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A Phenomenological Study of the Experiences of Successful Women in Science Fields

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A PHENOMENOLOGICAL STUDY OF THE EXPERIENCES OF SUCCESSFUL WOMEN IN SCIENCE FIELDS

by

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ABSTRACT

Girls and women face several forms of gender-based biases and discrimination in the science community. These issues create difficult circumstances for them to develop positive science identities. Since these difficult circumstances exist, science education and sociology researchers have used a deficit model to learn about their experiences, achievements, and attitudes. Understanding the experiences of successful women in science offers insight into how women can navigate the challenges presented by the science community and how science educators can support them. However, research studies that explore the experiences of successful women in science are scant. Therefore, the objective of this study was to learn about the experiences of successful women who are professionals in science fields. Twelve participants engaged in three semi-structured interviews. Findings showed that participants had access to and support in authentic science experiences. They developed a passion for science that was supported by a self-selected support system. Advancement in workplaces that were often dominated by males required a sophisticated understanding of organizational norms. This advancement required strategic agency in how they spent their time and the relationships that they built. Two differences in experiences were found that were based on race. The first difference based on race was that Black and Hispanic participants experienced racial and ethnic discrimination. The second difference was that Black and Hispanic participants discussed the centrality of their faith to their work in every interview. These findings provide insight for the science community. Science methods instructors could educate pre-service teachers about how participants navigated gender-based challenges in science communities. Furthermore, the stories of these women could structure lessons that cover inclusion and equity. For industry, all

employees should adhere to professional standards and mentors should be relatable to their mentees.

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peace

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CHAPTER ONE: INTRODUCTION

Part of the role of educators is to inspire students to accomplish goals that they may see as impossible. Helping students persist through challenges and experiencing the joy of success are two of the greatest pleasures that instructors can experience. Based on research, most girls overtime develop the belief that a successful and enjoyable future in science is not attainable (Brotman & Moore, 2008; Due, 2014; Hill, Corbett, & St. Rose, 2010; Scantlebury, 2014; Xie, Fang, & Shauman, 2015). This should be troubling to educators aiming to inspire, encourage, and teach their students for several reasons. First, science professionals have a meaningful impact on global issues that necessitates the perspectives of diverse groups of people. For example, they affect how nations respond to food production issues (Baudron & Giller, 2014; Borlaug, 2007; Kuyper & Struik, 2014). As global populations grow rapidly, production of the food will also have to increase. This increase in food production will demand changes to the environment. A diverse group of individuals should have a voice in this conversation so that there is equitable representation of perspectives. Without equitable representation, some perspectives are marginalized. This is one reason for all students to acquire science skills and knowledge. They then have the choice of whether they would like to choose a science field as a career path. Second, science professionals earn higher wages than those in non-science fields. An increase in women's representation in science fields would offer more of them economic stability and independence. Educators should be concerned about creating a level playing field for all their students to achieve economic stability, especially for populations that have been historically oppressed. Third, the underrepresentation of women in science fields has led to common misconceptions about a gendered discrepancy in cognitive abilities and interests. Girls

and women are often viewed as less capable of performing the required tasks of these science positions and as uninterested in science-related activities (Hill et al., 2010). This misconception often results in a fixed mindset that restricts girls' development in science areas (Dweck & Leggett, 1988). However, learning environments and the overall science culture has shown to have a significant impact on women's majors and career choices as well as academic success (Hill et al., 2010; Xie et al., 2015). Therefore, educators have an important opportunity to help girls and women see themselves as scientists. This would also give girls and women opportunities to develop scientific ways of thinking. Educators who are equipped with the understanding of seasoned professionals' experiences may be better able to inspire and encourage girls to accomplish goals that seem impossible.

Purpose Statement

The purpose of this study was to explore the experiences of successful women in science fields. Most of the science education and sociology literature has used a deficit model, as opposed to perspectives that offer empowering insight for girls and women in science communities (Scantlebury, 2014; Xie et al., 2015). Oppressive norms and biases can partially explain the underrepresentation of women in science professions for the past several decades. Therefore, understanding experiences of successful girls and women would offer a different perspective regarding these issues that could offer insight for how they can navigate discrimination and oppressive norms. This knowledge is meaningful to the world of science education for several reasons. First, research has been conducted to develop science identity models (Calabrese Barton et al., 2013; Carlone & Johnson, 2007) and findings from this study

may further develop this aim. Using a similar conceptual framework and data analysis procedures with a different sample has bolstered and challenged the current understanding of science identity. The science community values specific behaviors, beliefs, and abilities, which affect how members practice their identity (Holland, Lachichotte Jr., Skinner, & Cain, 1998). Therefore, the perspectives of experienced women offer insight into the constructs and relationships of science identity. Second, Carlone (2017) and Flyvbjerg (2001) argued that understanding science identity models assist science educators in developing learning experiences that interrupt oppressive norms. Science teacher educators and curriculum developers can use the knowledge gained from this study to develop lessons and programs that aim to promote inclusive environments. Specifically, science methods instructors could educate pre-service teachers about how participants navigated gender-based challenges in science communities. The stories of successful women in science could structure lessons that cover inclusion and equity for pre-service science teachers. Third, Hill et al. (2010) suggested events specifically designed for women and places that promote community building should be included in the experiences of undergraduate students in the sciences to help women feel welcomed and valued. The specific objectives of these programs could be substantiated by the stories of successful women in science.

Research Goals and Research Questions

There are women who enjoy their work as science professionals and are successful (Johnson, Brown, Carlone, & Cuevas, 2011; Robert & Carlsen, 2017). Gaining their perspectives was helpful for understanding theoretical information about science identity by

using research methods that were not previously employed and by developing programs and lessons aimed to build inclusive science communities. Therefore, my research goal is to learn about the experiences of successful women in science. The following are research questions with sub-questions that guided the study:

1. What are the experiences of successful women working in science fields?
    a. What were participants' experiences in science classrooms prior to and during college?
    b. What were participants' early work experiences in science?
    c. What are participants' current experiences as science professionals?
2. If any, what are the differences in participants' experiences based on race/ethnicity and pre-college socioeconomic status?

Conceptual Framework

Holland et al. (1998) theorized a sociocultural perspective on identity and identity formation that incorporated figured worlds and identity work. From this perspective, identity is seen as a social practice, a set of behaviors and attitudes that evolves through different experiences and is influenced by setting. Identity is not a static characteristic but involves fluid practices that are influenced by contextual factors. Figured worlds provide an analytical lens on how setting, culture, and historical factors affect the way people perceive and value themselves and others. An individual's identity can change with different settings, or figured worlds, and at different times in that individual's life. Identity formation is the accumulated experiences, feelings, and cognitive understandings that affect how people perceive themselves and their

figured worlds. These experiences motivate individuals to act or retreat in their engagement within the science community, which then affects how others perceive them. Finally, intersecting characteristics of an individual affect science identity. Calabrese Barton et al. (2013) suggested, "Identity is a powerful construct for understanding student learning because identities are constructed through practice—practice that requires knowledge, skills, and ways of thinking that characterize the discipline in which one is engaging" (p. 41). Learning the experiences of successful women in science has helped me to understand the significant factors of their figured worlds. This understanding also facilitated my understanding of how their science identity developed. *Figure 1* provides a visual of the conceptual framework for this study.

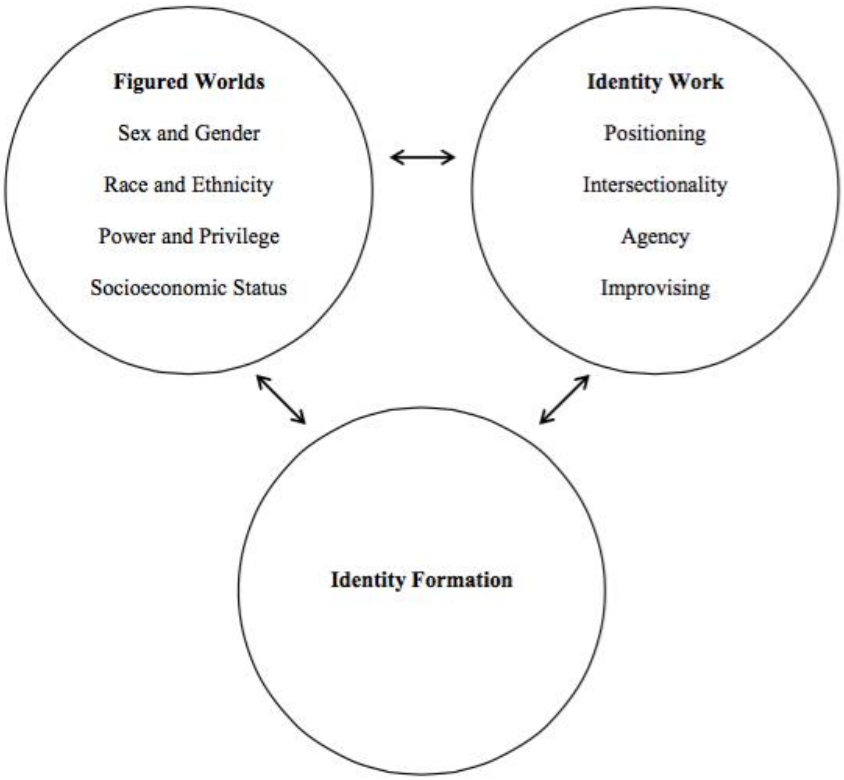

Figure 1: Conceptual Framework to Guide this Study of Women's Identity Formation in Science

Overview of Methodology

This qualitative study used descriptive phenomenological methods to explore the experiences of successful science professionals. Twelve participants were selected based on their length of time in a science field and having equitable racial and socioeconomic representation among the sample. The descriptive phenomenological interviewing process developed by Seidman (2006) was used for data collection. Each participant was interviewed for roughly one hour on three occasions. Data analysis followed the seven steps of the descriptive phenomenological process devised by Colaizzi (1978). Finally, steps such as member checking and analysis of my positionality are conducted to uphold the trustworthiness of my findings.

Definition of Terms

Key terms of the proposed study are defined as follows:

Agency: within the restrictions and possibilities of figured worlds, an individual's position, attitude, thoughts, and actions in aims to direct his or her path and achieve his or her goals (Calabrese Barton & Tan, 2010)

Anchors: meaningful people, events, and objects that have significantly affected the science experiences of participants in the past

Ethnicity: group of people who share, or believe they share, common ancestry, distinctive social traits, and socially important physical characteristics (Ferrante-Wallace & Brown, 2001)

Figured world: "… a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (Holland et al., 1998, p. 52)

Gender: performances along a continuum of behaviors, discourses, and beliefs that are associated with masculinity and femininity (Butler, 1990)

Identity: social practice that evolves through prior experiences and is influenced by figured worlds (Holland et al., 1998)

Identity formation: process of people learning about themselves and how others perceive them through social experiences over time that affects momentary behaviors (Holland et al., 1998)

Identity work: "… actions that individuals take and the relationships they form (and the resources they leverage to do so) at any given moment and as constrained by historically, culturally, and socially legitimized norms, rules, and expectations that operate within the spaces in which such work takes place" (Calabrese Barton et al., 2013, p. 2)

Improvisation: acting upon a vision that has not been made apparent based on observable circumstances that move an individual to act beyond structural circumstances (Holland et al., 1998)

Intersectionality: theoretical viewpoint that social identifiers (i.e., gender, race, ethnicity, or socioeconomic status) are simultaneously experienced by individuals, not in isolation of each other (Collins, 2015)

Positioning: appearance, dialogue, and actions that affect the power and privilege accessed by a member of the figured world (Holland et al., 1998)

Race: "… social construct for classification system for human beings with no biological justification… " (Atwater, Lance, Woodard, & Johnson, 2013, p. 7)

Science: studies and professions of physical sciences, earth sciences, and life sciences (DeBoer, 1991)

Science agency: the use of "… knowledge, practice, and context of science to develop their identities, to advance their positions in the world, and/or to alter the world toward what they envision as being more just …" (Calabrese Barton & Tan, 2010, p. 195)

Science communities: places and people that facilitate the learning and development of the physical sciences, earth sciences, and life sciences

Science identity: an individual's ongoing social existence within the science world

Socioeconomic Status: an individual's sense of origin regarding parental education and financial resources (Eagan Jr. et al., 2013)

Sex: genotype and phenotype that determine whether an individual is male or female

Organization of Paper

Chapter 1 of this paper lays the foundation for the study by explaining the purpose of the study and research goals. Research questions are identified, and key terms are defined. The conceptual framework and brief overview of the methods are also explained. Chapter 2 is a review of the literature on identity development theory and women's experiences in science fields. Chapter 3 explains the proposed methodology and methods of the study. Chapter 4 describes the findings through fundamental structures and thick descriptions. Chapter 5

discusses how the findings fit within existing literature. Then, implications, recommendations for future studies, and study limitations are explained.

CHAPTER TWO: LITERATURE REVIEW

This chapter provides an analysis of the literature on identity development theory and women's experiences in science. Merleau-Ponty (1956) argued that descriptions of participants' experiences should be developed without causal explanations of the phenomena (Merleau-Ponty, 1956). This perspective allows a researcher to understand participants' experiences without predetermined explanations and implicit biases that they hold. Therefore, it could be argued that using a conceptual or theoretical framework in this descriptive phenomenological study inhibits the purpose of this research design (Bevan, 2014; Seidman, 2006). However, developing a conceptual framework to build an understanding for the experiences of successful women in science fields is important for four reasons. First, my positionality has not naturally provided opportunities to become deeply sensitive and understanding of the experiences of women in science. Growing and developing as a white, lower-middle-class male has, in many cases, not allowed me to experience challenges and perspectives that many women in science fields have commonly experienced. One such challenge is that women are often expected to avoid arguments and to take on supportive roles. Due (2014) found that high school girls were expected by their peers to be supportive and avoid conflict during group work. Therefore, these girls were found to avoid making decisions. They often took the note-taking role during lab work and were not expected to conduct the experiments. As a high school and college student, I can recall being actively engaged in conducting lab experiments and directing others in the group. I do not recall my peers and instructors opposing these behaviors. Therefore, my conceptual framework has helped me in becoming aware and understanding of sensitive issues of women in science. Second, the conceptual framework contributed to developing meaningful

implications in the discussion of my study. The conceptual framework provides a basis to begin understanding the data, while not imposing constructs and relationships to participants' experiences. Third, the conceptual framework assisted in the development of the interview protocol. Fourth, the conceptual framework also helped in developing research questions that are relevant and meaningful to the experiences of successful women in science.

Figured Worlds

Holland et al. (1998) described figured worlds as "… a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p. 52). Using the concept of figured worlds as an analytical lens to the science fields provides a path to critically analyze the masculine characterization of the science community. Therefore, science classrooms and participants' places of work represent different figured worlds. Participants may have had support that interrupted the gender-based discrimination and biases.

Through a longitudinal qualitative study, Calabrese Barton et al. (2013) explored the experience of a middle school African-American girl who encountered a figured world that grew her interest for the sciences. Researchers were able to understand important aspects of the participant's figured world in science that shifted her career interests. Throughout the fifth grade, she aspired to be a dancer or professional singer. Over the course of a 3-year study, she attended a community youth center after school and joined the "Green Club," which focused on energy conservation. Leaders of the "Green Club" valued her work and provided her opportunities to become the expert on conservation matters. Furthermore, the principal of the

school was supportive of her group's findings and encouraged her to present methods to conserve energy to the school government. After 3 years, she aspired to be a "Green Designer." She wanted to utilize her artistic qualities and science knowledge to find new ways to conserve energy. Community leaders, teachers, and the school principal who valued her contributions played a significant role that influenced her career aspirations. The community center and principal played an integral role in creating science opportunities. This support was coupled with the teacher's instruction but was not completely reliant on the instruction. Several individuals ultimately affected her career aspirations and, significantly, her self-conception as a person who can thrive in the science community. Opportunities beyond the classroom allowed her to build meaningful connections regarding how science affects her surroundings.

To understand the experiences of successful women in science professions, asking them to describe or define their perspective of their upbringing that is relative to science and the workplace in figured terms may provide insight as to how they perceive different settings. Participants may have inhabited contexts, or figured worlds, that allowed them to position themselves as science experts. Calabrese Barton et al. (2013) provided an example of how a community program and an educational system valued the science work of a middle school African American girl. Participants may have had meaningful relationships built in this context that positively influenced the identity formation of participants. Understanding the science community from different contexts may be illuminating as to how successful women developed their science identity. Instead of understanding science communities as male oriented, it is possible that participants experienced different contexts that valued femininity.

Sex and Gender

The difference between sex and gender is important to distinguish because this delineation provides insight into aspects that educators can influence. Sex can be defined as individuals' biological makeup and will not change without surgical procedures. Gender can be viewed as performances along a continuum of behaviors, discourses, and beliefs that are associated with masculinity and femininity (Butler, 1990). Therefore, sex is determined by genetics, and gender is constructed, supported, and maintained by society. For example, boys stereotypically demonstrate masculinity in the science classroom by leading group work activity and directing others. Girls perform femininity by recording group activity and avoid being argumentative. This clarification is important because gender can be viewed as a social construct and practice that is fluid and can be developed by effective interventions. Feminine performances are typically valued less than masculine performances in the figured worlds of science. Therefore, power is usually given to boys and men in science communities.

Race and Ethnicity

Research has shown there to be structural barriers for women, but the intersecting identities for women of color add more barriers (Johnson et al., 2011). Therefore, I aimed to explore the experiences of successful women of color in science along with White women. Atwater et al. (2013) defined race as "… social construct for classification system for human beings with no biological justification …" (p.7). Although biological justification does not exist for racial classification, authors have argued that there are significant social implications, which

affect students' success in science. Science performance is linked to race and ethnicity (Atwater et al., 2013; Curran & Kellogg, 2016; Eagan Jr. et al., 2013; Kohlhaas, Lin, & Chu, 2010; Maerten-Rivera, Myers, Lee, & Penfield, 2010; Mutegi, 2011; Quinn & Cooc, 2015). This link begins at the kindergarten level and continues into college. Therefore, women of different races and ethnicities may have had significantly different experiences in science. This necessitated recruiting women of different racial and socioeconomic backgrounds for this study.

Power and Privilege

Within figured worlds, social power and privilege are assigned to people who are valued (Holland et al., 1998). The analytical lens of figured worlds allows for a critical understanding of social factors that provide context for participants' experiences. As this relates to power and privilege, understanding the experiences of women who are successful in science may lead to learning about figured worlds within science communities that valued women. Understanding this perspective may provide meaningful insight into how to facilitate these experiences for other girls and women.

Patriarchy

hooks (2000) expressed that patriarchy is the root of many issues in society. A community that positions men in places of authority and excludes women from these positions is a result of patriarchal philosophy. Generally, individuals in positions of authority govern acceptable practices, characteristics of individuals, beliefs, and communication styles in a

society. The science community systemically positions males as the leaders. From these positions, males have been able to sustain a male-oriented culture within the science community. Men holding positions of authority in the science community create a familiar and comfortable environment for people with characteristics like their own, meanwhile oppressing and marginalizing women and men of races and ethnicities that are different from them. The results of a patriarchal system in the science community are many and are oppressive to women. Men are often leaders in these fields and typically serve as instructors for science topics in high school and college. I would like to learn how participants handle oppressive systemic beliefs, procedures, policies, and behaviors within the science community. In the future, and beyond the scope of this study, I would like to ascertain the motives behind male dominant thinking within the science community. Furthermore, I would like to understand how oppressive mentalities could be sensitized to the experiences of women in science.

Without being consciously aware of these systemic issues, both women and men perpetuate oppressive beliefs and behaviors (hooks, 2000). For example, both men and women perceive women as less capable of conducting analytical thought, or women may ostracize another woman for being assertive. This understanding provokes inquiry about how other women have influenced the experiences of the participants. Learning from the participants about how patriarchal influences affected their activities may provide meaningful context in understanding their experiences.

The belief that males are naturally suitable for science and females are fit for domestic tasks is a manifestation of patriarchal ideology. In a 6-week, ethnographic study, Carlone (2004) found that the instructor of the course attributed success by girls to hard work and persistence

and boys' success was associated with inherent skills that allowed them to excel in physics. The norm communicated is that boys naturally fit in within the context of physics and have an innate understanding of the concepts. In contrast, the norm communicated to girls is that they must work hard to understand concepts of physics at the level boys are able to achieve.

Social Norms of the Science Community

The social norms of the science community often follow simplistic biases and assumptions that are detrimental to the experiences of girls and women. For example, Francis (2000) developed a binary dichotomy with males and the following words: "rationality, objectivity, science, 'hard,' 'the sciences'" (p. 35) and females with the following words: "emotion, subjectivity, nurture, 'soft,' 'the arts'" (p. 35). Science, technology, and mathematics have traditionally been viewed as masculine fields. Meanwhile, subjects such as art, language, and humanities have been viewed as feminine topics (Whitehead, 1996). By both males and females, girls and women are often viewed as naturally unfit for the demands of science (Hill et al., 2010; Scantlebury, 2014). Without critical analysis, this dichotomy persists as "normal" and shapes how people perceive themselves and others. Like other groups, the science community has developed social criteria for their members. Rationale and objective thought is a key component of scientific thinking. This type of thinking can be learned and developed. The assumption that men are inherently better at rational and objective thought than women should not be made by society. Individuals' biological features and social ability may or may not meet these criteria for granting them access to science opportunities and support for pursuing careers in science. These social norms were relevant and meaningful to participants' experiences.

Moreover, femininity is associated with being emotional (Francis, 2000) and possessing a strong interest for relationships, which affects how they are perceived in the science classroom. Skelton, Francis, and Read (2010) explored the gender performance of 36 eighth-grade girls who were high performers in science through qualitative methods. The researchers' main finding was that the girls felt that a high level of intelligence was a threat to their feminine gender performance because of the relational social norm. Thus, girls and women may feel they threaten their femininity by valuing science success over supporting others.

Identity Work

Using identity work as an analytical lens facilitated a focus on the participants' values, thoughts, and expectations contextualized by an understanding of each participant's figured world of science. Calabrese Barton et al. (2013) explained identity work as "… actions that individuals take and the relationships they form (and the resources they leverage to do so) at any given moment and as constrained by historically, culturally, and socially legitimized norms, rules, and expectations that operate within the spaces in which such work takes place" (p. 38). I expected that participants always were or became active agents of their success in science. In addition, I suspected that they were strategic about their behaviors in science communities and about the relationships that they built to promote their success in science.

Intersectionality

Humans are complex beings, and considering how different characteristics simultaneously affect participants provides researchers with a more nuanced perspective than using a single descriptor lens. Atwater (2000) pointed to the importance of understanding participants by the interaction of race, class, religion and sexuality in science education research. Collins (2015) suggested that factors of race, gender, sexuality, ethnicity, nation, ability, and age work simultaneously in an individual's experience. Therefore, simplistically constructing research questions and discussing results as participants' experiences through the lens of being female or feminine is not adequate. Women of different races, classes, and ethnicities may perceive and experience science communities differently. For example, hooks (2000) claimed that the feminist movement grew from groups of women discussing their experiences as women in patriarchal society to build consciousness about how the patriarchal system was sustained by both males and females. As the movement grew, the concerns of upper-class White women were given more attention by media and academic literature than lower-class women and Black women. For example, a gender pay discrepancy gained attention during the feminist movement and is now a recognized concern. Another common topic is that science-related career fields pay more than others do. However, there are different issues that arise from a society that holds patriarchal values that relate to intersectionality. One such narrative is that women who use welfare are demonized for being immoral and lazy. Another is that single mothers may be viewed as promiscuous and undeserving of assistance. This provides an example of how women experienced the feminist movement in different ways based on socioeconomic status. Understanding the experiences of successful women in science professions by incorporating

race, ethnicity, and socioeconomic status is important in gaining a clear story of their experiences and is included in my research questions.

Positioning

Within figured worlds, appearance, dialogue, and actions affect the power and privilege of a member. Power in the science classroom may be displayed by who leads laboratory activities and who records data. Making decisions about how to investigate the phenomenon directs the behaviors of others in the group. Recording data develops organizational skills but does not practice planning and problem-solving skills. Due (2014) found that among girls and boys in high school physics, girls took on the role of recording notes. Holland et al. (1998) operationalized positioning in general contexts:

> The dialect we speak, the degree of formality we adopt in our speech, the deeds we do, the places we go, the emotions we express, and the clothes we wear are treated as social indicators of claims to and identification with social categories and positions of privilege relative to those with whom we are interacting. (p. 127)

Science communities have their own figured worlds that place value on behaviors and outcomes for their members. The way girls and women communicate, the emotions they express, their appearance, and tasks they assume within the science community affect how they are positioned in relation to power and privilege in the science community. There are examples of girls positioning themselves in places of power and privilege in the science classroom. Archer, Moote, Francis, DeWitt, and Yeomans (2017) investigated the experiences of seven high school girls who aspired to pursue a career in physics. Researchers found that participants positioned

themselves as intelligent and competitive. For example, girls aimed to be the top performers in the class and showed confidence in their academic abilities, which was noticed by their peers and teachers. Four participants did not describe themselves as feminine or "girly" because they often swore and tended to wear jeans and t-shirts. These girls felt that is was important to behave how they felt scientists conducted themselves versus how femininity is stereotypically demonstrated.

Agency and Improvising

Agency can be defined as, within the restrictions and possibilities of figured worlds, an individual's position, attitude, thoughts, and actions that are directed to achieve their goals (Basu & Calabrese Barton, 2007; Calabrese Barton & Tan, 2010). Agency could have occurred by participants being strategic and self-promoting in their science endeavors. Moreover, participants may have improvised to persist and become successful in science. Improvising is seeing and acting upon a vision that guides an individual to move beyond structural circumstances of his or her figured world (Holland et al., 1998). Participants may not have significant support from their figured worlds but were creative and strategic with their resources to achieve their goals in science.

Identity Formation

Identity formation is the process of people learning about themselves and others through social experiences over time (Holland et al., 1998). This process involves people constructing their identity through experiences in figured worlds. Science identity can be viewed as fluid and

is contextualized by past experiences. For example, Johnson et al. (2011) found that successful minority women continually worked on their science identity. In each occupational change, they identified behaviors that earned positive and negative attention, and how they could develop their science identity without compromising their values. As science identities continue to form, women may be more or less equipped to move toward a positive science identity in the future than they were earlier in their lives. Past social experiences provide perspective on how people respond to future situations, such as in the workplace (Johnson et al., 2011). Therefore, asking participants to describe all of their past experiences as they relate to science was helpful in understanding how participants' identities formed over time. Holland et al. (1998) distinguished the difference between identities and identity formations as the following:

> We are interested in identities, the imaginings of self in worlds of action, as social products; indeed, we begin with the premise that identities are lived in and through activity and so must be conceptualized as they develop in social practice. But we are also interested in identities as psychohistorical formations that develop over a person's lifetime, populating intimate terrain and motivating social life. (p. 5).

The current identity that is practiced by each participant may be affected by years of identity formation. These formations are important for building context for participants' experiences in the science community. I came to understand the aspects of the participants' science identity formation through the telling of their experiences in science.

Gap in the Literature

A thorough review of the science education and sociology literature does not generate research studies on the experiences of successful women in science that use phenomenological methods and an identity formation conceptual framework that incorporates figured worlds and identity work (Holland et al., 1998). Researchers have explored the experiences of girls (Archer et al., 2012; Archer et al., 2017; Calabrese Barton et al., 2013; Carlone, Johnson, & Scott, 2015; Carlone, Scott, & Lowder, 2014; Johnson et al., 2011) and college-aged women (Carlone & Johnson, 2007; Hatt, 2007) through an analytical lens of identity work. Johnson et al. (2011) explored the experiences of three female science faculty members using a case study approach. Most similar to my study is the work of Rosa and Mensah (2016), which explored the lived-experiences of six Black female physicists through a lens of critical race theory. Therefore, this study added to the science education and sociology literature with a population that has shown longevity and persistence in science.

CHAPTER THREE: METHODOLOGY

Phenomenological studies aim to explore the essence of an experience, while suspending prior knowledge. I aimed to describe the experiences of successful women in science in the way that they experienced it (Bevan, 2014). Descriptions of experiences should be developed without causal explanations of these phenomena (Merleau-Ponty, 1956). I intended to describe their experiences with assistance from a conceptual framework that did not compromise the purpose of the phenomenological research. I used the conceptual framework to develop the interview blueprint and protocol and to sensitize myself to aspects that typically occur in science communities and women. However, I did not restrict the data analysis process to the conceptual framework's concepts and relationships. For example, I do not use the concept of figured worlds as a lens to describe participants' experiences in Chapter 4. In Chapter 5, I return to the conceptual framework to discuss the findings.

Exempt Research Classification

I gained approval from the University of Central Florida (UCF) Institutional Review Board (IRB) by submitting a full proposal, interview questions, and a summary of exempt research. This process required me to develop a document, known as an explanation of research, which informs participants of the purpose of the study, the benefits of the study, requirements of participating in the study, and explains that participants' responses and identities will be kept confidential. The UCF IRB determined this study to be exempt as evidenced by the approval

letter in APPENDIX E. Therefore, only an explanation of research was provided to participants, and written consent was not required from participants.

Sampling

Creswell (2013) and (Patton, 1990) suggested a purposive sampling method for qualitative research. The rationale behind purposive sampling is that participants can share the desired information. The purpose of this study was to learn the experiences of successful women in science. Therefore, successful women in science compose the purposive sample because they are able to describe the phenomenon from their perspective and experiences. Patton (1990) discussed different types of purposive samples. The second research question suggests an equitable representation among race and socioeconomic status. This requirement aligns with the following description for *stratified purposeful sampling* provided by Patton (1990): "Illustrates characteristics of particular subgroups of interest; facilitates comparisons" (p. 182). This type of sampling allowed me to capture differences in experiences that may exist based on race but not precollege socioeconomic status.

Recruitment of Participants

Participants were recruited by three methods. First, I recruited scientists through a program that I planned and facilitated during the Fall 2017 Semester at UCF entitled, Women in STEM: Aim Higher. The main objective of this program was to inspire a vision of success for women in science technology, engineering, and mathematics (STEM) majors. Involvement in

this program helped me connect with science professionals who work in the Central Florida area. I invited them to participate in this research study. Furthermore, I used the snowball method to recruit participants. The snowball method involves one person recommending other people who they feel are suitable for the study (Gall, Gall, & Borg, 2007). This occurred through planning and facilitating the program, which connected me with a professional in the UCF STEM Initiatives Department. This connection also led to opportunities to connect with science professionals. I used the snowball method with these participants when rapport was established to increase the number of available and willing participants. Second, I again used the snowball method that began with personal connections in science fields. Inviting participants through this method increased the trustworthiness of the findings. Participants who were recruited through the snowball method were less likely to be affected by social desirability bias in descriptions of their experiences since I did not have relationships with them prior to the study. In addition, these connections had rapport with participants. They were helpful in communicating the purpose and meaning of the study in a trustworthy fashion. Third, faculty members of my dissertation committee had connections to science professionals. Therefore, I worked with them to recruit additional participants that meet the sample criteria (detailed in the next section). These recruitment methods facilitated geographic representation of participants beyond Florida.

Sample Criteria and Sample Size

Participants met several criteria to be included in the sample. First, all participants were science professionals. This criterion excluded undergraduate or graduate students. Second, the term "successful women" meant that participants had worked in a science position for a

minimum of 5 years and have been promoted or have progressed in the tenure process. Third, science fields included the physical sciences, earth sciences, and life sciences. These are the fields that participants worked in to be considered a science professional. These subject areas were chosen because they have been historically known as science content areas in U.S. education (DeBoer, 1991). Fourth, the conceptual framework of this study highlights social delineation by race and socioeconomic status (Collins, 2015; Holland et al., 1998). Moreover, science performance is linked to race and ethnicity (Atwater et al., 2013; Curran & Kellogg, 2016; Eagan Jr. et al., 2013; Kohlhaas et al., 2010; Maerten‐Rivera et al., 2010; Mutegi, 2011; Quinn & Cooc, 2015) and socioeconomic status (Maerten‐Rivera et al., 2010). Therefore, my goal was to have equitable representation of race and socioeconomic status among the sample. However, I was not able to learn these characteristics until the interviews, which led to low racial diversity among participants. For this reason, the inability to ensure equitable representation of race, ethnicity and socioeconomic status is a limitation of the study. Creswell (2013) was not clear about sample sizes for phenomenological research, so my goal in data collection was to reach data saturation, which was obtained by interviewing 12 participants.

Data Collection

The most common method of data collection for phenomenological studies is interview (Bevan, 2014; Creswell, 2013). Through interviews, participants can tell their stories as they relate to science (Bevan, 2014; Seidman, 2006). For phenomenological research, semi-structured interviews are useful because this format allows the flexibility that is required to

question the different responses of participants for deeper understanding (Bevan, 2014; Mason, 2002; Seidman, 2006). Bevan (2014) suggested the following three aims for phenomenological interviews: contextualizing, apprehending the phenomenon, and clarifying the phenomenon. Contextualizing builds background information that provides meaning for the participants' experience.

I invited participants to explain how they came to be a science professional. Apprehending the phenomenon narrows the focus to the phenomenon being studied by asking descriptive questions, so I invited participants to tell me about the earliest experience or person that helped them identify with science. Clarifying the phenomenon occurs by imaginative variation. Therefore, I prompted participants to tell about their future plans so that they were given an opportunity to imagine based on their previous experiences. Seidman (2006) offered a similar process aiming to gain similar information from three separate 90-minute interviews.

Interview Protocol

The first interview focused on the life histories of each participant as they related to science. I invited participants to tell me as much as they could about their past lives up until their current position as a science professional. For the first interview question, Johnson et al. (2011) invited science faculty to tell their life history in science. In a similar way, I asked participants to explain their experiences prior to their current positions as they relate to science. I helped participants recall specific events from their past by discussing anchors. Anchors can be people, events, and projects that have affected the experiences of participants in the past. Much like hearing a song that generates thoughts of past experiences and emotions, anchors can

stimulate descriptive memories that offer opportunities for explaining experiences that occurred in the past. Holland et al. (1998) described anchors as, "…a means by which figured worlds are evoked, collectively developed, individually learned, and made socially and personally powerful" (p. 61). An anchor could be a sixth grade science project that helped a participant believe that she could be a scientist in the future or a teacher who consistently challenged and encouraged her to develop scientific ways of thinking. These anchors helped participants explain their experiences and feelings that affected their science identity formation and provided context for their current experience. They also helped participants to avoid reconstructing their memories based on experiences and beliefs that are more recent. I asked participants about anchors during their elementary, secondary, and post-secondary experiences. Near the end of each interview, participants were asked if there was something that we missed about their science experiences. This gave them an opportunity to discuss topics that they felt were important in relation to science experiences. After the interview, I listened to the audio recording and generated questions to ask participants in the second interview.

The second interview focused on the descriptive experiences of participants' current profession. To begin the interview, I discussed my understanding of their responses from the first interview and asked clarifying questions. This process allowed me to member-check to support the trustworthiness of my findings. Then, participants explained work projects that were typical of their experiences as scientists. They also discussed situations that helped me comprehend how they felt working as an employee of their organization. This helped me understand their perspective on organizational culture and their fit within their work communities.

The third interview focused on the reflections of what participants have told me in previous interviews. Similar to the second interview, I began the third interview with a discussion of my understanding for their responses during the first two interviews. This discussion included questions that helped me clarify their previous responses. In addition, this process allowed me to continue to member-check. Then, participants were asked to reflect on their science experiences. They discussed how science fits within their identity. They also explained aspects of science and the science community that were reasonable and unreasonable.

The instruments that facilitated the three interviews are in APPENDICES B, C, and D. These protocols followed the interview blueprint in APPENDIX A. After gaining permission from each participant, all interviews were audio recorded. This allowed me to focus on the flow of the interview rather than taking extensive notes. I took minimal notes during the interviews to help me remember participants' responses, but not too many to avoid distracting the participants and me. I also re-voiced my understanding of participants' responses if I felt that my attempt to clarify would not distract them from telling me their experiences. The main goal for the interviews was to give participants an opportunity to describe their experiences in science.

Pilot Study of the Interview Protocol

The interview protocol was piloted with two science education faculty members to ensure the questions prompted participants to tell their experiences as they related to science. One participant was given the interview questions prior to her interview and the other participant was not. I found that providing the questions prior to the interview allowed the participant to be more responsive when recalling prior experiences. Therefore, the interview questions were provided

to participants prior to their interviews. I did not make changes to the interview questions because I was satisfied with the quality of responses.

Data Collection Location

Interviews occurred in locations that were first convenient to participants and within geographic parameters for both the research and participants. Since, most participants did not live in Florida, most interviews occurred via Zoom, which is online video conference software. For these interviews, telephone calls were used as a back-up measure when bandwidth interruptions were experienced. Other interviews occurred face-to-face in several locations that did not hinder participants' ability to provide authentic responses. These locations included private offices, conference rooms, and a coffee shop. For all interviews, I requested that participants allot at least an hour that was free of distractions for the interview. The interviews often lasted longer than an hour, which provided participants opportunities to share their experiences in a detailed fashion.

Data Analysis

Data analysis followed the descriptive phenomenological process devised by Colaizzi (1978) with a change to Step 7 as described below. Based on Colaizzi (1978), Sanders (2003) recommended the following steps for data analysis:

1. Gain a sense for each transcript by reading its entirety;
2. Highlight significant statements;

3. Develop generalized restatements of the highlighted statements;
4. Organize the generalized restatements into groups of themes;
5. Describe the phenomenon in detail;
6. Describe the structure of the phenomenon, and
7. For validation, return to the participants to ensure that descriptions of the phenomenon represent their experiences.

First, each interview was transcribed using Inqscribe and online transcribing services. Then, I read the transcripts to gain a general idea of participants' experiences. Second, I reviewed each transcription by listening and removing grammatical errors to ensure accuracy. I then highlighted statements that were significant as being relevant to participants' experiences in science while providing rationale for the significance of the statement. As Step 6 and 7 indicate, this process aims to develop structures and descriptions of the phenomena that focus on experiences of successful women in science fields. Therefore, for Step 2, I identified statements that were essential components of participants' experiences. Step 3 indicates a process of developing generalized statements. This allowed me to draw similarities among participants' experiences, which were grouped into themes during Step 4.

The second research question predicted differences among participants based on race and socioeconomic status. This prediction was based on intersectionality theory, which suggests that the complexity of humans offers opportunities in discovering differences in the experiences based on several intersecting identities (Collins, 2015). Therefore, if differences existed among the essential components of participants' experiences based on race and socioeconomic status,

they were recorded and grouped. These differences are included in the discussion of the dissertation through insights gained from literature and the proposed conceptual framework.

In Step 5, rich descriptions comprised of examples and quotes were detailed as indicated. All ideas that were generalized were in this description. Then, in Step 6, the essential structure of the phenomenon was explained. The essential constructs and relationships of the experience of successful women in science were thus explained. Finally, the last step in the data analysis process directs researchers to member check, which aims in ensuring the trustworthiness of the findings. During the interviews, I often re-voiced participants' responses to ensure that I understood their message. In addition, I began the second and third interviews with questions that were generated from the previous interview. Finally, to ensure the trustworthiness of the data, I used long verbatim quotes and described my positionality to ensure the trustworthiness of the analysis (Creswell, 2013).

Trustworthiness of Findings

Trustworthy findings are needed so that the discussion and implications of my dissertation are worthwhile to readers. Data that produces untrustworthy results would generate a misleading discussion and harmful implications. Creswell (2013) suggested that for qualitative research, transparency of held biases of the researcher improve the trustworthiness of the findings. As the instrument of the study, my explicit and implicit biases pose threats to the trustworthiness of the data. Explicitly discussing these biases and my positionality assists audiences in determining how I have affected the data collection, data analysis, discussion, and implications.

Implicit Biases

I am unable to discuss implicit biases about the experiences of successful women in science without taking steps to build personal awareness about them. This process helped me bracket my natural perspective, which incorporates implicit biases regarding the phenomenon. Merleau-Ponty (1956) suggested that phenomenological researchers recognize their own natural attitude about the phenomenon being studied. For this reason, I took the *Gender-Science Task* implicit association test offered by Harvard University (Implicit, 2011). This test required me to quickly sort words into groups and to answer questions about gender and science. The test produced results that showed I had a strong implicit bias for men being in science and math careers and women being in the arts and social sciences.

Orientation of Care

Minikel-Lacocque (2013) discussed her positionality as a White researcher who studied the transition of six Latino/a students to a predominately White university. The first point she made was that neutrality and objectivity are undesirable aims of the study. As a White male researcher, claiming neutrality and objectivity about the experiences of participants would distort their stories. I do not claim to have experienced the negative effects of patriarchal and racist thoughts and behaviors that are pervasive within science communities.

Positionality Statement

During the early years of my development, I only socialized with middle- and lower-class White people who were members of the Christian church. By the church, women were taught to submit to their husbands, and men were taught to lead the household. I noticed gender patterns for occupations and household responsibilities. Men were typically managers, owners of companies, farmers, and technical workers. Fathers and sons were responsible for jobs outside of the house. Women were often nurses, caretakers, mothers, and elementary and middle schoolteachers.

During college, I socialized with several atheists and agnostics. I also worked with people of different races, ethnicities, and sexual orientations from mine. Socializing and working with people is much different from living and feeling the experiences of others. At my workplace during this time, the University of Wisconsin Oshkosh, policies protected the autonomy of individuals. As a professional, I taught at a high school that served Black students who were of low socioeconomic backgrounds. In addition, my spiritual, work, and social experiences in Florida have allowed me to engage with people of many different backgrounds. These experiences have helped me to understand and appreciate differences in beliefs, values, and differences in communication patterns. I was exposed to meaningful situations that I only understood as narratives that were not relatable to me. For example, prior to my experiences as a high school teacher, I was not aware of high school students who assisted their parents with paying rent. Some students I taught helped their parents pay for rent. This experience allowed me to appreciate my students' work ethic. However, there are deficiencies in my socialization

process that did not sensitize me as to what and how women commonly experience in science communities.

Given my positionality, member checking was important to support the trustworthiness of my data (Creswell, 2013). When it was appropriate during the interview, I re-voiced participant responses to ensure that I understood their message. In addition, after the first and second interviews, I listened to the audio recordings and generated questions to ask participants during the interviews that followed. Furthermore, I analyzed one interview with a doctoral class to gain their perspectives on the data. This process aligned with my analysis of the data.

The second point is that the researcher focuses on relationships that formed during the study. Minikel-Lacocque (2013) explained that showing participants that she cared about their stories was important. I similarly took steps to show I cared about each participant. These steps also helped me build rapport with them. First, I used the three-interview structure (Seidman, 2006), which provided time for me to listen to previous interviews and ask follow-up questions. Second, I did not limit interviews to an hour when participants had more time to share with me. Showing authentic care and rapport building assisted in upholding the trustworthiness of the data.

Reconstruction of Experiences

In the quest to understand the past experiences of participants, reconstructions of experiences posed a threat to trustworthiness of the data. Therefore, two steps were taken to help ensure that participants described their experiences and were reconstructing them. First, discussions about their anchors helped participants describe experiences that have occurred in

their past. Second, I interviewed participants on three occasions, which gave me the opportunity to check if there was alignment with their previous responses.

CHAPTER FOUR: FINDINGS

This chapter presents the findings that respond to the following research questions:

1. What are the experiences of successful women working in science fields?
    a. What were participants' experiences in science classrooms prior to and during college?
    b. What were participants' early work experiences in science?
    c. What are participants' current experiences as science professionals?
2. If any, what are the differences in participants' experiences based on race and socioeconomic status?

Therefore, this section begins with an explanation of the fundamental structure of participants' experiences. This fundamental structure includes the central components of the participants' experiences. Participant bio-sketches then provide contextual information about each participant. Finally, thick descriptions, using participants' verbatim quotes, are explained to support the claims that are made in the fundamental structure.

Fundamental Structure of Participants' Experiences in Science

Research Question Number One

From the data analysis, a common, fundamental structure emerged to describe the experiences of successful women working in science fields. Early in life, the participants had positive science experiences with adults, which were often with their fathers and male teachers. These adults provided positive reinforcement in response to their science endeavors by first

noticing their interest in science. These adults facilitated the participants' participation in science fairs, outdoor camp experiences, and hands-on classroom lessons. The participants' interest and appreciation for science developed due to these relationships and experiences. Furthermore, most participants grew up enjoying the outdoors, which helped them wonder about the natural world on an individual basis. Participants did well in elementary and high school and were more interested in science and math than they were in other school subjects.

During their college experiences, participants often were not sure which major to pursue but knew that it should be related to science. Supportive peers, mentors, and advisors helped direct these choices. Some participants entered into their major by happenstance. During college, participants participated in the following authentic science experiences: research assistantships, science internships, and field trips. These experiences allowed them to gain technical skills and deepened their passion for science as they saw science in a more authentic form than before.

During their early career experiences, participants discussed the technical and social components of their work. The technical component of their experiences followed a common progression. Participants began to develop lab or field skills under the leadership of a professor or supervisor. These experiences were often validating in terms of a science identity because they demonstrated to the participants that they could 'do' science. This led to independently asking scientific questions and having the skills and professional networks to answer those questions. Then, through grants that they received or contractual agreements, they managed groups of scientists and students. They highlighted the importance of collaborative work with a sense of appreciation and discussed its vitality in accomplishing meaningful work. During

personal struggles and experiences involving discrimination against them, their stubbornness, persistence, and work ethic helped them to find ways to advance. Furthermore, participants studied the organizational norms of their communities. For example, many observed superiors in their workplace who displayed positive behaviors, such as assertive communication during meetings, and the participants learned how to perform these behaviors themselves.

In their current positions, the participants discussed leading collaborative projects that were guided by sophisticated research problems. These projects often affected international communities. Their roles required sophisticated interpersonal skills, which they felt well equipped to perform. In some regards, participants spoke of their science communities like families because they spent much of their lives with their colleagues. They valued relationships and often prioritized their needs after others. However, their gender often led to relational tensions with their male colleagues. For example, turning down sexual overtures from men sometimes led to added difficulty in professional advancement. These issues were often long lasting, which the participants handled with well-planned behaviors such as developing healthy boundaries.

To advance in a workplace that was often dominated by males required a continued understanding of organizational norms. Moreover, this advancement required strategic agency in how they spent their time and the relationships that they built. A network of mentors, who were employed by outside organizations, often helped them navigate this complicated professional landscape. Participants were selective of their mentors because some offered advice that did not align with their personal aims. Some mentors were more equipped to provide professional

advice than guidance about personal issues. A well-developed support system was crucial to all participants.

Research Question Number Two

From the data analysis, a common, fundamental structure emerged to describe the differences in experiences based on race and ethnicity. No common differences emerged based on pre-college socioeconomic status. The first difference based on race and ethnicity was that Black and Latina participants experienced discrimination because of this aspect of their identity. Both Black and Hispanic participants described how their intersecting identities affected their science identity. They experienced racism beyond their workplace as it related to science. The second difference based on race and ethnicity was that Black and Hispanic participants discussed the importance of their faith to their work in every interview. They referenced lessons from scripture and their participation in Christian groups in most interviews. White participants did not describe their faith as being central to their experiences.

Participant Bio-sketches

Rosa and Mensah (2016) have provided short stories of Black women physicists that have inspired this findings section. These stories highlighted the participants' educational experiences and upbringing. Similarly, participant bio-sketches were developed to provide a snapshot of each participant's educational experiences, early-work experiences, and their current work experiences. In addition, events in their lives that were pivotal to their science experiences

have been included. The participants' words were used to show how they described their experiences. Participants' pseudonyms, race, and educational background are provided in Table 1.

Table 1 Participants' Race and College Degrees

Pseudonym	Ethnicity/Race	Educational Background
Barbara McClintock	White	B.S. Biology M.S. Genetics
Dr. Marie Curie	White	B.S. Physics M.S. Physics Ph.D. Geophysical Sciences
Rachel Carson	White	B.S. Biology M.S. Environmental Sciences
Dr. Helen Rodríguez Trías	Hispanic	B.S. Chemistry M.S. Chemistry Ph.D. Chemistry
Margaret Nice	White	B.S. Biological sciences M.S. Biological Sciences
Fanny Hesse	White	B.S. Biology
Dr. Marie Maynard Daly	Black	B.S. Chemistry Ph.D. Chemistry
Dr. Alice Wilson	White	B.S. Geosciences M.S. Earth Sciences Ph.D. Environmental and Atmospheric Sciences
Dr. Lise Meitner	White	B.S. Physics Ph.D. Physics
Dr. Beatrice Hicks	White	B.S. Chemical Engineering M.S. Geological Sciences Ph.D. Environmental and Atmospheric Sciences
Dr. Dorothy Hodgkin	White	B.S. Chemistry Ph.D. Physical Chemistry
Dr. Ruth Patrick	White	B.S. Geology M.S. Environmental Science and Master of Public Affairs Ph.D. Forestry and Environmental Sciences

Barbara McClintock

Barbara is a first generation college student. She had a ninth grade teacher who made science feel like, in her words, a "contact sport." This meant that the science was engaging and hands-on. To make her parents happy, she completed a three-year nursing program at the top of her class and was a nurse for five years before returning to college to earn her biology degree. During her time as a student, she described her academic performance as "blowing out the curve" to indicate that she earned high grades. A prominent professor selected her to work in his lab and became an influential mentor for her experiences. She worked in industry for 15 years, writing grant applications and publishing papers. Due to her passion to teach, she decided to be a college lecturer and took a significant pay decrease. As a lecturer, she has taught several introductory courses in biology that utilized a virtual lab. She has significantly reduced the drop, withdrawal, and fail rate in these courses. She hopes to earn a Ph.D. in science education.

Dr. Marie Curie

Dr. Curie attended a Catholic Grammar School as a child and had several high school teachers with Ph.D.'s. During high school, a research scientist gave a guest talk that helped her understand the nature of scientific inquiry. She was always in gifted programs prior to college. She attended the same college for her undergraduate and graduate degrees. She discussed the "rush" of scientific exploration that can also be tedious. As a research scientist, she has undertaken work on learning about several atmospheric topics. Her scientific work has won several awards, including contributions for a project that was awarded the Nobel Peace Prize.

Rachel Carson

Rachel enjoyed the outdoors growing up and bonded with her parents at the beach. Her dad was a forester and a wildlife biologist, and her mother had a thorough knowledge of marine environments. She recalled having an impactful teacher who facilitated science fairs, which helped her feel like a "young scientist." Overall, she described her pre-college teachers as outstanding people whom she remains in contact with to the present. She chose to major in biology rather than a foreign language because she liked the faculty of the Biology Department more than the French Department. She learned that she loved to teach and was a high school teacher before taking up her current position. She currently manages a team of 10 men who ensure the lake health of an urban area. Her current position allows her to facilitate educational outreach, which she describes as "rewarding."

Dr. Helen Rodríguez Trías

Dr. Rodríguez Trías described her parents as poor and hardworking. During her primary and secondary education, German sponsors paid for her to attend a private Christian school where she worked hard to honor her parents' work ethic. Her faith has been a central component of her life. She does not believe that someone of her circumstances could have experienced her achievements without God working on her behalf. She has earned a bachelor's, a master's, and a doctorate degree in chemistry. She is currently an assistant professor and sees her role as a way to help students academically and professionally.

Margaret Nice

Margaret recalls loving nature from a young age and enjoyed hiking with her parents. Her mother told her that her first word was "bird." As an adolescent, she aspired to be a veterinarian, but then learned that she was more interested in working with undomesticated animal species. She earned her undergraduate and graduate degrees in biological sciences and emphasized that she was "not a particularly stellar student." She has worked for the same company for over 30 years, monitoring wildlife and conducting research to decrease the negative impact her company's work has on the environment.

Fanny Hesse

Fanny is a first generation college student. When she was young, she wanted to be a doctor, so her dad called her "doc." She chose her undergraduate major in health science because she was guaranteed a job after graduation and her peer support group followed the same path. She did an internship at the company that is her current workplace. In her current role, she works to protect the health and safety of workers and guests. She aims to continue to gain new responsibilities and earn promotions.

Dr. Marie Maynard Daly

Dr. Daly recalled sleeping through most of her pre-college education. She found it difficult to be black, female, and intelligent during high school. Dr. Daly explained in detail the importance of her "board of directors" or her support network. They have educated her and

guided her through a socially complex career path. In addition, she found a peer support network that encouraged her intersecting identities at a highly ranked, historically Black university during her undergraduate years. Here, she earned her bachelor's degree in chemistry. During this time, she worked in many internships. She quickly moved into graduate school and earned her Ph.D. by her mid-twenties. She has advanced quickly in her progress towards being tenured in her current profession as an assistant professor of chemistry and forensic science. After being tenured, she plans to open a forensic science camp for under-represented students.

Dr. Alice Wilson

Dr. Wilson lived in France before coming to the United States. She began the first interview by explaining that she was dyslexic, which helped her appreciate abstraction, logic, and numbers. She was a proud kid who was at the top of her class. She grew up in a rural area and her grandparents were farmers. She earned a bachelor's and master's in geosciences and a Ph.D. in environmental and atmospheric science. During her undergraduate program, she interned for a research lab that investigates the atmosphere. She is currently a research scientist for an organization that monitors factors that impact climate on a global scale. Her large goal is to make the world a "better place" by mitigating harm on people and the environment that could have been prevented.

Dr. Lise Meitner

Dr. Meitner enjoyed studying "everything" prior to college and wanted to pursue a career where she could learn all day. She emphasized that she was interested in learning about how things worked. Despite social and academic challenges, she earned all of her degrees in physics through perseverance. She spent most of her free time with teachers. Dr. Meitner is now a manager at a physics-testing lab that has collaborations with several international organizations and a consortium of more than 80 universities. In the future, she would like to propose a new testing lab and update the facility.

Dr. Beatrice Hicks

In elementary school, Dr. Hicks appreciated the competitive and individual nature of her science classes. Earning straight As and being a "perfectionist" was very important to her. Her ninth grade science teacher facilitated projects, such as an egg drop activity, that she greatly enjoyed. In high school, she was allowed to take an additional math class in place of her foreign language classes based on her strong dislike for foreign language. Her dad was a physical scientist and her mom was a postsecondary educator, which she believes affected her career decisions. She earned all of her degrees in chemical engineering. She was a research scientist and recently received a promotion that entails more administrative work.

Dr. Dorothy Hodgkin

Dr. Hodgkin grew up in the southeastern region of the United States. Her family was religious, and she attended a Christian elementary school. Her family did not value science. Her high school science fair was impactful because it gave her a process to answer questions that she had about the world. After high school, she began college immediately and initially majored in math and music. At the same time that she found that music was not interesting, she had an "entertaining" organic chemistry professor. Therefore, she changed her major to chemistry and continued to earn a Ph.D. in chemistry. She currently develops grant postings and evaluates proposals for funding atmospheric research studies.

Dr. Ruth Patrick

From eight to 21 years old, Dr. Patrick engaged in an outdoors camp, which incorporated outdoor experiences, hands-on learning and inquiry-based investigations. Dr. Patrick reflected on a scientific field experience during her undergraduate years that allowed her to see how much she could learn in a short period and develop scientific skills. She is currently an assistant professor and teaches undergraduates on the block schedule. She enjoys working with her students in her lab. She does not feel respected in her current role by her colleagues because of the academic hierarchy that exists in her field.

Thick Descriptions of Participants' Experiences

In this section, thick descriptions are used to describe participants' experiences as they relate to science following the research questions. The following four participants were chosen to represent the sample: Dr. Curie, Dr. Rodríguez Trías, Dr. Daly, and Dr. Patrick. These participants were chosen because their interview descriptions provided clear examples for most of the themes that are presented to support the claims made in the fundamental structure of participants' experiences. Several studies exploring women in science (Carlone & Johnson, 2007; Johnson et al., 2011; Rosa & Mensah, 2016) have used long quotations (longer than 40 words) in their findings. This method emphasizes participants' words and provides context in understanding their experiences (Creswell, 2013).

Influential Early Life Experiences Related to Science

Prior to college, the participants had access to positive experiences in science that were often led by supportive adults, such as their teachers and parents. These experiences were important to participants because they sparked and reinforced their interest in science. Most participants did well in school and described science teachers who led engaging science lessons. Participants enjoyed learning a process to answer questions that they had about the natural world. Positive science experiences also occurred after school and during the summer, which included science fairs and activities at outdoor camps. Many participants stated that they appreciated nature and spent time outdoors with their parents. In school, and outside of school, experiences

were often positively influenced by their fathers. Participants described how their fathers gave them access to science resources and opportunities.

Positive In-School Experiences

Prior to college, many participants enjoyed science more than other classes. They excelled in all of their classes but were particularly drawn to science classes. Dr. Curie described the positive reinforcement that she received in science classes, "People would listen to me in class. Fellow students wanted to be my lab partner. It was the winning path for me." Dr. Patrick explained, "Um, I remember doing, like science fair projects on like photosynthesis. You know, but, um, and I was always better at science and math than I was at like history and English." Similarly, Dr. Rodríguez Tries said, "Although, I wanted to become better in everything. But always was easy to do this science part for me." Furthermore, Dr. Rodríguez Trías emphasized that her parents were supportive and hard working. Their work ethic and care motivated her to do well in school. Her father taught her poems, which helped her develop her memory. Through her academic work and experiences with her father, she noticed that she had a special ability for math and science. She said:

> Although, I was really good at memorizing things… my father starting teaching poems since I was four or five years old, so my memory is really good. But I think it's easy to become better at math because you learn the smaller stuff and then you can do so many things with that. So, I think I was good at math, good at science, and easy to get an A.

Dr. Rodríguez Trías' academic success continued into high school. She honored her parents' and financial sponsors' support and worked diligently on her course work. Therefore, her teachers "mentioned" that she should think about college. She explained:

> I was in this first or second place in my class, so they will, they will mention to me, you should go to college. But they didn't make me. I may still try and go to technical school. That is why many of my friends went to technical school instead of the college. But, later on, they pursue the college. So that was kind of the idea.

The positive reinforcement that Dr. Rodríguez Trías received was important in her path to continue to college. The school counselor recognized her academic achievements by suggesting that she attend college. This was different from many of her peers who were expected to attend technical schools.

Outside of School Experiences

Participants also received positive reinforcement through science experiences that happened beyond school. They described positive experiences in school and beyond school. They did not describe a single key person or experience that developed their passion for science. Rather, they described several people and experiences that drove this desire. For Dr. Patrick, her experience as a camper and then camp counselor provided a figured world, beyond what her familial system provided, that helped her build confidence for her understanding of nature. She participated in this experience from eight years old to 21, which provided consistent positive reinforcement to her inquisitive nature. She said:

> Like I would desperately want to fit in and I never did, you know, and I was like too geeky and too smart and whatever. Right? Um, but I don't know. So, I think that, that… like the earliest... I can't remember not liking being outside and not liking water and that sort of stuff that, but my family, they're not hikers. Like, I was never taken skiing. My family did not take me camping. Like, those are not things that are part of my family, but I was sent to this camp when I was eight and I'm like, you know, so in high school I led on backpacking trips, right? Like, so I was very, you know, but it was just, it was all like I can say it was rooted in that one thing. And then, um, and I think it really helped my confidence.

Many participants discussed science fairs as highlights of their pre-college education. This experience gave them a process for investigating questions that they had about the natural world. Dr. Rodríguez Trías felt fortunate because German sponsors funded her to attend a private Christian school that could afford to facilitate learning experiences such as science fairs. Therefore, she valued the opportunity to learn through this experience. This special opportunity to engage in science fairs motivated her. Science fairs also gave Dr. Rodríguez Trías' father an opportunity to use his skills as a technician to support her learning. She said:

> But for people who are significantly, who are really poor…. So, it's weird. Because of this school I had opportunities in the sense that they did like fairs, science fairs. And I think... I was motivated by those science fairs because of this school. Although, I was poor because of the situation and my dad. My dad was kind of like a technician. But he was always very supportive in me trying to get a very nice experiment in the science fair.

Prior to college, Dr. Daly did not have positive experiences in school. She described being bored in school and she often slept through classes. However, she was still able to earn As. As a high school student, she developed a path for forensic science while societal awareness about the field was still developing. This path was sparked after watching a forensic science television show and realizing that science could be used to determine who committed crimes. Dr. Daly described the moment when she had this realization:

> And I was like, oh my God, they can solve murders with science. Like that embodies everything that I want. Like I can... excuse me, solve murders, murder mysteries. I can use science to do it and I can help people because I liked helping people at that time. And I said, and this is one career, like bam, this is it. This is all I want. And I told my mom about that and she was like, "Nobody can do that." And I was like, yeah, they can. And um, from there I just tried to find every forensic relevant book and I followed it. I, I did my own research because nobody really knew about it.

As a high school student, Dr. Daly recognized the meaningfulness of forensic science by watching a TV show about solving murder mysteries. Then, she took the initiative to learn about this topic after her mom did not believe scientists could help solve murder mysteries. Dr. Daly showed an ability to enact good work habits, which is another theme among participants. She was first able to find her own meaning in science by realizing science could help solve mysteries around crimes. Then, she forged a career path by conducting her own research. Participants often labeled this persistent quality as "stubborn" for their goals.

Influential Fathers

Fathers often provided positive reinforcement for participants. Through relational experiences, fathers provided access to science resources and experiences that supported their daughters' interest in the topic. Fathers also expected their daughters to perform well in school. Dr. Daly's father loved science and encouraged his daughter to engage in learning about it. He discussed math and sciences to create normalcy about this area of study and provided her with resources for further exploration. She explained:

> … my dad would always tell me things like, science and math are easy, and he'd always sit down and talk math with us and talk about science. And I learned later, um, that he used to read textbooks, like novels, like organic textbooks. Like no, like he loves science. So, he would always tell us that was easy. He'd always buy like these microscope kits and I always, always got excited to run outside and grab something and put it under the microscope.

Science education research has discussed parents having gendered expectations that facilitate normalcy for boys to engage in science and girls to engage in literature and arts (Scantlebury, 2014). Participants' parents did not allow gendered biases to affect the experiences they facilitated for their children as exemplified by Drs. Daly's and Rodríguez Trías' experiences.

Dr. Rodríguez Trías respected her father's work ethic and showed this by diligently applying herself to her academic work. She explained on several occasions that her father was supportive in this area of her life. When asked about her science fair experience, she explained that her father supported her in completing a "very nice" experiment, which indicated that he had high expectations for her. This is different from having mediocre science expectations for her

and not supporting her science fair experience because of implicit biases about girls and science. Therefore, he showed her that he cared about her academic success by helping with her schoolwork and having high expectations.

Good Work Habits

Good work habits permeated all of the participants' science experiences. These habits often led to positive moments about how they saw themselves as scientists. One of these habits was persistence, which was often labeled as "being stubborn" by participants. This quality helped participants to lead groups and research projects that often had global impacts. It helped them connect with relatable mentors. This quality also helped them persist through adversity. Another habit was their high-level of work ethic that helped them perform the significant workloads that often characterize science paths. Finally, participants had specific professional goals that they planned to achieve.

Persistently Stubborn Through Adversity

Participants were "stubborn" about pursuing their paths in science. This habit allowed them to persist through significant challenges and adverse circumstances. These challenges covered a spectrum of issues from developing a positive identity in hostile environments to completing large workloads. Also, participants were persistent despite deep social issues that questioned their identities. For example, as a high school student, Dr. Daly discovered her interest in forensic science while watching a TV show. She did not feel comfortable sharing this

with her peers because they might not understand why she had this interest. However, she decided to continue along this path and now others value the science aspect of her identity. Dr. Daly described:

> Some of my experiences have actually allowed me to grow completely, right? Because in high school I felt like I really couldn't be open about my science because nobody would understand it. Not that I was, you know, that I'd feel like I'd be bullied because of it. It was just like I didn't think anyone would want to understand it. So, the conversation in that is dead, right? But in the sense of work, I think, now, people really see me as a scientist, regardless of their internal biases or whatever.

Her persistence may have been driven by her early realization that science can help identify criminals. She spoke about this aspect of science with excitement. In addition, her father encouraged her to pursue science at a young age. Therefore, although her high school peers may not have appreciated her science identity, her father facilitated an expectation that she should pursue this interest.

After noticing how frequently Dr. Rodríguez Trías described experiences where she showed persistence, I asked if she would characterize her persistence as a habit. She responded, "Exactly, very persistent. Very persistent. Yeah, always trying to succeed, always trying to be the best." Participants were often "stubborn" about taking paths that would allow them to accomplish their goals.

Participants' "stubbornness" often led them to disagree with teachers, professors, and advisors. These experiences entailed positive and negative consequences. Dr. Curie described an experience as a graduate student where she disagreed with a prominent professor in the field:

> The interesting thing there was that... we were looking at the satellite data that no one had ever looked at before. And, he was coming up with a theory on how it was working and I could understand that his way of thinking of things wasn't very accurate. Even though he was a professor and I was a student. And, therefore, you know, I shouldn't be criticizing him. I should be learning from him. But I told him that I didn't think it worked that way and that if he used a random number generator and processed the data in the same way as what he was just saying it would give him similar answers and he did that. And I was right.

After discussing how she completed her dissertation from start to finish, Dr. Patrick contrasted her dissertation work with other doctoral students who received more assistance than she did. She highlighted that she earned a grant to fund her own research and had autonomy in all aspects of her dissertation study. She was proud to accomplish these tasks on her own. That route brought added challenges, but she was "stubborn" to value what she learned because of her independent work. She explained:

> So, I don't know, I feel like I've just… I feel like I have, um, I don't even think I've been deliberate about choosing those opportunities that are challenging. I just think like, I've ended up in them and I persevered and therefore I have these quails, you know? But, I don't know, I also think, just… I'm really stubborn.

She continued discussing her autonomy on her dissertation study later in the interview. Like other participants, she emphasized the importance of having independence in her learning experience, although it was challenging. She stated:

> I mean at [school], like we don't… We are encouraged to get outside grants. So like my dissertation work was funded by grants that were to me not to my major advisor. Right? And I did a contract that I was not involved in. Right. I mean, and it's just like when you have to do it that way at the time you're like, oh my fucking God. Just sucks. Like there's people that I met at this conference and their advisors just gave them a project and like so much further along than me. Bla, bla, bla... right? But, like, also, right, you know, you have to do it from more or less the beginning. It's a little bit easy, like it's hard, but you learn a lot more.

Participants' "stubbornness" is important because their journeys often incorporated people who did not value their work. There were people who did not have high expectations for them because they were female scientists. However, there were people and experiences that supported their "stubbornness" in pursuit of science paths.

Strong Work Ethic

Most participants described their high level of work ethic by engaging in a large portfolio of science experiences prior to their current positions. They also showed this quality by advancing in their current positions. This quality is useful in science because the nature of inquiry incorporates unexpected issues and requires ongoing effort. Dr. Curie provided an example of the tasks involved with large research projects that require teamwork and a strong work ethic from everyone involved:

> It's all about being a part of other people's groups and seeing, oh, yeah, yeah. Getting the model to actually run can take a couple of months and analyzing data sets can take

> many months. Testing to make sure the quality is okay can take a while. Even after once we have our final conclusions, checking how robust those conclusions are, whether they would have been altered tremendously if we had only half the data or something. Checking to see if there are other things that should be done. You start to learn that there are these various processes and that they each take days to months to complete.

Dr. Curie recognized the necessity of persistence, a strong work ethic, and interpersonal skills in her scientific work. The enactment of these skills was driven by her passion for science. Furthermore, she was prepared to carry out these requirements because many developmental science experiences such as graduate assistant and postdoctoral research positions required these qualities and skills.

Dr. Rodriguez demonstrated her work ethic in two ways. First, she described the nature of scientific work as challenging because experiments often do not go as planned. She expressed how she enjoys this challenge but recognized the amount of work that is involved in achieving a successful experiment. She stated that successful experiments do not occur as often as unsuccessful experiments. She also discussed enjoying a challenge and feeling proud of successful experiments. In her own words, she described these circumstances:

> And that persuasion for you to keep pursuing is for you to be challenging. So, that's why it goes a long very well with being a scientist, I think, in chemistry. Because, like, people say, like, for a 100% of what you do in a experiment, maybe 20% works. And this 20% is the one that you really proud of and publish and 80% just doesn't work. And that's how we keep here because of that right so. That challenge goes along with that.

Second, Dr. Rodríguez Trías expected herself to be successful in her career, which involved writing grant proposals, managing teams of researchers, instructing on college courses, and advising students. She also cared deeply about her family and held her position as a mother and wife in high regard. She explained:

> Because I do need as a mom, I do need to take care of my kids, as a mom. Now, as a mom is looking… Are the kids growing, are they OK, and they eat, and they sleep, and they fight, right? So, I'm now, I'm now like that person. May be because of my country. I don't know. It's just because… care of my kids, as I have a job. So, I hope to do the same job, I will do with my kids, if I will not have a job.

She held herself to high expectations in her personal and professional life. Achieving this expectation required her to have a daily routine of waking up at 4:30 in the morning to complete work assignments before her husband and children began their days. This routine required discipline, a strong work ethic, and sacrifice. Moreover, due to the workload of being a scientist, there were instances when Dr. Rodríguez Trías began her day earlier than 4:30 to complete work assignments such as grant proposals. Here she stated an extreme example of waking up earlier to complete a grant proposal:

> Well, yeah, my, my, myself will define somebody as a hardworking... people who will sacrifice. For example, today, for me to do whatever… everything that I need to do today. So, for example, I didn't do that every day OK, but today I woke up at 1:40.

Like Dr. Rodríguez Trías , Dr. Patrick worked well past business hours to facilitate the scientific development of her students. She described how maintaining professional boundaries was difficult for her:

> But yeah, I don't know, it's um... I would say that, like, typically if class ends at 3:30, it's really hard for me to leave before 5 and I'm usually with students until then. Like they follow me back to my office and like then ask me more questions. Or, I have meetings with students after my lab because they're working on their thesis or something like that. So, I would say, and I would say that I answer... I'm really bad about setting boundaries so I probably answer emails from students until 10, probably.

Future Plans

The last good work habit that was apparent for all participants was that they had future professional goals. Participants were able to provide goals because they saw a future for themselves in the sciences. Science education and sociology literature have demonstrated that women in science often leave because of unwelcoming or "cold" environments (Hill et al., 2010; Scantlebury, 2014). If participants experienced these conditions in their workplace, they may not have established plans in science because their future as a scientist seemed unbearable.

Drs. Daly and Rodríguez Trías' had plans that incorporated service to their science communities. Dr. Daly explained that first she wanted to earn tenure, which required gaining grants and writing publications. She has progressed in this process with an approved grant proposal and accepted manuscripts. Then, she wanted to start a forensic science camp and write a book:

> Then, I mean, if it grows, yeah, bring it to medicine, but I think medicine has a lot of summer camps. So, I don't think there's a lot for like forensic students. So I think that's what I'd like to start. Maybe, by then, if I had my druthers I will be… I'll be able to like

> write my first book on forensic lubricants analysis and hopefully have that instituted or operationalized in some crime lab.

Her forensic science camp would serve populations that are under-represented in forensic science to support their awareness about the field and provide them with access to learning opportunities. Dr. Rodríguez Trías also had made progress towards tenure through an accepted grant proposal and accepted manuscripts. Furthermore, Dr. Rodríguez Trías planned to earn her master's degree in public administration. She wanted to learn how to bring positive change for many people. She emphasized that she needed to be in a specific position to achieve this goal. She explained:

> But what I see myself, I have a some other interests. In meaning, to do something impactful, helping people in the way I would like to get more being prepare. How to manage people more. How to be, be able to do... convince people to follow some idea. Some to make a difference. To convince people to follow something. So, how to… For example, this Master in Public Affairs that I like to do it. So... leadership, I'm look towards leadership becoming... I know managing just by, where everything is good. But I guess I can try to be better manager. Right, so, that's, I wanted to prove myself in the way I can... I can be in a better position. Because I think you want to make a difference, you need to be in specific position.

Then she explained her plans that she would like to complete through education:

> Yeah, like in the culture department there is education department. So this kind of things. Have the ability… Not here in the United States, okay. But in South America. So maybe someday... to have the ability to actually change. So make this country different by

> education. I believe the undeveloped country can change a little bit by educating the people. Not by giving more money to the people. By educating them. So something like that. But to change things, you need to have a little bit of power. Right?

Dr. Patrick discussed obtaining a future position that allowed her to devote more time to research. Her current position requires her to teach for the majority of the year. Therefore, in her figured world that valued research, she expressed the desire to conduct more scientific investigation rather than teaching.

Progressive Participation in Authentic Science Experiences

Often, girls and women have less access to science opportunities than boys and men. However, the participants in this study excelled in authentic science experiences through early work experiences such as working as interns, research assistants, and postdoctoral researchers. Several factors helped them gain access to these opportunities that affected each participant in contextualized ways. Their support systems encouraged their engagement in these experiences. Good work habits enabled them to pave paths to these experiences and led them to be successful. Furthermore, these positive qualities combined with good interpersonal skills and early work experiences enabled them to gain their own contracts and grants. This progression ultimately put them in leadership positions that required them to manage large budgets and research teams.

Engaging in authentic science experiences generated several benefits that affected the participants' attitudes about science, science self-efficacy, and professional networking. They were allowed to engage in the process of science that responded to meaningful questions that affected their field of study and had influence on the well-being of humans. As they progressed,

their work became increasingly impactful. These experiences helped them to develop positive attitudes about science by validating their skills and knowledge, which ultimately helped them to feel like scientists. Furthermore, through these experiences, they developed the scientific skills required in their fields. Their engagements in science experiences grew in number and diversity as they matured. Finally, these experiences connected them with mentors and colleagues that were pivotal in their career advancement.

Research Assistantships

All participants worked as research assistants under a professor during their undergraduate and/or their graduate years. These experiences required participants to oversee a lab or carry out research tasks because their professors trusted their management abilities. Dr. Rodríguez Trías worked as a research assistant as an undergraduate student, which helped her develop in areas beyond her experiences as a student. She said:

> So, this led me to have a very nice things. Working with him in his research lab. Besides my duties as a student becoming a chemistry major. So, that was like something that would give more. Teach you the other part, like my students learn here, right?

Dr. Curie discussed how her graduate assistantships developed skills that were useful for her next position. She developed unique skills, such as large dataset analyses and computer programming, which were fruitful for subsequent positions. She explained:

> So, there was... it was kind of very quickly on my niche became working on data. Working on observations. Working on sort of some of the first satellite images of the earth and figuring out what information did have for us. So yeah, it was... It kind of like,

you kept building from one to the next to the next. I wouldn't say that the career path was always like straight a dead line. But having the skills, like being able to program a computer and then being able to work with large data sets and then being able to do the statistics on those data sets. And each set of skills I was able to carry on to the next position, for the next challenge. And so that was really what kind of helped me along.

Like Dr. Curie, Dr. Patrick developed statistical analysis skills during her graduate research assistantship. Her graduate research assistantship also led to an additional work experience that allowed her to develop lab skills. She explained:

I had two RA's when I was at [State], like one was for a statistician who was looking at him like hazardous waste rules and regulations and whatever. So I learned a lot of SASS doing that, which was really helpful in terms of like data analysis and I worked as a lab technician in another lab. Um, after I'd taken a class with him and done well enough, but I didn't get a great grade but I was good in lab. Right? And so he hired me to do that, and I was like the volunteer coordinator or something and I occasionally crossed the samples, but I think... but those were like, even then, like I remember like those were carrying out other people's directives. Right? Like, I had freedom to think about stuff, but I was bringing that to them and then they were saying yes or no or whatever. Right.

Dr. Patrick emphasized the importance of autonomous work when discussing her dissertation experience. Here, she remarked, "I had freedom to think about stuff, but I was bringing that to them and then they were saying yes or no or whatever." Dr. Patrick valued autonomous learning experiences. She understood that this path required a significant amount of work and continued to seek these opportunities because she valued learning.

Internships

Like experiences gained as a research assistant, a common early work experience for several participants was an internship. Through these positions, participants developed scientific skills and developed relationships with mentors. Dr. Daly emphasized her efforts in participating in several internships. Internships allowed her to see what aspects of her field she enjoyed. She explained:

> Well, when I graduated with my bachelor's, I hustled to get every forensic internship I could on my own. Right. I made it to get to the ATF. Um, I did an intern... well I did three years with [company]. And then my dad told me about this center here and I called the director, was like, let me come and do an internship with you. You don't have to pay for me, you don't have to figure out how to get me there. I have my own car, just however long, two weeks, whatever. And he was like, sure.

Dr. Rodríguez Trías worked as an intern for a company after completing her undergraduate degree. She was successful in this position and had an option to continue working, but decided to earn her master's degree because her internships lacked opportunities to conduct research. Therefore, she was persistent in following her goal of conducting research despite being offered a work opportunity. During interviews, she frequently discussed how her pre-college socioeconomic status affected her science experiences. Her decision to pursue a master's degree instead of working highlights her "stubbornness" to follow her plan given her background. She explained:

> You go to company, that's kind of thing and that's the thing. You finish the undergrad. My professor even did not have Ph.D. at that point. Now they have. But when I finish,

and you go to a company and work kind of thing. Because there is no research going on there. So, when I went to the company to do whatever I was doing in that company. Because they... I performed really well I guess. So, my boss like me and my boss talk to his superiors and they say that we should offer a master's to me to fill. So, because she is good, and she is a good material I guess. So, then she can keep, she can stay and grow with a company. So, I didn't go. So that is why they offered me. So, they call me to the office in the main place of the company and they said that you can... you have, like a good future here. We can send you... like if you are here after you one or three years of being of working for us, we can send you to master's in Spain. That's what they offered me at that point. After I work was there for five or six months I guess. So... but I didn't continue. I went to Brazil to do my master's. So, I kind of stop my job there. Before I went to Brazil, I went to the air force to work for a little while and then I went to Brazil to do my master's.

Dr. Patrick described an internship that she engaged in during high school. She had achieved the requirements to leave school and served at a biomedical lab. Here, she gained exposure to a hospital laboratory. She explained:

> Um, so if you had done certain number of community service hours up until that point, then you essentially... the last quarter of the year you could do an internship instead of class and um, if you're in AP classes than you had to do classes in the morning and then go. But I worked at Mount Sinai Hospital in New York City in like a biomedical lab. Right. Just, um, you know, it was like the science thing that I found, right.

Postdoctoral Researchers

All of the participants who earned a Ph.D. worked as postdoctoral researchers. In most cases, they worked as postdoctoral researchers at more than one institution. These experiences entailed an advancement of responsibilities of the internships, which most participants felt well prepared to perform because prior experiences had given them opportunities to manage research projects and oversee labs. Several participants worked in this role in multiple positions to gain more experience. Dr. Patrick identified her postdoctoral researcher experiences:

> So first I was a NSF post-doc at the USGS in Boulder, so for two years. And then I was a post doc in... at Rice for a year and then I was a visiting professor at Barg for a year and then I was a post-doc at Rutgers for two years. And then I got my job. It's a lot of post-docing.

Dr. Curie identified two postdoctoral researcher positions that she had undertaken and that took place in Europe, "I took a postdoc at the, in Stockholm, Sweden. And then working on ultraviolet radiation. And then I took a postdoc working for the World Health Organization in France, Lyon, France."

These positions show that Drs. Patrick and Curie gained science experience at several places. Dr. Rodríguez Trías postdoctoral research helped her believe that science could explain "a lot of things." When I asked her when she realized this applicability of science, she explained, "I think like that every day. And starting, when I realize that, I don't know. Maybe, maybe when I was starting my post-doc. After I finished my Ph.D. So maybe in the latest of my education." The applicability of science was important to her because she valued using her knowledge to help others.

Dr. Daly mentioned that she worked as a postdoctoral researcher while she was searching for jobs. This job search was prompted by adverse working conditions. She spent a significant amount of time and energy applying for different positions, albeit, having accomplished many professional achievements. This experience helped her validate her science identity while she was searching for jobs. She explained:

> I had a pretty good resume, but I think they realized like between a Ph.D. at [age], in 2007 and into 2013, you've run eight educational programs. You've taught in two universities... well university or community college. No, you had a post-doc at another university. You worked with generals, you started a human research protection program. You started an internship program for the [Company]. Like nobody does that. You know? In what's that for seven years. So it was disheartening to constantly get turned away from job after job and I just started looking for fucking anything, anything that wanted a chemist.

Participants had access to and engaged in several science experiences that prepared them for their current position. These experiences also helped them develop science identities that showed them that they were brilliant scientists.

Deep Appreciation for Science

Participants described having a deep appreciation for science. They were proud of their quirkiness as they often described it. When describing their experiences relevant to science, participants described an interest in science that affected how they thought, their personal life, and career trajectories. They also discussed how their work was meaningful because it helps

people. Therefore, this was a deep motivation that affected how they thought about themselves and the world.

Growing Understanding for Science

Like many young children, the participants began their journeys in science with wanting to know "why" and with an appreciation for learning how things worked. They wanted an explanation for what adults often find uneventful and normal. As a young girl, Dr. Daly's favorite question was "why?" Early in the first interview, after I asked her to tell me about her experiences as they related to science, Dr. Daly explained:

> My favorite question was why? And then I got to the point where I knew that it was annoying people, so I would do it extra hard. I would be like, yeah, why? Why, why, why? But I just wanted, I guess I just wanted to know.

Asking "why" is, often, how scientific investigations begin. Many young children want to know "why?" Participants had support systems (teachers, parents, mentors) who cultivated this curiosity. From a gendered perspective, girls are often expected to be concerned about "why" questions that concern human relationships. Questions such as, "why does she feel that way?" or "why does he not understand my perspective?" Boys are often encouraged and given access to explore questions that investigate how things work.

However, the participants in this research expressed an early interest for exploring how things worked. This interest was cultivated by participants' support systems and was carried out because participants were persistent. Participants explained that they were intrigued about how the parts of the natural world (e.g. animals, plants, non-living things) existed together. As young

girls, the participants did not know the meaning of science and they did not see themselves as scientists. However, they were curious about how things worked. Dr. Patrick stated, "I think I just really liked thinking about how things worked. I didn't think about a specific question. I just think that was appealing to me, was like understanding stuff." Her usage of the word "stuff" exemplifies many of the participants' broad curiosity for how things worked early in their lives.

As participants developed, they described many different experiences that helped them understand science in a more authentic form. These experiences also helped them believe that they could "do" science. For participants, these experiences challenged their previous understanding of science as being terms and diagrams in a textbook. Dr. Curie shared a revelation that she had during high school after a research scientist gave a guest lecture on his research study:

> But I could see how he was doing that unique way of thinking about something. And but then that he had to do all the steps to end up convincing not just himself but his colleagues of it. And it just... it was... it sounded so cool and so interesting and so other worldly. Like science had been facts that you memorized out of a book. Well he was describing it not as facts that you memorized out of a book but as an activity. And not an activity like, like all those labs that we would do in high school biology. You know, identify the liver and identify this or something. And where the teacher knows all the answers. You know to me that's. Yeah. OK. That might be nice practice, but this guy was doing science and I was like wow.

Dr. Curie's previous conception of science of being "facts that you memorized out of a book" was challenged by listening to a guest lecture given by a research scientist while she was a high

school student. She described this "nice practice" of doing science as "indescribably wonderful." She further explained her process of coming to understand science that was facilitated by a physics professor:

> That's the dividing line to advance that a little bit, is like something that you have to be Isaac Newton and like beyond brilliance and that before you can push that boundary of knowledge you need to learn like everything that's ever been learned and known. You need to memorize a gazillion facts and learn everything and then maybe you can if you're brilliant push the envelope forward and he said that's just not true. All you have to do is find one little edge just one little edge and work on it and you can probably push that boundary between what is known and what is not known forward. And I didn't really believe him, but it really stuck with me. And then the first time I ever actually did that and started to learn something that no one in this world had ever known before... and I could. I was the first one to figure it out. And then I needed to explain it to my colleagues. And there was just a rush. That is indescribably wonderful.

Through a geology field camp, Dr. Patrick discussed her growing understanding of science. She also discussed how her abilities aligned with the common qualities of a scientist, which was important for her science identity development. Through this experience, she discovered that she was able to learn a great deal of information by the grades she earned on course assignments and her final course grade. At the beginning of the camp, she was earning Ds on course assignments and ultimately earned an A for the final course grade. She perceived this change to be an important indicator of her ability to learn and apply knowledge as scientists do. She explained:

> And so, um, but that summer, so I don't know how familiar you are with geology field camp, but essentially you're like taken places and then you... essentially are taught how to walk around a landscape and then reconstruct the history of what happened, like millions of years ago. And so it kind of feels like a superpower, right? Or that's how I felt.

She continued:

> And you know, it's so rare that we can be reflective enough on ourselves to see learning when it's happening. It was one of those times when I was like, oh my God, I can learn so much. Like I can do this. Like that's what being a scientist says, right? It's like a capacity to learn and like apply that knowledge. And it was like the first kind of time that I felt like I had that power and I often talk about like superpowers and being an unicorn and things like that.

Through this experience, she understood that she was capable of learning a significant amount of information and was able to apply it to scientific questions. This experience affirmed her scientific skills. In this case, she was generating inferences about ancient environments through observations of land formations. She understood her ability to learn and apply this knowledge as special and powerful like a unicorn.

Participants' Unique Qualities and Science

Often participants understood that their interest for deeply investigating questions about how things worked, or their inquisitive quality, was unusual for their peers. Their science journeys helped them value their scientific attributes. Science communities gave them a space

where their inquisitiveness could be productive and appreciated. Dr. Curie explained that "dressing nicely" was not as important as being scientific. She discussed having a natural fit with science:

> So, like I don't really care about dressing nicely and all sorts of other things. But I do care about analyzing things and getting it right and rechecking my results and figuring out how it fits in with other things. You know there... there are things that I can do naturally. There are other things that come naturally to other people that do not come naturally to me and so, I think science is a great place for people who are just a little bit different.

Dr. Patrick explained that science fit her "super technical personality," which was satisfying:

> And for a super technical personality, that's very appealing. When I say the power of science, I mean those unicorn, Pegasus moments that are all sparkly, that you're like, "Really? No! What?" And, all of a sudden, your world gets reorganized and it makes more sense, but you didn't know it didn't make sense before. That's what I mean when I'm talking about that. It doesn't happen very often, right? But when all of a sudden, a new puzzle piece comes into your being or your knowing, and it inserts itself in your file cabinet that is our brain. And somehow that puzzle piece gets all those files reordered, and all of a sudden it all makes sense. And I feel like being a scientist, I'm looking for those things, and I really enjoy that process. I find it very appealing. And satisfying, it's just very satisfying.

Dr. Patrick appreciated the “power” of science. Her unique talents could be utilized to advance the discovery of knowledge. Science communities provided figured worlds that gave participants a place where their technical and inquisitive talents were valued.

Identification with Science

Beyond their professions, participants were aware of how their scientific way of thinking was different from their friends and family who are not scientists. They were proud of their scientific way of thinking. Several participants identified with science. Dr. Patrick explained, “It infiltrates every part of my life, and I can’t imagine not being a science professor. I can’t imagine not being a scientist.” Not being a scientist would cause Dr. Patrick to lose a part of her identity. Dr. Curie was proud of her science identity because she earned her position as a scientist. She described:

> Oh, I own it. I feel like I earned this spot in life. I will introduce myself as Dr. Curie, like if I’m talking to United Airlines or something. I don’t like it if they call me Miss or Mrs. I’m like, "No, I’m Dr. Curie." I absolutely feel like I earned this, and I won’t have it just swept aside as if it’s nothing. I chose to put a fair amount of my time into becoming a scientist, being a scientist, and that’s just part of who I am. Being a scientist to me also means there’s a strong sense of honor. Truth is incredibly important, so when I say I’m a scientist, what I’m partly saying to people is that I care very, very much about the truth. I care about understanding things. I don’t want to be told what to think. I’m happy to engage. It’s a process. Being a scientist is part of who I am, but it’s saying something to other people.

Dr. Curie described her science identity with a sense of honoring her time commitment and her respect for empirical truth. In addition, being called a scientist shows respect for the time she spent to earn her terminal degree. Being a scientist also meant that she was concerned with truth. When asked about her science identity, Dr. Daly described how other people perceived her:

> So, I think, you know, I think of it in that sense, like I don't know how many people really think about me as a scientist outside of work. I think they see the full me, but I do see that it plays... like I do see like my critical mind that I've learned as being a scientist show up in my real life. Like, um, matter of fact, I just thought about this yesterday. Something happened and I was like, well, what if I tried to do this? And, sure enough it actually worked. It was something benign. Like I was trying to get something from the supermarket or I was trying to find something and I was like, wow, if I wasn't a critical thought person, I probably never would've thought about finding my answer through this route.

She described her critical think as sometimes being performed unconsciously during every day experiences. Dr. Daly's experience exemplifies how developing scientific habits of mind can impact life beyond the science laboratory.

Anthropologist of the Science Community

Participants were active in the study of their organizational norms. Organizations are figured worlds that value and interpret specific actions of certain individuals (Holland et al., 1998). Norms are the common behaviors, thoughts, attitudes, and values of the organization. The participants studied these aspects of their workplaces. They were also introspective about

their fit within the organizations. They learned that collaboration was important to conduct meaningful work, which often aligned with their preferences and skillsets. For example, they took leadership positions, which prepared them to be principal investigators of research projects. Also, they understood that science is a competitive environment. They discussed how being competitive in science can help scientists advance and inhibit the discovery of knowledge. Often, science communities included colleagues who did not have to comply with professional standards. Finally, many participants described hierarchies in their science communities. These hierarchies often controlled advancement opportunities. Participants studied these aspects of their science communities and used this understanding to take agency in their experiences.

Study of Organizational Norms

General Awareness

General awareness of their organizations helped them identify patterns of behaviors among their colleagues. Based on this understanding, they could make strategic decisions about whom they worked with in collaborative projects. Dr. Rodríguez Trías studied patterns among her colleagues' research behaviors. She identified a spectrum of preferences among professors in regard to isolated versus collaborative research. She explained:

> Meaning, some professors will stay in their office, will read, read, read and will write, write, write, write will be very successful this way, absorbing as much knowledge they can and with no collaboration. They can do that. There are professors who collaborate a lot and all of their research will be based on collaborations. It's also good, but not good.

> So, either of these two are good. So, basically, this isolates and this does not isolate at all. But you can kind of be in the middle. You can do your research as you want to do it, but you can also collaborate. So kind of, yes, so that is two things. Or, also, there are professors who do not have research lab who don't have management of money or people to take care of, they only teach. So those professors will kind of isolate because they only go and teach, go and teach. They will have office hours. They don't have really to work with, right? So yes, there is the idea that the professor has their office, close the door and the professor come, leaves, no one knows. Yeah, I don't like that.

During her experience as a graduate student, Dr. Patrick recognized that different departments' populations followed different patterns. She explained:

> I mean, the like sort of vibe of the department is really different between universities and then adding university between departments. Right? Like, I mean I'm sure you've noticed this, right? And it's in some of those things, like it was like you can imagine as you started having like more data points for that, right? You start seeing patterns and I, I wouldn't say that was like, oh all of a sudden on my, like seventh lab visit I was like, oh, it doesn't seem like I'm meeting lots of women. Right. Or, you know, I just think that I did notice somewhere in my Ph.D.

Gendered Expectations

Part of science is to engage in argument with fellow scientists. Dr. Curie learned that there were different expectations regarding how men and women communicated during

argumentation. She was not expected to disagree directly with her male colleagues while males could directly disagree with each other. She explained:

> And that's also where I found that the way that the men disagreed with each other, when I tried to mimic them, was not successful. It was not acceptable when I went head-on-head with a senior male and said, "No, I can't agree with that." That's not appropriate. That sort of... I was just trying to mimic what I'd seen men do, but that kind of approach was treated almost with horror, almost with shock, like they didn't know what to do, like this woman is going ballistic or something.

Male colleagues perceived her actions as being unusual, which hindered the scientific process. Scientific argumentation is important because it critiques claims that scientists may hold, which ultimately strengthens future claims. Later in the interview Dr. Curie explained that it was unacceptable for women to argue like men and that it was difficult for her to resolve this issue:

> So it was really difficult because I just found that me arguing the way men argued didn't work, just didn't work. And it didn't get to the final good result. So that was challenging for me and at that stage of my career, I didn't find a lot of successful women models to model myself after. I kind of learned a slightly different tact, but I can't say that I ever really, really mastered it in how to do leadership at that level.

Gendered and Racial Expectations

While working for the army, Dr. Daly experienced discrimination based on her race, age, and gender. She was aware that others perceived her as being different by describing her setting and colleagues in detail. She was not naive about how her colleagues perceived her. Due to

biases that her colleagues held about her as a young Black, female scientist, her mentor gave her detailed instructions on how to travel to the bathroom. She explained:

> So it comes in double. And I saw a lot of that in the, in the army and the crime lab. And so I was the first Black scientist that they hired in nearly 30 years. I was 27, I was a female and I had one... I was one of four PhDs in the entire laboratory of 300 people. So a lot of people were watching me, for different reasons. And I remember my mentor, who was this Black lady, she'd been there 34 years, 35 years. She says to me, she goes, whenever you walk to the bathroom, always carry a book with you. I was like, why? She said, because people see you and they think you're just lolly gagging around the lab, the laboratory, just walking the halls, not doing work.

Due to her intersecting identities, Dr. Daly was advised to walk to the bathroom while carrying a book so that her colleagues would not believe she was wasting time in the hallways. She described often being judged by meritless assessments due to a discriminatory figured world.

Collaboration with Colleagues

Participants described collaborations with colleagues as being critical for successful work. They were strategic about whom they worked with because some colleagues were overtly sexist, racist, or a combination of these negative characteristics. Their colleagues brought complementary skills, experiences, and knowledge that helped answer meaningful research questions. Dr. Curie described how her colleagues helped her understand which lines of inquiry were important and which were not. She explained:

> So the way that's sort of emblematic of what it's like to work where I work is that quite a few of my colleagues were right down the hall from me and I was able to just ask them questions and get data from them, and ask them what was important, and ask them to look over the draft. They were co-authors on the paper, so they were happy to do that.

Dr. Rodriguez Trías explained her strong appreciation for working with people:

> Yeah, I think I like this work because I work with people. So, "people" meaning my students, my peers, and also my colleagues. Professors, I like to work with them. So in general I like people. That's what drives me I think.

Dr. Rodriguez Trías further explained her collaborative work on research projects:

> I do have a team that involves three professors and then two to three students. So that team will be six. And I do have a team who involves 13 professors... and may be like 20 to 25 students, but I don't lead that team. The team I lead is the, the team that involves six to five. But, so for me to have a grant, let's say $300,000, that will be my team. Like six, seven, to eight people. That professor who leads this million dollar grant, he would have a team of 20 to 30 people.

That's Just Who He Is

Participants had male colleagues who did not treat women with respect. These colleagues were frequently temperamental and sexist, but were not reprimanded. Participants often avoided working with men that were not required to uphold professional standards. Dr. Curie described having a brilliant and frequently temperamental supervisor:

> He was about to hold a press conference to declare this great insight he now had. Before I helped him understand that it was a complete artifact. So on the one hand he was really grateful because it wouldn't have, you know, it really would have made him look kinda stupid. So on the one hand he was really grateful. On the other hand he had that sort of like... but he was a very hot-headed person. I think he fired me six times in the next six months. I mean he would just sort a blow up and he would, you're fired don't come back from. But that's just who he was. That's how he was. You know? He's just a hotheaded person. But yeah, that was my introduction to being an active research scientist.

Dr. Daly discussed different degrees of egotism in her male colleagues. There were male colleagues who were disrespectful in terms of every aspect of life. Then, there were colleagues who were respectful outside of work, but switched identities at work. She explained:

> Because, you know when I talked about, you have, you have fully egotistical people, you have partially egotistical and like one facet of life and then you have people that are just normal. Like I never experienced somebody who is like partially egotistical until I got to the army. Like there was this one, maybe two guys, straight assholes in the lab. Like real talk and they just said some real foul to me and I'm like, "What?" And then you hear, like everybody, everybody complains about them. But then you hear these same people hanging out with them and going camping with them. I'm like, "How?" Like this guy is an asshole. And they're like, "Yeah, he's an asshole at work, but out he's a, he's a cool person." Until we were at a barbecue and I was like, "Well who the fuck?"

Ironically, Dr. Patrick described being bullied by a male colleague while working on a project that aimed to increase the participation and advancement of women in science and engineering careers. She explained:

> Right? Essentially this fall, I was answering questions from reporters about this ADVANCE grant that I am on this six-PI team for. And at the same time, I'm essentially getting bulled by my chair. The irony is not lost on me.

Dr. Patrick also described White men who had issues with a change in the power structure at her workplace:

> We've never had a provost before… This is a new thing. And who freaked out? All the old White men. Because they were like, "Our flat power structure is changing," and they had power because they had fucking been there long enough. And who would think that the art department is the center of power at [company]? You would never know that. But if you're there long enough, you find out that they've figured it out. That's a department that knows how to get what they need. And in large part, it's like old white men who complained very loudly. But you know, he does it because he can. And there are essentially no consequences on him.

Science is Competitive

Science communities are often described as favoring competitive behaviors and attitudes (Ong, Smith, & Ko, 2018). For example, scientists compete for grants to fund their research projects and budgets are shrinking. Therefore, competition for funding has increased. Also, scientists build their professional reputations by publishing papers. They need to be strategic

about how they use their time and money to achieve this goal. In addition, scientists' professional reputation and accomplishments allow them access to jobs (Fang & Casadevall, 2015).

Participants explained that, besides these circumstances, there is an intrinsic value in discovering new knowledge. Most participants appreciated the competitive nature of science, but also discussed how competition inhibits the process of science. Dr. Daly described feeling territorial about her research area and how most scientists have a tendency to defend their "niche". She explained:

> When somebody, when you're doing research and this is your niche and you started seeing somebody else doing that niche, your immediate thing is don't take mine. You know? And so because of that you become overly and outwardly... offensive is not the right word, but like you're like, "No! I'm just going to tear you down because I don't want you encroaching on mine." And honestly I, I've felt that way. But then my rational brain was like this, this needs to be some... somebody needs to do it.

Dr. Curie reflected on how she felt after being considered competition for her professor. This occurred after she had disagreed with him. She said:

> That was kind of fascinating that, because he was quite a famous professor. And for him to think of me as competition was weird, was really weird. And that is how real science works. People are very competitive, very competitive. They don't want others to succeed necessarily. They want themselves to succeed.

Similarly to how Dr. Curie discussed the competitive aspect of science, Dr. Patrick explained that the "ivory tower" is an arms race. She stated that more collaboration is necessary to advance knowledge. She said:

> And I think that we haven't thought of ourselves as a community enough. We all exist in these communities, but the idea of an ivory tower is every man, and literally every man for himself. It's not people working collectively to solve problems. Society's view of how problems are solved and how science is done has not shifted with the reality of how science is done.

Participants' understanding of the competitive aspect of science helped them aim for a form of competition in science that is productive.

Hierarchy in the Field

Participants described social and intellectual hierarchies in the science community. Participants' positions in these hierarchies affected their access to funding, promotions, and political influence within their communities. Awareness of these hierarchies further demonstrates participants' study of their organizational cultures. Dr. Curie discussed the power structures of intellect and funding:

> There are actually two types of hierarchy. One involves being in charge of money, so being like the head of an institute or having climbed that sort of ladder. And when you're in charge of money, people are always sort of sucking up to you because they want to maybe benefit from that. So there's that one type of hierarchy.

Dr. Curie also discussed the intellectual hierarchy:

> And another type of hierarchy really just has to do with how smart you are. That's based on both how you write papers ... Well, I would say it's based on three things: your papers, your talks that you give, and how well you participate in community discussions, whether you're a constructive person in those discussions or not. I'm not at all high on the hierarchy of money, and I've never really tried to be. It's just not a goal of mine. But I'm pretty high on the hierarchy of paper-writing and coming up with the science ideas and understanding what's going on. So I get invited to a lot of meetings because of that and ... Yeah, there's just a sort of... that's the niche that I feel most comfortable in.

Dr. Curie identified two hierarchies in her organization that adhere to specific values and norms. Scientists can move up the funding hierarchy by social means that are not based on scientific endeavor. This maneuver she labeled as "sucking up." Then she described the intellectual hierarchy based on scientific merit and identified the following three ways to move up: papers, presentations, and meeting participation. Understanding these hierarchies has allowed her to situate herself in positions that value her skills, knowledge, and abilities. This understanding has also helped her advance into leadership positions. Therefore, she has been able to advance professionally while upholding personal values. Dr. Daly explained that applied and theoretical chemists have different opinions about what is "real" science. She described:

> So like the theoretical chemists, they feel like if you're doing applied chemistry, it's not real science because you're not looking at the molecular stuff. And then the applied scientists feel like, well, theoretical chemistry is all great and stuff, but if you can't apply it to anything, it doesn't get funding. You know what I mean? So like, so you tend to hear some, some comments about that. But it's always just about the science. It's just science.

Dr. Patrick explained that the type of school affected how her colleagues perceived her within the science hierarchy:

> I think one thing that's sometimes challenging is that, you know, as a professor at a small liberal arts school, there's, feel like there's some bias with that title in like in the scientific community. It's like, oh, you're not good enough to make it or whatever at a R one school. Um, I definitely, like sometimes feel that bias, which is annoying to say the least. But I don't know, I feel like I definitely... It's like one of those things that I hear, but then more when I'm in situations where it's not my field, so they don't know me, they don't know my work, like if I'm in sort of my zone or my science, like I think people know who I am to some extent, right? And that is enough, but I think when I'm outside of that space that's like very clearly mine, um, or where I fit, I think sometimes it's a negative.

Dr. Patrick described that within the larger research community, scientists evaluated one's professional reputation by one's place of work. This bias could place value on meritless qualities and ultimately hinder the advancement of science.

Deep Support System

Participants selected a support system of mentors, advisors, and supporters that served specific roles that assisted them through adversity and typical professional advancements. For example, some mentors supported participants by coaching them on how to communicate with their colleagues or how to negotiate job offers. Other mentors provided emotional and intellectual support. Dr. Patrick held a leadership position in a women's network of

geoscientists. This role gave her connections to many scientists that were prepared to help her in unique ways. She was then able to choose mentors that suited her needs. Dr. Patrick explained:

> Oh my gosh, yes. So, I, I have a bazillion mentors because I also must look desperate or something, and lots of senior women have really taken it upon themselves to like offer me advice throughout time. Um, but I have, yeah, I would say I have a lot of people that I think of as mentors and then I can turn to for advice in different situations. Um, yeah, but they are not at [School].

Many people had helped participants on their science journeys. Dr. Daly was selective about members of her support system, which included her parents. Fittingly, she called her support system, her "board of directors". She said:

> Whereas my mom, and my mom is, is, um, a really good mentor and she's so... my mom, my dad are both on my personal board of directors along with the Verizon guy and my three best friends. And um, my director here and my mom is one of those.

Dr. Daly's "board of directors" helped her make personal and career decisions. The supported her when she faced adversity at her workplace. Dr. Daly also had a peer network during her undergraduate years. This group of friends was devoted to achieving academic success. They helped Dr. Daly come into her science identity by supporting her academic journey. This was different from her high school experience where she had to hide her science identity from her peers. Her science identity was accepted and supported by her peers during her undergraduate years. She explained:

> And that group of people, it turned out that there was a girl that had just bonded with and we had met almost four years prior at an, um, A... Able conference which is Alliance of

> Black telecom, telecommunications employees, right? Her, her mother was in and my mom was in it. So we clicked there, but we never maintained friends. We just so happen to go to Howard together. So through this clique of kids, we were all like really dedicated. We all graduated the university in about four or five years. Except for my one girlfriend, she was the only physics major. And I think that that hindered her because she didn't have a support system. I could support her in a lot of classes that we took together, but she took all these classes I didn't know how to help with, but, um, but I think that group of students made it feel comfortable to like science.

Dr. Rodríguez Trías described three mentors that were meaningful to her success:

> My first mentor was in my undergrad. My second mentor is the PhD, the Japanese professor. And my third one is the one I knew in Auburn and during my exchange, who is the same as the one who I come back to the post-doc with him. So he's my third mentor.

Part of Dr. Rodríguez Trías' support system was an advisor who had a strong work ethic resembling that of her parents. She valued this quality of her advisor.

> Maybe why I say this was, he was really hard-working like my parents, because I had my... Ah, yeah... I had parents who were very hard worker or worked really hard. And he was also... he also has that type of characteristic.

Dr. Rodríguez Trías also respected the reputation that this mentor had developed in their field. She explained:

> So I went to... I talked to my advisor something in Brazil, who is one of the best in my area. So he was a Japanese descendant and he was really good. He always worked a lot

like my parents in Brazil. He was working there. He is my second mentor. So, I always admire him for his be... being hard working Japanese kind of guy.

The professional reputation of participants' mentors affected how participants received guidance and support from them. Mentors who were well respected by other scientists were able to indicate to participants that the advice came from someone who had achieved success. Also, their reputation in the field meant that they had connections to future career opportunities. Dr. Rodríguez Trías described the value that she placed on her mentor's advice:

> But, I think because who he was, and he was telling very specific things... yeah, I think, I may take him more in consideration because sometimes you question... right if somebody, let's say I don't know like homeless people tell you something. You will think about that right. Like, that person tell me that so it's kind of was really important for me I guess.

Sexism

At some point in their science experiences, participants experienced sexist discrimination. Often, participants' colleagues had unwarranted expectations of women. This discrimination created barriers that affected their advancement opportunities and their reputation among their colleagues. They worked with their support systems to overcome or circumvent these issues. As their science efficacy developed, they could identify that sexist colleagues were anomalies on their journey. Dr. Curie described how her colleagues did not believe women could do breakthrough science. She said:

> It is much harder for people to take new ideas when they don't expect to be receiving those new ideas. I think it's a little bit similar to you don't expect the secretary for the group to have a massive scientific insight into the data. She, he, could have a male secretary, who might walk in and say, "Oh, it looks like it's more like quadratic or something," and everyone's going to roll their eyes because they're not expecting the secretary to say anything helpful or useful on this topic. There's a little bit of what they expect from you. Even though women are absolutely respected for doing careful work, et cetera, we're not always respected for doing original sort of shifting of how one thinks on a subject type of work.

Dr. Curie demonstrates an overall understanding of her organizational culture that helps her understand that her community has an implicit bias. This understanding allows her to say "It is much harder for people to take new ideas…" rather than saying, "I am not capable of developing breakthrough science." Her understanding of the implicit bias that existed within her organizational culture allowed her to respect her own scientific abilities, even if her colleagues did not. She continued by describing the negative social implications that were consequential on her actions that did not align with the communities' gendered norms:

> But in 2004 when I was fighting to get the concept in, literally, people wouldn't talk to me at coffee breaks. They would not. People didn't go out to dinner with me. I was not behaving as they wanted me to behave, which was as a nice, supportive woman. There were a lot of men there arguing their points, and they often just won their point after a little bit of arguing. It was okay for them to argue, but as I was arguing, and I knew I was

> right, positively knew I was right, it finally got to the point where it was clear they didn't like me arguing that way.

Dr. Curie does not describe a personal inadequacy, but evidenced gender discrimination by her community. With this understanding, she does not question her abilities as a scientist. She seeks ways to continue doing her scientific work with the understanding that she has added challenges as a woman. Dr. Rodríguez Trías experienced difficulty in earning a research assistantship position because the supervising professor did not believe she was physically strong enough. She explained:

> So he said like he was looking for... to help us or something like that. Once I was chemistry major or assigned to that lab. And then I went and talked to him and he said he need a man because whether he was going to doing it like this you know to be strong to carry out stuff. He put up advertisement because he was going to give a class for people to know those things. So, yeah, that was my first experience trying to get into the research lab. And I told him that I will do it because I can do everything that I man can do because I held my parents to construct my house.

Finally, Dr. Patrick described how her appearance affected how others perceived her work. She described:

> I mean, I think I'm like, once again, I don't know how successful I've been. I would say that I haven't had a job where I haven't been harassed. I haven't had a job where I haven't been told essentially I'm too pretty to be smart.

Differences Among Participants

Racism

Drs. Daly and Rodríguez Trías experienced racism, but other participants did not describe racist experiences that were directed toward themselves. Dr. Daly described her experiences with racism chronologically. At high school, Dr. Daly was part of a group of students who wanted to celebrate several cultures, but their efforts were not recognized or supported by the school leaders. Dr. Daly described:

> Um, but it wasn't really black history, it was, it was black history month, but what we did is we found Black, Hispanic, um Indian... AKA, like all non-White scientists. People that represented each of the disciplines, because, yeah, like a physics bill... or science building. So we found scientists and we made posters about them. We found English people, math people, we made up posters to like say like, yeah, everybody we study in these books are probably going to be White, but there are other people who have... you know? And we put all those up on a Friday and by Monday they were all gone. All of them.

During her undergraduate years, Dr. Daly aimed to get an internship. She was told that the leadership of the company did not like Black people. She said:

> And so he invited me and he told me, he goes, yeah, to be honest, I don't know if you'll get an internship because you're a black female. And the medical examiner wasn't really keen on females or black people unless they were like, like the staff level.

Because of her intersecting identities, Dr. Daly often questioned the honesty of compliments she received in her work experiences. She said:

> And I, and I, and I only recognize that at the end where they, they turn around and they'll say things like, oh wow, that was really impressive. And I'm kinda like, is that a backhanded compliment or is that genuine? Like, oh, you're impressed with what I did, or oh, you're super impressed because you didn't think I could do what I did because I'm young or I'm Black or I'm a female, or you know, I'm Jamaican. Like I don't know what it is, but I try not... I, I guess I'm pretty oblivious to a lot of stuff. But I like when it's apparent, I just try to say, well, what the fuck ever.

Experiences like these significantly affected how Dr. Daly perceived herself as a scientist. On several occasions, she described her continuation in the field. Dr. Rodríguez Trías experienced others being surprised when she told them that she was a scientist. She explained:

> So, people who come from Southern America... they is unlikely that they are proficient as here. So, not many they, they do office, they just work at some places and most of the people think that about me. So, they think, oh I'm a, you know people who cut the hair or who is waitress or something like that. So when they ask me what are you doing, and I start to talk, so it's them things. I was at a fair last Saturday and then home fair, or garden something in Orlando Center. And then we started to, I asked question, I start to ask question about the solar energy from the company that started it. Yeah. Yeah, they were all surprised because the question I was asking. And then he asked me like, "What are you doing? What do you do?" "I'm a professor in chemistry." "Okay." So, so this kind of thing. So I always get that. So people, first thing that I am a person who doesn't have a

> profession. And then when they get that I am a professor and I do chemistry and then they, yeah, it's funny.

Dr. Rodríguez Trías described this experience as "funny" and did not describe it having an impact on her experiences as a scientist. These examples of racism exemplify the importance of distinguishing components of participants' figured worlds. Participants experienced different degrees of racism and had different perspectives on this aspect of their science journeys.

Faith

Black and Hispanic participants highlighted their faith in their journeys to becoming successful scientists. None of the White participants expressed faith as a significant component of their journeys. Drs. Rodríguez Trías and Daly described that their faith helped them through adversity in the workplace. They also discussed their appreciation for how God helped them achieve professional success. Dr. Rodríguez Trías illuminated this appreciation:

> Yes. No, not of what comes ahead. Maybe a little bit may be, but sometimes I don't believe that so many good things could happen with this small brain. You know what I mean? I would say, I didn't grow up in a family with a lot of money. I didn't grow up in a family with a good education. I didn't grow up in this, you know, in this environment, yeah, so, that's it. That's where I come, kind of... I am surprised, happy, I... yes. I think only God can do this because otherwise this is crazy.

Dr. Rodríguez Trías restated that God is central to her life and influences all aspects of her experiences. Dr. Daly discussed a biblical mindset that helped her cope with racism within the workplace. She expressed pain and strong resentment towards her colleagues because they were

racist and sexist. On a daily basis, she worked in environments that were hostile towards her intersecting identities of race, age, and gender to the degree that she began to question her abilities as a scientist. This type of figured world played a role in seeking a different position with a new company. Initially, she felt forced to leave her company because of factors that were not based on merit. She replaced the idea of being "pushed out" with the idea that God was making it clear that there was a new place being prepared for her. She said:

> So, in the Bible, it always talks about you know, you, you… When difficult times are ahead, always looked back and remind yourself what God has brought you through. Right? So that you don't lose faith that he's not going to be there for you. So I remember one day I was on the phone... my girlfriend and she was telling me, I was telling her all this bullshit and she goes, but Dr. Daly, you're, you're brilliant. Like looking at all that you've done. And in that same light as that parable, I looked back and I was like, wow, you've done a lot of stuff. You know what I mean? You've done a lot of stuff that people don't normally do. Like this person you are right now is not who you are. And I remember like going into work the next day, it would like this fuck you attitude. Like you don't know. I'm not going to be here. I know I'm not going to be here. So fuck you.

Dr. Daly's experience exemplifies how the science community negotiates its value for objective thinking for negative biases. Based on meritless criteria, such as gender and race, Dr. Daly's colleagues caused her to question her scientific abilities. These circumstances ultimately provoked her to seek different employment opportunities. Her faith provided a path to a positive perspective while she experienced this type of adversity. This component of her identity helped

her to understand that God was clearly directing her to move to a different job. With God, she had autonomy in making this decision, as opposed to her colleagues forcing her to leave.

Compare and Contrast Between Findings and Research's Prior Beliefs

Given my positionality, an analysis of the themes that shifted my understanding of the experiences of successful women in science is meaningful. This analysis adds to the trustworthiness of my data by further discussing my positionality. I was able to deconstruct biases that I held and build awareness around personally unknown experiences of women in science. Prior to conducting this study, I was not aware of the deep level of agency that facilitated participants' success in science. This agency was demonstrated by understanding how participants became anthropologists of their organizational cultures and selecting support systems that were personally meaningful.

Another finding that increased my sensitivity to the experiences of successful women in science is that all women experienced sexual discrimination and some experienced racial discrimination. Participants described in detail how meritless factors affected their experiences in science. This discrimination inhibits the progress of science and more importantly in my opinion, negatively affects deeper relational issues between people. hooks (2000) claimed, and I agree, that operating under hurtful patriarchal norms inhibits humans from having honest and meaningful relationships. Given the ideal that scientists are objective thinkers, they should have the professional motive to welcome and appreciate the most brilliant scientists into their communities. Ideally and hopefully, this motive would facilitate meaningful relationships across gender, race, and socioeconomic status.

Table 2 summarizes my prior beliefs on the themes that emerged from the data. The table identifies the themes in the left-hand column. In the middle column, I identify how the theme fits into my previous understanding prior to conducting this study. The right-hand column provides an explanation of my beliefs prior to conducting this study. This table provides a summary of the growth in my positionality on the experiences of successful women in science because of this study.

Table 2: Comparison of Researcher's Prior Beliefs of Themes

Theme	**Comparison to Prior Beliefs**	**Researcher's Prior Beliefs**
Influential early life experiences that related to science that often included their fathers.	Partially corroborate	Identity begins to develop at a young age. Therefore, this finding corroborates my prior beliefs. I was not aware of the significance of paternal influence.
Good work habits.	Corroborate	Paving paths in hostile environments requires the qualities of good work habits.
Progressive participation in authentic science experiences.	Corroborate	To be and feel competent, scientists need the knowledge and skills that are developed through authentic science experiences.
Deep appreciation of science.	Corroborate	Scientific exploration is fulfilling for a diverse group of people.
Participants were anthropologists in their fields.	Different	This finding was new to me.
Participants had deep support systems.	Different	This finding was new to me.
Participants experienced sexism.	Different	I did not understand the extent of sexist mindsets and behaviors within science communities.
Black and Latina participants experienced racism in the science community.	Different	I did not understand the extent of racist mindsets and behaviors within science communities.
Black and Hispanic participants saw faith as a central component of their lives.	Different	I did not think many natural scientists were religious.

There are two other findings I did not anticipate before the study began. These findings include the features of participants' support systems and the role that faith played in the experiences of Black and Latina participants. All findings are further explored within the context of prior research and scholarship in Chapter 5.

CHAPTER FIVE: CONCLUSION

This chapter provides an explanation of how the findings of this research study fit within the literature. To accomplish this aim the following questions guided the first part of this chapter:

1. How do the findings corroborate prior research and scholarship on girls and women in science?
2. How do the findings contradict prior research and scholarship on girls and women in science?
3. How do the findings add to research and scholarship on girls and women in science?
4. How do the findings provide nuances to existing literature?

The main components of the conceptual framework (figured worlds, identity work, and identity development) are woven into this discussion followed by deliberation on the practical implications. Finally, recommendations for future studies, the limitations of the study, and concluding remarks are provided.

Corroboration of Prior Scholarship

Identity as a Social Practice

All of the emergent themes corroborated the theoretical perspective that identity is a social practice which incorporates figured worlds and identity work (Holland et al., 1998). Participants performed different social practices, such as practicing good work habits and establishing deep support systems, which facilitated positive progression in their science

identities. Furthermore, the perspective that science identity forms over time by people learning about themselves and others through social experiences (Holland et al., 1998) has been corroborated by this study. For example, as participants matured, they developed a deeper understanding of the nature of science through authentic science experiences. Calabrese Barton et al. (2013) found a similar positive progression in the identity development of a middle school girl over three years. The findings revealed that she received positive reinforcement when engaging in science from teachers, afterschool leaders, and the school principal. She was also given access to meaningful science work that affected her school's usage of energy. This positive progression in identity development is similar to the early life experiences of the participants. Participants had figured worlds that valued their identity work in science early in their lives, which had long-term impacts.

Resilience in Hostile Figured Worlds

The findings revealed that participants were resilient in hostile figured worlds that required a significant amount of identity work. The sexism theme reveals that their science communities held sexist norms that negatively affected their science experiences. Dr. Patrick described how her appearance lowered the expectations that her colleagues had for her research. In essence and in her own words, she was "too pretty" to be smart for some of her colleagues. However, Dr. Patrick performed many acts of resilience to achieve career success. For example, she valued and strived for autonomous learning experiences, which prepared her for her professional endeavors. Dr. Daly experienced several forms of discrimination based on her intersecting identities as a young, Black, female scientist. However, she deeply valued the

impact her work had on investigating crimes. Furthermore, her resilience through these adverse circumstances was supported by a deep support system that she selected.

Through interviews with parents and participants, Archer et al. (2012) found that 9- to 10-year-old girls had similar resilience in figured worlds where it was challenging to be both feminine and maintain aspirations to be scientists. Authors labeled participants either "feminine scientists" or "bluestocking scientists". Feminine scientists valued a balance between their science and feminine identities. Therefore, they appreciated being fashionable and having relationships with boys, while engaging in science. Parents were proud of their girls' abilities to maintain this balance of not being too "geeky," but still advancing their science interests. Bluestocking scientists were described as "nongirly." They did not value fashion and relationships. This identity was risky, because they saw themselves as being different from their peers, yet they persisted in valuing their science identities.

Rosa and Mensah (2016) explored the experiences of six Black women scientists. This women experienced isolation during their graduate programs. Entering into study groups was difficult, because they were not informed of meetings and they experienced micro-aggressions, such as being the only Black woman in study groups. Also, study resources were not shared with these participants. However, they were persistent in their science journeys and sometimes resolved the issue of isolation by forcing themselves into study groups. They also took the initiative in reaching out to colleagues to learn about meetings. Participants in the current study showed similar resilience that could be based on their passion for science and reinforced by their support networks in their figured worlds.

Racism Exists

The racism theme corroborates the literature (Atwater et al., 2013; Hill et al., 2010; Rosa & Mensah, 2016) that argues that the intersecting identities of race, ethnicity, and gender affect an individual's science experiences. Both Dr. Daly and Dr. Rodríguez Trías experienced racism and sexism in science communities. Experiencing these intersecting identities show an additional layer of identity development tension that White participants did not describe. In a phenomenological study, Johnson et al. (2011) explored the science identity development of a Black, a Latina, and an American Indian woman. One finding is that participants had negative identities, such as that they were not seen as credible scientists, ascribed to them during their journeys in science. Drs. Rodríguez Trías' and Daly's experiences included times when people did not believe they were credible scientists. In some cases, people were shocked when Dr. Rodríguez Trías' told them that she was a scientist. She explained that these people were surprised because they associated Hispanic women with doing secretarial and custodial work. In another case, Dr. Daly was coached to walk to the restroom with a book in her hand so that her colleagues would not think she was being lazy and wasting time. Ongoing racial discrimination ultimately provoked Dr. Daly to question her scientific abilities.

Patriarchal Science Communities

The theme that the participants were anthropologist of their science communities corroborates hooks (2000) perspective on patriarchal societies. In all of the science communities, men were at the top positions of the organizational structure. Therefore,

patriarchal norms and ideologies often infiltrate science communities, which creates problems for all workers, especially women. For example, all women experienced sexist behaviors in their workplaces. Dr. Curie was not expected to argue as men argued. She was also not expected to be able to do breakthrough research. Instead, she was supposed to be "nice" and supportive to the other researchers. Another example is that Dr. Patrick was believed to be "too pretty" to conduct sophisticated research. Patriarchal norms were present in the current work experiences of all participants. All participants had to perform sophisticated identity work to be productive in their work to progress in their work places.

Contradictions with Prior Research

Positive Model Instead of a Deficit Model

This section identifies and explains how the findings contradict prior research and scholarship. Most of the science education and sociology literature about girls and women in science has used a deficit model. Focusing on deficits arguably makes it hard to offer insights that empower girls and women in science communities. For example, research revealed that adults often believe that boys are more suitable to do science than girls (Scantlebury, 2014; Xie et al., 2015). The findings from this study contradict these results. All emergent themes provide examples of how participants developed a positive science identity. For example, the figured worlds of participants' early experiences included several adults that supported their science identity development. Also, prior scholarship demonstrated that girls become less interested in science activity as they matured (Carlone, 2017; Carlone et al., 2014). The findings of this study

revealed that participants developed a positive identity over time that included supportive early experiences in school and after school.

Additions to Prior Scholarship

Methodological Gap

Many of the additions to prior scholarship may be due to the aim of addressing the methodological gaps in the literature about women in science. Prior to this study, research into the experiences of successful women in science, using an interview protocol that explored participants' life histories, current experiences, and reflections (Seidman, 2006), was not conducted. Similarly, research into the experiences of successful women in science analyzed by an identity formation conceptual framework that incorporates figure worlds and identity work (Holland et al., 1998) was not conducted. Therefore, this study explored an ongoing issue in science education from a different methodological lens.

Paternal Influence

The study indicates the importance of fathers' influence on their daughters' science identity development. In participants' figured world, most of their fathers helped provide access to science experiences. Fathers bonded with their daughters through science experiences. For example, Dr. Daly's father created normalcy around her interest in science by discussing it with her and providing her with resources to explore her interests. Her experiences exemplify how participants' scientific abilities were noticed, valued, and facilitated by their fathers.

Types of Identity Work

The findings show that participants engaged in two forms of identity work that has not yet been examined in the existing literature. First, participants studied the organizational norms of their figured worlds, which helped them execute strategic agency in their science experiences. This aspect of their experience was mainly highlighted in the theme that shows how participants were anthropologists of their science communities. For example, Dr. Curie's understanding of the intellectual and funding hierarchies helped her find a place within the community where her values aligned with the community ideals. Second, participants took the initiative to develop their own support systems that held important qualities. Members of their support system were relatable to participants and served different roles. Participants selected mentors who could coach them through different situations. As Dr. Patrick explained, members of participants' support systems had different roles. Mentors helped participants with career decisions and assisted participants through adverse situations. Their support system also helped participants develop their science identities. Often, they were assigned mentors that were not helpful. Therefore, they engaged in identity work by developing relationships with people who could support their needs.

Nuances to Prior Scholarship

Black and Hispanic Participants Told Counter-Narratives

The findings provide nuanced information to the quantitative literature (Curran & Kellogg, 2016; Eagan Jr. et al., 2013; Kohlhaas et al., 2010; Maerten-Rivera et al., 2010; Quinn

& Cooc, 2015) that shows a science achievement gap based on race. These studies found that White students scored higher than Black and Latina students did on science assessments. The findings from this study align with outliers from the mentioned quantitative studies and provide qualitative nuances to their experiences. Both Drs. Daly and Rodríguez Trías performed exceedingly well throughout their science experiences and ultimately earned their Ph.D.'s.

Girls Can Naturally Love Science

Gender essentialism is the perspective that boys and girls naturally have different interests and skills (Scantlebury, 2014). Given the implicit biases often held about science, parents, guardians, teachers, school administrators, and community members often assume that girls naturally do not like science because they are females (Due, 2014; Scantlebury, 1995; Weinburgh, 1995). This assumption negatively affects girls' access to science opportunities (Alexander, Johnson, & Kelley, 2012).

Therefore, understanding counter narratives helps to disrupt the assumption that boys like science more than girls do. Studies have been conducted that explore how girls developed and used their agency through their positive science identities (Archer et al., 2012; Archer et al., 2017; Johnson et al., 2011). Similarly, all emergent themes from this study show that participants developed and used their science identities. Moreover, the findings indicate that the participants deeply enjoyed the process of science by the theme that participants had a deep appreciation for science. Drs. Curie and Patrick clearly discussed the joy they found in scientific discovery. Therefore, the findings of this study challenge the assumption about science based on gender essentialist ideology because participants were passionate about their work.

Implications for Educators

Based on this study, the practical implications for educational settings are discussed. One perceived benefit before beginning this study was that it would guide future programming through deeper knowledge of issues regarding women in science and suggest for strategies to circumvent these problems. Carlone (2017) and Flyvbjerg (2001) argued that understanding science identity models will assist science educators in developing learning environments to interrupt oppressive norms such as sexist and racist biases. Most implications are directed at this aim, because the conceptual lens that was used to frame this discussion explores science identity formation.

Focus on Building Positive Science Identities in the Classroom

Teachers should focus on building positive science identities for all students. From the conceptual lens of this study, that aim involves the following three main factors: figured worlds, identity work, and identity development. Parents, teachers, and administrators play a significant role in each of these three science identity factors (Tytler, 2014). The findings guide three implications for all who are involved in education.

Building Consciousness around Implicit Biases

Building awareness around implicit biases will highlight the values and norms of figured worlds that may need to be disrupted so that all students have access to equitable science opportunities. Early in their lives, the participants had access to figured worlds that valued their

science identity. Therefore, educators should build awareness around their implicit biases in regard to science (Hill et al., 2010). Due to biases that teachers often hold (Scantlebury, 2014; Xie et al., 2015), they should be particularly conscious of their thoughts and interactions with girls and students of different races than their own. Then, educators should help their students understand their implicit biases about their peers. A first step in building awareness around implicit biases is to take an assessment such as the *Gender-Science Task* implicit association test (Implicit, 2011). The next step is to discuss the results with people who have diverse perspectives and backgrounds. This discussion can ease the fear around discussing controversial topics if productive conversation expectations are established. Critical awareness of biases can help structure learning communities, or figured worlds, that value all students. Ultimately, this awareness can help establish norms in learning communities that positively affect the science identities of all students.

Challenging Stereotypes

A further argument for teachers to become aware of their implicit biases is that stereotypes can negatively affect the science identities of students. Two examples from the findings are provided to illuminate this point. First, Dr. Patrick explained that people in her figured world did not believe that she could be both physically attractive and scientifically intelligent. Second, Drs. Daly and Rodriguez Trías were not perceived as credible scientists based on racial discrimination. Teachers should become aware of their implicit biases to disrupt these stereotypes. They should also know how to structure learning environments that are supportive of the development of all students. Calabrese Barton et al. (2013) argued that part of

positive science identity development for a middle school girl was discussing racial and gendered stereotypes. These discussions provided students with opportunities to identify detrimental experiences in their own stories and then develop mechanisms to overcome them. Therefore, teachers need to develop consciousness around stereotypes that they hold. Then, they need to learn how to integrate their consciousness of these stereotypes in the classroom. This development could happen in a multicultural competency course.

Engagement in Quality Multicultural Competency Courses

Educators can also build awareness of their implicit biases and stereotypes through multicultural competency courses that facilitate authentic connections between cultures. These courses should also lead to meaningful relationships that help students to truly welcome and value diverse perspectives. As a preservice teacher, I took a course entitled, "Foundations of Multicultural Education." We learned about concepts related to diversity by readings and classroom activities. Alone, this course was insufficient for understanding meaningful multicultural lessons. Educators and supervisors told me to "value diversity" and "be inclusive," but this was void of experiential understanding. However, my experience as a White male from a small city teaching at a high school with Black students in a large city provided lifelong change to my development as an educator and as a human. This dissertation study is another example of moving into unfamiliar areas to learn from experiences that are significantly different from my own. Through these experiences, I have developed relationships that have helped me deeply understand concepts such as diversity and actions that I can take to be inclusive.

Therefore, I suggest that educators engage in multicultural competency courses that incorporate an experiential component. The experiential component should place them in educational settings that are different from their own experiences. This may allow educators to experience different paths in science. This argument is supported by the findings of this study. Participants' journeys to success were diverse and faced different forms of discrimination. They constructed and found paths that allowed them to achieve their goals in science. Ignorance of these issues and a lack of understanding for coping mechanisms leave teachers and students unprepared for the challenges that they will face in the future.

Facilitate Authentic Science Experiences

Educators should facilitate authentic science experiences for all students. Participants had authentic science experiences that equipped them with useful skills and provided positive reinforcement. Participants valued autonomy in their scientific work and appreciated projects that impacted their communities and environments. These experiences should allow students to explore questions that are relevant to their interests and should have a meaningful societal and/or environmental impact (Calabrese Barton et al., 2013). Participants also discussed their persistence in their science journeys. Often, their experiments fail and their grant proposals are not accepted. Dweck and Leggett (1988) argued for celebrating the struggles of learning. Therefore, the struggle of the science process should be celebrated. Students should learn how to persist through scientific challenges and see their struggles as gains in learning.

Facilitate the Development of Students' Support Systems

Educators should provide students with opportunities to build relationships with scientists who are relatable to students. Participants had deep support systems that were developed prior to college. Therefore, educators should welcome scientists into the classroom and facilitate meaningful internships opportunities. Educators should also teach students how to develop mentoring relationships. For example, students should learn how to communicate respectfully with professionals. Also, students need to learn how to establish professional expectations with their mentors.

Facilitate Women in Science Events

Educators should facilitate women in science events that welcome successful women in science to share their stories with students. These events can provide opportunities for students to develop their support systems (Hill et al., 2010). The findings reveal that developing deep and diverse support systems was important to the participants' development of positive science identities. During her undergraduate years, Dr. Daly had friends who supported her science identity. They affirmed her dedication to her studies and this support helped her identify as a scientist. Women in science events can be a place for students to meet other students that support their science identities. Furthermore, participants had many mentors who played meaningful roles in their support system. Therefore, networking between scientists and students should be facilitated at these events (Hernandez et al., 2017).

Implications for Industry

Based on the findings, two implications have been developed for industries. First, companies should require professionalism and respect from all employees. Second, methods for connecting female scientists to relatable mentors are suggested. These two implications aim to facilitate working places that disrupt discriminatory norms. These could be applied to educational settings as well.

Require Professionalism and Respect from Everyone

Participants suggested that there were people that they avoided in their workplaces because they were sexist, racist, and temperamental. Often, participants labeled these people as "assholes" or "just that guy." These people did not experience negative consequences for their harmful behaviors and attitudes. Hill et al. (2010) argued that women often leave their science positions because the climate of their workplaces is not "warm" or welcoming. "Assholes" and people who fit the criteria for being "just that guy", should be required to uphold professionalism and respect for others. Therefore, scientists should have opportunities to evaluate their workplace climate through quantitative and qualitative measures along with methods to report inappropriate behaviors anonymously. Negative consequences should be in place for people who are not professional.

Relatable Mentors for Female Scientists

Female scientists should have access to mentors that are able to address their needs. The findings indicate that participants often had assigned mentors who were unsatisfactory. Therefore, they took the initiative to find their own mentors. One implication for companies that follows from this finding is to facilitate connections with support groups for women in science. This will help them gain access to a supportive network of scientists where they will be able to select mentors who they feel are relatable to their needs. A second suggestion is to have sophisticated methods to pair mentors and mentees based on their experiences, backgrounds, and needs. A third suggestion is to have educational workshops on how to be a mentor for women in the sciences. There is a small number of female mentors available, because women are under-represented in the sciences. Therefore, these workshops could be educational for men who mentor women. Hernandez et al. (2017) found that these three implications helped first- and second- year- undergraduate students persist in science fields. The findings from this study indicate that they had a positive impact on the science identity of the participants.

Recommendations for Future Studies

The findings from this study have led to several inquiries about the experiences of women in science and associated implications for schools and science industries. The following are three questions for further exploration:

1. What are the experiences of successful women in science from Eastern countries?
2. How does the load of discrimination affect the progress of scientific work?

3. What are some effective ways for helping men in positions in power to become sensitized to the experiences of women in science?

This study, coupled with the literature that was reviewed in Chapter 2, provide empirical evidence for exploring these paths of inquiry.

Experiences of Female Scientists from Western Countries

The first question to investigate is: What are the experiences of successful women in science from Eastern countries? The figured worlds affect the experiences of women in science. Eleven of the 12 participants grew up in the Western Hemisphere. My search of the literature did not generate a research study on experiences of successful women in science from countries in the Eastern Hemisphere. Therefore, learning about the experiences of women in science from this hemisphere may provide further insight in developing constructive learning environments for girls and inclusive working environments for women.

The Load of Discrimination

The second question to investigate is: How does the load of discrimination affect the progress of scientific work? Successful women in science deal with sexual discrimination that produces emotional and cognitive loads that could be used to explore and develop scientific inquiries. Therefore, their energy has to be spent on coping with hostile working environments rather than doing scientific work.

Participants discussed in detail the identity work that they engaged in to maneuver around organizational norms that were discriminatory. For example, they attempted different methods of arguing because women were not expected to argue the same way that men discussed disagreements. They also learned how to deal with men who were not required to uphold professional ethics. Understanding the load that learning and implementing these behaviors requires, would deepen the argument for requiring all employees to uphold professional standards. Furthermore, Johnson et al. (2011) suggested:

> … women of color like them who have made it to this stage may be more talented than their White, male peers in such jobs, given that they have had to engage in more complicated tasks: Not only successfully bidding for recognition, but doing so while avoiding having negative identities ascribed to them and finding places where their racial and gendered identities do indeed intersect with their science identities, so that they do not have to step away from one identity to achieve another.

It is logical to assume that if successful women worked in spaces that allowed them to use all their talents on advancing science, they would be more productive. This perspective of the discrimination load is compounded when considering intersecting identities such as race, ethnicity, and gender. This inquiry would further demonstrate the need for learning how to facilitate inclusive science classrooms and workplaces for people of diverse backgrounds.

Learning Experiences to Impact Individuals in Positions of Power

The third question to investigate for future inquiry is: What are some effective ways for helping men in positions of power to become sensitized to the experiences of women in science?

Everyone in the workplace sustains organizational norms, especially individuals in positions of power. People in positions of power can be supervisors and individuals who are able to guide cultural norms. In the current state of science communities, the majority of people in these positions are White men. From the data, women often describe having men as mentors and reporting to men. Therefore, research should aim to learn how to educate people in positions of power about the value and necessity of work environments that are welcoming to many people of intersecting identities. Carlone, Webb, Archer, and Taylor (2015) explored how this privilege continues to be reproduced. This study investigated what kind of boy does science. They discussed the problem of a shallow understanding of the White male who does science. This understanding is required to sensitize them to the experiences of women in science. DiAngelo (2011, 2018) discussed how White people commonly respond to discussions about race, power, and privilege by expressing that they feel victimized and blamed for other people's problems. From this perspective, White men in positions of power in science communities can separate themselves from the experiences and struggles of the men and women that they oversee.

Study Limitations

Lack of Observational Data

The first limitation of the study is that the only form of data collected was interviews. Observational data would have assisted my ability to respond to the interview questions because I would have been able to see their experiences. After observing participants, I could have clarified my observations through follow-up questions. Also, during the interviews, I asked

participants to recall events that occurred in the past and then describe them. This may have affected the accuracy of their descriptions.

Lack of Sociodemographic Data to Guide Sampling

Thorough precollege sociodemographic data were not collected prior to the interviews of this study. I could not select participants based on race and precollege socioeconomic status resulting in most of the women in the sample being White. A more racially diverse sample would have allowed me to respond to the second research question with greater accuracy. Furthermore, having diversity among precollege socioeconomic status may have changed my response to research question number two. Therefore, the finding that no differences existed based on precollege socioeconomic status should be understood with caution.

Concluding Remarks

Understanding the experiences of successful women in science from an identity development lens is informative for educators and science industries. This study provides insight into how educators can support girls in science because the findings reveal what was meaningful to the identity development of the participants. Participants had access to authentic science experiences that provided positive reinforcement to their inquisitive nature. Therefore, both boys and girls should have access to authentic science experiences. These experiences should value the struggle of science to help students develop persistence in the process of discovering new knowledge. Participants' experiences were supported by a substantial support system with

people who were relatable and were able to help them in specific ways. Therefore, students and employees should have access to a network of mentors during their development. Students should also learn how to take agency in their science experiences.

This study also provides insight into how to support women who are currently scientists in industry and working as college faculty. All participants described how they experienced sexual discrimination. Two participants described how they experienced racial discrimination. Therefore, professional standards should be expected from all employees. Employees should have anonymous methods to report discriminatory behaviors. Finally, organizations should structure mentoring systems that are supportive of mentees' needs.

APPENDIX A:
INTERVIEW PROTOCOL BLUEPRINT

My blueprint offers connections between research questions and the main interview questions. Furthermore, rationale is given using constructs identified in the conceptual framework. The main constructs of the conceptual framework are the following: identity work, figured worlds, and identity development. Patriarchy, gender, and norms of the science community may be described in each response. The interview protocol that follows this blueprint was used for the pilot study and this research study.

The following are the research questions:

1. What are the experiences of successful women serving in science fields?
    a. What were participants' experiences in science classrooms prior to and during college?
    b. What were participants' early work experiences in science?
    c. What are participants' current experiences as science professionals?
2. If any, what are the differences in participants' experiences based on race and socioeconomic status?
3. What design principles can we derive from the experiences of successful women in science to make educational and work contexts more inclusive?

Interview One Blueprint

Number	Interview question/prompt	Research question	Rationale
1.	Going as far back as possible, please tell me about yourself prior to becoming a science professional as it relates to science.	All	Participants will be prompted to provide their socioeconomic status, race, and educational backgrounds to help ascertain possible differences in participants' experiences based on these factors. Therefore, concepts of intersectionality will be identified that will help contextualize responses that follow.
2.	How did you become a science professional?	All	This question prompts her to provide more specific context than the previous question to her current position as a science professional.
3.	What was your earliest memory of being interested in science? Please describe that experience as much as you can.	1a, 2, and 3	These questions prompt participants to discuss their experiences in terms of identity formations and figured worlds. Gender norms of the science community may be discussed as well. These questions will help me understand the influential components that affect their science identity development and practice.
4.	As much as you can, please describe an experience during your time as college student that would help me understand your development in science.	1b, 2, and 3	
5.	Try to remember when someone else noticed your interests and skills in science. Please describe that person and your interactions with her or him as much as possible.	All	The figured worlds of participants may include another person who played a significant role in their journey. A description of this person and relevant interactions would offer important data about each participant's social practice.
6.	I want to take away a clear and complete picture of your experiences in science; is there anything else that I should know?	All	This question provides participants an opportunity to add relevant information based on their understanding of the purpose of the study and the questions that were asked.

7.	Member-check Paraphrase the key data and inferences 1. Participant background 2. Description of pre-college science experiences 3. Description of college science experiences Ask for responses and clarification.	All	This prompt reminds me to take a step in ensuring that the data are trustworthy.

Interview Two Blueprint

Number	Interview question/prompt	Research question	Rationale
1.	As much as you can, please describe a recent experience in your workplace that would help me understand what it is like to work there.	1c, 2, and 3	These questions prompt participants to discuss their experiences in terms of identity formations and figured worlds. Gender norms of the science community may be discussed as well. These questions will help me understand the influential components that affect their science identity development and practice.
2.	Similar to the prior question, please tell me about a work project that helps me understand the type of work you do, who you collaborate with, and the role you usually take in work projects.	1c, 2, and 3	This question continues into understanding factors of figured worlds that affect participants' daily social and technical practices in the workplace.
3.	I want to take away a clear and complete picture of your professional experiences in science; is there anything else that I should know?	All	This question provides participants an opportunity to add relevant information based on their understanding of the purpose of the study and the questions that were asked.
4.	Member-check Paraphrase the key data and inferences 1. Description of participant's current work experience 2. Description of the type of work that the participant does Ask for responses and clarification.	All	This prompt reminds me to take a step in ensuring that the data are trustworthy.

Interview Three Blueprint

Number	Interview question/prompt	Research question	Rationale
1.	Given what you told me about yourself prior to becoming a science professional, how does being a scientist affect your identity?	All	Prompts participants to describe the meaning that science has in their lives.
2.	How does science make sense to you?	All	Prompts participants to discuss what is logical about science.
3.	How do your experiences in science not make sense to you?	All	Prompts participants to discuss what is illogical about science.
4.	Given what you said prior to this point, where do you see yourself going in the future?	All	Provides an opportunity for participants to discuss their futures in relation to science.
5.	I want to take away a clear and complete picture of you experiences in science; is there anything else that I should know?	All	This question provides participants an opportunity to add relevant information based on their understanding of the purpose of the study and the questions that were asked.
6.	Member-check Paraphrase the key data and inferences 1. Understanding of being a science professional. 2. What is reasonable and unreasonable about being a science professional? 3. What are you future plans as they relate to being a science professional? Ask for responses and clarification.	All	This prompt reminds me to take a step in ensuring that the data are trustworthy.

APPENDIX B:
INTERVIEW ONE PROTOCOL

Objective: to build context for her experience.

Number	Main question	Prompts and elicitations
1.	Going as far back as possible, please tell me about yourself prior to becoming a science professional as it relates to science.	What were your experiences in the following areas as related to science: • School • Family • Friends • Neighborhood • Work
2.	How did you become a science professional?	What events led you to becoming a science professional? • Summer programs • After school programs • Science fair
3.	What was your earliest memory of being interested in science? Please describe that experience as much as you can.	• Why is this important to you? • Who was involved? • What resources, if any, were needed? • What feelings and emotions are associated with what or who you described? • What were the long-term effects?

4.	As much as you can, please describe an experience during your time as a college student that would help me understand your development in science.	• Other than guided by program requirements, how did you decide what courses you would take? • Describe a laboratory experience that would help me understand this type of experience in your coursework? • Describe an early work experience that would help me understand your preparation for a career in science.
5.	Try to remember when someone else noticed your interests and skills in science. Please describe that person and your interactions with her or him as much as possible.	Possible people could be: • Family member • Mentor • Teacher or professor • Scientist or engineer
6.	I want to take away a clear and complete picture of your experiences in science; is there anything else that I should know?	
7.	Member-check Paraphrase the key data and inferences 1. Participant background 2. Description of pre-college science experiences 3. Description of college science experiences Ask for responses and clarification.	

APPENDIX C:
INTERVIEW TWO PROTOCOL

Objective: to learn the descriptions of her current experience in science.

1.	As much as you can, please describe a recent experience in your workplace that would help me understand what it is like to work there.	• How does this experience represent your work?
2.	Similar to the prior question, please tell me about a work project that helps me understand the type of work you do, who you collaborate with, and the role you usually take in work projects.	• Who is usually involved? • How does this project represent the type of work you do?
3.	I want to take away a clear and complete picture of your experiences in science; is there anything else that I should know?	
4.	Member-check Paraphrase the key data and inferences 1. Description of participant's current work experience 2. Description of the type of work that the participant does Ask for responses and clarification.	

APPENDIX D:
INTERVIEW THREE PROTOCOL

Objective: to reflect on the meaning of her experience.

1.	Given what you told me about yourself prior to becoming a science professional, how does being a scientist affect your identity?	• What meaning does being science professional have to you?
2.	How does science make sense to you?	• What is reasonable about being a science professional?
3.	How do your experiences in science not make sense to you?	• What is unreasonable about being science professional?
4.	Given what you said prior to this point, where do you see yourself going in the future?	• What are your five-year and 10-year plans?
5.	I want to take away a clear and complete picture of you experiences in science; is there anything else that I should know?	
6.	Member-check Paraphrase the key data and inferences 1. Understanding of being a science professional. 2. What is reasonable and unreasonable about being a science professional? 3. What are your future plans as they relate to being a science professional? Ask for responses and clarification.	

APPENDIX E:
IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Determination of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Jonathan L. Hall**

Date: **December 13, 2017**

Dear Researcher:

On 12/13/2017, the IRB reviewed the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	A Phenomenological Study of the Experiences of Successful Women in Science Fields
Investigator:	Jonathan L. Hall
IRB Number:	SBE-17-13635
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

This letter is signed by:

Signature applied by Gillian Morien on 12/13/2017 01:48:35 PM EST

Designated Reviewer

APPENDIX F:
EXPLANATION OF EXEMPT RESEARCH

EXPLANATION OF RESEARCH

Title of Project: A Phenomenological Study of the Experiences of Successful Women in Science Fields

Principal Investigator: Jonathan Hall, Science Education Ph.D. Candidate

Faculty Supervisor: Dr. Malcolm B. Butler, Ph.D., Professor of and Program Coordinator of Science Education

You are being invited to take part in a research study. Whether you take part is up to you. You can stop participating at any point without penalty.

The purpose of this study is to learn about the experiences of successful women in science fields. Understanding your experiences may help science educators and employers structure more inclusive environments for all genders with the understanding of meaningful factors that help participants achieve success in their journeys.

You will be asked to interview for roughly one hour on three occasions. Ideally, there will be no longer than a week between interviews. The first interview will focus on your life history as it pertains to science. Then, the second interview will concentrate on your descriptive experiences as a professional. Finally, the third interview will attend to the reflections of what you discussed in previous interviews. Your permission will be requested to audio record the interviews. These audio recordings will be used for research purposes that uphold your confidentiality. After transcription, audio recordings of your interviews will be destroyed.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints: Jonathan Hall, Ph.D. Candidate, Science Education, UCF College of Education and Human Performance, (920) 296-4754 or by email at Jonathan.Hall@ucf.edu or Dr. Malcolm B. Butler, Faculty Supervisor, UCF College of Education and Human Performance, at (407) 823-3272 or by email at Malcolm.Butler@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

REFERENCES

Alexander, J. M., Johnson, K. E., & Kelley, K. (2012). Longitudinal analysis of the relations between opportunities to learn about science and the development of interests related to science. *Science Education, 96*(5), 763-786.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). "Balancing acts": Elementary school girls' negotiations of femininity, achievement, and science. *Science Education, 96*(6), 967-989.

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). The "Exceptional" Physics Girl: A Sociological Analysis of Multimethod Data From Young Women Aged 10–16 to Explore Gendered Patterns of Post-16 Participation. *American Educational Research Journal, 54*(1), 88-126.

Atwater, M. M. (2000). Females in science education: White is the norm and class, language, lifestyle, and religion are nonissues. *Journal of Research in Science Teaching, 37*(4), 386-387.

Atwater, M. M., Lance, J., Woodard, U., & Johnson, N. H. (2013). Race and ethnicity: Powerful cultural forecasters of science learning and performance. *Theory Into Practice, 52*(1), 6-13.

Basu, S. J., & Calabrese Barton, A. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching, 44*(3), 466-489.

Baudron, F., & Giller, K. E. (2014). Agriculture and nature: Trouble and strife? *Biological Conservation, 170*, 232-245.

Bevan, M. T. (2014). A Method of Phenomenological Interviewing. *Qualitative Health Research, 24*(1), 136-144. doi:doi:10.1177/1049732313519710

Borlaug, N. (2007). Feeding a hungry world. *Science, 318*(5849), 359-359.

Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45*(9), 971-1002.

Butler, J. (1990). *Gender trouble and the subversion of identity*. New York, NY: Routledge.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal, 50*(1), 37-75.

Calabrese Barton, A., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *The Journal of the Learning Sciences, 19*(2), 187-229.

Carlone, H. B. (2004). The cultural production of science in reform ‐ based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching, 41*(4), 392-414.

Carlone, H. B. (2017). Disciplinary Identity as Analytic Construct and Design Goal: Making Learning Sciences Matter. *Journal of the Learning Sciences, 26*(3), 525-531. doi:10.1080/10508406.2017.1336026

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187-1218.

Carlone, H. B., Johnson, A., & Scott, C. M. (2015). Agency amidst formidable structures: How girls perform gender in science class. *Journal of Research in Science Teaching, 52*(4), 474-488.

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching, 51*(7), 836-869.

Carlone, H. B., Webb, A. W., Archer, L., & Taylor, M. (2015). What kind of boy does science? A critical perspective on the science trajectories of four scientifically talented boys. *Science Education, 99*(3), 438-464.

Colaizzi, P. F. (1978). Psychological research as the phenomenologist views it. In R. S. Valle & M. King (Eds.), *Existential-Phenomenological Alternatives for Psychology* (pp. 6): Oxford University Press.

Collins, P. H. (2015). Intersectionality's definitional dilemmas. *Annual Review of Sociology, 41*, 1-20.

Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Curran, F. C., & Kellogg, A. T. (2016). Understanding science achievement gaps by race/ethnicity and gender in kindergarten and first grade. *Educational Researcher, 45*(5), 273-282.

DeBoer, G. E. (1991). *A history of ideas in science education: Implications for practice*. New York, NY: Teachers College Press.

DiAngelo, R. (2011). White fragility. *The International Journal of Critical Pedagogy, 3*(3).

DiAngelo, R. (2018). *White fragility: Why it's so hard to talk to white people about racism*. Boston, MA: Beacon Press.

Due, K. (2014). Who is the competent physics student? A study of students' positions and social interaction in small-group discussions. *Cultural Studies of Science Education, 9*(2), 441-459. doi:10.1007/s11422-012-9441-z

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological review, 95*(2), 256.

Eagan Jr., M. K., Hurtado, S., Chang, M. J., Garcia, G. A., Herrera, F. A., & Garibay, J. C. (2013). Making a difference in science education: the impact of undergraduate research programs. *American Educational Research Journal, 50*(4), 683-713.

Fang, F. C., & Casadevall, A. (2015). Competitive science: is competition ruining science? *Infection and Immunity*, IAI. 02939-02914.

Ferrante-Wallace, J., & Brown, P. (2001). *The social construction of race and ethnicity in the United States*. Upper Saddle River, N.J: Prentice Hall.

Flyvbjerg, B. (2001). *Making social science matter : why social inquiry fails and how it can succeed again*: Oxford, UK ; New York : Cambridge University Press, 2001.

Francis, B. (2000). The gendered subject: Students' subject preferences and discussion of gender and ability. *Oxford Review of Education, 26*, 35-48.

Gall, M., Gall, J., & Borg, W. (2007). *Educational research: An introduction* (8th ed.). Boston, MA: Pearson.

Hatt, B. (2007). Street smarts vs. book smarts: The figured world of smartness in the lives of marginalized, urban youth. *The Urban Review, 39*(2), 145-166.

Hernandez, P. R., Bloodhart, B., Barnes, R. T., Adams, A. S., Clinton, S. M., Pollack, I., . . . Fischer, E. V. (2017). Promoting professional identity, motivation, and persistence: Benefits of an informal mentoring program for female undergraduate students. *PloS one, 12*(11), e0187531.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. In. Retrieved from https://www.aauw.org/files/2013/02/Why-So-Few-Women-in-Science-Technology-Engineering-and-Mathematics.pdf

Holland, D. C., Lachichotte Jr., W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

hooks, b. (2000). *Feminism is for everybody: Passionate politics*. Cambridge, MA: South End Press.

Implicit, P. (2011). Retrieved from https://implicit.harvard.edu/implicit/index.jsp

Johnson, A., Brown, J., Carlone, H., & Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. *Journal of Research in Science Teaching, 48*(4), 339-366. doi:10.1002/tea.20411

Kohlhaas, K., Lin, H.-H., & Chu, K.-L. (2010). Science equity in third grade. *The Elementary School Journal, 110*(3), 393-408.

Kuyper, T. W., & Struik, P. C. (2014). Epilogue: global food security, rhetoric, and the sustainable intensification debate. *Current Opinion in Environmental Sustainability, 8*, 71-79.

Maerten‐Rivera, J., Myers, N., Lee, O., & Penfield, R. (2010). Student and school predictors of high‐stakes assessment in science. *Science Education, 94*(6), 937-962.

Mason, J. (2002). *Qualitative Researching* (2nd ed.). London: Sage.

Merleau-Ponty, M. (1956). What is Phenomenology? *CrossCurrents, 6*(1), 59-70.

Minikel-Lacocque, J. (2013). Racism, college, and the power of words: Racial microaggressions reconsidered. *American Educational Research Journal, 50*(3), 432-465.

Mutegi, J. W. (2011). The inadequacies of "Science for All" and the necessity and nature of a socially transformative curriculum approach for African American science education. *Journal of Research in Science Teaching, 48*(3), 301-316.

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching, 55*(2), 206-245. doi:doi:10.1002/tea.21417

Patton, M. Q. (1990). *Qualitative evaluation and research methods*: SAGE Publications, inc.

Quinn, D. M., & Cooc, N. (2015). Science achievement gaps by gender and race/ethnicity in elementary and middle school: Trends and predictors. *Educational Researcher, 44*(6), 336-346.

Robert, J., & Carlsen, W. S. (2017). Teaching and research at a large university: Case studies of science professors. *Journal of Research in Science Teaching*.

Rosa, K., & Mensah, F. M. (2016). Educational pathways of Black women physicists: Stories of experiencing and overcoming obstacles in life. *Physical Review Physics Education Research, 12*(2), 020113.

Sanders, C. (2003). Application of Colaizzi's method: Interpretation of an auditable decision trail by a novice researcher. *Contemporary Nurse, 14*(3), 292-302. doi:10.5172/conu.14.3.292

Scantlebury, K. (1995). Challenging gender-blindness in preservice secondary science teachers. *Journal of Science Teacher Education, 6*(3), 134-142.

Scantlebury, K. (2014). Gender Matters: Building on the past, recognizing the present, and looking toward the future. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of Research on Science on Education* (Vol. 2, pp. 187-203). New York, NY: Routledge.

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and social sciences*. In. Retrieved from http://library.ucf.edu/

Skelton, C., Francis, B., & Read, B. (2010). "Brains before 'beauty'?" High achieving girls, school and gender identities. *Educational Studies, 36*(2), 185-194.

Tytler, R. (2014). Attitudes, identity, and aspirations towards science. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of Research on Science Education* (pp. 82-103). New York, NY: Routledge.

Weinburgh, M. (1995). Preparing gender inclusive science teachers: Suggestions from the literature. *Journal of Science Teacher Education, 6*(2), 102-107.

Whitehead, J. M. (1996). Sex stereotypes, gender identity and subject choice at A‐level. *Educational Research, 38*(2), 147-160.

Xie, Y., Fang, M., & Shauman, K. (2015). Stem Education. *Annual Review of Sociology, 41*, 331-357.