST space helped girls re-figure the world of science in ways that extend beyond school science and include their everyday experiences, but these shifts were limited and not necessarily long-lasting in terms of what counts as "real science" and how they consider themselves in relation to science. In essence, their shifting viewpoint was limited by time and space and did not necessarily persist over time. The results of an investigation into the Lang Science Program at the American Museum of Natural History revealed that long-term participation in the program helped young women (middle and high school age) develop positive STEM identities, confidence in their ability to do science, and persistence in the face of challenges (Adams, Gupta, & Cotumaccio, 2014). Although there are mixed results regarding the influence of extracurricular programs, it seems that there is potential for these types of programs to have long-term effects on girls. Further study is needed to identify what makes programs successful, and the larger societal and economic factors that may either help or hinder program development, as well as the impact of these programs on girls who do not have prior science interest and achievement (Brotman & Moore, 2008).

Models of Extracurricular STEM Learning

Many interventions and programs to increase STEM achievement have been investigated, and two widely used models of STEM learning afterschool have emerged according to Bevan and Michalchik (2013). The first includes expanded learning, which is a wide range of content-rich opportunities in the hours outside of school, including summer camps. These operate on the assumption that in structured OST programs, children can learn concepts or develop capacities or interests that will later enhance their engagement in everyday as well as academic settings. The other model is based on extended learning, in which afterschool aligns more closely with the school curriculum. High-quality programs can lead to increased interest and improved attitudes toward STEM fields and careers, increased STEM knowledge and skills, and increased likelihood of pursuing STEM majors and careers (Afterschool Alliance, 2011b). Many STEM program instructors include mastery experiences, such as laboratory work, experiments, design projects, and other applied activities, as part of the course curriculum. Several after-school programs, workshops, and summer camps have also been designed to provide girls of all ages with opportunities to gain STEM knowledge and skills through hands-on experience (American Association of University Women (AAUW), 2004).

OST STEM Programs for Girls

STEM afterschool programs designed specifically for girls tend to have a lot in common, although curriculum and methodologies differ from program to program. Techbridge, Girls Go Techbridge, and Access for Young Women are all STEM programs serving girls in grades 5-12. Techbridge requires girls to make a one-year commitment to the program, which operates as an afterschool program in schools that is taught by a combination of teachers and Techbridge program coordinators. This program explores engineering, science, and technology through hands-on activities, interactions with role models, career exploration, and field trips to provide real-life examples of STEM careers and helping to dispel stereotypes (Mosatche et al., 2013).

An adaptation of the Techbridge program established in conjunction with Girls Scouts of America, Girls Go Techbridge, provides user-friendly pre-packaged programming focused on science and engineering that allows facilitators to implement lessons without having to spend time researching activities and preparing supplies. The lessons in this program can be implemented as an afterschool program in schools but can also be implemented as a resident and day camp, and as one-off lessons at large events and Girl Scout Troop meetings. Rather than being facilitated by teachers, Girls Go Techbridge is taught by Girl Scout council volunteers and staff, although the lessons maintain the hands-on structure.

Access for Young Women, created by the Queens Community House, was originally developed as a comprehensive 20-session leadership and advocacy curriculum for girls. However, with increasing public attention on the importance of STEM education, an emphasis on science and math was added to the leadership focus. Designed as an afterschool program in schools or community centers, this program focuses on discovering science in everyday life (using the scientific method in the social and natural sciences) and using research to advocate for oneself and others (using technology for research and presentations via leadership activities, including a girl-led research conference, science and math tutoring, and college visits. This program is facilitated by social workers and youth workers rather than experienced STEM teachers.

While these three programs have been successful in sparking and/or deepening girls' interest in STEM fields to some degree, they also experience challenges and leave areas open for improvement. All three programs: employ facilitators that are trained to deliver content and to interact effectively with young girls; provide opportunities for the girls to work with each other and with STEM professionals via fieldtrips and partnerships; engage girls in a hands-on curriculum; and inspire girls to explore careers in STEM fields (Mosatche et al., 2013). All of these programs demonstrate the need for well-qualified and well-trained facilitators who are comfortable with both teaching STEM and interacting with adolescent girls. Instructors in these programs found that it was sometimes difficult to strike the right balance between holding girls to high expectations while giving them the freedom to socialize and enjoy STEM activities that make the programs fun and keeps the girls engaged (Mosatche et al., 2013). It is also imperative that facilitators understand the issues that adolescents face and are knowledgeable about their culture while maintaining a certain level of authenticity. Participants in these programs indicated that they want adults to be comfortable teaching STEM topics but also willing to admit when they don't know an answer and that they need facilitators who help them feel comfortable trying innovative strategies and making mistakes as they figure things out (Mosatche et al., 2013). The most effective science teaching encourages students to learn from their mistakes. This encourages perseverance in the face of unclear results, which then results in procedure and dead ends that are vital in making progress (DeHaan, 2011).

Effects of Informal STEM Learning

Extracurricular science programs can play an important role in influencing the trajectory of science learning for young people, especially students from groups that are underrepresented in science and who attend schools with inadequate science education resources – like girls, minorities, and the socioeconomically disadvantaged (Rahm, 2008). These interventions can improve girls' confidence in their science capabilities and increase their interest and perception of competence in science (Mosatche et al., 2013) by providing high-achieving female role models from backgrounds similar to those of the participants and creating an environment that inspires curiosity, generating long-term interest in science (Halpern et al., 2007).

Programs that connect girls and young women with women in STEM careers often not only involve female STEM professionals as instructors but also as on-going mentors, supplying the participants with continual STEM-related career advice. Research has shown that a role model's effect on young women's self-efficacy is greater when the role model addresses gender inequity in STEM fields (AAUW, 2004). This allows girls to reinterpret past negative feedback about their own and other female's performance in science to discrimination rather than lack of ability. Role models can also help to dispel girls' negative stereotypes about scientists and engineers by showing that they have interesting lives outside their labs or other work environments (Mosatche et al., 2013).

While there is a growing body of empirical research examining the experiences of women and girls (especially women and girls of color), research on the environments and experiences that allow women and girls to pursue and persist in STEM majors and careers is still needed (Ong, Wright, Espinosa, & Orfield, 2011). More research into what makes intervention programs successful, and the impact of these programs on girls who do not have prior science interest and achievement is also necessary (Brotman & Moore, 2008). There should also be more investigation into the type of curriculum and instruction that addresses the needs of both girls and boys in STEM classes (Brotman & Moore, 2008; Parker & Rennie, 2002) – i.e., a gender-inclusive curriculum and teaching methods.

Identity Formation

According to Atwater (2000), studies dealing with gender often fail to acknowledge how ethnicity, class, gender, language, lifestyle, and religion interact to create the experience of an individual, ignoring the diversity that exists within gender groups. For students to learn science, their own multifaceted identities need to be compatible with the pursuit of science and scientific identities (Brickhouse, Lowery, & Schultz, 2000; Jammula & Mensah, 2019). Identity formation is essential to learning because per situated cognition theory, learning is a "matter of deciding what kind of person you are and want to be and engaging in those activities that make one a part of the relevant communities" (Brickhouse & Potter, 2001, p. 286). How and why students learn science is connected to who they are and who they are becoming in their lives and communities both inside and outside the classroom, and whether or not these identities overlap with the communities of practice that engage in science (Brickhouse, 2000). Schools and teachers can unintentionally reject girls' unconventional scientific identities and marginalize students who are otherwise interested and confident in science (Brickhouse et al., 2000).

Theoretical Frameworks

Self-Efficacy

Self-efficacy refers to a person's belief in their ability to complete tasks and affect events that impact their lives (Unfried et al., 2011). It is defined as a judgment about one's ability to organize and execute the course of action necessary to attain a specific goal; self-efficacy judgments are related to specific tasks in a given domain (Pajares, 2005). Self-efficacy influences the choices individuals make in terms of goal choice, the effort expended to reach those goals, and persistence when difficulties arise (Pajares, 2005). There is growing evidence that self-efficacy is a significant predictor of academic achievement (the level of motivation for a task and ultimately task performance), and a critical factor in student career interests (Britner & Pajares, 2006; Loo & Choy, 2013; Zimmerman, 2000;).

Self-efficacy judgments are not inherently evaluative, and they are made without consideration of others' capabilities. Rather, self-efficacy beliefs are based largely on mastery experience, an individual's task-specific experiences, and interpretation of those experiences. Self-efficacy also affects the goals individuals set; higher self-efficacy is related to the adoption of more challenging goals and greater commitment to those goals. Moreover, self-efficacy influences whether discrepancies between performance and goals are motivating or discouraging (Zimmerman, 2000). Self-efficacy is particularly important as individuals work toward long-term goals. Progress toward the end goal is marked by smaller, proximal goals, and these proximal goals provide opportunities for task-specific mastery experience that strengthens self-efficacy (Rittmayer & Beier, 2009). Self-efficacy beliefs are based on four primary sources of information: mastery experience, vicarious experience, social persuasion, and physiological reaction (Pajares, 2005).

Mastery Experience. Mastery experience refers to previous experience and performance - opportunities to learn and practice the rules and strategies necessary to perform a task effectively (Rittmayer & Beier, 2009). Mastery experiences provide evidence of whether an individual has the capability to succeed. Typically, successful outcomes boost self-efficacy and failures diminish self-efficacy.

Vicarious Experience. Vicarious experience refers to learning through observing others perform tasks. This is why role models are especially influential when they are perceived as similar to the observer. Vicarious experience is a particularly powerful determinant of girls' and young women's STEM self-efficacy (Zeldin & Pajares, 2000).

Social Persuasion. Social persuasion refers to others' judgments, feedback, and support. Positive feedback and encouragement, especially from influential others (e.g., parents, teachers) enhances self-efficacy and is most effective when the feedback is perceived to be genuine (Rittmayer & Beier, 2009). Negative feedback erodes self-efficacy. Social persuasion is particularly powerful when it accompanies a mastery experience. Feedback about task-related strengths and weaknesses is more informative when it is tied to a specific learning experience or previous performance (Pintrich, 2003).

Physiological Reaction. An individual interprets his or her emotional and physical states to determine his or her self-efficacy beliefs (Rittmayer & Beier, 2009). If nervousness and a fear of failure occur during task preparation, an individual is likely to doubt his or her ability to succeed, and the increased anxiety is likely to have a detrimental effect on performance.

Feminist and Gender Theories of Learning

Feminist theory addresses, above all else, the question of women's subordination to men: how this came about, how and why it is perpetuated, how it might be changed, and sometimes, what life would be like without it (Acker, 1987). Most accounts of feminist theory identify three major divisions within contemporary Western feminism: liberal feminism, socialist feminism, and radical feminism. Liberal feminism argues that women's liberation cannot be fully achieved without any major alterations to the economic and political structures of contemporary capitalist democracies (Eisenstein, 1984). Socialist feminism argues that class, race, and gender oppression interact in a complex way, and that class oppression stems from capitalism, and capitalism must be eliminated for women to be liberated. Radical feminism holds that gender oppression is the oldest and most profound form of exploitation, predating and underlying all other forms including race and class.

Liberal Feminism and Education. Securing equal opportunities for the sexes is the main goal of liberal feminism. Concerning education, liberal feminists intend to remove barriers that prevent girls and women from reaching their full potential, whether these barriers are located in the school, the individual psyche, or discriminatory practices (Acker, 1987). A second major concern of liberal feminists in education focuses on socialization, specifically gendered roles and stereotyping. Girls and boys are socialized by the family, school, and media into traditional attitudes and orientations which limit their futures to gender-stereotyped occupational and family roles (Acker, 1987). Socialization also inadvertently encourages patterns of relationships between the sexes that disadvantage females by placing them in a position of dependency and subservience to males, and disadvantage males by forcing them to suppress their emotional and caring potential (Acker, 1987).

Attitudes figure prominently in socialization. Attitudes of teachers, for example, are seen as contributing to gender-stereotyped subject choices within schools, and eventually occupations once students leave school. This raises great concerns for science and technology because educators steer girls away from these classes at the higher levels of secondary education, effectively limiting their options for professional success in these fields later in life. Liberal feminist strategies for changing teachers' and students' attitudes include reviewing aspects of school organization, analyzing curriculum materials for stereotyping, and persuading girls not to drop science and technology subjects (Weiner, 1986). Another strategy is providing both preservice and in-service teachers with ideas for combating sexism.

Socialist Feminism and Education. Socialist feminism theories have focused on women's position within the economy and the family. Concerning education, this involves looking at how education is related to the reproduction of gender divisions within capitalism (Arnot & Weiner, 1987). A major concept in this area of feminism is "reproduction" - how schooling, by a variety of mechanisms, perpetuates (reproduces) class and gender divisions within the workforce and society in general. Socialist-feminist writing on education shows increasing awareness that gender, race, and class interact in complex ways to shape girls' lives in and out of school (Brah & Deem, 1986).

Radical Feminism and Education. Radical feminists also want to see a fundamental change in the social structure that will eliminate male dominance and patriarchal structures. Radical feminists sometimes use a concept of reproduction as well (Mahony, 1985), but what is being reproduced is the domination of men over women, denying girls and women full access to knowledge, resources, self-esteem, and freedom from fear and harassment. Two major concerns categorize radical feminism: the male monopolization of culture and knowledge, and the sexual politics of everyday life in schools.

According to Dale Spender (1982), what we know is the record of the decisions and activities of men that are presented under the guise of "human" knowledge. Women's contributions and understandings have been largely ignored or disparaged throughout history. Radical feminism seeks to uncover: the logic of male dominance and the contribution schools make towards it; the ways gatekeeping processes silence women and allow men to dominate decision-making in educational and other contexts; and the role of language in controlling the ways women conceptualize themselves and their world (Spender, 1982). The implications here for school curriculum and female teachers' and girls' access to power and policymaking in education are significant.

Concerning the sexual politics of daily life in educational institutions (at all levels), two aspects of the problem have been clearly delineated: teacher attention is unequally divided between the sexes to the advantage of boys, and the potential although diluted benefits of single-sex schooling for girls (Spender, 1982). Radical feminists see schools, especially mixed secondary schools, as amplifiers of male tendencies towards violence (both physical and sexual). It is not simply that girls receive less teacher time but that their classroom contributions are met with systematic ridicule from boys and their existence outside classrooms is filled with verbal and physical abuse (Mahony, 1985).

One of the major issues for educational theorists and other feminists is the issue of universality and diversity, one of the paradoxes of feminism. Both theory and practice in feminism have historically had to deal with the fact that women are both similar to and different from men, and the fact that women's gender identity is not separable from the other factors that make up our "selves": race, religion, culture, class, and age (Cott, 1986).

Feminist Perspectives on Science Learning. The work of some feminists shows how scientific knowledge, like other forms of knowledge, is culturally situated, and therefore, reflects the gender and racial ideologies of societies (Brickhouse & Potter, 2001). Scientific knowledge, like other forms of knowledge, is inherently gendered. Therefore, it cannot produce culture-free gender-neutral knowledge because the epistemology of science is infused with cultural meanings of gender. Culturally defined values associated with masculinity (i.e., objectivity, reason, logic) are also those values most closely aligned with science (Keller, 1985). Not only is masculinity culturally defined in opposition to femininity, but "scientific" is also defined in opposition to femininity. Since science is gender-biased, women face contradictions as teachers when they must adopt the language and ideas of our "fathers" to teach - ideas that often exclude women or describe them in oppressive ways (Pagano, 1988).

The very process by which science operates is dependent on a set of dualisms that reinforce a male/female binary. Therefore, feminist epistemologies present two major challenges to traditional epistemology: 1) what is taken to be universal, value-free truths are actually situated knowledge embedded in cultural values, including gendered ones; and 2) the construction of alternatives to the conventional dualisms of objectivity/subjectivity, mind/body, masculine/feminine are part of what is necessary to create a science that is truly by and for everyone (Keller, 1985).

Learning and Gendered Identities. To understand learning in science, we need to know how students engage in science and how this is related to who they are and who they aspire to be. Wenger (1998) describes this as a learning trajectory - as students transform their identities, the requisite knowledge and skills for being part of new communities are learned, and these identities will also be gendered since gender is a part of who we are and what we desire. For example, a girl who sees herself as someone who needs credible explanations for how the world works and aspires to understand this scientifically may engage in science differently than a girl who wants to be an "A" student but does not aspire to know more about science than is required of her (Brickhouse& Potter, 2001). Traditional school science practices imply that science consists of narrowly defined tasks and present science as a finished body of knowledge, which promotes restricted science identities that do not appeal to a broad range of students (Gilbert & Yerrick, 2000). Broadening students' participation in science requires paying strict attention to the kinds of people we ask students to become as they participate in science activities and the ways that girls, women, and students of color embrace and resist the promoted science identities (Carlone, 2003). When participating in traditional science curriculum (focusing on lecture and verification labs), girls tend to embrace the certainty of knowledge because it appeals to their "good student" identities, which allows them to earn good grades; however, they do not develop science identities because the nature of the tasks deemphasizes scientific thinking, discussion, and the use of tools (Carlone, 2003). The concept of identity accounts for the importance of both "individual agency as well as societal structures that constrain individual possibilities" (Brickhouse, 2000, p. 286), both of which are necessary for any adequate understanding of gender relations.

While the process of identity development is an individual one, it is a process that is socially situated. Students' actions are an expression of gendered identities because these identities organize their activity (Lloyd & Duveen, 1992). For example, a girl who is silent in science class may well be acting this way because she aspires to be a "good girl" – meaning she wants to be viewed as a good student and be well-liked by the teacher to earn good grades (Carlone, 2003). Girls who take on easily recognizable social roles for girls and bring with them the usual experiences and talents attributed to girls garner a more positive response from teachers (Brickhouse et al., 2000). Even though girls' identities are personal, they have significant political consequences and can dictate how they are perceived by others, especially those from which they seek approval, and ultimately how successful they are in science classes. Violating school-sanctioned gender norms of what a good student is may have negative academic consequences, even when the identities schools select against are potentially advantageous for succeeding in science (i.e., problem-solving, assertiveness, etc.) (Brickhouse et al., 2000). Individual identity is also not necessarily singular or stable. A person can be a part of different communities simultaneously, and the communities we participate in change (Brickhouse, 2000). Therefore, it is important to consider multiple social identities when educating students.

Identity Theory

There is a need to understand how major systems of oppression (e.g., racial, heteronormative, patriarchal) hinder the development of science-related attitudes, including identity, as a means of determining why certain groups are under-represented in STEM. Identity is defined by Stets and Burke (2000) as the composition of self-views that emerge from participation in certain activities and self-categorization in terms of membership in particular communities or roles. Identity is created by the internalization of our experiences and is socially constructed with others in a specific context. When it comes to science identity, this involves both whether an individual wants to become a "science person" and the socialization of individuals into the norms and discourse practices of science (Brown, 2004).

The Nature of Science Identity. Researchers have presented three conceptualizations for what drives science identity: 1) a sense of community and affiliation; 2) it is built by consistent extrinsic and intrinsic attitudinal factors; and 3) a match between school science and real science.

A Sense of Community and Affiliation. Influential others - such as family, friends, teachers, and mentors - can play an important role in providing a feeling of community and affiliation, which then shapes identity, especially in early adolescence (Vincent-Ruz & Schunn, 2018), when youth development involves constant tension between exploring ones' differences and fitting in with others. Perceived interactions with others can be critical in influencing identity development and internalization. Being viewed by influential others as competent with scientific practices - i.e., the ability to demonstrate knowledge and understanding of science content, and fluency with scientific talk lends one to recognition by themselves and others as a "science person" (Carlone & Johnson, 2007). Thus, understanding how people negotiate the cultural norms within their community, in this case, the science community, and become either affiliated with or alienated from science is crucial to understanding the role of science identity in persistence in science studies and careers (Stets, Brenner, Burke, & Serpe, 2017).

Consistent Extrinsic and Intrinsic Attitudinal Factors. Many attitudinal constructs have been linked to science identity, including interest or intrinsic motivation, which has been marked as a primary driver of science identity. It has frequently been said that the bigger the science interest, the more solidified the science identity (Maltese & Tai, 2010). There is often an assumption that when interest leads to participation in science activities and learning, and participation leads to the development of career goals, then a science identity exists (Crowley, Barron, Knutson, & Martin, 2015). Based on the expectancy-value theory, science identity can lead to science-related choices when the learner also has strong perceptions about the extrinsic value of science and high levels of science self-efficacy or competency beliefs (Eccles, Fredricks, & Baay, 2015). It is worth noting that there is some disagreement over whether the related attitudinal constructs drive identity development or these constructs are part of identity (Vincent-Ruz & Schunn, 2018).

Match Between School Science and Real Science. Learners may form a science identity by comparing their characteristics and performance with perceived characteristics of scientists (Vincent-Ruz & Schunn, 2018). Youth experiences with school science shape their perceptions about their performance and characteristics of science. Many students perceive a mismatch between what it means to do science in the classroom and what science in real life involves, and this mismatch influences identity development (Braund & Driver, 2005; Zhai, Jocz, & Tan, 2013). When learners are young, most science experiences will come from a formal setting (i.e., schools) rather than informal environments. Informal environments can provide minoritized students with opportunities to understand themselves as scientists and have a more realistic experience with how science works (Farland-Smith, 2012). Even though there is not equal access to informal science settings and these experiences are generally optional, it is important to appreciate how identity connects to participation in optional and extracurricular experiences (Vincent-Ruz & Schunn, 2018).

Science Identity Formation in Women. According to Carlone and Johnson (2007), a person with a strong science identity could be described as competent: she demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world scientifically; she has the skills to demonstrate her competence to others with scientific practices (use of tools, fluency with scientific talk, interacting in formal and informal science settings, etc.); and she recognizes herself and gets recognized by others as a "science person". Thus, Carlone and Johnson's (2007) science identity model illustrates the interplay of these three dimensions of science identity: competence, performance, and recognition, and how science identity is affected by one's gender, racial, and ethnic identities. A science identity is accessible when, as a result of one's competence and performance, she is recognized by meaningful others - people whose acceptance matters to her as a science person.

Cultural production, defined as "meanings developed by groups in their activities that reflect or counter meaning implied by larger social structures" (Eisenhart & Finkel, 1998, p. 44), allows for the study of the ways sociohistorical legacies (i.e. the way practicing scientists are predominantly white men) are reproduced in local practice and how groups (for example, women/girls of color participating in science) in their everyday practice, might contest these legacies to create new meanings (Carlone, 2003). Cultural production reminds us that women are not free to develop any kind of science identity that suits them. Their choices are shaped by a larger and more pervasive meaning of "science people" stemming from sociohistorical legacies of science, as well as historical and political meanings of being a woman (Carlone and Johnson, 2007). Thus, recognition – which requires validation of one's performance as credible by practicing scientists throughout every phase of the educational and career process - can be problematic and have a major influence on the formation of a science identity in girls/women because it is a mechanism for reproducing the status quo in science. It is much easier to get recognized as a scientist if your ways of talking, looking, acting, and interacting closely align with prototypical notions of scientists (Carlone & Johnson, 2007), which make it more likely that members of the discipline will keep reproducing members who look, talk, act, interact, and think the way they do (like white males) to the exclusion of females, hindering the development of a strong science identity in girls/women.

Identity Formation and Stereotype Threat. Stereotype threat is defined as being at risk of confirming, as self-characteristic, a negative stereotype about one's group (Steele & Aronson, 1995). Negative stereotypes, such as girls are bad at math, science is for boys, and students of color are academically inferior, raise inhibiting doubts and high-pressure anxieties that may cause some students – such as African Americans and girls – to do poorly on academic performances (Spencer, Steele, & Quinn, 1999; Steele, 1997). Steele (1997) and Spencer et al. (1999) have examined the way group stereotypes can threaten how students evaluate themselves, which then alters their academic identity and intellectual performance. This predicament can impact members of any group about whom negative stereotypes exist. According to Aronson (2004), a lot can be done to enhance both achievement and the enjoyment of learning in school by understanding and attending to these psychological processes, thereby eliminating the power of stereotypes and prejudice to hinder the academic aspirations of young people who "just by virtue of being born black, brown, or female, are subjected to suspicions of inferiority" (p. 17). Research shows that this threat dramatically reduces the performance of women and people of color, and it causes disidentification with school, particularly with the content areas in which they are traditionally stereotyped (like science and math) (Steele, 1997). Practices that reduce this threat (i.e., more inclusive curriculum, more nurturing teaching methods, and more accepting learning environments) can reduce these negative effects (Steele, 1997).

Outside-of-school-time science programs could be instrumental in increasing girls' interest in science and their participation and persistence in higher education science classes and science careers. If these extracurricular programs employ more gender-inclusive curriculum and teaching methods – texts and learning materials that include/focus on the contributions of women to science and teaching methods/learning environments that are collaborative and supportive – they could provide vital opportunities for girls to experience hands-on science that is relevant to their lives while providing them with examples of successful women in STEM as role models. This exposure to a version of science that is not fixed, strict and white male-dominated, but rather creative, exploratory, and inclusive could improve girls' self-efficacy, giving them confidence in their ability to do science and helping them to create a strong science identity that reflects who they are and who they want to be. With a stable science identity, a connection to science content, and an adequate support system (from teachers, parents, role models, etc.), girls could establish and maintain an interest in science and the motivation to work through systems of oppression (both patriarchal and racial) that hinder their participation and achievement in science classes, and keep women from being equally represented in science-related fields.

Intermediary – Chapter III

BACKGROUND INFORMATION

HYPOTHEkids

Established in 2013, HYPOTHEkids is a non-profit STEM organization based in West Harlem that provides programming for K-12 students in and around New York City. HYPOTHEkids has a mission to provide underserved students with hands-on science and engineering education and mentorship experiences such that they can thrive in the high-tech economy of tomorrow. Currently, HYPOTHEkids is operating six programs designed to serve a variety of needs in the community.

Pop-up Events

STEAM the Streets. STEAM the Streets is designed to bring science and engineering experiences to unexpected places in New York City. These pop-up events provide short, fun activities for kids of all ages to experience science and engineering as they are out and about in the city. Staffed by HYPOTHEkids teachers, scientists, and teaching assistants, these programs can occur all over the place, including the Intrepid, the Brooklyn Bridge, Union Square, and West Harlem Piers Park just to name a few.

High School Programs

New York Bioforce. New York Bioforce is designed for high school students who are interested in life sciences research. It combines an intensive six-week lab training program with opportunities for students to participate in paid summer internships in cutting-edge research labs at Columbia University, Weill Cornell Medicine, and Memorial Sloan-Kettering Cancer Center. The goal of this program is to prepare students for higher education in STEM fields and ultimately to join the workforce as the next generation of scientists conducting essential life sciences research.

Hk Maker Lab. Hk Maker Lab is committed to providing engaging and meaningful engineering design experiences for New York City high school students. This six-week summer program brings together 28 students from around the city for hands-on learning in Columbia's Department of Biomedical Engineering. Students work in teams to identify a health problem, develop and test a functional prototype, and create a business plan around marketing and producing their device. The program culminates in a pitch event where student teams present their work to distinguished members of the biotech community. Exemplary students are eligible for a paid internship in a biotech company or research lab at Columbia University.

In addition to working with high school students, Hk Maker Lab recruits high school STEM teachers from around NYC to join and work with our educators to develop novel engineering courses with high-quality curriculum for their schools. By partnering with local teachers and administrations and supporting the teachers throughout the school year as they implement the engineering curriculum, HYPOTHEkids strives to make authentic engineering experiences a critical component of high school STEM education.

Middle School Program

STEAM Up. STEAM Up! is a three-week program for 6th-8th grade students that uses a project-based learning approach to STEAM. This program encourages young scientists to tap into their creativity as they explore sustainability, engineering, and innovation while applying principles of biology, chemistry, and environmental sciences to real-world problems. Students learn about the engineering design process through various exercises and then use what they've learned to complete a project that solves a problem that humanity is facing today. The program culminates in a presentation that is open to family and friends. In addition to STEAM Up!, which runs in the summer, Hk staff also support teachers in local middle schools in the classroom throughout the school year by helping them revise and/or implement new science and math curriculum in their classrooms.

Elementary School Programs

HYPOTHEkids Science Clubs (HkSCs). As of 2021, HYPOTHEkids is offering free STEAM programming to community-based organizations serving students in need anywhere in New York City. To aid organizations in offering afterschool, school break, and summer programs, HYPOTHEkids helps them start science clubs by providing:

- Engaging hands-on science lessons and labs developed by our staff based on STEAM themes like Powered by Nature, Engineer It, Our Universe and Beyond, My Body Alive, Living Nature, Up & Away, and Mathcrush.
- HYPOTHEkits – all the required materials for each science lesson packed up individually for ease of use.
- Trained teachers/facilitators to run the club sessions.
- Real-time virtual lesson support from an Hk Scientist during club meetings.

Hk Summer STEAM. Hk Summer STEAM is a full-day summer STEAM enrichment program for students from rising kindergarten through fifth grade. This program runs for six to eight weeks in the summer, with each week covering STEAM content areas from microbiology to chemistry to coding. Each week is standalone, which means that kids can attend anywhere from one to eight weeks. In addition to completing three activities/labs per day in the area of focus for the week, the students get daily outdoor and community bonding time and take one field trip each week that relates to what they are learning. While this program is not free of charge, about 70% of participants receive full or partial scholarships to help families with the financial burden of attendance.

HYPOTHESISters. HYPOTHESISters, which began in 2019, is an afterschool program that focuses on making 4th and 5th-grade girls from the New York City area leaders and giving them confidence in the science classroom. At HYPOTHESISters, the girls build science skills and broaden their content knowledge while exploring the contributions of successful female scientists and engineers from the past and present who are or were working on the cutting edge of their respective fields of study. HYPOTHESISters aims to sharpen girls' creativity, and ability to ask questions and solve problems using both science and practical knowledge while having fun, making friends, and honing natural inquisitiveness and creativity to explore and make projects about things that are interesting to young girls. Each season of HYPOTHESISters focuses on an area of science that girls may not be exploring in their school science, like outer space, chemistry, and engineering, and addresses these subject areas through activities, projects, discussions, and presentations that give girls the opportunity to fully express their ideas and work collaboratively with each other, with the support of female teachers and scientists.

HYPOTHESISters Curriculum

HYPOTHESISters curriculum was designed by two women scientists of color who are also experienced educators: me and Trisha Barton. The curriculum focuses on the contributions of women scientists of color that study outer space (space travel and the universe) and the activities and projects that girls engage in are based on these scientists' particular areas of expertise.

We began planning our curriculum by picking a theme to center our lessons. Our goal was to choose something in stark contrast to what the girls were most likely covering in their school science classes and to expose them to an area of science that would be new and fresh for them. In our past experiences working with rising kindergarten through fifth-grade students, we witnessed a strong interest in the universe and found that students of all ages are excited to learn about outer space. We also realized that this is a subject area that does not receive a lot of attention in elementary school science, and when it does, the focus is on the basic structure of the solar system.

After settling on outer space as our theme, Trisha and I explored elementary standards and curriculum to determine what is generally taught in this area. Knowing that we wanted to push beyond what students are usually exposed to in school, we came up with a list of space and universe related topics that move beyond the surface level basics (i.e., the order of the planets, the position of the sun, the type of stars, etc.). Trisha and I came up with a list of topics we felt the girls would find interesting and that we felt could adequately be covered within the time timeframe of the program. Those topics included the Milky Way galaxy (what is in the galaxy besides just our solar system), measurements in the Milky Way galaxy (specifically astronomical units), space travel and forces in space (Newton's laws and rockets), and black holes (what they are, where they are, and why they happen).

After selecting the aforementioned topics, Trisha and I researched current studies and advancements in these areas and women who have and are currently working in specific areas of science. We made sure to look for women in various areas of study related to space science to show the girls a variety of career options and many ways to use math and science beyond the classroom. After individually researching women scientists in the areas of physics, aerospace engineering, and mathematics, we came up with a list of women that we felt were appropriate for our teaching/learning needs. After discussing each woman on the list, we eliminated those that we felt have a specialty that was too complex for the age group or fell outside of the purview of our goals. In our final selection of the ladies we highlighted in our curriculum, we were also careful to choose women of varying ages and at different stages of their careers to show that there is no particular age or aesthetic associated with being a scientist.

Once we selected our four scientists: Aisha Bowe, Katherine Johnson, Mae Jemison, and Jedidah C. Isler, we set about creating lessons with content and activities related to what these women study and do in their professions. Pulling from projects and activities that we had done in our previous teaching experiences, we decided to include a modified version of a lesson that Trisha and I had taught together before – the galaxy in a jar - as a means of exploring the Milky Way galaxy and the universe at large, as well as canister and bottle rockets (which I had done in some form before), a black hole piggy bank (designed by Trisha to show how black holes work), and an astronomical units bead mobile, which was a project neither of us had tried before and was the result of our collaboration as we envisioned a fun way to include math with the science that would give the girls and opportunity to design something to their liking and display both during the club and at home.

Table (Intermediary) 3.1

Women Scientists, Areas of Study, and Related HYPOTHESISters Lessons

Scientist	Area of Study	Lessons
Aisha Bowe	Aeronautical Engineering (Space Exploration)	Galaxy in a Jar
Katherine Johnson	Research Mathematics	Measuring in the Milky Way AU Bead Mobile
Mae Jemison	Aerospace Engineering (Space Travel)	Cannister Rockets Bottle Rockets
Jedidah C. Isler	Astrophysics (Black Holes)	Black Hole Piggy Bank

Trisha and I spent time researching the backgrounds of each of our chosen scientists and finding out their trajectories in science so that in each lesson time could be devoted to introducing and discussing each scientist: where they are from, how they got into their chosen STEM field, what kind of education they received, challenges they faced and how they overcame them, and where they are now in their careers. We used their stories to spark discussions about the girls' personal experiences in science, in education in general and in their personal lives – the struggles they face, individually and collectively, both in and out of the classroom, and how they can overcome these challenges like the women scientists. Trisha and I also used these discussions to share our personal journeys with the girls – how we ended up studying science , where we found strength and support over the course of our education and careers, and why we have chosen to teach and help other students find their way in science as well.

After these discussions, which we called "sister chats" we introduced the science content for the day's activity or project with either a lead-in activity or question and/or a video or visual aide. This introduction would be followed by short instruction on the concepts being studied for the session, and then the main activity or project would be introduced. It is important to note that each girl had an iPad to use at each session on which they could access any videos, visual aids, or power point slides that were presented as well as do research about the women scientists we introduced or the topics they were learning. The remainder of each session would be spent with the girls working on the activity or project either as one large group, small groups, or pairs, with the facilitators checking in with each student/pair/group, answering questions, and providing assistance as needed. Any presentations or demonstrations of completed projects would take place in the last part of the session, as this often involved a change of location or rearrangement of the learning space (moving outdoors or moving tables and chairs for presentations) (see Appendix F). Each session of HYPOTHESISters also included a community bonding and/or leadership activity - for example, an improv game – to help create a supportive learning community where the girls feel comfortable working together and learn to depend on and look to each other and within themselves for leadership.

Chapter III

METHODOLOGY

Research Approach

Qualitative Research

Qualitative research is an inquiry process for understanding a social or human problem based on building a complex, holistic picture formed with words, reporting detailed views of informants, and conducted in a natural setting (Creswell & Poth, 2018). To capture expressive information and gain an in-depth understanding of participants' experiences and perceptions, the methodological approach in this study (qualitative research) was based on describing, interpreting, and identifying recurring patterns as themes. This study was a description and analysis of a group of young girls' experiences participating in an extracurricular science program.

Case Study. According to Creswell and Poth (2018), case study research is a qualitative approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual materials, documents, and reports, etc.) and reports a case description and case themes. Case studies have a few defining characteristics (Creswell & Poth, 2018):

- Case study research requires the identification of a specific case that will be described and analyzed – typically current, real-life cases in which accurate information can be gathered.
- Cases must be bounded – defined or described within certain parameters, such as a specific location or timeframe in which the case is studied.

- Qualitative case studies generally fall into two major categories: intrinsic cases that illustrate a unique case that needs to be described and detailed or instrumental cases which are selected to best understand a specific issue, problem, or concern (Stake, 1995).
- Qualitative case studies present an in-depth understanding of the case, which is accomplished through the collection and integration of many forms of data (i.e., interviews, observations, documents/artifacts, audiovisual materials, etc.).
- Generating a description of the case or cases involves identifying case themes.
- Case studies often end with assertions or building patterns (conclusions formed by the researcher about the overall meaning or general lessons learned from studying the case(s)) (Stake, 1995).

Qualitative case studies provide a means to study complex phenomena within their contexts and can be valuable for evaluating programs and developing/improving interventions. For those reasons, an intrinsic case study was conducted for this research to do an in-depth and descriptive investigation into young girls' experience working with a gender-inclusive science curriculum and how this impacts their perception of who can be a scientist and their ability to do science. This case was bounded by both location and timeframe since all participants attended the same extracurricular science program at the same place over a semester (12 weeks). Multiple points of data were also collected, including video recordings of club sessions from which field notes were taken, assignments (artifacts) from the participants, participant interviews, and a questionnaire. Themes and patterns that emerged from studying the case were also identified and described.

Setting and Participants

Setting

This study was conducted through an extracurricular STEM program created by the researcher for HYPOTHEkids – a non-profit organization that seeks to provide underserved students with hands-on science and engineering education and mentorship experiences such that they can thrive in the high-tech economy of tomorrow. HYPOTHEkids has several programs for students ranging in age from rising kindergarten to twelfth grade, that run throughout the school year and in the summer. These programs include in-school and after-school support for local schools in Community Board 9, after school programs, pop-up activities at events all over New York City, formal lab training at Columbia University in the School of Engineering and internships at Columbia University and other partner organizations, and full-day summer enrichment programs typically located on the Upper West Side of Manhattan.

This particular program, an out-of-school (OST) science club for girls called HYPOTHESISters, was operated in partnership with The Forum at Columbia University. The Forum, located in Manhattanville, is a community gathering space that is open to all of Columbia University as well as the local New York City community. It is a multi-use venue that houses a state-of-the-art auditorium, meeting and event spaces, and communal work areas. In partnership with university faculty, staff, and students, non-profit organizations, and other community groups, The Forum hosts academic lectures, conferences, performances, and cultural events designed to spark conversations and civic engagement. The Forum provides a space where scholars and community leaders can come together, and where Columbia University and the local community can interact with New York City and beyond (https://theforum.columbia.edu/).

Participants

The participants were drawn from schools primarily on the Upper West Side of Manhattan (mostly West Harlem) and the surrounding areas. Girls from grades 4 and 5 were allowed to apply for the program via HYPOTHEkids' website. Families of elementary-age girls that were already affiliated with HYPOTHEkids through past participation in other programs and events were emailed an informational flyer with a link to the application on the website. They were also encouraged to pass the flyer along to their friends and refer them to the website for more information. Flyers were also handed out at local elementary schools (in Community Board 9) and community organizations. The girls' applications were considered in the order received, and participants were selected on a first-come-first-serve basis. To keep a low student to teacher ratio (8:1), 16 girls total were selected for participation in HYPOTHESISters, and from those 16 girls, five were selected, based on their responses to a questionnaire administered at the start of the program, and consented to be part of the study. HYPOTHESISters was taught by two female teachers of color with backgrounds in STEM areas: me and Trisha Barton, who also aided in the development of the curriculum (see Appendix E).

Table 3.1

Participants

Participant Pseudonym	Age	Grade	School Pseudonym	Race/Ethnicity*
Sandra	9	4	Poet Elementary School	Biracial (Jewish/Cuban)
Talia	9	4	Poet Elementary School	Asian (Indian)
Mia	9	5	University Elementary School	Italian
Abigail	10	5	Park Elementary School	Black/African American
Michelle	8	4	Academy of Achievement	Biracial (Black/Puerto Rican)

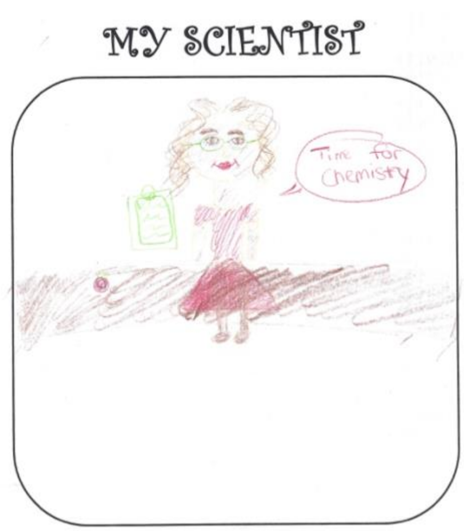
*Self-Identifies

Participant Profiles

Participant 1: Sandra. Sandra is a nine-year-old girl in the fourth grade at Poet Elementary School, where she receives science instruction twice a week. She self-identifies as Jewish and Latina because her mother is Jewish, and her father is Cuban. Her family resides in Morningside Heights, and she has participated in programs run by HYPOTHEkids with her older sister in previous years. Sandra is a self-professed tomboy, describing herself as "not wearing anything sparkly or frilly because sweatpants, basketball shorts, and sneakers are more comfortable". When given options on projects, she generally picks color schemes that involve a lot of black and gray. Sandra enjoys flexibility in projects and likes to create unique projects that are different from everyone else's. She takes pleasure in her individuality. Sandra generally prefers to work alone, and when assigned a partner, she converses with them socially while mostly working individually. Sandra has a short attention span, so she only stays engaged in work that holds her interest. She is not shy, even with adults, and frequently asks questions, seeks help, and voices her opinions. Sandra prefers the hands-on aspect of science learning to listening to lectures or having discussions. She likes to "create stuff" because scientists "explore and discover stuff".

Figure 3.1

Sandra's 2nd Scientist Drawing

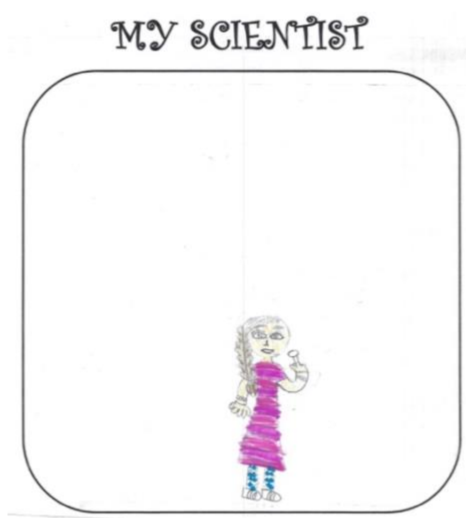


Note: "The scientist is like a girly girl. She wears, like skirts and stuff, and she's sassy because she's Cuban like me. She's doing chemistry like in a lab and she's writing stuff down all the time."

Participant 2: Talia. Talia is a nine-year-old girl in the fourth grade at Poet Elementary School where she has science class twice a week. She self-identifies as Asian (from India). Talia resides on the upper west side of Manhattan and this is her first time participating in a program run by HYPOTHEkids. Talia enacts socially normed behaviors for girls – wearing bright colors, flowers, and patterns, and choosing bright colors (i.e., pink and yellow) when given the option during projects. Talia considers herself "artistic" and works well alone and with partners. She is more reserved than some of the other girls and is generally quiet unless she's working with her friends (she knew a couple of girls coming into the program). Talia is generally articulate and composed, and while she never complained about any of the projects, she was not overly enthusiastic about them either. She commented that she "doesn't really like science even though she participates in class". She also mentioned that art is her favorite school subject.

Figure 3.2

Talia's 2nd Scientist Drawing



Note: "She's a research scientist from India who works in a lab. She's like 30 years old."

Participant 3: Mia. Mia is a nine-year-old fifth-grader at University Elementary School. She lives on the upper west side of Manhattan and self-identifies as Caucasian, and more specifically

Italian. This is her first time participating in a program run by HYPOTHEkids. Mia has science 2-3 times a week at school. She is quiet and hard-working, but not shy. She participates regularly, volunteering to answer questions and sharing her thoughts during group discussions. She seems thoughtful and reflective, giving relevant responses that advance the conversation. Mia does not come off forceful or overly confident, but her contributions to the class are noticeable. She works well both independently and with others – she can interact with her peers and teachers while staying on task. Mia has successfully completed every project, and while expressing things she would do differently next time, she seems satisfied with her work. Mia vocalizes when she is having difficulty with a concept or activity, and even when she is visibly frustrated. She has strong problem-solving skills and always comes up with a solution for each challenge. While Mia seems interested in science, she admits that science is not her favorite subject and that she is "better at other things".

Figure 3.3

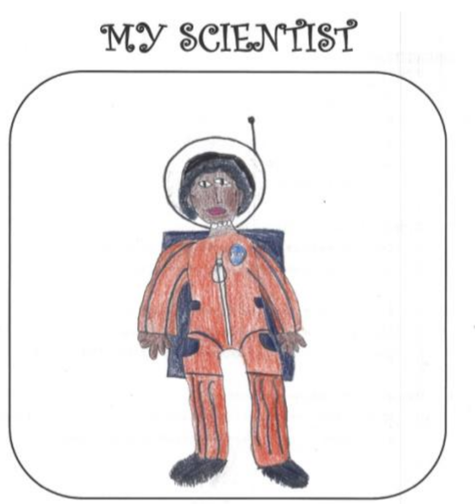
Mia's 2nd Scientist Drawing

Note: "She's a science teacher and she works in a classroom."

***Participant 4: Abigail**.* Abigail is a ten-year-old fifth-grade student at Park Elementary School, where she does not have a dedicated science class. Abigail lives in Harlem and self-identifies as African American. She is quiet and reserved, but detail-oriented and carefully constructs each of her projects to look the way she has envisioned them, even when that means taking extra time to complete them. Abigail does not complain about any of the work and has stated many times that she really likes science. However, when things are difficult for her, she shows frustration and then usually attempts to problem solve on her own, only asking for help when absolutely necessary. Abigail works well independently and with partners – she seems open to other people's ideas, although she expresses disappointment when things do not turn out the way she would have liked. Abigail's mother continually looks for opportunities for Abigail to engage in science so that she does not lose interest during this time when science is not being taught at her school.

Figure 3.4

Abigail's 2nd Scientist Drawing

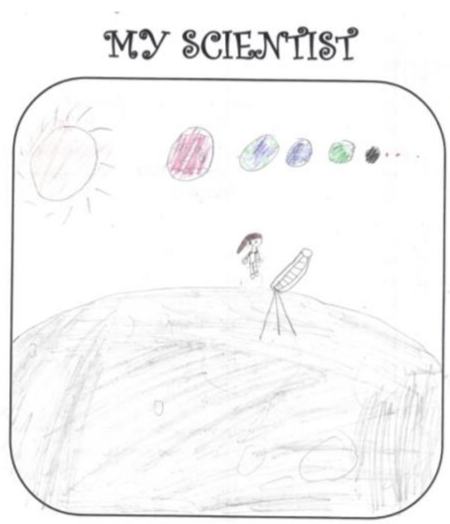


Note: "My scientist is an astronaut that works at NASA. She's getting ready to leave on a mission, so she's wearing her space suit."

Participant 5: Michelle. Michelle is an eight-year-old fourth-grader at the Academy of Achievement. She lives in the Bronx and self-identifies as African American and Latina. Michelle is conscientious and works slowly because she is weary of making mistakes. Michelle prefers to work alone and really only enjoyed working with one other girl in the program. Michelle shows a lack of confidence in her skills, often declaring that she cannot do things before even attempting them. Michelle is easily frustrated when she tries something, and it does not go as expected, or she is unsure how to go about completing a project. She frequently asks for help and requires attention from both other students and teachers. Although Michelle shows some interest in science, she does not consider herself a scientist.

Figure 3.5

Michelle's 2nd Scientist Drawing



Note: "She's an astronomer and she works at an observatory looking at the solar system through a telescope."

Trisha Barton, Co-teacher

Trisha is an interaction designer and STEM/Maker Education consultant and educator, with a Bachelor of Arts degree in Psychology from Spelman University, and a master's in art education concentrating in Creative Technologies from Teachers College, Columbia University. Trisha has researched the role of stress in education and how technology can be used to learn, explore, and create, and used her knowledge of maker labs and art to facilitate workshops for children, adolescents, and adults and develop programs that revolve around making, creative technologies, STEM, and the relationship between inquiry-based projects and career development. Trisha's work is focused on the affordances of hands-on experience in understanding, transferring, and integrating multiple subjects when making.

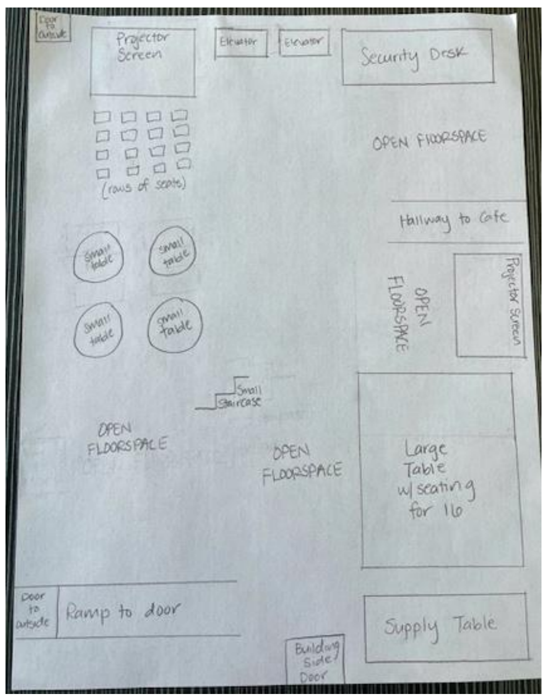
For the last four years, Trisha has also researched STEM curricula and pedagogy while working with students of diverse genders, ages, and ethnicities. She has consulted for various organizations, including STEM Kids NYC, YW NYC, Brooklyn College Community Partnership, The Giant Room, and HYPOTHEkids on implementing STEM/STEAM curricula and projects, helping educators and youth develop necessary 21st-century skills, and empowering minorities and girls/women to engage and pursue STEM careers. In her capacity as both a consultant and teacher for various HYPOTHEkids programs, she has collaborated with the primary researcher prior to this program (HYPOTHESISters) to create curricula for a virtual engineering design-based program for middle school students (STEAM Up).

HYPOTHESISters Program Structure

The program was conducted in a space that was different or outside the traditional school setting to provide a change of scenery and promote an atmosphere of collaboration and creativity. The girls had the opportunity to see others working together in the space to solve problems and make discoveries as there were frequently groups of college and high school students collaborating on projects and working on presentations, as well as businesspeople conducting group meetings. The Forum also provided adequate space with room for differentiation between areas for whole group work/discussions, small group/pair work, and open spaces for project building and experimentation.

Figure 3.6

The Forum Diagram



The program focuses on girls in fourth and fifth grade (ages 8-10) because it is well documented that girls lose interest in science as early as late elementary school (Barmby et al., 2008; Potvin & Hasni, 2014), and the hope was that by catching them at this age, we can help prevent their loss of enthusiasm for science and sustain their interest through high school and beyond.

The program ran in twelve consecutive sessions for two hours on Saturday mornings (10 am-12 pm). A typical session was loosely structured as follows:

- Icebreaker - a confidence/leadership building activity
- Prompt/Story involving a female scientist/engineer/mathematician – may include themes about courage, pioneering, leading others, and dealing with negativity from others
- Introduction of the science concept(s)
- An activity (project or lab) relating to the scientists' areas of study
- Sharing out/presenting/debriefing

By observing the participants' interactions and behavior with each other and the teachers, listening to their conversations, facilitating discussions with the girls, and evaluating their work it was possible to determine if their ideas regarding science and their ability to do science were changing in positive ways.

Data Collection Methods

Questionnaire

A questionnaire consisting of both Likert scale and open-ended questions was administered at the very first session of the program. As each girl arrived for the first day, they were given the questionnaire to complete for the first 20 minutes of the session. All 16 participants were able to finish the questionnaire within those twenty minutes. The Likert scale questions are adapted from the science section of the William & Ida Friday Institute Student Attitudes Toward STEM (S-STEM) Upper Elementary Survey, which invites students to give information about their attitudes towards science, post-secondary pathways, and career interests (Friday Institute for Educational Innovation, 2012). The S-STEM survey has four clear constructs measuring student attitudes toward science, math, engineering and technology, and 21st-century skills. These constructs can help measure the impact of various interventions on student interest and confidence in STEM subjects, including programs that implement new curricula, use new instructional strategies, or provide new learning opportunities (Faber et al., 2013). As such, the S-STEM survey is a powerful and useful tool to evaluate student attitude changes during STEM educational programs (Luo et al., 2019). The open-ended questions were written by the primary researcher and were intended to gauge how the participants felt about scientists and science in general, as well as their school science classes. Based on their questionnaire responses, five girls were chosen to be participants in the study due to either their lack of interest in science, their lack of confidence in their ability to do science, or their traditional view of who can do science and what doing science looks like, or some combination of these characteristics.

Interviews

Interviews were conducted with the five girls selected for participation in the study to determine their feelings about science in general, who can be scientists, their ability to achieve in science, and their science identities (or the lack thereof). At the final program session, interviews were scheduled (via their parent(s)/guardian(s)) with each of the five girls under study. All of the interviews were conducted within the two weeks following the end of the program (December 8-20, 2019).

Each of the five participants was interviewed individually by the primary researcher. Although parents were invited to sit in on the interviews as well, only two participants (Abigail and Sandra) had a parent present during their interviews. The interviews were conducted at the Forum in Room 317, which is a stand-alone meeting room on the third floor of the building that is set up with a conference table and chairs. Each interview lasted no longer than 20 minutes and included ten questions regarding their experience with learning science at HYPOTHESISters, their experiences learning science at school, their thoughts/feelings/ideas about who can be a scientist and what it means to do science, and their belief in their ability to do science (see Appendix I). Each interview was recorded, transcribed by a transcription service, and then checked/edited for accuracy by the primary researcher.

Videotaped Observations

Since the primary researcher was also teaching parts of every session and therefore unable to observe the lessons and take field notes at the moment, the club meetings were videotaped from beginning to end, and then reviewed and transcribed by the primary researcher. The videotapes captured all aspects of the sessions – discussions, presentations, projects, and activities – except those that took place outdoors since the camcorder was not able to be transported. After transcription, the primary researcher viewed each recording and took field notes/made observations about each session, noting interactions between the girls, between the girls and the teachers, whole group/small group discussions, moments of frustration/failure and success, and moments of leadership and displays of confidence.

Collection of Artifacts

Artifacts were also collected from the five participants. Two artifacts were collected from each student for analysis: their first "Picturing the Scientist" drawing, completed during the first meeting of the club, and their final "Picturing the Scientist" drawing, completed during the last club meeting. By comparing the two drawings, the primary researcher was able to compare if/how the participants' idea of who can be a scientist and what scientists do change throughout the program.

Table 3.2

Research Questions & Data Collection Methods

Research Questions	Data Collection Methods
What is girls' experience working with a gender inclusive curriculum that focuses on the contributions of black women to science?	Videotaped club meetings; participant interviews
How does participation in an informal science program that employs a gender-inclusive curriculum impact young girls' perception of who can be a scientist?	Questionnaire; artifacts from lessons; participant interviews
To what extent does participation in a gender inclusive science program grounded in stories of women in science affect girls' perception of their ability to do science?	Questionnaire; videotaped club meetings; participant interviews

Data Analysis Methods

Open-Ended Survey Questions

The open-ended survey questions (see Appendix G) were organized by the participants into a table which the primary researcher used to take notes on each response and engage in memoing emergent ideas (Creswell & Poth, 2018). Once the initial reflexive thinking was completed, the researcher engaged in in-vivo coding to break down, examine, compare, conceptualize, and categorize the data (Boeije, 2010). During in-vivo coding, the entire document was read first, and then the text was re-read line by line and broken into informational fragments. Once the text was broken into fragments, the researcher gleaned meaning from each fragment to determine whether or not each section was meaningful to the research. If the segment was determined to be of importance to the research, an appropriate code was created and assigned to the piece of text by the researcher. The different sections were then compared to each other so that those fragments which addressed the same topic received the same code - a summarizing phrase for a piece of text which expressed the meaning of the fragment (Boeije, 2010).

Table 3.3

In-Vivo Coding of Sandra's Open-Ended Questionnaire Responses

#	Phrase	Code
1	Somebody who explores and discovers	What Scientists Do
2	Old European guy	Who can be a scientist
3	Works in a lab and outside	What scientists do/what is science
4	Wears a lab coat and goggles	What scientists do/what is science
5	White hair	Who can be a scientist
6	Have to do math every day because it's really important	Importance of subject content area
7	Other subjects we don't need every day, like science	Importance of subject content area
8	It's fun sometimes, but also boring a lot of the time	General interest/feelings
9	It's easy	General Interest/feelings
10	Teacher tells us exactly what to do	Feelings about teaching methodology
11	Just have to follow directions	Feelings about teaching methodology
12	It's easy if you follow directions	General interest/feelings
13	No work like reading and writing in science	Feelings about teaching methodology
14	How I do in science depends on how hard the work is	Feelings about ability to do science
15	I can't do hard science stuff	Feelings about ability to do science

After in-vivo coding was completed, fragments that were assigned to the same code were compared and grouped into relevant categories, which were then defined so that the properties of each category were distinct (axial coding) (Boeije, 2010).

Table 3.4

Axial Coding of Sandra's Open-Ended Questionnaire Responses

Code	Text Fragment	Category
What scientists do	• Somebody who explores and discovers • Works in a lab and outside • Wears a lab coat and goggles	Perception of scientists
Who can be a scientist	• Old European guy • White hair	Perception of scientists
Importance of content area	• Have to do math every day because it's really important • Other subjects we don't need every day like science	Perception of science
General feelings/interest	• It's [science] fun sometimes, but also boring a lot of the time • It's [science] easy • It's [science] easy (if you follow directions)	Perception of science
Feelings about teaching methodology	• Teacher tells us exactly what to do • Just have to follow directions • No work like reading and writing in science	Science curriculum and pedagogy
Ability to do science	• How I do in science depends on how hard the work is • I can't do hard science stuff	Confidence in science skills/abilities

Likert-Scale Survey Questions

The Likert scale survey questions (see Appendix G) were used to determine whether each club participants' (all 16 girls) overall attitude toward science was generally positive, negative, or neutral. The primary researcher averaged the scores marked on each question to get an overall sense of whether or not the student had a negative or positive attitude towards science in general and towards the possibility of a future career in a science field at the start of the HYPOTHESISters program.

Figure 3.7

Talia's Likert Scale Questions Analysis

<u>Likert Scale Questions</u>

1. I feel good about myself when I do science. — Disagree (2)
2. I might choose a career in science. — Strongly Disagree (1)
3. After I finish high school, I will use science often. — Disagree (2)
4. When I am older, knowing science will help me earn money. — Neutral (3)
5. When I am older, I will need to understand science for my job. — Strongly Disagree (1)
6. I know I can do well in science. — Neutral (3)
7. Science will be important to me in my future career. — Strongly Disagree (1)
8. I can understand most subjects easily, but science is hard for me to understand. — Agree (4)
9. In the future, I could do harder science work. — Disagree (2)

Overall Attitude Toward Science: Negative (Disagree) 2.1

- Not planning on choosing a career in science and doesn't think it will be important to her life in the future General Interest/Feelings
- Lacks confidence in science ability Feelings about science skills/Ability to do science
- Finds science difficult to understand General Interest/Feelings
- Low self-esteem when it comes to science Feelings about science skills/Ability to do science
- Does not see herself as a scientist at all (Lack of) Science Identity

These scores were also used, along with their responses to the open-ended questionnaire questions, to choose the five girls that were selected for interviews and artifact collection.

Interviews

Each participants' interview was analyzed using three different types of open coding: In-Vivo coding, emotion coding, and versus coding. Applying multiple coding methods gave the researcher a richer perspective on the same data set.

In-Vivo Coding. Each participants' interview recording was first transcribed by a transcription service and then reviewed and edited by the primary researcher for accuracy. After each transcript was reviewed, the primary researcher read through each transcript and engaged in memoing to capture initial ideas and impressions. The researcher then read each transcript line by line and engaged in In-Vivo coding to conceptualize the data and break it into meaningful fragments. Portions of text that were important to the research were highlighted and then assigned a code, and then the different fragments were compared and grouped so that those addressing the same topic were labeled with the same code.

Table 3.5

In-Vivo Coding of Michelle's Interview Transcript

Spkr	Time	Transcript	Phrase	Code
SI:	00:38	Um, it's pretty fun because we get to do experiments and we can work together.	• It's pretty fun • Do experiments • Work together	Description of school science class
RR:	00:44	Okay, great. Picture a scientist in your head. Who are you picturing? Describe this person to me.		
SI:	00:52	I actually think of two different people.		
RR:	00:55	Okay, describe them both to me.		
SI:	00:58	Well, one of them is my science teacher, and the other person is an astronaut.	• My science teacher • An astronaut	Examples of scientists

Emotion Coding. After In-Vivo coding was completed, the transcripts were reviewed line-by-line a second time to highlight sections of the text and label the emotions recalled and/or experienced by each participant or inferred by the researcher about the participants (emotion coding). Evaluating the participants' emotions, defined as "a feeling and its distinctive thoughts, psychological and biological states, and range of propensities to act" (Goleman, 1995, p. 289), allowed the researcher to explore the intrapersonal participant experiences and gave the researcher deep insight into the participants' perspectives. The emotion codes produced were a combination of In-Vivo codes and the emotional states and reactions of the participants.

Table 3.6

Emotion Coding of Mia's Interview Transcript

Spkr	Time	Transcript	Code
RR:	03:57	Can you give me an example of what makes science at our girls' club different from school science? Why do you want school to be more like Saturdays?	
SRo:	04:07	Because it's just [8]more fun on Saturdays. We get to do [9]more creative stuff and more things with science that are fun. Like [10]it was really fun to learn about astronomical units with the beads. Even though we had to do math,[11]it was fun because we made a scale with the beads, and everyone's projects came out so pretty even though they were all different because we picked our own bead colors and stuff. [12] We had more choice, which made [13]our projects come out better.	[8]Fun/enjoyment [9]Creativity [10]fun/enjoyment [11]fun/enjoyment [12]Empowerment [13]Pride

The different highlighted sections of the transcript were compared and grouped so that those which identified the same emotions were grouped and labeled with the same emotion code.

Versus Coding. Versus coding acknowledges that humans are frequently in conflict, and captures the actual and conceptual conflicts within, among, and between participants (Saldaña, 2013). Versus codes identify in dichotomous or binary terms the individuals, groups, social systems, organizations, phenomena, processes, concepts, etc. in direct conflict with each other (Saldaña, 2013). After emotion coding was completed, the transcripts were reviewed line-by-line a third time to highlight sections of the text and identify and label with appropriate codes those ideas/concepts which are in opposition to each other or pose some sort of conflict for the participant. The different fragments were compared and grouped so that those addressing the same topic were labeled with the same code.

Table 3.7

Versus Coding of Abigail's Interview Transcript

Spkr	Time	Transcript	Code
RR:	03:35	Why? What makes it different?	
AH:	03:37	Because in our [1]school we're working on world things that happened in the world and here we're working on science that I wouldn't be learning in school.	[1]School Science vs. Girls' Club Science
RR:	03:46	So different kinds of science?	
AH:	03:47	Yeah.	
RR:	03:48	What about the way you learn? Is it different in school than it is on Saturdays?	
AH:	03:52	Yeah because on Saturdays we have a lot of fun and do creative, colorful projects where [2]everyone is doing something different. In school, we are all basically doing the same thing.	[2]School Science vs. Girls' Club Science
RR:	04:04	Do you like working with other people when you do science, or would you rather work by yourself?	
AH:	04:09	[3]I like working with other people. It makes things more interesting than working alone because there's more ideas.	[3]Working Alone vs. Working with Others

After all, three types of coding were completed, fragments that were assigned to the same code were compared and grouped into relevant categories, which were then defined so that the properties of each category were distinct (axial coding) (Boeije, 2010). The data was then reduced into several major themes that were present across the data.

Video Recordings of Sessions

Each video recording was viewed by the primary researcher and detailed field notes were taken from the videos. These descriptive notes summarized, in chronological order exactly what happened during each club meeting during whole group discussions, presentations, small group, and pair work, interactions among the participants and between the participants and the teachers, as well as during projects and activities that took place indoors (outdoor activities were not recorded). Along with recounting exactly what occurred, the researcher also wrote personal notes and reflections (memos) on what happened throughout the club meetings and drew conclusions about the meaning of the interactions and situations that occurred.

Table 3.8

Field Notes from Video Tape of Lesson 4.

Time Stamp	Observation	Thoughts/Notes/Questions
01:26	SR demonstrates that she knows the answer to the question with her fingers but doesn't raise her hand to share the answer with the group.	Why doesn't she want to share? Is it because she's not confident that her answer is correct?
1:40	Students are struggling to make the conversion from AU to beads so the teacher moves to a physical demonstration with actual beads.	Using manipulatives as a way to clarify concepts.
2:21	Teacher reviews with students (4 beads is 1 AU) and then tells them they can also think of it as money, where 4 quarters = $1. Then she asks if she just wants 50 cents or half an astronomical unit, how many beads does she need. AH replies two and SR once again holds up her two fingers but doesn't respond out loud.	Is SR just embarrassed or too shy to verbalize the answer? Or is this a confidence issue?
2:50	Teacher moves to the next planet and asks the students if the number in AU needs to be rounded and AB quickly replies "no".	AB replies no with complete confidence and goes on to explain why without hesitation.
04: 05	Teacher asks how many small beads are needed for Venus and calls on AB because she raises her hand. AB replies three – the correct answer. AB also indicates that no big beads are needed.	AB is clearly confident that she understands how the conversion works well enough to share the answers with her peers.
04:27	Teacher asks how many AU for Earth and calls on SI to answer. AB holds up her finger to indicate that Earth is 1 AU. When SI looks down at the table and doesn't respond, RD raises her hand to answer. Teacher continues to	SI freezes when called on for the answer, even though the answer is on the paper in front of her – lack of confidence.

	work with SI until she's able to give the correct answer.	
05:10	Teacher asks how many small beads for Earth and two girls (RD and EB) show the amount with their fingers as the other girls are writing on their charts.	Clearly most of the group is now confident that they understand how to make the proper conversions.

Instances uncovered from the field notes were grouped along with the themes uncovered from the interviews and questionnaires to support and provide examples of those findings.

Elements of Rigor

Reflexivity/Positionality

As both the primary researcher in this study and the lead teacher at HYPOTHESISters science club, my positionality made me both an insider and an outsider relative to the participants. As the lead instructor of HYPOTHESISters, I was positioned as a participant observer over the length of the study. This means that I had a dual relationship with the participants as both a teacher/mentor and as the primary investigator on the study. One of the participants was also previously acquainted with both instructors because she has participated in other programs run by HYPOTHEkids in the past, the company with which both teachers are employed. This means she was either taught by us before, participated in other STEM activities that we have organized/run at events around New York City, and/or have attended Hk Summer STEAM, the summer program for which I have been the Site Director and Trisha has been a lead teacher. As a teacher for many years, I am also influenced by my own experiences and perceptions related to gender equity in curriculum, pedagogy, and teaching methodology.

Given the areas of Manhattan that the participants came from, in addition to sharing the same gender as the participants, I also shared a similar racial and ethnic background with some of them. This may have made it easier for them to open up to me during interviews and the actual programming. For those with whom I did not share a common racial and/or ethnic background, I was more of an outsider, even though we shared other things in common. In all cases, I had to be mindful of my position as the researcher, a co-author of the curriculum being implemented, and the person in charge of the program operations – all of which might have been seen as positions of authority. Being perceived as having some sort of authority over the participants, may have altered the girls' behavior, interview, and survey responses.

Triangulation

Triangulation was achieved in this study by the use of multiple data sources. Survey responses, interviews, videotaped observations, and artifacts of student work were compared and cross-checked during analysis as a means of increasing credibility and quality (Merriam & Tisdell, 2015). The researcher also engaged in member checking by asking additional questions and clarifying participant responses to make sure that the interpretation of participant statements, both verbal and written were accurate.

Challenges and Limitations

Challenges associated with this research included getting every participant to complete each part of the data collection process, specifically completely answering all the open-ended survey questions and attending every club meeting. A couple of the participants had to miss club sessions, which did not allow for observations of their behavior and interactions during those club meetings, even though all the participants managed to complete each activity/project. Given the young age of the participants, it was sometimes difficult to get clear descriptions and in-depth responses to the open-ended survey questions and interview questions, as they often could not find the words to describe their thoughts or feelings. Sometimes, the researcher had to ask additional questions to get enough information from the participants to glean what their feelings and experiences were. It was also challenging to get permission from each participants' parent(s)/guardian(s) to participate in all aspects of the data collection, including consistent attendance, one-on-one interviews, and especially videotaping. This meant that one participant that was initially selected to join the study could not do so because her parents did not return the consent forms.

Limitations included the interpretations of the researcher, which were restricted by personal experiences and knowledge that influenced the interpretation of observations and written responses, as well as conclusions drawn related to the research questions. There was also a limit on the number of participants that could be included in the study. Due to the breadth of data collected and the amount of time required to analyze all the data collected, the number of girls included in the case for the study was restricted to five. There was also no way for the researcher to record activities that were conducted outside of the building during sessions because the video recorder and tripod could not be transported to every location that was used for activities. Also, due to the onset of Covid-19 and the quarantine requirement in New York City, the researcher was unable to collect the second set of data from the second group of participants, which was the initial plan for this research study.

Chapter IV

FINDINGS

Girls' Experiences with Gender-Inclusive Curriculum

Feminist and gender theories of learning posit that scientific knowledge is inherently gendered. Since science is most closely aligned with culturally defined values associated with masculinity, feminist epistemologies present challenges to traditional epistemology (Grasswick, 2011), which directly impacts how girls relate to and learn science. Students' identities are also naturally gendered, and as students transform identities and learn the requisite knowledge and skills to become members of new communities and develop new identities, like a science identity, these new identities will be gendered as well (Vincent-Ruz & Schunn, 2018). In addition to this, identity theory helps us examine how the internalization of our experiences and the socially constructed nature of identity hinders the development of science-related attitudes by women in STEM. Examining girls' experiences with the gender-inclusive curriculum through these lenses provides insight into girls' dissociation with science and underrepresentation in STEM fields, as well as ideas about how to make science learning more inclusive and learning environments more supportive of girls' specific learning needs.

Curriculum & Methodology: School Science vs. HYPOTHESISters' Science

Research has shown that context and environment play an important role in how girls feel about science and their level of interest in science (Baker & Leary, 1995). As girls progress from elementary to secondary school science, they experience a shift in the classroom environment and teaching methodology that leaves many of them feeling excluded and with a less favorable opinion of science. Girls are more relational and cooperative and less competitive than boys in general, striving for a deeper conceptual understanding of concepts and rejecting more formulaic, rote learning (Zohar & Sela, 2003). This does not fall in line with the way many science classes are taught, especially as students get older, and teachers are held more accountable for meeting standards and focus shifts to standardized test scores. Girls often find themselves feeling stifled in their science classes, unable to explore and be creative together. The girls in this study are no exception.

School Science: Prescriptive, Infrequent & Lacking Creativity. Although the five girls in this study attended four different schools (two of them went to the same school), they generally described their science classes at school as being rigid and sometimes boring, dominated by extensive lecturing, and lacking in interesting activities and labs. During her interview, Sandra specifically mentioned that while her science class "can be fun sometimes", it's "mostly boring" and her science teacher "talks forever". Sandra recounted that when she and her classmates are going to do an activity or project, there is always lecturing for an extensive length of time before they actually get to do anything. The long delays cause Sandra to get bored and lose focus, and then by the time the class starts the project/activity, Sandra "doesn't really care about it that much and sometimes I don't have time to finish it".

Talia also explains that her science class involves a lot of listening and taking notes, interspersed infrequently with activities:

Interviewer:	What's your science class like? How would you describe it?
Talia:	We mostly take notes down. She'll teach us, my science teacher will teach us stuff about science, and we'll take notes down and ask questions. And sometimes, it's a little rare, but sometimes we'll do experiments or go on the computers for research about something.

While most of the participants (four of the five) did not express a particular dislike of science, they did describe their science classes as difficult and the science concepts they learn as hard to understand. Talia was particularly vocal about her difficulties with her school science class, expressing in her questionnaire that her science class at school is "complicated and disorganized", and that she frequently finds science concepts hard to understand. She reiterated these feelings during her interview, mentioning that science is different from art, her favorite subject because "it's hard to understand science because it's difficult and has math and stuff". Talia says that science "isn't really her thing" because science is challenging, which makes her question her skills and ability to do high-quality science work.

HYPOTHESISters' Science Club. There was a consensus among the girls that HYPOTHESISters was fun, but they each had different reasons for what made it more engaging and enjoyable than their school science classes.

Abigail. Abigail described HYPOTHESISters as fun and interesting because she was learning things that she was not learning at school. She described what she learns at school as "world things" and then went on to say that they were learning about climate change at school. She described HYPOTHESISters as doing "real science", which she defines as "studying lots of things and figuring out the answers to important questions" or "making things work better". She also mentioned getting to do hands-on projects and activities that were "creative and colorful". She emphasized that everyone was doing something different instead of following a set of instructions that makes everyone's projects turn out exactly the same, which made it "fun to see what everyone did and what they learned".

Sandra. For Sandra, the high level of engagement and the collaborative environment made HYPOTHESISters more enjoyable than her science class at school. Sandra found the topics and types of discussions at HYPOTHESISters to be interesting, noting that "we get to talk about things we don't talk about at school like black holes and cool scientists". She also emphasized the fact that science club was better because of the collaboration on projects and activities – "we did all the math together as a whole group" (referencing the astronomical units bead mobile project) and in general "we do most things together so you're not like on your own if you don't get things". She went on to say that "the projects are more interesting and the way we learn doesn't feel boring" because the mode of learning is varied, with videos, discussions, and games, and sometimes go outside for experiments and activities. She also enjoyed the space for individual expression in the projects: "My favorite project is the bead one (See Figure 4.1) because I liked how it looked at the end. Mine was different from everyone else's. I got to make it the way I wanted it to be like the galaxy globe, where my planets were the way I wanted them (See Figure 4.2) because we didn't have to follow an exact pattern."

Figure 4.1

Sandra's AU Bead Mobile

Figure 4.2

Sandra's Galaxy Globe Planets

For Sandra, all of these attributes combined to give her a pleasant, memorable experience that helped her retain the information she was learning: "Astronomical units (AUs) is the distance between planets. I remember because it was like a code that we made for the beads and the AUs – it looked so cool!"

Mia. Mia explained that the Saturday girls' science club was more fun than school science because the projects and activities gave her more choices, which allowed her to be more creative and ultimately made her projects higher quality. She also expressed how much she liked being able to collaborate with the other girls and get help on her projects because it made the work seem less strenuous.

> Because it's just more fun on Saturdays. We get to do more creative stuff and more things with science that are fun. Like it was really fun to learn about astronomical units with the beads. Even though we had to do math, it was fun because we made a scale with the beads, and everyone's projects came out so pretty even though they were all different because we picked our own bead colors and stuff. We had more choice, which made our projects come out better.

Figure 4.3

Mia's AU Bead Mobile

Talia. Since art is Talia's favorite class at school, she found HYPOTHESISters science club fun because it felt like "an art class where you learn about science" and the projects are aesthetically pleasing because they "involve arts and crafts and pretty things". She also liked that the supportive environment created intellectual security, mentioning that "…it's okay to make mistakes and try things different ways and no one will get mad at you or make you feel like you did it wrong or like yours isn't good because it's not like someone else's". The freedom to display science knowledge in her way was an important aspect of the curriculum for Talia, as it made her feel comfortable enough to incorporate her artistic skills into her science work, which ultimately made her more confident in the work she was producing.

Michelle. Like Talia, Michelle enjoyed the artistic and creative nature of the curriculum in the girl's science club, describing it as "doing art and learning science at the same time". However, she also mentioned the challenge of having to "do a lot more stuff on my own" and make more of her own choices with regards to "which way things go because we all have different ideas". She also "liked having two teachers that both know a lot of science" available for help because having knowledgeable scientists available to answer her questions and support her throughout the projects encouraged her to work through difficulties and "do her best" on her projects. Lastly, Michelle emphasized how happy she is at HYPOTHESISters because she "likes working with you [primary researcher] and scientist Trisha" and "it was cool to learn about women scientists" because at school "we rarely talk about them, even though they do science too" and the emphasis is on men's contributions to science.

Based on the questionnaire responses and interview excerpts, the participants seem to enjoy the gender-inclusive, hands-on curriculum and collaborative, nurturing teaching methodology of the science club more than their school science classes, and they find the science at the girls' club more fun than the science they engage in at school. This is important since problem-solving, creativity, and design have been identified as essential skills in students' STEM development (Cooper & Heaverlo, 2013). Providing students with experiential learning that incorporates these skills and offering them investigative opportunities into science that may not be part of the regular school day is an essential function of extracurricular and afterschool activities. The findings in this study further demonstrate the necessity of emphasizing the use of creativity and design in both attracting girls to STEM subjects and maintaining their interest. Science classes that blend science content knowledge with creative exploration allow girls to envision a space for themselves in science that does not force them to restrict their imagination.

Who Are Scientists and What do They Do?

At the start of HYPOTHESISters, all 16 girls who signed up for the program were given a questionnaire to fill out. The questionnaire was comprised of Likert scale questions adapted from the William & Ida Friday Institute Student Attitudes Toward STEM (S-STEM) Survey (Friday Institute for Educational Innovation, 2012) and was designed to gauge the girls' interest in and attitudes toward science, as well as what role science plays or could play in their current and future academic and professional lives. In addition to the Likert scale questions, the questionnaire also contained six open-ended questions, written by the primary researcher, to ascertain the girls' general opinions on who scientists are and what they do, if they identify themselves as scientists, and their school science class curriculum and methodology. These responses were then used as a basis for creating an interview protocol that would further explore their thoughts and feelings in these areas.

The results from the questionnaire, which was completed at the start of the first session, did not reveal a clear pattern across all the girls as far as their vision of who is or can be a scientist and what they do.

Table 4.1

Questionnaire Responses (Questions 10 and 11)

Participant	What is a Scientist	Name a Scientist	Describe a Scientist
Abigail	A person who studies lots of things.	N/A	N/A
Michelle	Someone who studies science.	Ms. Miron	My science teacher
Sandra	Somebody who explores and discovers stuff.	Alexander Graham Bell	Old European guy that does physics; works in a lab and out in nature; wears a lab coat and goggles; has white hair
Mia	A person who studies science.	An engineer, mathematician	N/A
Talia	N/A	Albert Einstein	Poufy gray hair; white lab coat; science experiment tools

Of the three participants who provided a written description of the scientist they were picturing in their heads, two girls (Talia and Sandra) included four of the seven regularly occurring features that Chambers (1983) described in his study as indicators of the standard image of the scientist:

- A lab coat
- Goggles
- Mention of hair (color and/or distinguishing features, facial hair)
- Symbols of research – i.e., scientific instruments and laboratory equipment of any kind

Talia and Sandra also named the specific scientist they were thinking of in the description – Albert Einstein and Alexander Graham Bell, respectively. Studies about scientist stereotypes since the 1980s, conducted on children as young as six years old, have consistently yielded drawings and descriptions of the stereotypical, quintessential scientist to the exclusion of female scientists and scientists of color. Chambers (1983) and other researchers (Meyer, Gueuther, & Joubert, 2019;

Ozel, 2012; Samaras, Bouoti, & Christidou, 2012) who have repeated his experiment or performed similar experiments found that stereotypes about scientists develop at an incredibly early age and persist, independent of student identity (socioeconomic status, racial/ethnic background, and gender). Even in classes full of girls, a context similar to HYPOTHESISters, students overwhelmingly draw males, and underrepresented racial and ethnic groups overwhelmingly draw Caucasian scientists. This is significant as Michelle and Abigail self-identify as African American.

Picturing the Scientist, Drawing #1

At the very first girls' science club meeting, the participants were asked to draw what they picture when they hear the word scientist and write a description of the person and surroundings they drew.

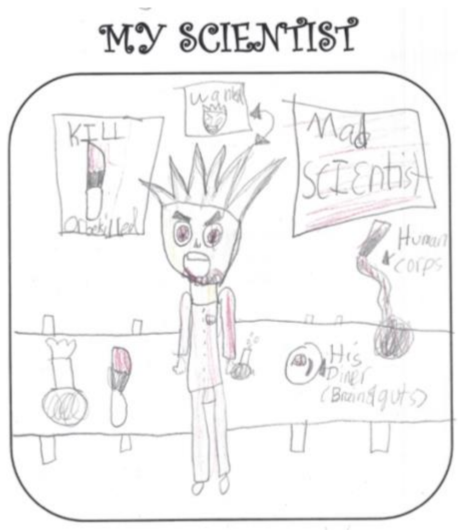
Figure 4.4

Sandra's 1st Scientist Drawing

Note: "The scientist is an old European dude with like white hair who works in a lab."

Figure 4.5

Michelle's 1st Scientist Drawing



Note: "He's a crazy mad scientist that does wild experiments in his secret lab where he like blows things up. His hair is all crazy and there's scary stuff in his lab.

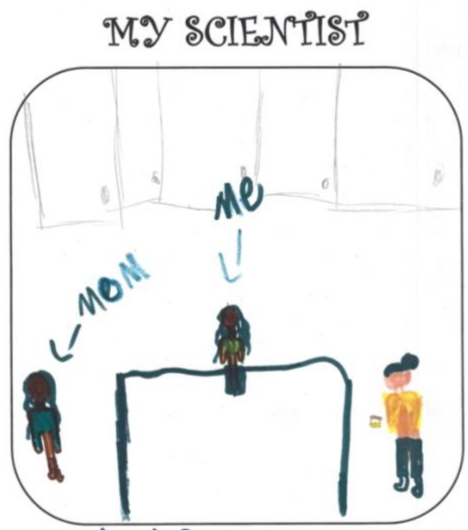
Figure 4.6

Talia's 1st Scientist Drawing

Note: "She's a doctor who works in a doctor's office where she sees patients. She always has on a lab coat and a stethoscope.

Figure 4.7

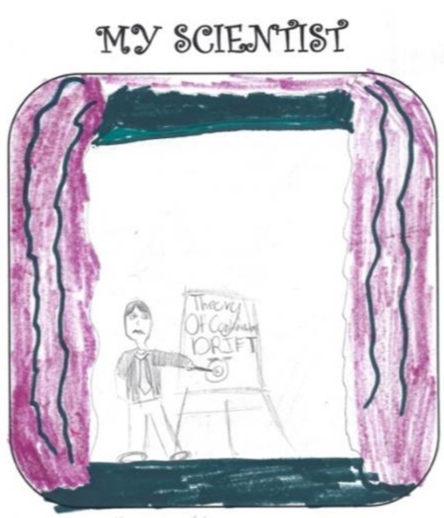
Abigail's 1st Scientist Drawing



Note: "I think of my mom as a scientist because she's a doctor. So, I drew a woman who works in a hospital standing behind a counter talking to her patient.

Figure 4.8

Mia's 1st scientist drawing



Note: "He's an Earth scientist that works in an observatory. He's talking to other scientists about continental drift because he's an expert on that. He's kind of old, but not super old.

Although each girl gave different descriptions and drew something different, Sandra and Mia described older white men (of European descent) who work in a lab and an observatory, respectively; Talia describes a middle-aged white female (of European descent) who works as a doctor in an office; Abigail described a middle-aged black female who works as a doctor in a hospital; and Michelle describes an older Indian man (from Dubai) who is a "mad scientist" working in a laboratory.

Table 4.2

Scientist Drawing #1 Analysis

	Sandra	Talia	Mia	Abigail	Michelle
Job Title	Physicist	Doctor	Earth Scientist	Doctor	Mad Scientist
Gender	Male	Female	Male	Female	Male
Race	White (European)	White	White	Black	Indian (from Dubai)
Age	"old"/"no longer living"	40	50	40s	"old"
Work Setting	Lab	Office	Observatory	Hospital	Laboratory
Description of Picture	Old white guy with white hair standing in a room with a long table that has lots of equipment on top of it (beakers and flasks)	Woman with a white lab coat and a stethoscope around her neck handing a bottle of medicine to a patient	White man, wearing a tie, doing a presentation, pointing to a board that says "theory of continental drift"	Black woman with long hair, shirt, pants, and boots standing behind a counter talking to a patient. Behind her are lots of doors to other patient rooms.	Man with tan skin, spikey white hair, thick eyebrows, angry red eyes, open mouth, and beard; holding a beaker bubbling liquid; 3 posters say "kill", "wanted", and "mad scientist"; counter with a "human corpse", lab tools, a plate of "brains and guts".

Research shows that children hold fairly stereotypical images of scientists which are related to their views of scientific knowledge and practice, their attitudes toward science, and their personal, professional, and social aspirations (Samaras et al., 2012). This stereotypical perception of scientists is persistent and pervasive across grade levels, gender, racial groups, and national borders (Finson, 2002). Children's drawings of scientists consistently include seven indicators: a lab coat, eyeglasses, facial hair, research and knowledge symbols, technology, and relevant captions (Chambers, 1983). These characteristics lean toward male scientists, and many students, regardless of gender, draw something similar to the popularly circulated image of Albert Einstein: an older white man with crazy white or gray hair and a beard or mustache, who wears a lab coat and glasses and is doing something in a laboratory setting with equipment like a beaker or flask. Although two of the study participants (Sandra and Mia) did draw a scientist in this vein, three of them (Abigail, Talia, and Michelle) drew something that was less stereotypical, indicating that they may have a more flexible, open view of who can be a scientist that includes women and minorities. It is interesting to note that the three girls who drew a non-traditional scientist (either a woman or a person of color, or both) self-identify as students of color themselves, which may be a factor influencing their perceptions.

Picturing the Scientist, Drawing #2

During the last meeting of the HYPOTHESISters science club, participants were once again asked to draw a picture of a scientist. Each participant demonstrated a shift in their thinking regarding the characteristics of scientists. In contrast to the first set of drawings in which three of the five participants drew men, all five participants drew women for this second drawing task. Four of the five participants also drew their scientists as being something other than white, instead depicting scientists with varied racial/ethnic backgrounds that included Cuban, Indian (from India), Black, and Latina (Dominican).

Also of significance, the areas of science depicted in the second set of drawings were more diverse as well. Instead of describing their scientists as working in a lab setting or doctors or using the generic term "scientist", the type of scientists depicted in the second set of drawings were more specific and expanded in scope to include a chemist, a science teacher, an astronaut, and an astronomer in addition to a researcher.

Table 4.3

Scientist Drawing #2 Analysis

	Sandra	Talia	Mia	Abigail	Michelle
Job Title	Chemistry	Researcher	Science Teacher	Astronaut	Astronomer
Gender	Female	Female	Female	Female	Female
Race	Cuban	Asian (from India)	American (white)	Black/African American	Latina (Dominican)
Age	40	30	50 or 60	35	40
Work Setting	Chemistry Lab	Laboratory	Classroom	NASA	Observatory
Description of Picture	Woman with tan skin and brown curly hair with glasses and red lips; wearing a skirt and top and holding a clipboard; standing in front of a long counter with a beaker full of liquid on it	Woman with peach skin with long braided hair; smiling and has long eyelashes; wearing a striped dress with polka dot socks and sneakers, bracelets on both arms; holding a beaker	Woman with peach skin, thin red lips, and short brown hair; wearing a short-sleeve shirt and a skirt	Woman with brown skin and black hair dressed in an astronaut suit with NASA written down the side and holding a helmet; she's standing next to a spaceship that also says NASA on it; waving and smiling; background sky with moon and stars	Woman with tan skin in a lab coat and skirt with glasses and long black hair; standing next to a large telescope pointing at other planets in the solar system; telescope is on a deck at the top of a domed building

These changes indicated a small shift in ideology that allowed for the inclusivity of marginalized groups of people (women and minorities) in the exclusive society of scientists. These young girls were beginning to see people who reflected themselves as scientists that have made and continue to make significant contributions to the current and future body of scientific knowledge and advancement.

Verbal Descriptions of Scientists

During their individual interviews after completion of the program, each girl was asked to picture a scientist in their head and describe the person they pictured. Two of the girls, Sandra and Talia, defaulted to the traditional idea of a scientist that society presents to children, describing an old Caucasian man with white or gray hair that works in a lab. While each of these girls named a different scientist, Alexander Graham Bell, and Albert Einstein respectively, there were similarities in their physical descriptions of both the scientist and their workplace. In contrast, Abigail gave a very general description of a scientist, indicating that she did not have a specific person in mind. She described the workplace and what scientists actually do rather than giving a physical description of what the person looks like. The other two participants, Michelle and Mia, described female scientists – Michelle described her science teacher and an astronaut (although she did not specifically name them), and Mia also described her science teacher.

Sandra's Scientist. When asked to describe a scientist, Sandra specifically named Alexander Graham Bell. She made sure to mention that he was around a long time ago and that he was deceased. She described him as a physicist that "looks like an old man with a white beard", descriptors that are commonly used by young children when they describe scientists. Sandra also mentioned in passing that they had recently studied Alexander Graham Bell at school, which is probably why he was at the forefront of her mind even though the focus of HYPOTHESISters was women scientists and the content theme was outer space. Clearly, the topics and people that Sandra is exposed to at school have a large impact on how she views science and who practices science, so much so that despite being exposed to science activities that do not take place in a laboratory for weeks, Sandra maintains a traditional view of science as experiments that happen in a laboratory, and references physics, a traditionally male-dominated area of science, in her description.

Talia's Scientist. When asked to picture a scientist in her head, Talia described a man with "poufy white hair, science goggles, gray mustache, in a lab coat" and even mentioned Albert Einstein by name. She also described his work environment as having "gray, dusty-ish walls, some chemistry sets", alluding to a laboratory. Talia still held a stereotypical view of who can be a scientist and what scientists do even after studying black female scientists in various science fields and being taught science by two women of color for weeks. Although she drew a scientist that was non-traditional in her second drawing, she reverted to a famous white male scientist that she was exposed to in school, rather than discussing any of the women scientists she learned about during HYPOTHESISters.

Abigail's Scientist. Unlike Talia and Sandra who pictured a specific scientist when asked to think of a scientist and describe them, Abigail was unable to name a specific scientist and instead gave a general description of where the scientist works and what they actually do, describing a non-gendered person "wearing safety glasses and working on experiments" in a place that has "beakers and chemicals everywhere". Abigail did not name or describe any of the women discussed during HYPOTHESISters or any of the scientists that young students commonly learn about in school. The inability to name a scientist or give details about what they do could speak to a lack of exposure to information about scientists throughout Abigail's schooling. The lack of gender assignment in her description could indicate that she viewed men and women as equally capable of being scientists and thought of scientists more in terms of the tools they use and what they do rather than what they look like.

Michelle's Scientist(s). Rather than describing just one person or one type of scientist like the other girls, Michelle opted to discuss two different scientists: her science teacher and an astronaut. Michelle gave a vivid description of what the astronaut looked like and what she does, describing her as "…pretty, even though she has to wear a space suit and sometimes you can't see her face. She also fixes rockets and makes them launch better, so she uses special equipment…she's strong because she can lift and move the spaceship parts, and she's smiling because she loves working at NASA". In contrast to the description of the astronaut, Michelle focused on how she feels about her teacher rather than what her teacher does or looks like. She said that her teacher is "really nice and knows a lot of science stuff…I really like her".

Neither of these descriptions was surprising because, during our sessions, we talked about Mae Jemison and Aisha Bowe, both of whom are black women who worked for NASA as an astronaut and an engineer, respectively. We also discussed science teachers being trained scientists, using the girls' club instructors as examples – one of us being a biologist and the other a computer scientist. Michelle was influenced by our conversations, which broadened her view of who can be a scientist to include women and those using their science training outside of traditional settings.

Mia's Scientist. Like Michelle, Mia thought of her science teacher when asked to picture a scientist during her interview. She described a woman who "has short black hair and usually wears a skirt" instead of traditional lab clothing (i.e., lab coat, goggles, gloves, etc.), highlighting her femininity. She also mentioned what her teacher did during science classes at school: "she uses her hands for mostly everything, even like touching dirt". Two things emerged from Mia's description of a scientist: 1) she classified her teacher as a scientist based on what she does, not on what she looks like or wears; Mia has shifted focus from her original idea of a scientist as a person who fits a physical description and works in a designated area to one who "does science"; and 2) Mia had begun to see women as scientists.

What Is Science?

Although not specifically asked what scientists actually do, it became evident through the girls' descriptions of scientists and their surroundings what they believed about the nature of science and what scientists do. Most of the girls described someone who works in a lab and uses standard lab equipment, like beakers and flasks to mix chemicals. For example, on her questionnaire, Abigail described scientists as "having beakers and chemicals everywhere" while "they're working on experiments", and in her interview she mentioned that scientists "study lots of things" and "create something new". Being someone who enjoys science and likes to cook, Abigail identified with the creative aspect of science, and explained that this was how she felt when she cooks: "it's like mixing chemicals and making something new that people will like to eat". Linking chemistry and lab science to cooking gave Abigail a personal connection to science that kept her interested and wanting to learn more. She also noted that scientists "discover things, learn more about things, and find better ways for us to do things", alluding to the fact that science improves our lives and that scientists are constantly uncovering new information and improving on their knowledge.

Talia never really explained exactly what scientists do; however, she mentioned that they "work in a lab" and "use chemistry sets" and "science experiment tools" – the traditional view of scientists and where they work. Clearly, she thought that science was about mixing chemicals and being stuck in the lab, rather than discovery and exploration.

Michelle described scientists as "people who study science" and explains that you have to "be able to do a lot of different things and do lots of experiments", but she did not give any details about what those "things" might be. She was under the impression that scientists have a lot of knowledge and that they do experiments, but there was no description of how they go about conducting experiments or uncovering new information. Unlike the other participants, Michelle did not mention a laboratory as a scientist's workplace; however, her description of what scientists do was along traditional lines. Sandra never truly explained what scientists do, only describing a scientist as "somebody who explores and discovers stuff". She also mentioned them "doing physics" and "working in a lab" on her questionnaire, which showed that she held a traditional view of science work prior to starting HYPOTHESISters that began to shift by the end of the program.

Views of Self as Scientist

As an informal science education program HYPOTHESISters has the potential to influence the development of young girls' science identity. To gauge whether or not the girls see themselves as scientists or members of the scientific community and to determine if their perception changed throughout the program, we asked them to express their thoughts at the beginning and end of the program by responding to questionnaire questions and answering interview questions.

Confidence and Perception of Science Skills/Ability

Of the five girls' participating in the study, only one, Abigail, seemed confident in her ability to do science and identified herself as a scientist (See Table 4.4). Abigail agreed that she feels good about herself when she does science at HYPOTHESISters and that she believes she can do well in science, indicating that she has formed or at least begun to form a science identity and feels that she is, to some degree, a member of the scientific community. Three of the participants – Michelle, Sandra, and Mia – gave neutral responses when asked if they feel good when they do science and if they feel they can do well in science. This implies that they are not totally confident in their ability to succeed in science classes and that they lack a true connection to science content and the science community. However, they did not express negativity towards science or learning science, which could mean that they are open to learning science. The last participant, Talia, was the only girl to express negativity towards science and strongly express doubt in her ability to excel in science. She views science as not having a place in her life and not being important for her future endeavors. For

Talia, science is just something that she must learn at school, not something that she enjoys or finds particularly interesting and meaningful.

Table 4.4.

Questionnaire Responses (Questions 1, 2, 6, and 7)

	Q1: Feel good about myself when I do science	Q2: I might choose a career in science	Q6: I know I can do well in science.	Q7: Science will be important in my future career.
Abigail	Agree (4)	Agree (4)	Agree (4)	Agree (4)
Michelle	Neutral (3)	Strongly Agree (5)	Neutral (3)	Strongly Agree (5)
Sandra	Neutral (3)	Disagree (2)	Neutral (3)	Disagree (3)
Mia	Neutral (3)	Neutral (3)	Neutral (3)	Disagree (2)
Talia	Disagree (2)	Strongly Disagree (1)	Neutral (3)	Strongly Disagree (1)

Membership in the Science Community

The participants in this study expressed varying relationships with the scientific community, with some of the participants considering themselves scientists in some way, shape, or form, some feeling far removed from the scientific community, and others falling somewhere in between.

- Abigail steadfastly asserted that she is a scientist. She likes science and sees a place for science in her personal and academic life, as well as membership for herself in a science-related field in the future, possibly because she has a consistent role model in her mother, who is a doctor.
- Sandra also declared herself a member of the science community, but in a junior position. In her interview, she refers to herself as a "baby scientist" because she "needs more practice to be a real scientist". Sandra believes that she is not yet qualified to be a full-fledged scientist but indicates that she could someday work her way up into that position.

- Mia described herself as "sort of a scientist", stating that she likes science, but it is not her favorite subject, and therefore, she cannot be a scientist. Like a lot of young girls, her sense of membership and belonging in the science classroom and the larger community is strongly linked to her enjoyment of the content. While she may see a place for herself in the science community, there is a level of uncertainty as to where that placement lies, and as of now, it seems to lie at the fringes rather than on the front lines, in a position of importance.
- Talia clearly does not see a place for science in her life, academically or otherwise, as she declared: "I'm not a scientist – science isn't really my thing". For Talia, science is a school subject that she must endure rather than a pathway to her future career or a source of information that affects her current existence. Talia seems to lack a science identity altogether.
- Michelle does not consider herself to be a scientist: "I don't really consider myself a scientist. I'm pretty good at science, but not good enough to be a real scientist. I need to learn a lot more and I still need a lot of help". She has the beginnings of a science identity but feels that her lack of skills and science knowledge preclude her from being a scientist at the moment. However, Michelle also hints that she could be a scientist when she has acquired more expertise and understanding in the future.

Doing Science in the Future

Table 4.4 shows that two of the five participants, Abigail and Michelle, were considering a career in science and felt that science will be an important part of their lives in the future. When asked about her science class, Abigail mentioned that she recently "wrote about climate change" and that if she could change her science class, she would "want to go places and look and write what we see". Abigail was enthusiastic about science and wanted to explore and discover in a way that was more authentic than what she was doing in her class at school. While this was in line with Abigail's confidence in her science abilities and her interest in science, this was not in line with Michelle's lack of confidence in her science ability. Michelle also indicated on her questionnaire that she did not necessarily feel good when she does science, and she was not completely sure that she can do well in science. However, the fact that Michelle was considering a future in a science-related field indicates that she had an interest in science, even if that interest was overshadowed by her low self-efficacy, which resulted in doubt regarding her content knowledge and skills.

Michelle described her science class as "fun when we do experiments because the experiments we do are teamwork involved" and stated that art and science are her best school subjects. This was interesting because a lot of students do not make a connection between art and the creativity involved with science experimentation, but Michelle had linked them, and she enjoyed science classes that foster collaboration, like HYPOTHESISters. Since Michelle was not always confident in her science skills and content knowledge, the security of working with others greatly appealed to her learning aesthetic and relieved some of the anxiety that she felt around doing science. Alleviating some of this pressure allowed Michelle to enjoy science and engage more with the content, which may be why even though her confidence was lacking, she was still considering a career in science.

Mia seems unsure of whether or not she will choose a career in science but does not feel that science will be a major part of her life in the future. Mia's interest in science is tentative and she is insecure about her science-related skills. Mia does not see science as something that has value in her every day or future life, but rather as simply a school subject.

Unlike Abigail, Michelle, and Mia, the remaining two participants –Talia and Sandra- have a strong aversion to the idea that science will be important in their future careers. Talia in particular has decided, even at this early age, that she does not want a science-based career and that science will have no place in her life beyond the requirements of school. However, after participating in

HYPOTHESISters, Talia described science as a subject that allows her to "express her creativity and explore the world in a different way". She also mentioned being glad to know science because it "helps me understand how to figure out the answers to my questions", which is something that will help Talia regardless of her career choice.

Sandra, much like Talia, seems to have dismissed science as a possibility for the future because she did not see its applicability to real life. Sandra stated that math is her favorite subject because "…it's an everyday thing. We have to do math every day and some other subjects we don't need every day". This implies that school subjects that are given less time, like science, are less important and therefore have less value than others. The way subjects are organized at her school has given Sandra the idea that school content areas have a hierarchy, which is likely to persist into secondary school and beyond and will keep science from being at the forefront of her academic and career choices.

Along with the classification of subjects based on the time spent focusing on each one, the structure of Sandra's science class has factored into her attitude towards science as it relates to her future. When asked about her science class, Sandra said:

> Well, it's fun. You can win prizes and it's easy. Like the teacher tells us exactly what to do a lot of the time so you just have to follow directions. I'm not always good at listening and following directions, but if I do then it's easy.

What Sandra seems to enjoy about her science class is that it does not require her to do much other than follow explicit directions (cookie-cutter labs and activities). There is no indication that critical thinking or the true scientific process of exploration and discovery is employed in her school science class. Sandra also mentions that she would reduce the amount of "work" in her science class: "less writing stuff and reading, and more just creating stuff". Sandra's science class does not hold her interest and she would like more hands-on exploration as opposed to rote science work, which could be negatively affecting how she views science as it relates to her real life and her future career choice.

Chapter V

DISCUSSION OF MAJOR FINDINGS

The purpose of this study is to investigate girls' experiences working with a gender-inclusive hands-on curriculum focused on the achievements of women in science, and how working with this curriculum impacts their perception of who can be a scientist and their ability to do science. Once again, the research questions for this study are:

1) What is girls' experience working with a gender-inclusive curriculum that focuses on the contributions of black women to science?
2) How does participation in an informal science program that employs a gender-inclusive curriculum impact young girls' perception of who can be a scientist?
3) To what extent does participation in a gender-inclusive science program grounded in stories of women in science affect girls' perception of their ability to do science?

Major Findings

The data shows that young girls' experience with a gender-inclusive curriculum in an outside-of-school-time (OST) science program is largely positive and broadens their perception of who can be a scientist to include women and people of color while improving their confidence in their science skills and belief in their ability to succeed in science. The major findings of this study are that:

1) Anchoring the lessons on discussions of women's trajectories in science fields and their contributions to science and basing the activities and projects on their areas of study helped the girls connect better with the science content.

2) The exploratory and creative aspects of HYPOTHESISters curriculum and the nurturing, collaborative atmosphere were conducive to girls' science learning.
3) Some girls' perceptions of who can be a scientist and what scientists can do began to include women and people of color.
4) Participation in HYPOTHESISters helped the girls experience success in science, which improved the girls' confidence in their science skills and belief in their ability to do science, as they began to see a place for themselves in the science community in both the present and future.

In girls' descriptions of their experiences working with a gender-inclusive curriculum and depictions of scientists doing science, some themes emerged that correspond to theories of learning. The ensuing discussion places their experiences in the context of self-efficacy theory, identity theory, and feminist and gender learning theory.

The participants describe the science that they engaged in at HYPOTHESISters differently than school science when recounting their experiences, most notably mentioning ownership over their work stemming from the freedom to express their science learning creatively at HYPOTHESISters that doesn't exist in their more traditional school science classes, where masculine attributes are revered to the exclusion of girls. Conventional school science practices depict science as a set of narrowly defined tasks and present science as a rigid body of knowledge that can only be displayed in a singular manner, which is antithetical to the way that girls learn and express their knowledge, according to feminist theories on science learning (Weiner, 1986). The alienation that girls experience from school science, stems from an automatic association between masculinity and the practice of science, and educators' tendency to steer girls away from science and math (Howes, 2002). This negatively impacts girls' STEM self-efficacy and prevents them from seeing themselves as scientists and entering into STEM fields professionally.

The perception of scientists as a group that includes women and people of color expands membership in the scientific community to encompass girls and supports girls' belief that they are capable of being respected, contributing members of the scientific community. This notion is supported by literature on how gender-inclusive curriculum supports girls in STEM, which also mentions how this curriculum, along with instructional strategies that increase girls' achievement in science, the promotion of successful female role models in science, and afterschool and mentoring programs, encourages girls to persist in science (Baker, 2013; NGSS Lead States, 2013; Scantlebury, 2014) and supports girls in developing STEM identities (Kim, Sinatra, & Seyranian, 2018). Based on my findings, girls' learning in science is linked to an equitable curriculum that exposes girls to women's contributions to science, as well as supportive environments in which girls can safely express their creativity and nurture their innate curiosity as they develop their scientific skills and knowledge.

The descriptions outlined in the findings depict how girls' experiences with science are tied to curriculum, teaching methodology, and learning environment, which can either enhance or hamper girls' enthusiasm for science and confidence in their science skills and knowledge. An inclusive curriculum that makes girls feel a part of the scientific community by providing them with examples of successful women in science, a collaborative and supportive learning environment, and hands-on activities that allow girls the flexibility to express their science knowledge in a way that is meaningful for them and reflects who they are, can bolster girls self-efficacy around science and help them begin to see themselves as scientists.

Including Women in Science Learning

Anchoring the science content to stories of women in science through discussions of those women's trajectories and contributions to science helped spark the girls' interest and connected them to the science topics being learned on a more personal level. According to Bamberger (2014), exposure to women's work in science leads girls to appreciate women scientists as smart and creative, characteristics that girls relate with and sometimes even attribute to themselves. Providing girls with positive female role models and sharing their trajectories in STEM has a positive and significant effect on content enjoyment, the importance attached to the content, expectations of success, and girls' aspirations in STEM, as well as negative effects on gender stereotypes (Gonzalez-Perez et al., 2020). Michelle talked about how much she enjoyed learning about women scientists because in school the focus is mostly on men. Notably, she talked about how pretty and trendy the scientists were, and how she was amazed that they were normal people like her. Adding images of female mathematicians or scientists into learning materials and assigning work that contextualizes women's achievements in these subjects can shift perceptions about who belongs (Berwick, 2019). Michelle demonstrated that exposure to successful women in science reflected the girl's lived experiences and the adequate representation of women is a positive influence on girls and helps re-shape their image of scientists, as evidenced in the shift in her science drawings (from a stereotypical white man to a woman of color).

Flexible and Supportive Learning Environment

The variety and autonomy that was infused into the projects and activities at HYPOTHESISters in combination with a collaborative and supportive learning environment that created intellectual security aided the girls in the development of their science skills and content knowledge, by building up their confidence. Fostering a growth mindset in students, emphasizing that knowledge is not fixed, and skills can constantly be improved, helps them persist through challenges, a trait that is particularly advantageous for girls in math and science (Berwick, 2019). A study conducted by Fredricks et al. (2018) found that students' engagement was higher in classrooms with more student-centered instructional practices, and girls described teacher support and personally relevant instruction as being important to their interest and motivation in math and science. All of the study participants referred to having the freedom to personalize projects and to work with each other and get help from the instructors relieved their anxiety and made their learning more enjoyable. Removing the fear of failure and doing things wrong and creating an accommodating learning environment allowed the girls who participated in HYPOTHESISters to build their confidence and increase their self-efficacy. These results align with Falco and Summers (2019) argument that effective strategies for enhancing adolescent girls' STEM learning (and ultimately their STEM trajectories) and addressing low STEM self-efficacy include managing anxiety and using verbal persuasions and encouragement, as well as incorporating topics associated with STEM motivation while addressing perceived barriers, including gender issues, into interventions.

Although learning environments are personal, each individual's constructions are mediated by the actions of others in the social setting (i.e., peers and teachers), and the characteristics of the culture where the learning is situated (Lorsbach & Jinks, 1999). Student perceptions of the learning environment influence self-efficacy, which in turn impacts learning behaviors and academic performance. As the girls in this study demonstrated by completing each activity/project despite difficulties and setbacks, learning environments that are conducive to discovery, allow for creativity, and foster students' agency in learning increase self-efficacy, which sustains task involvement and results in greater achievement. All five of the participants in this study articulated an ability to be creative with their projects and individualize their expressions of learning, while still being allowed to work collaboratively through the science concepts and get support from each other. Michelle specifically spoke to the agency she felt at HYPOTHESISters, mentioning that she had to "choose which way things go and decide how to show what [she] learned".

Self-efficacy is also affected by other social aspects of the classroom environment, like the students' relationships with teachers, and the way goals, incentives, and expectations are created and maintained (Lorsbach & Jinks, 1999). For girls especially, teacher approval - experienced as positive reinforcement and encouragement - is an important factor contributing to their belief that they can complete tasks successfully. An atmosphere like HYPOTHESISters where girls have a positive relationship with their teachers and emphasis is placed on accomplishing learning goals rather than managing behavior creates meaningful mastery experiences for students (Bandura, 1997). According to Sandra, Michelle, and Mia, this allows space for girls to "make mistakes" and "try different things" with the help and support of teachers who will not "make them feel bad for getting something wrong" or "give up on them", which makes them feel like they are capable of completing projects and achieving their learning goals.

Expanded Perceptions of Who Can Be A Scientist and What Scientists Do

After exposure to the accomplishments and contributions of female scientists of color, the girls who participated in HYPOTHESISters revised their perceptions of who can be a scientist and what they do to include women, people of color, and less conventional branches of science like earth scientists and astronomers that work in observatories.

Picturing the scientist. Typically, when students participate in any version of the Draw-A-Scientist Test (DAST), the images overwhelmingly reveal the presence of traditional gender stereotypes of who is allowed to do science, what these scientists look like (white males), and what they do (mix chemicals and use science tools in a lab) (Chambers, 1983; Lachance, 2020; Thomson, Zakaria, & Ramona, 2019). These stereotypical views of scientists start from an early age and persist regardless of student identity. The girls participating in HYPOTHESISters are no exception – Sandra, Mia, and Michelle (two of whom are girls of color) drew a version of the white male stereotype complete with common indicators (i.e., a lab coat, eyeglasses or goggles, facial hair/wild hair, symbols of research, technology, and relevant captions) (Chambers, 1983). This speaks to an internalization of the ideas of the middle-aged, white male scientist that studies have revealed over decades of DAST testing. Although Talia and Abigail drew female scientists, they depicted them as doctors. Research has shown that students perceive differing levels of male-favoring explicit and implicit stereotypes in each discipline, with women being largely restricted to health and biological sciences (Smyth & Nosek, 2015) and the corresponding professions associated with them (i.e., doctors and nurses). As such, even though Talia and Abigail drew women as scientists, it is clear that they are still indoctrinated with a specific view of scientists that is confining and exclusionary of women.

After exposure to women who have achieved success in mathematics and the physical sciences and doing this type of science themselves, the second round of scientist drawings revealed a shift in the way the girls perceived who is allowed to be a "legitimate scientist" and what their role in the scientific community can be. All of the girls drew female scientists, and four of the five girls (Sandra, Talia, Abigail, and Michelle) portrayed women of color, with a racial/ethnic background similar to their own, engaging in physical sciences in various roles (a chemist, a researcher, an astronaut, and an astronomer). The introduction of relatable role models who reflect the racial/ethnic and social backgrounds of the girls helped expand the girls' view of who can be a scientist and what they can do to start to include women of color in various areas of STEM and with a wide range of STEM professions. Similar to Hughes, Nzekwe, & Molyneaux's (2013) results, having positive STEM role models (in the form of the scientists they were learning about and their teachers) that resembled the girls and women in their lives improved their self-concept, which enhanced their STEM identity because they could begin to see themselves as someone interested in STEM and has the potential to be a legitimate participant in STEM careers. This suggests that prolonged exposure to positive role models in science could lead them to picture themselves as members of the scientific community, building/strengthening their science identities, and making them more likely to choose STEM classes and possibly even STEM professions in the future (Carlone, 2003; Good, Woodzicka, & Wingfield, 2010; Scantlebury, 2014).

Deference to stereotypes. When given time to think about and draw a scientist in their workplace after exposure to stories of women in science and experience related to their areas of expertise, all of the girls depicted women in various science fields. However, when asked to describe a scientist off the top of their heads in an interview taking place within two weeks after the conclusion of the HYPOTHESISters program, some of the girls (Talia and Sandra) defaulted to the traditional, white male scientist. This indicates that while a one-off exposure to alternative views of scientists for a short length of time may begin to broaden girls' ideas of who scientists are and what they do, more prolonged and consistent exposure throughout their learning experiences is necessary to make more long-lasting changes that deeply impact girls' perceptions of scientists and identification with science. These findings are in line with those of Buck, Leslie-Pelecky, & Kirby (2002), in which fourth and fifth-grade students largely retained their stereotypical images of the behavior and appearance of scientists after engaging in eight activities led by three visiting female research scientists (two white and one black) over three months. Much like the girls at HYPOTHESISters, some of these students' stereotypical images of scientists changed to a degree, but the presence of women scientists (one of whom was a woman of color) did little to make any marked progress in dispelling stereotypes that may prevent girls and students of color from considering careers in science. A crucial part of science identity formation is recognition - recognizing others as scientists and being recognized as a scientist by respected others (Carlone & Johnson, 2007). As such, if girls' can identify women who share a likeness with them as scientists, and these women are validated as scientists by the scientific community, it will be easier for the girls to see themselves as scientists, and if this recognition occurs more frequently, it will bolster girls' science identities.

Scientists do more than mix chemicals in the lab and work in medicine. By the end of HYPOTHESISters, some of the girls' opinions of what scientists do began to extend beyond the stereotype of mixing chemicals in a lab or treating patients in a medical office. Research shows that children, starting at a very young age, form traditional views about the nature of scientists' work that commonly includes indoor activities for making artifacts or materials and for the study of animals/human beings – i.e. "doing experiments" in a lab that range from dissection to mixing chemicals (using beakers, Bunsen burners, and scalpels) and to a lesser extent examining patients (using equipment that includes syringes, stethoscopes, and medical masks) and giving out medications (Chambers, 1983; Thomson et al., 2019). Half of the girls in this study retained this restrictive view of science even after exposure to other types of science that take place outside and in places other than traditional laboratories. This creates a disconnect between how "real science" is done and the type of science that girls experience at school, which is often in the classroom, or in an outdoor space on the school grounds or the surrounding area, and frames science as something separate from the girls' lived experiences, lessening the likelihood that they will see themselves as scientists.

However, three of the girls broke from tradition and included a classroom, an observatory, and a space station as places where scientists work. This shows that they are separating the idea of doing science from being in a formal laboratory or a doctor's office, which opens them up to learning in spaces – science camps, outdoor exploration programs, museums, aquariums, etc. – that are supportive environments for science learning (NRC, 2009). Engaging with science content and practicing scientific processes in unconventional places/formats supports the formation of science identity and efficacy in girls, as they author and negotiate identities as learners of science through positioning, discourse, and performance (Riedinger & McGinnis, 2017; Todd & Zvoch, 2019).

I Can Do Science

The girls who participated in HYPOTHESISters underwent varying degrees of improvement in their confidence in their science skills after completing the program, which speaks to a range in their feelings of self-efficacy (Zimmerman, 2000). Abigail displayed high self-efficacy, describing a strong belief in her ability to succeed in science, and including a career in a science field in her future. Michelle and Sandra conveyed more tentative levels of confidence, describing themselves as fringe members of the science community ("baby scientists"), which is still an improvement since neither one of them considered themselves to be "good at science" at the start of the program. Although finding the activities and concepts at HYPOTHESISters challenging, both Sandra and Michelle specifically credit what they learn at HYPOTHEkids programs, including HYPOTHESISters, with making them " better at science" and able to "do projects and experiments better than [they] used to", respectively. This supports Zimmerman's (2000) and Pajares's (2005) findings that as students can meet increasingly more challenging goals successfully, their self-efficacy grows stronger. Whether or not these effects persist and continue to improve as the girls continue to encounter science throughout their academic lives remains to be seen.

Informal and Formal Science Education

Informal science education has been called an "invisible infrastructure" – the rich diversity of places and pursuits that ignite our curiosity and support lifelong learning about science (CAISE, 2010). Across a lifetime, the average American will spend less than 5% of their lives in the formal education setting (CAISE, 2010), which means that the vast majority of people's learning occurs outside of school. By the time children are eighteen and have completed their compulsory education, they will have spent less than 20% of their waking hours in a classroom (CAISE, 2010), so even for children, most of their STEM learning occurs outside of school. The public uses a vast "invisible" informal science education infrastructure of museums, science centers, zoos, aquariums, community groups, community-based organizations, STEM organizations, books, broadcast media, and the internet to learn STEM. Less inhibited, by physical restrictions, rigid requirements, and bureaucracy, OST programs have significant potential to engage young people in science learning. It is estimated that approximately 8.4 million children participate in afterschool or OST programs for approximately 14.5 hours weekly (Afterschool Alliance, 2012). Children from populations that are traditionally underrepresented in STEM are more likely to participate in these programs, which presents an opportunity to reach the very populations that need more inclusion in STEM fields through experiences that supplement and complement the school day.

HYPOTHESISters is part of the informal science infrastructure, providing a space for young girls to engage in STEM experiences that are different but perhaps of equal value to those they engage in at school. Like other informal science spaces, HYPOTHESISters affords girls the opportunity to engage more deeply in scientific discovery and express their ideas in a way that they are unable to do in school. Without the pressure of meeting rigid standards and getting "good grades" while competing with boys for attention, girls can sharpen their critical thinking and problem-solving skills that apply not only to science but to life in general, while having fun and learning the part that science plays in their lives. Although like many informal science education experiences, the timeframe of HYPOTHESISters is short and the effects may not immediately manifest themselves, this program provides an instance where girls' interest can be sparked, and their vision of science can be expanded. Additionally, sustained informal programs, and even some short interventions, can radically influence a student's interest in science (Stocklmayer, Rennie, & Gilbert, 2010).

In contrast to informal science experiences, school science classes provide defined learning goals (in the form of standards), structured ways to measure the achievement of those goals (formal and informal assessments), and longevity, as students are provided with continuous and connected learning. However, the breadth of science topics that need to be covered in a school year, in combination with an exaggerated focus and a lot of time devoted to math and English achievement, as well as the teachers' limited knowledge and resources sometimes makes significant and persistent learning and retention in the school setting difficult (Berg & Mensah, 2016). Often it seems that information is thrown at the students, rather than them experiencing, learning, and connecting with the content.

Although the formal sector is the main custodian of science education, there could be ways for formal science education to make explicit use of the special capabilities of the informal sector, e.g., access to up-to-date science and opportunities for self-directed inquiries. Incorporating some tenets of informal science education into the school science setting would promote excitement for science alongside scientific rigor to create a third space for science education to produce a population that can actively participate in science and evaluates scientific issues critically. A fresh approach using the expertise and talent of the informal sector in combination with continuity and longevity of the formal sector could offer science content that is more likely to be grounded in or substantially related to contexts that are recognizable in the world today and in the future. Alternative spaces for science learning have a wealth of practical, with hands-on expertise and ways of presenting science for engaging and entertaining students that could be incorporated into formal classroom learning by:

- Providing free choice, like students being able to design projects and conduct their research.
- Offering challenging activities that challenge the students, motivating them to learn.
- Including aspects of the wonder of science.
- Producing entertaining presentations that include student performance, demonstrations, and films/videos.
- Attending to a holistic approach that includes aspects of community involvement, economics, environmental issues, and integrating science principles.

- Using students' prior knowledge and incorporating recent research for discussions and investigations.
- Developing and using models and simple, jargon-free explanations.
- Making connections to the students' lives and the local community.
- Conveying to students that learning and doing science is a messy, flawed human endeavor.

Creativity in Science

This study highlights a need to invoke the arts and the traditions that it brings into science. Science, and the practices associated with it, have long been positioned as a masculine endeavor – rational, logical, and devoid of emotion and subjectivity – eliminating the possibility of being simultaneously feminine and scientific (Carlone, Johnson, & Scott, 2015) . Science has often been described as "objective", separating the emotional from the intellectual as a requirement for scientific pursuits (Henry, 1997), and thus overlooking the inherent creativity in asking questions and the emotional connection that comes with a truly open inquiry (Jammula & Mensah, 2020). Art, on the other hand, is commonly described as an expression of creativity that is meant to capture the imagination and invoke one's feelings.

HYPOTHESISters' curriculum dabbles in the idea of infusing art into science by giving girls the room to engage in activities and projects that are both scientific and "pretty". Allowing students, especially girls of color, to embrace the exploratory and creative aspects of science practices could permit the reclamation of science as a human, rather than masculine, endeavor that transcends the biases that claim to remove the emotional and subjective from the scientific enterprise. Curriculum and teaching practice could be implemented in a way that showcases the creativity in asking questions, the elegance of solving a problem, and the emotional investment that is inherent in the investigative practices associated with science. A deeper connection to one's creativity could be made that transcends the surface level of decorating projects to make them "pretty" and delves into the beauty of asking new questions, thinking outside of the box, expressing ideas in different ways, and feeling the emotions that come with the process of discovery that unfolds each time a person engages with the scientific process, unearthing the true prettiness of science. Engaging in a more creative and artistically expressive science curriculum, teaching methods, and even research could set the stage for the introduction of a "radically different science" (Keller, 1985, p. 177) both in and out of school.

Chapter VI

CONCLUSION, IMPLICATIONS & FUTURE RESEARCH

The findings of this study suggest that curriculum and teaching methodology contribute to young girls' perception of what it means to do science and be a scientist, the development of girls' confidence in their science skills and content knowledge, and their belief in their ability to do science. Curriculum that highlights the contributions of women to science, both past and present, and the way science lessons and projects are constructed and taught can influence how young girls, as early as six years of age (Newton & Newton, 1992), view science content and scientists, and ultimately how they view the role of science in both their personal and academic lives. In analyzing young girls' experiences working with a gender-inclusive curriculum and how that experience impacts their perception of who can be a scientist, what it means to do science, and their ability to do science, themes emerged related to how the girls view scientists and what scientists do, their need for curriculum that allows for personal expression and creativity, a learning environment that is collaborative and supportive.

The findings in this study contribute to an ongoing discussion in science education about how girls' learn (Calabrese-Barton et al., 2013; Chatman, Nielsen Strauss, & Tanner, 2008; Zohar & Sela, 2003), their feelings of disconnection with science (Jammula & Mensah, 2020; Miller et al., 2006; Jones et al., 2000), and how to make school science curriculum and pedagogy more inclusive (Kim et al., 2018; Mosatche et al., 2013; Parker & Rennie, 2002) while building girls' confidence in their ability to excel in science-related areas both academically and professionally (Seymour, 1995; Eccles, 1994; Zeldin & Pajares, 2000) by documenting girls' experiences with gender-inclusive curriculum in an informal science setting and how it impacts their opinion of scientists and what they do, and their self-confidence and ability to succeed in science. This study provides valuable insight into children's, particularly young girls', perception of scientists and what science is and how gender-inclusive curriculum affects these ideas, teaching methodologies and learning environments that can be conducive to girls' feeling successful in science, and how participation in informal science programs that focus on inclusivity and collaboration can help improve girls' confidence and belief in their ability to do science.

Based on this study, there were connections between girls' experiences with gender-inclusive, project-based curriculum in a nurturing, collaborative informal science setting and their perceptions of science and scientists, and girls' confidence and science self-efficacy. All of the participants, even Talia (the one with the most decidedly negative attitude towards science) expressed how much they enjoyed HYPOTHESISters and wished that their school science classes were more like HYPOTHESISters science club. The cooperative group setting and supportive teaching methods allowed them the space to experiment and make mistakes, which is conducive to their learning and retention of science content.

The participants also connected with the colorful, aesthetically pleasing, artistic aspects of each project, citing them as something that is missing from the projects and activities they engage in at school. While Sandra seemed less concerned with pretty, colorful aesthetics she particularly enjoyed the freedom of choice and autonomy the girls experienced with the project-based curriculum format. All of the girls liked that everyone was doing something different with their projects and did not have to follow an exact pattern even though they were all demonstrating knowledge of the same scientific concepts. Since most of the girls included art among their favorite subjects at school, giving them the space to use an artistic expression in their science projects allowed them to communicate their knowledge in a way that was comfortable and pleasurable for them, which made them more invested in the work they were doing.

Although only one participant (Abigail) identified herself as a scientist at the beginning of the study, by the end the participants fell along a spectrum regarding their science identities, with one confidently identifying herself as a scientist (Abigail), two identifying themselves as more "junior" scientists, not on the level of adult scientists (Mia and Sandra), one describing herself as a fringe member of the science community with the potential to be a scientist (Michelle), and one failing to identify herself as a scientist at all (Talia), although she did feel capable of doing science. The girls' experiences participating in HYPOTHESISters bolstered their confidence in their science skills to some degree and helped them see that they are capable of doing science, even when the concepts and activities are challenging.

Throughout this study, the girls started to form, or deepened, a positive view of science and realized that they can achieve success in science, which made the science content more interesting to them. With exposure to more positive experiences with science that include role models the girls can identify with and learning environments that are collaborative and supportive, these girls' science self-efficacy will strengthen, which could open them up to further science education learning and possibly science careers in the future.

Implications

There are many implications for this study that are attended by the project-based gender-inclusive curriculum, the collaborative lesson structure, and the nurturing teaching methodology employed by the program.

Implications for Young Girls' View of Science and What Scientists Do

To create and teach a science curriculum that is inclusive of all students' learning needs, it is important to consider the nature of the instructional environment for both girls and boys, and the effect that this environment has on how and what the students learn. For example, single-sex grouping often creates environments in which teachers can implement gender-inclusive science instructional strategies more readily and effectively than in mixed-sex settings (Parker & Rennie, 2002) because teachers are better able to address previous educational shortcomings, like the lack of exposure to hands-on activities and open-ended problem solving that girls commonly experience. It is difficult for girls to develop a favorable view of science and what scientists do in a stifling environment in which males dominate what they read and hear and are given more opportunities to explore and discover the nature of science. Stereotyped views of science and scientists are perpetuated by teachers in science classrooms (Mensah, 2011) and can influence the attitudes of youth as they make decisions about future studies and careers (Chambers, 1983), making them reluctant to choose to study science or plan a career in a science-related field (Haggerty, 1996).

For the girls in this study, science was presented as creative and exploratory, rather than rigid and restrictive. For example, when the girls were learning about astronomical units and distances in space, the participants, along with their teachers created an astronomical unit scale represented by large and small beads, and then used that scale to create a bead mobile that showed the distance between each planet and the sun. While each girl used the same agreed-upon scale to build their mobiles, each mobile looked different because the girls made their own creative choices about how to organize and construct their mobiles, freedom of expression that they are not usually afforded in their school science classes. Creativity, the ability to produce novel and appropriate work is one of humanity's most important traits, and the idea that science is a creative endeavor is indisputable; scientific ideas are creations of the mind (Hadzigeorgiou, Fokialis, & Kabouropoulou, 2012). As such, these girls, and students at large need to understand that even everyday scientific work requires the imaginative thinking they already engage in, and they need to be encouraged to incorporate that innovation into their science experiments and projects, and that ingenuity needs to be valued and encouraged.

One fundamental goal for science education is the creation of a scientifically literate citizenry that can understand the nature of scientific knowledge and discovery (NGSS Lead States, 2013). As such, the development of an understanding of the enterprise of science as a whole – the wondering, investigating, questioning, data collecting, and analyzing – is an integral part of science education (NGSS Lead States, 2013). Human beings have an innate need to know and understand the world around them. In some cases, this need to know originates from satisfying basic needs in the face of potential dangers, and sometimes, it is a natural curiosity, or the promise of a better, more comfortable life. Either way, science is the pursuit of explanations of the natural world and the discovery of means of accommodating human needs, intellectual curiosity, and aspirations, which are present at a very young age. Children are naturally curious but lose that curiosity over time as they are made to conform to societally acceptable ways of expressing it. For girls, it is made clear early on in their educational career that science, especially the physical sciences, and math are domains reserved for boys, stifling their innate desire for discovery and their creativity in these subject areas. As the participants in this study have shown, girls can flourish in the sciences when given the liberty and opportunity to express themselves without fear of reproach.

Implications for Who Girls Believe Can Be a Scientist

Despite the recent emphasis on equity in science education and the role of women in STEM, when asked to depict a scientist, more often than not children's work still resembles that of earlier generations: a white, middle-aged male scientist with a lab coat, glasses, and facial hair working indoors under sometimes dangerous or secretive conditions (Kelly, 2018). The participants in this study were no exception to these results. When asked to describe a scientist on their questionnaires, three of the five girls described someone who works alone mixing and pouring chemicals in a lab – the stereotypical idea of a scientist that is proliferated in society; one girl described her science teacher (a woman), and the other was unable to give a detailed description at all. Similarly, when the participants were first asked to draw a scientist, two of the five girls drew a male physicist or chemist in a lab coat mixing chemicals, and one drew a male earth scientist giving a lecture. However, two of the girls drew female doctors – an "acceptable" role for women in the science community. In general, it seems that these young girls have a narrow conception of science and who can be a scientist that was created and is consistently reinforced by their schooling.

Implications for Girls' Belief in Their Ability to Do Science

In the report Shortchanging Girls, Shortchanging America, the American Association of University Women revealed that girls' confidence in their academic abilities drops dramatically from elementary to high school, especially in math and science (AAUW, 1991). This confidence gap – gender differences in belief in math and science abilities (Sadker & Sadker, 1994) – is partly responsible for the shortage of women in STEM classes and careers (Eccles, 1994). The belief in one's ability to perform a specific task is referred to as self-efficacy – a judgment about one's ability to organize and execute the courses of action necessary to obtain a specific goal (Bandura, 1997). Self-efficacy judgments are related to specific tasks in a given domain (Pajares, 2005; Zimmerman, 2000) – in this case, science content. Unless people believe they can produce desired effects by their actions, they have little incentive to undertake activities or to persevere in the face of difficulties.

The participants in this study fell along a spectrum of their confidence and belief in their ability to succeed in science, with only one girl (Abigail) definitively declaring that she does well in science.

> I'm doing well in science class because I'm always focused. I can answer a lot of questions and I can help my classmates when they don't understand things. I like science.

The other girls expressed varying levels of doubt as to whether or not they are capable of excelling in science classes, with most of them showing some lack of confidence and low self-efficacy even after participating in HYPOTHESISters.

Sandra: I understand a lot of things now. The things I learn here make me smarter in science, so I do pretty good in science. I can do science projects and experiments better than I used to.

Michelle: In science, like I'm not good at explaining things. I don't know if I understand things sometimes. It takes a while for me to do projects. I don't know if I'm good at it [science]. I'm not bad at it [science], but it's not my best subject. I'm better at science since this club started.

Mia: I do okay at science, but I'm better at other things like English and Art. Science is not my favorite. Like, it's interesting but it's also hard for me.

Talia: I usually get check pluses in science and sometimes my teacher will let me help other people, but I'm not as good at science as I am at art. That's my favorite subject. Science is like difficult and sometimes I don't know what's going on. But I do all my work, so then I do well.

Although they exhibit wavering confidence in their science skills and knowledge, Michelle and Sandra expressed a surge in self-assurance as a result of their participation in HYPOTHESISters science club and indicated that these enhanced skills were helping them do better in their school science classes. According to McLure and McLure (2000), there is a positive relationship between out-of-school science accomplishments and in-class science achievement because students who have the opportunity to participate in experiential, science-related extracurricular activities in a nonthreatening environment feel competent, particularly when adults are available to offer suggestions, support student inquiry, and provide enrichment activities. For Sandra and Michelle, a budding interest in science stimulated enhanced effort and deeper commitment to academic coursework, which led to stronger self-efficacy and belief in their ability to acquire even greater science knowledge and skills and to succeed in science both in and outside of school in the future.

Implications for Teaching Methodology and Classroom Environment

Studies have shown that teachers and the way they conduct their classes are meaningful in developing students' attitudes and interest in science and can influence students' behavior concerning science studies (George, 2000). Teaching methodology can have a positive or negative influence on students' attitudes depending on teachers' interactions with students. Studies have shown that students label classes as being "good" when they perceive the teacher to be warm, good listeners, understanding, patient, encouraging, supportive, and the students' feel that they have a personal or meaningful connection with the teacher (Raved & Assaraf, 2011). HYPOTHESISters was designed to establish a good rapport and comfortable relationships between the teachers and the participants through icebreakers, games, and discussions at each session that the teachers both facilitate and participate in with the girls. This allowed the girls to see the teachers as scientists as well as approachable adults that they could trust with their learning. An intellectual safety net was created, which allowed the girls to ask questions and explore without fear of disapproval from their teachers. For example, Michelle described the benefits of having two teachers and how having helpful, patient teachers made her feel secure when asking questions or trying new things:

> Michelle: I also like having two teachers that both know a lot of science, so, there's always someone to answer my questions.
>
> I liked working with you and scientist Trisha because you guys are really nice and help me a lot, but I don't feel bad if I mess up or ask for a lot of help. I feel happy when I'm here.

Just like a positive connection with and mutual respect for the teacher is pivotal to student success in science classes, an effective teaching environment supports positive attitudes toward science, and students who have a positive attitude generally maintain greater interest in science as they progress through school (Mihladiz, Duran, & Dogan, 2011). As they get older, students perceive a deterioration in the quality of teacher-student interactions in terms of less leadership, less help and friendliness, less compassion, and less freedom/more restrictions, which can dampen their enthusiasm for science and science-related classes (Ferguson & Fraser, 1998). The structure and curriculum of HYPOTHESISters science club allow the girls the freedom to choose how to display and share what they have learned with others. They were able to express themselves more artistically, which increased their interest, learning, and the quality of their work.

> Abigail: …on Saturdays we have a lot of fun and do creative, colorful projects where everyone is doing something different.
>
> Sandra: Yeah, it's [astronomical units bead mobile] pretty cool. And mine was different from everyone else's. I got to make it the way I wanted it to be because we didn't have to follow an exact pattern.
>
> Mia: It's just more fun on Saturdays. We get to do more creative stuff and more things with science that are fun. Like it was really fun to learn about astronomical units with the beads. Even though we had to do math, it was fun because we made a scale with the beads, and everyone's projects came out so pretty even though they were all different because we picked out our own bead colors and stuff. We had more choice, which made our projects come out better.

Declining interest and negative attitudes toward science classes can also develop as a result of teaching methodology. A more traditional approach to science instruction often does not include enough imagination, creativity, objectivity, inquiry, and openness to new ideas – all of which are paramount to truly engaging with the scientific process. In science classes, students should be learning how to attain knowledge through discovery, and how to reconstruct their previous knowledge based on new information (Hacieminoglu et al., 2011). Teacher-oriented instruction (i.e., lectures, drill, practice problems, and structured cookbook lab activities) ignore students' interests, which eliminates student motivation and natural curiosity (Lee & Erdogan, 2007). This can be problematic because studies have indicated that classroom learning environment and pedagogy are strong factors in determining and predicting students' attitudes and interest in science (Hacieminoglu, 2016). With this in mind, the HYPOTHESISters curriculum was designed to allow students to attain scientific knowledge through hands-on, cooperative learning in a small group that is facilitated but not dominated by the teachers. This approach made the learning more stimulating and less intimidating for the girls, which made them more invested in understanding the science content and successfully completing the projects.

Sandra: It's [science club] more interesting. Like, the projects are more interesting and the way we learn doesn't feel boring. And we do most things together so you're not like on your own if you don't get things.

I remember the astronomical units because I thought the project looked cool and it was like a code that we made for the beads and the astronomical units.

Mia: It's [science club] better because we get to work together and we're always allowed to help each other. Projects and experiments seem less hard and scary when you can work with your friends or get more help and ideas from the teacher.

Implications for the Formation of Science Identity

Identity is defined as a core sense of self or an internal self-constructed, dynamic organization of drives, abilities, beliefs, and individual history that explain and predict behaviors (Steinke, 2017). Therefore, science identity is perceptions of oneself as a scientist, and much like identities in general, it is malleable and changes as individuals encounter and react to events, circumstances, and elements in their social environment, making it both individually constructed and socially imposed (Steinke, 2017). A science or a STEM identity has been cited as important for understanding a wide range of STEM-related outcomes including engagement, interest, learning, motivation, persistence, and commitment.

Many studies have focused on the development and negotiation of science identities and science identities-in-practice for girls in both formal and informal science educational contexts (Brickhouse et al., 2000; Brickhouse & Potter, 2001; Tan, Barton, Kang, & O'Neill, 2013), and have highlighted the importance of developing a science identity, particularly for female students learning science (Brickhouse et al., 2000) and for underrepresented minority students' science career commitment (Chemers et al., 2011). As such, it is important for young girls to engage in positive personal and social interactions with scientists and the various fields of science as often and as early in their school careers as possible. As they consistently have these experiences, they internalize them as members of the science community, thereby strengthening their overall science identities as they progress through their K-12 education and think about careers beyond secondary school.

HYPOTHESISters used women of color as positive scientist role models in combination with a gender-inclusive curriculum and hands-on cooperative learning to help girls find a place for themselves in science and see themselves as scientists. Most of the participants in this study experienced subtle shifts in their view of science and their relationship to science, although in varying degrees. Having the opportunity to learn science in a manner that is conducive to their learning styles and needs, and the ability to understand women's contributions to science created a personal connection that allowed the girls to broaden their vision of who can be a scientist, in some cases far enough to encompass themselves as a part of that image. Sandra, Mia, and Michelle, while acknowledging that they are still learning a lot of science skills and content, saw themselves as fringe or junior members of the science community by the end of the program because they were able to explore and experiment and learn new things throughout the program.

Implications for Girls of Color

Since girls of color often feel excluded from true participation in science classes, educators need to understand how to provide positive experiences for girls of color to learn and engage in

STEM activities. To create an environment that is conducive for girls of color to learn science, the curriculum and teaching methodology must embrace positive reinforcement and acknowledgment. Since girls consistently seek approval from influential others (like teachers) (Carlone & Johnson, 2007), it is important for teachers to be responsive to their unique needs and to build an inclusive community of learners in the classroom, creating a safe and supportive learning environment to learn science (King, 2017) where girls of color are recognized when they do something positive but not chastised or put down for making mistakes.

Educators need to embrace students as learners and position themselves as learners with flexible and contestable knowledge, to build communities of learners in their classrooms (King, 2017). Ensuring that the content in each lesson is in some way relevant and applicable to the girls' everyday lives creates an expectation for students to be producers of knowledge by linking new concepts and information to things with which they are already familiar and knowledgeable, which creates deeper engagement with the material and more learning opportunities.

Successful teaching of girls of color also requires teachers to leverage students' interests, strengths, and needs in the classroom to support their participation. Girls of color in particular need space for creative expression, and teachers must be intentional about providing rich and meaningful learning experiences where girls of color can maintain individuality while still actively participating in the science community created within the classroom. Giving girls the space to think about their interpretation of science content and express the meaning they glean from the content in a way that is meaningful for them provides the support they need for science learning and identity development. Allowing girls of color some room for creative expression and inquisitiveness creates a safe and supportive learning environment, freeing them from traditional constraints on their learning.

Implications for Science Education

Many advances in the fields of science have been made by those we do not traditionally read and hear about. The science curriculum needs to highlight women, people of color, and other gender-creative people who have and are still making contributions to the field. According to the National Science Teaching Association (NSTA), gender equity is critical to the advancement of science and the achievement of global scientific literacy (NSTA Position Statement, Gender Equity in Science Education, n.d.). The NSTA defines gender equity as "ensuring that all students of any sex, gender identity and/or expression, or sexual orientation - regardless of racial or ethnic background or ability – are empowered, challenged, supported, and provided full access to become successful science learners" (NSTA Position Statement, Gender Equity in Science Education, n.d.).

The Next Generation Science Standards (NGSS) cite girls as a marginalized group in science education due to women's persistent underrepresentation in science careers, especially in engineering and technology (NSF, 2015; NGSS Lead States, 2013). Despite efforts made to encourage more girls to take STEM classes, girls continue to take fewer advanced-level science courses in secondary school and graduate from college with fewer STEM degrees (Sadler et al., 2012; National Center for Education Statistics (NCES), 2012), even though they demonstrate equal STEM talent (Wang & Degol, 2013). A recent study by Miller et al. (2018) suggests that although students associate women with science more frequently than in earlier decades, the stereotype of scientists being male persists and becomes stronger as students progress through school.

A variety of research-based best practices for supporting girls in STEM have emerged, including 1) instructional strategies that increase girls' achievement in science; 2) promotion of successful female role models in science; and 3) classroom, school, and district structures (i.e., afterschool and mentoring programs) that encourage girls in science (Baker, 2013; NGSS Lead States, 2013; Scantlebury, 2014). These practices – along with a well-planned gender-inclusive curriculum, and educators and policy makers addressing their own gender biases – can support girls in developing their STEM identities (Kim et al., 2018). Science teachers can capitalize on the rich and diverse strengths and experiences of all students by first recognizing and addressing their own biases and becoming familiar with the array of practices that can support students of any race, gender identity, sexual orientation, and socioeconomic status.

A gender-inclusive science curriculum benefits all students by promoting diversity and teaching them about the myriad of identities in their communities. Science curriculum can serve as a mirror of sorts when it reflects individuals and their experiences to students, becoming a sort of self-affirmation. An inclusive science curriculum can also introduce and provide the opportunity to understand the experiences and perspectives of those who possess different identities that are commonly overlooked. An inclusive curriculum supports students' ability to empathize, connect, and collaborate with a diverse group of peers – skills that are increasingly important in our multicultural global society.

If we as science educators want our students to be creative and flexible, we must think critically about how we present all information. All too often, our curriculum centers around narratives of white men. Children of color and girls are frequently left without adequate representation, and therefore, do not see a place for themselves in science.

To promote gender equity, all stakeholders must support the adoption of equitable practices at all levels of the education system. For science teachers, this means creating an inclusive learning environment that respects, values, and empowers all students by encouraging them to fully and consistently participate in class discussions, activities, and labs; selecting curriculum materials that promote gender inclusiveness through their text, illustrations, and graphics with emphasis on past and current inequities; offering students opportunities to see scientists who represent all expressions of racial and gender identity; building a rigorous, supportive, and empowering classroom environment that includes high expectations and acceptance of all students regardless of race, culture, religion, ability level, gender identity, gender expression, or sexual orientation; and utilizing instructional practices that recognize the multi-faceted cultural backgrounds and experiences of underrepresented groups in STEM fields (NSTA Position Statement, Gender Equity in Science Education, n.d.). Teacher educators and professional development providers must aid teachers in creating an inclusive learning environment by ensuring that professional development and science teacher education programs include discussions about gender equity pedagogy and provide strategies and examples for combating inequity and challenging stereotypes (NSTA position Statement, Gender Equity in Science Education, n.d.).

Curriculum designers and administrators should design and/or select curriculum materials that accurately and equitably portray diverse gender identities, religions, cultures, and races, ages, languages, and abilities through text, pictures, graphics, activities, and assignments (NSTA Position Statement, Gender Equity in Science Education, n.d.). These curricula must also emphasize these diverse and marginalized groups in positive and contributing roles across all disciplines. Although curriculum developers must be sure to devise varied assessments so that all students can be evaluated fairly in science, it is up to administrators to support the implementation of a range of assessment methods that give diverse students more latitude to demonstrate their knowledge and understanding, and foster learning, while simultaneously encouraging all staff to be inclusive and facilitating communication about gender equity among all stakeholders.

When it comes to designing and implementing a gender-inclusive curriculum, educators must make sure to create an environment that fosters curiosity. The U.S. Department of Education's Institute of Education Sciences (2007) reported that girls enjoy hands-on, open-ended projects and investigations (Chatman et al., 2008; Denner & Werner, 2007), and it is widely recognized that it is necessary to create a classroom environment that sparks initial curiosity while fostering long-term interest in science and math. As educators, we must create inquiry-based activities that get students to think more deeply about the content and apply it to various situations rather than simply generate right-or-wrong answers. This will benefit all students, engaging girls as well as boys. Projects must also be personally relevant and meaningful. Girls, in particular, become motivated when they feel their tasks are important and they can make a difference (Mosatche et al., 2013; Lyon & Jafri, 2010; Patrick, Mantzicopoulous, & Samarapungavan, 2009). A gender-inclusive curriculum embeds problems and activities in contexts that are interesting to both boys and girls and encourages them to use science as a tool to explore topics they care about.

Using real-world problems and scenarios in the science curriculum is key because kids often make connections from these stories to their own lives. The science curriculum should also incorporate various learning styles and opportunities for creativity. Girls are more motivated when they can approach projects in their way, applying unique talents and preferred learning styles (Calabrese Barton et al., 2013; Calabrese Barton, Tan, & Rivet, 2008; Lyon & Jafri, 2010). In curriculum and assessments, students should be encouraged to communicate their findings using a variety of techniques, including writing, reflection, and other methods that tap into their imaginative spirit.

A gender-inclusive curriculum should also expose students to positive female role models in STEM-related careers (Mosatche et al., 2013; Holmes, Redmond, Thomas, & High, 2012; Lyon & Jafri, 2010). Incorporating videos of women scientists and engineers discussing their work, including biographical info about women in STEM careers, and calling attention to current events highlighting the achievements of women in math and science helps to normalize women excelling in math and science. Seeing women who look like them and have similar backgrounds that have succeeded in STEM helps inspire and motivate girls, especially when they can relate to these role models as people with lives outside of the lab. Role models and mentors not only broaden all students' views of who does science but expand girls' vision of what is possible in their own lives.

Implications for Teacher Education and Elementary Science

The curriculum and teaching methodologies employed in this are progressive in the way they were developed and implemented, and these methods can be replicated and translated into a formal science setting. Traditionally, elementary science teacher education has left teachers without visible and attainable models of excellence, which prevents them from giving students the necessary foundation of scientific knowledge and understanding of scientific practices that is necessary as the students progress through school and beyond. As a result of science teachers' inadequate preparation, which causes low confidence, science often takes a back seat to other subjects or is taught in a way that removes the wonder of and enthusiasm for science that should be instilled in students at a young age (Mensah & Jackson, 2018), and that is critical for the creation of a well-informed citizenry and society, as well as the next generation of scientists and innovators. When done well to prepare elementary teachers, their growth and learning for curriculum development allows for student leaning also (Mensah, 2021).

It is well-known that teachers often lack the confidence to teach science at the elementary level and studies have shown that teachers with a higher science self-efficacy employ instructional strategies in science lessons that are more exploratory and child-centered than teachers with low personal science self-efficacy (de Latt & Watters, 1995; Gunning & Mensah, 2010). Many elementary teachers leave their teacher education programs with an inadequate amount of training (McClure et al., 2017), feeling incapable of explaining science concepts/principles, conducting science experiments, and providing students with challenging tasks that engage their interest as well as implementing curriculum that meets the needs of all their students (including marginalized students like girls and students of color).

Although formal science education at the elementary level and beyond, is making strides at structuring science so that it is rich in content and practice, arranged coherently across disciplines, and feels more natural and applicable in life, especially with the implementation of the Next Generation Science Standards, there is still room for the non-traditional science experience to co-exist with the formal science space, moving toward more progressive science learning to address the learning needs and interests of all students. Gender-inclusive curriculum and teaching methods, like the type employed in HYPOTHESISters, can provide the means for teachers to make science feel more interconnected and authentic, which would allow more students to develop an enthusiasm for science and build confidence in their skills. Giving elementary science teachers, both pre-service and in-service, access to an inclusive curriculum like HYPOTHESISters as part of their science curriculum to experience it themselves and/or see it in action could bolster teachers' confidence in curriculum development and science learning. By providing them with a model for designing curriculum and teaching science in this gender-inclusive way, there is space for authentic learning and teaching for them and their students. It introduces new knowledge to learn about scientists with whom students may relate to as well as allows for more authentic engagement in showing what they learn through students' creative artifacts.

Limitations

Along with the implications, there are some limitations of this study. One limitation of this qualitative case study is the small number of participants. With five participants it is not possible to make sweeping generalizations and the results of this study only apply to this set of participants. However, the strengths of using a small number of participants for a qualitative case study are providing detailed information about each participant and offering insight for further research. Case studies ultimately allow researchers to investigate topics in far more detail than might be possible if they were attempting to deal with a large number of research participants with the goal of "averaging" (McLeod, 2019). For the examination of complex and sensitive topics like gender equity and science identity formation in young girls, qualitative methods are appropriate as they are exploratory and not meant for generalization, but rather for the generation of new ideas and to convey aspects of a person's life or experiences (McLeod, 2019).

Along with only focusing on five girls, the study is also limited by the educational settings from which the participants came, which included a total of four schools: two public schools, one private school, and one charter school. This does not give a large landscape for evaluating the effects of formal science experiences for girls in general but rather speaks to the experience that a few girls are having in a rather specific setting. Given this limitation, the findings of this study may not be representative of the experiences that girls at large are having in formal science settings, and how those experiences affect perceptions of science and scientists, as well as their confidence and belief that they can do science.

The instrumentation used in the study also created limitations. The use of a version of the DAST, first introduced by Chambers (1993) to ascertain students' perception of the characteristics of scientists and glean their understanding of what scientists do, is structured so that the researcher must garner meaning from the participants' perceptions. Despite students providing captions and verbal descriptions of their drawings, ultimately the meaning of the drawing is left to the researcher's interpretation.

Also, the questionnaire that students completed at the start of the program provided insight into their attitudes toward science, their vision of scientists, and their feelings about school science. However, the questionnaire did not provide insight into the participants' science self-efficacy and science identity. Although the questionnaire contained nine Likert scale questions in addition to open-ended response questions, the generality of the questionnaire items in combination with the participants' limited experience with discussing introspective and/or difficult topics posed a hindrance to obtaining the desired information. The age of the participants, ranging from eight to ten-years-old, could have also impacted their ability to express their feelings clearly and fully explain their ideas and experiences.

Future Research

There is a need for further research to determine the long terms effects of gender-inclusive science curriculum and teaching methodologies on girls' perceptions of science and scientists, the formation of their science identities, the belief in their ability to do science, and their pursuit of science careers. Although the DAST has proven effective at identifying the stereotypes that young children harbor about scientists, it may be necessary to move beyond acknowledging stereotypes to establishing ways to alter these views in favor of more diverse views of who can be a scientist and what scientists do. Along the same vein, the William & Ida Day Friday Institute Student Attitudes Toward STEM (S-STEM) Survey measures students' confidence and interest in STEM subjects and careers. However, it does not address why they have these attitudes, and it is the "why" that we need to uncover to make positive changes in interest and attitudes towards science and math studies and careers. Thus, a follow-up survey or discussion that digs deeper into the origin of these attitudes and feelings would be needed as a supplement to the S-STEM survey and the DAST for this study.

More research is also crucial for the examination of the long-term impact of gender-inclusive curriculum and teaching methodologies on girls' interest in science, the formation of their science identities, confidence in their science skills and abilities, and their achievement in school science. In future studies, it could be useful to ask the following questions: How can science curriculum be designed to address the female perspective without compromising content learning and the effectiveness of science skill development? Do outside-of-school-time (OST) science programs significantly impact students' achievement and interest in school science, and how could stronger connections be made between the two for deeper impact? Can gender-inclusive curriculum and teaching methods be implemented with the same level of effectiveness in both mixed-sex and single-sex settings? While it may be difficult to extract information from young children, we must continue to explore research methods that give us insight into their thoughts and feelings so that we can understand their needs around building confidence and being successful in science, especially the girls.

It is also essential to address how future educators are developing their pedagogy and curriculum design techniques in pre-service teacher education programs. Re-thinking the structure and content of science teacher education programs is critical for producing science educators who understand the necessity for equitable science classrooms and who have the skills necessary to produce and sustain them with the support of administrators and district officials. Girls and boys do not display a significant difference in their abilities in math and science, which means that the cause for the gender gap in STEM achievement is social and environmental (Hill et al., 2010). Gender differences appear in boys' and girls' interest and confidence in STEM subjects starting at a very young age, and this disparity can be linked to a negative self-perception (Halpern et al., 2007). Thus, it is important to spark and strengthen girls' interest and confidence in STEM subjects before high school, when academic choices can either open or close doors to postsecondary STEM studies and careers (Halpern et al., 2007). This is why researchers and educators must figure out how to combine gender-sensitive, inquiry-based activities with inclusive classroom environments and positive role-modeling to foster girls' interest in STEM and positively shape their attitudes toward these fields, all while avoiding unconscious behaviors and structures that can contribute to STEM-focused climates that are unfavorable for girls.

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Appendix A

IRB Study Approval

TEACHERS COLLEGE
COLUMBIA UNIVERSITY

Teachers College IRB Exempt Study Approval

To: Rashida Robinson
From: Myra Luna Lucero, Research Compliance Manager

Subject: IRB Approval: 20-277 Protocol Date: 04/17/2020

Thank you for submitting your study entitled, "*How Gender Inclusive Curriculum Affects Girls' Confidence and Interest in Science*;" the IRB has determined that your study is **Exempt** from committee review (Category **4**) on 04/17/2020.

Please keep in mind that the IRB Committee must be contacted if there are any changes to your research protocol. The number assigned to your protocol is **20-277**. Feel free to contact the IRB Office by using the "Messages" option in the electronic Mentor IRB system if you have any questions about this protocol.

As the PI of record for this protocol, you are required to:

Use current, up-to-date IRB approved documents
Ensure all study staff and their CITI certifications are on record with the IRB Notify the IRB of any changes or modifications to your study procedures Alert the IRB of any adverse events

You are also required to respond if the IRB communicates with you directly about any aspect of your protocol. Failure to adhere to your responsibilities as a study PI can result in action by the IRB up to and including suspension of your approval and cessation of your research.

You can retrieve a PDF copy of this approval letter from Mentor IRB. Best wishes for your research work.

Sincerely,
Dr. Myra Luna Lucero Research Compliance Manager IRB@tc.edu

Appendix B

Parental Informed Consent

(GUARDIAN and/or) PARENTAL CONSENT FORM

Protocol Title: How Gender Inclusive Curriculum Affects Girls' Confidence and Interest in Science
Principal Researcher: Rashida Robinson, Teachers College, rmr2179@tc.columbia.edu 347-566-2998

INTRODUCTION Your child is invited to participate in this research study called "The Effects of a Gender Inclusive Curriculum on Young Girls' Confidence and Interest in School Science, and the Formation of their Science Identity." Your child may qualify to take part in this research study because they are currently in the 4^{th} or 5^{th} grade and will be attending all sessions of HYPOTHESISters Girls Club. The principal researcher of this study, Rashida Robinson, is also the instructor who will be teaching and leading the activities at the HYPOTHESISters Girls Club sessions. Your child will likely participate in HYPOTHESISters for up to 16 hours (over the course of 8 weeks). If you agree, your child will be asked to participate in approximately 1 hour of study related activities (questionnaire and interview).

WHY IS THIS STUDY BEING DONE? This study is being done to determine how an outside of school time (OST) science program for girls that uses curriculum created by female scientists/science educators and highlighting the contributions of women in science, technology, engineering, and math (STEM) fields affects girls' confidence and interest in school science.

WHAT WILL MY CHILD BE ASKED TO DO IF I AGREE THAT MY CHILD CAN TAKE PART IN THIS STUDY? If you decide to allow your child to take part in this study, the primary researcher will ask your child to complete a questionnaire and individually interview your child. We may also interview your child's teacher for background information about your child's science class at school.

At the beginning of the first meeting of the girls' club, your child will be asked to complete a questionnaire (pre-survey) that explores their attitude toward and interest in science. This questionnaire will take about 15 minutes to complete. During the last meeting of the girls' club, your child will be asked to complete a questionnaire (post-survey) that explores any changes in their attitude toward and interest in science. This questionnaire will also take about 15 minutes to complete.

During the individual interview, your child will be asked to discuss their experience and feelings about science class at school and during the girls' club, their views about science, and their perception of who can be a scientist. This interview will be audio recorded and once the recorded interview has been transcribed, the original recording will be deleted. If you do not wish for your child to be audio-recorded, your child will still be able to participate. The researcher will just take hand-written notes. This interview will take approximately 20 minutes. Your child will be given a pseudonym or false name in order to keep their identity confidential.

Each meeting of the girls' club will be videotaped so that the primary researcher can make observations of what went on during each club meeting. Pertinent sections of the videotaped will be transcribed by the primary researcher, and again your child will be given a pseudonym to keep their identity confidential. Once each recording has been viewed and notes have been taken, the recordings will be deleted.

Finally, two pieces of your child's work – one from the first day of the club and one from the last day of the club – will be collected for analysis upon their completion during the club session. Both of these assignments relate to who they believe can be a scientist. Their names will be removed from these assignments and replaced with their assigned pseudonym, and their work will be kept by the primary researcher.

All of these procedures will be completed at The Forum where the science club meetings are taking place at a time that is convenient for your child. The researcher will set up a time that is convenient for your child either before or after club sessions to conduct interviews. All other procedures – questionnaires, artifact collection, and session videotaping will be done within the normal club meeting time.

During the individual interview, the researcher will audio record you child. Your child can choose whether or not they would like to be audio-recorded. If they choose to be audio-recorded (and you agree), the researcher will notify them when the audio-recorder is started and when it has been stopped. If you or your child are uncomfortable having the interview audio-recorded, the researcher will take hand-written notes.

When the entire group of girls is being recorded at each session, students not participating in the study will be seated in an area that is off camera but still with the entire group. The video recorder will be set up by the primary researcher, and the recording will last for the entire two-hour club meeting.

WHAT POSSIBLE RISKS OR DISCOMFORTS CAN MY CHILD EXPECT FROM TAKING PART IN THIS STUDY? This is a minimal risk study, which means that the harms or discomforts that your child may experience are not greater than your child would ordinarily encounter in daily life while taking part in routine physical or psychological examinations or tests. Your child might feel embarrassed answering questions about science content or presenting information to their peers. Your child does not have to answer any questions or share anything they do not want to talk about. Your child can stop participating in the study at any time without penalty. You might feel concerned that things your child says might get back to her teacher. Your child's information will be kept confidential.

The primary researcher is taking precautions to keep your child's information confidential and prevent anyone from discovering what they say or their identity, such as using a pseudonym instead of their name and keeping all information on a password protected computer and locked in a file drawer.

You may feel that you have to agree to allow your child to be in this study in order for your child to participate in the afterschool program. However, this study is voluntary. Your child does not have to be in this study. If you choose not to allow your child to be in this study, they will still have access to the afterschool program activities and they will not be excluded.

WHAT POSSIBLE BENEFITS CAN MY CHILD EXPECT FROM TAKING PART IN THIS STUDY? There is no direct benefit to your child for participating in this study. Participation may benefit the field of science education to help determine how science curriculum and teaching methodology can be more gender inclusive.

WILL MY CHILD BE PAID FOR BEING IN THIS STUDY? Your child will not be paid to participate. There are no costs to you for your child's participation in this study.

WHEN IS THE STUDY OVER? CAN MY CHILD LEAVE THE STUDY BEFORE IT ENDS? The study is over when your child has completed the interview, participated in each club meeting, completed the pre- and post- questionnaire, and their selected assignments have been collected for evaluation. However, your child can leave the study at any time even if they have not finished.

PROTECTION OF YOUR CHILD'S CONFIDENTIALITY The primary researcher will keep all written materials locked in desk drawer at their place of residence. Any electronic or digital information (including audio and video recordings) will be stored on a computer that is password protected. The Audio recordings will be transcribed and then subsequently destroyed. There will be no record matching your child's name with their pseudonym.

For quality assurance, the study team, the study sponsor (grant agency), and/or members of the Teachers College Institutional Review Board (IRB) may review the data collected from you as part of this study. Otherwise, all information obtained from your participation in this study will be held strictly confidential and will be disclosed only with your permission or as required by U.S. or State law.

HOW WILL THE RESULTS BE USED? The results of this study will be used as part of a doctoral thesis paper and may be published in journals or presented at academic conferences. Your child's identity will be removed from any data your child provides before publication or use for educational purposes. Your child's name or any identifying information about your child will not be published. This study is being conducted as part of the dissertation of the primary researcher.

CONSENT FOR AUDIO AND VIDEO RECORDING Audio recording and video recording is part of this research study. You can choose whether to give permission for your child to be recorded. If you decide that you do not wish for your child be recorded, they will still be able to participate in this research study.

______I give my consent for my child to be recorded ______________________________

Signature

______I **do not** consent for my child to be recorded ______________________________

Signature

WHO MAY VIEW MY CHILD'S PARTICIPATION IN THIS STUDY

___I consent to allow my child’s written, video and/or audio-recorded materials viewed at an educational setting or at a conference outside of Teachers College, Columbia University

____
Signature

___I **do not** consent to allow my child’s written, video and/or audio-recorded materials viewed outside of Teachers College, Columbia University

____
Signature

OPTIONAL PERMISSION FOR FUTURE CONTACT

The primary researcher may wish to contact you (or your child) in the future. Please initial below to indicate whether or not you give permission for future contact.

The researcher may contact my child or me in the future for other research opportunities:

Yes ______________________ Initial   No______________________ Initial

The researcher may contact my child or me in the future for information relating to this current study:

Yes ______________________ Initial   No______________________ Initial

WHO CAN ANSWER MY QUESTIONS ABOUT THIS STUDY?
If you have any questions about the study or your child’s taking part in this research study, you should contact the primary researcher, Rashida Robinson, at 347-566-2998 or at rmr2179@tc.columbia.edu.

If you have questions or concerns about your child’s rights as a research subject, you should contact the Institutional Review Board (IRB) (the human research ethics committee) at 212-678-4105 or email IRB@tc.edu or you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY 10027, Box 151. The IRB is the committee that oversees human research protection at Teachers College, Columbia University.

PARTICIPANT’S RIGHTS

- I have read the (Guardian) Parental Permission Form and have been offered the opportunity to discuss the form with the researcher.
- I have had ample opportunity to ask questions about the purposes, procedures, risks and benefits regarding this research study.

- I understand that my child's participation is voluntary. I may refuse to allow my child to participate or withdraw participation at any time without penalty. I understand that my child may refuse to participate without penalty.
- The researcher may withdraw my child from the research at their professional discretion if the child misses a club session and/or their teacher is unable to cooperate with the researcher to complete their portion of the study.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to allow my child to continue participation, the researcher will provide this information to me.
- Any information derived from the research study that personally identifies me or my child will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- Identifiers may be removed from the data. De-identified data may be used for future research studies by the same researcher without additional informed consent (or permission) from you (the guardian, parent, or the research participant's representative) or your child (the research participant).
- I should receive a copy of this (Guardian) Parental Permission Form document.

<u>My signature means that I agree to allow my child to participate in this study:</u>

Print Parent or guardian's name: ____

Parent or guardian's signature: ____

Child's name: ______________________________________ **Date**: ______________________

Appendix C

Child Assent Form

ASSENT FORM FOR MINORS

Protocol Title: How Gender Inclusive Curriculum Affects Girls' Confidence and Interest in Science
Principal Researcher: Rashida Robinson, Teachers College, rmr2179@tc.columbia.edu (346) 566-2998

My name is Rashida Robinson. I am trying to learn how girls feel about science and their interest and confidence in science, and their science identity. I am the researcher who will be conducting this study, and I will also be your teacher for the girls' science club.

I am asking you to be in this study because you are a fourth or fifth grade student and you have expressed an interest in afterschool Science, Technology, Engineering, and Math (STEM) programs. I hope to have twenty girls like you in this research.

If you are in the research, this is what will happen:

- I will have you fill out a questionnaire that asks you to describe your feelings about science.
- I will interview you and audio record what you say about your experiences and feelings about science class at school and during our girls' science club, your views about science in general, and your idea of who can be a scientist.
- If you let me, I will collect an assignment that helps me understand what you think makes a good scientist.
- I will video record what you say and do doing our weekly girls' club meetings.
- If possible, I will also talk to your science teacher at school.

The research will take place one day per week for a total of ten weeks. I cannot guarantee that you personally will be helped by being in this study. However, I may learn something that will help teachers figure out a better way to teach science and help students learn science in a way that is more engaging and more effective.

Risks associated with this study:

- You might feel embarrassed answering questions about what your you're learning or have learned in science or when presenting information to your peers. You do not need to answer any questions you do not want to.
- If anything you are asked to do makes you feel sad, scared or uncomfortable, it is okay for you to stop any time you want to.
- You may also be worried that I will take to your teacher about you. I am not grading you or collecting any of your grade information from your teacher. This study will not affect your grades or your class standing at all. I am only interested in understanding how you feel about science and if your teacher has noticed anything about you in your science class.

- You may feel that you have to be in the study. However, the study is voluntary, and you may choose to be in the afterschool program without being in the study.

Both you and your parent/guardian must agree to you being in the study. Even if your parent or guardian says yes, you may still say no, and that is okay. You do not have to be in this study if you do not want to. Nothing bad will happen to you if you say no now or change your mind later after starting the study. You just need to tell me if you want to stop being in the study. I will ask you later if you want to stop or if you want to keep going. It's okay to say yes or no. Even if you do not want to participate in the study or decide to stop participating, you can still participate in the girls' club.

You can choose to participate in this study and not be video recorded. If you want to be in this study and not video recorded, you can sit in a part of the room where you will not be recorded but will still be part of the group.

I will keep the information I collect for the study safe and secure. I will not share information that has your name on it with people who are not part of the research team, unless we have to.

If you have questions, you can contact the researcher, Rashida Robinson, at (347) 566-2998 or rmr2179@tc.columbia.edu or Dr. Christopher Emdin at ce2165@tc.columbia.edu.
If you want to talk to someone else besides the researcher you may contact the Teachers College Institutional Review Board (IRB) at 212-678-4105 or by email at IRB@tc.edu.

Assent Statement

I____ agree to be in this study, titled The Effects of a Gender Inclusive Science Curriculum on Young Girls' Confidence and Interest in School Science, and the Formation of Their Science Identity. What I am being asked to do has been explained to me by Rashida Robinson, the Principal Investigator.

I understand what I am being asked to do and I know that if I have any questions, I can ask Rashida Robinson at any time. I know that I can quit this study whenever I want to, and it is perfectly OK to do so. It won't be a problem for anyone if I decide to quit.

Name: ____

Signature: ____

Witness Name: ____Date: _______________

Appendix D

Recruitment Script

How Gender Inclusive Curriculum Affects Girls' Confidence and Interest in Science

Dear Study Participant,

My name is Rashida Robinson, and I am a doctoral student in the math, science, and technology department at Teachers College, Columbia University. I am conducting a research study examining how gender inclusive curriculum affects young girls' confidence, interest in school science, and the formation of their science identity, and you are invited to participate in the study. If you agree, you are invited to participate in an interview, complete a questionnaire, have specific assignments collected for analysis, and to have your participation in the girls' club videotaped.

The survey is anticipated to take no more than 15 minutes and interview is anticipated to last no longer than 20 minutes and will be audio-recorded.

Participation in this study is voluntary.

Your identity as a participant will remain confidential both during and after the study.

You will be assigned a pseudonym and all identifiers will be removed for the purposes of the study and data will be collected at the girls club location either before, during or after girls' club meetings.

If you have questions or would like to participate, please contact me at rmr2179@tc.columbia.edu.

Thank you for your participation,

Rashida Robinson
Teachers College, Columbia University
Department of Math, Science, and Technology
Doctoral Candidate

Appendix E

Informational Flyer

HK HYPOTHEkids | HYPOTHESISTERS

In a series of two-hour workshops, girls, aged 9-12 (grades 4 and 5) are engaged in the story of a diverse female scientist, learn the STEAM practice she mastered and then design and make a related project. The girls leave the workshops empowered with the knowledge that they can and will make a meaningful difference to their communities and beyond.

Two HYPOTHEkids teachers would facilitate the free workshops held at the Forum on successive Saturday mornings 10.00-12.00 for twelve weeks in Fall 2019.

Background:

HYPOTHEkids is starting an afterschool STEAM club for girls designed with three goals in mind: 1) to get girls to see themselves as scientists by redefining who/what a scientist is; 2) provide girls with the tools to assume leadership positions in math and science classes (and at large) by building confidence in their abilities in these content areas, and 3) increasing girls' awareness of the prominence of women in science and math.

A "gender-inclusive" science curriculum and pedagogy draws on both girls' and boys' experiences, interests, and preconceptions; prioritizes active participation; provides a supportive environment; uses real-life contexts; addresses the social and societal relevance of science; pays attention to issues of sexism and gender bias in curriculum materials; and includes the "her story" and the "lost women of science" (Parker, L.S., & Rennie, L.J., 2002). A curriculum that incorporates gender-inclusive features can have a positive effect on students and is consistent in a lot of ways with general science education reform recommendations that attempt to improve science education for all students through constructivist approaches (Roychoudhury, A., Tippings, D.J., & Nichols, S.E., 1995; National Research Council, 1996). This is why these types of curricula have proven beneficial for both boys and girls.

We hope to provide girls with additional academic support in math and science, while simultaneously building their leadership skills and confidence, by having them attend after school sessions led by female scientists. During these sessions, a group of girls would participate in leadership building activities and collaborative, inquiry-based science lessons/activities to build content knowledge. A session would involve discussing diverse female scientists and engineers of the past and present to create a mirror for themselves as the future. This can be done by engaging in activities, or projects, relating to the individual's' accomplishments as well as grade level science standards, and reinforcing agency that is continued in the classroom to their peers. The lessons will also be designed to include the local neighborhood and the New York City environment as much as possible so that the students can make connections between the science concepts and their everyday lives.

The program would be led by:

Rashida Robinson

Rashida is a California certified science teacher, and also holds an administrative credential from the state of California as well. She taught sixth through eighth grade science for eleven years before leaving her tenured teaching job to attend graduate school at Teachers College. Rashida is currently in her third year of the doctoral program in Sci ence Education, working towards a Ph.D. After working as the Site Director for HYPOTHEkids Summer STEAM program this summer, Rashida joined the HYPOTHEkids administrative staff as the K-8 Curriculum Director in September. In her capacity as Curriculum Director, she is creating elementary STEAM curriculum for grades K-5, as well as engineering-based curriculum for grades 6-8. Upon completion of her doctoral degree, Rashida hopes to work with preservice teachers at the graduate level on developing curriculum and pedagogy that is more inclusive of girls and minorities.

Trisha Barton

Trisha has a BA in Psychology from Spelman University and a master’s in art and Art Education concentrating in Creative Technologies from Teachers College, Columbia University. Trisha has used her knowledge of maker labs and art to facilitate workshops for children, adolescents and adults to develop programs that revolve around making, creative technologies, and the relationship between inquiry-based projects and career development. Trisha has taught Creative Technologies in the afterschool program at TCCS and is a lead teacher at Hk Summer STEAM.

Appendix F

HYPOTHESISters Curriculum Outline

Session 1: Introductions
Icebreaker Games
Picturing the Scientists Activity & Discussion
Scientist of the Week Research/Discussion: Aisha Bowe
Sister Chat #1: What does it mean to be a leader?

Session 2: Leadership Building Activity
Topic: What's in outer space?
Project: Galaxy in a Jar

Session 3: Icebreaker Game
Scientist of the Week Research/Discussion: Katherine Johnson
Sister Chat #2: What were some of Katherine Johnson's obstacles? What do you think she did to overcome them? How do you overcome obstacles in your own life?
Topic: Measuring in the Milky Way – Intro to Measuring & Units

Session 4: Team Building Game
Topic: Astronomical Units
Project: Astronomical Units Bead Scale & Mobile

Session 5: Icebreaker Game
Activity: Cannister Rockets
Scientist of the Week Research/Discussion: Mae Jemison
Topic: How do rockets launch?

Session 6: Leadership Building Game
Topic: Newton's Laws of Motion
Introduction to the Engineering Design Process
Activity: Marshmallow Towers
Design Challenge Intro: Bottle Rockets

Session 7: Icebreaker Game
Topic: Forces on a Rocket
Project/Design Challenge: Design & Create Bottle Rockets

Session 8: Team Building Game
Activity: Launch Bottle Rockets
Discussion: Which rockets stayed in the air the longest? Went the highest? Hit the target and delivered the message? Why?

Session 9: Icebreaker Game
Project: Bottle Rocket Re-design and Build

Activity: Bottle Rocket Launch #2
Discussion: Did our rockets go higher? Stay in the air longer? Hit the target with more accuracy? Why or why not?

Session 10: Leadership Building Activity
Scientist of the Week Research/Discussion: Jedidah C. Isler
Sister Chat #3: How can we communicate most effectively? What are different ways to express our ideas?
Topic: Black Holes
Project: Black Hole Piggy Bank

Session 11: Icebreaker Game
Project: Travel Pitch – "Visit part of the Milky Way Galaxy"

Session 12: Final Game: Kahoot Challenge
Activity: Milky Way Travel Pitch Presentations
Activity: Picturing the Scientist Drawing & Discussion
End of Program Celebration & Goodbyes

Appendix G

Participant Questionnaire

Questionnaire

Instructions
There are lists of statements on the following pages. Please answer based on how you feel about each statement. For example:

Example 1:	*Strongly Disagree*	*Disagree*	*Neither Agree nor Disagree*	*Agree*	*Strongly Agree*
I like engineering.	O	O	O	O	O

As you read each sentence, you will know whether you agree or disagree. Fill in the circle that describes how much you agree or disagree.

Even though some statements are very similar, please answer each statement. This is not timed, so work carefully.

There are no "right" or "wrong" answers! The only correct responses are those that are true for you. Whenever possible, let things that have happened to you help you make a choice. PLEASE FILL IN ONLY ONE ANSWER PER QUESTION.

	Strongly Disagree	*Disagree*	*Neither Agree nor Disagree*	*Agree*	*Strongly Agree*
1. I feel good about myself when I do science.	O	O	O	O	O
2. I might choose a career in science.	O	O	O	O	O
3. After I finish high school, I will use science often.	O	O	O	O	O

4. When I am older, knowing science will help me earn money.	O	O	O	O	O
5. When I am older, I will need to understand science for my job.	O	O	O	O	O
6. I know I can do well in science.	O	O	O	O	O
7. Science will be important to me in my future career.	O	O	O	O	O
8. I can understand most subjects easily, but science is hard for me to understand.	O	O	O	O	O
9. In the future, I could do harder science work.	O	O	O	O	O

Answer the following questions in your own words. Write as much as you need to in order to completely answer the question.

10. What is a scientist?

11. When you think of a scientist, who comes to your mind? Describe this person.

12. What do you consider to be your best school subject? Why?

13. How would you describe your school science class?

14. If you could change anything about your science class, what would it be?

15. Do you feel that you are able to help other students in your science class learn things? Why or why not?

Appendix H

Picturing the Scientist Activity

PICTURING THE SCIENTIST

INSTRUCTIONS

1. In your mind, picture a scientist…ANY scientist…what comes to mind?
   - What is the gender of the scientist? ______________________
   - What is the age of the scientist? ___________________________
   - What is the race (ethnic background) of the scientist?
     ____
   - What is the scientist's job title? ___________________________
   - Where does the scientist work? ____________________________
2. On the **OTHER SIDE** of this paper, draw a scientist at work. Make sure to…
   - ☐ Include the workplace in the **background** (ex: a chemistry lab).
   - ☐ Show the scientist busy **DOING** work (ex: conducting an experiment), **NOT** just standing there.
   - ☐ Include some of the **tools** (ex: beakers) the scientist would use at work.
   - ☐ Show the scientist's **gender, age, and race** in your drawing.
   - ☐ **Color the scientist and the background.**
3. Once you have finished drawing and coloring:
   - ☐ Write the information about the scientist's gender, age, race, job title, and work setting (where they work) on lines provided **underneath the drawing.**

Name________________________________

MY SCIENTIST

Job Title:____

Gender: ____________________________ **Race:** ______________________

Age: ___________ **Work Setting:**_________________________________

Description (What's happening in the picture?):

____

____

____

____

____

Appendix I

Interview Protocol

Child Interview Protocol

Interviewer: Hello! Thank you for doing this interview. The things that we talk about here today are going to help me with my research study as I try to figure out what makes science interesting for you and what makes you feel good about doing science. If you want mom or dad to it in our interview, that's totally fine. Remember, there are no wrong answers to any of these questions – I just want to know your thoughts, feelings, and ideas about each question. Also, you can feel free to ask me questions at any time. Do you have any questions before we get started? I am going to tape record our conversation just so that I don't forget anything that we talk about, okay? Alright, let's get started.

<u>Interview Questions</u>

1. Describe your science class at school.
2. Name the first scientist who pops into your head. Describe this person.
3. Do you think that you are "good" at science or that you do well in your science class at school? Why or why not?
4. Do you feel confident participating and asking questions in your science class at school? Why or why not?
5. Do you feel comfortable answering questions during science class? What about helping other students? Why or why not?
6. Do you consider yourself to be a scientist? Why or why not?
7. If you could change one thing about your science class at school, what would it be?
8. Do you feel different at HYPOTHESISters than you do in your science class at school? Why or why not?
9. Describe HYPOTHESISters in comparison to your school science class.
10. Do you like working in groups when doing science? Or do you prefer to work alone? Why?