Gender, Ethnicity, and Physics Education: Understanding How Black Women Build Their Identities as Scientists

Katemari Diogo da Rosa

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

COLUMBIA UNIVERSITY

2013

ABSTRACT

Gender, Ethnicity, and Physics Education:

Understanding How Black Women Build Their Identities as Scientists

Katemari Diogo da Rosa

This research focuses on the underrepresentation of minoritized groups in scientific careers. The study is an analysis of the relationships between race, gender, and those with careers in the sciences, focusing on the lived experiences of Black women physicists, as viewed through the lens of women scientists in the United States. Although the research is geographically localized, the base-line question is clear and mirrors in the researcher's own intellectual development: "How do Black women physicists describe their experiences towards the construction of a scientific identity and the pursuit of a career in physics?" Grounded on a critical race theory perspective, the study uses storytelling to analyze how these women build their identities as scientists and how they have negotiate their multiple identities within different communities in society. Findings show that social integration is a key element for Black women physicists to enter study groups, which enables access to important resources for academic success in STEM. The study has implications for physics education and policymakers. The study reveals the role of the different communities that these women are part of, and the importance of public policies targeted to increase the participation of underrepresented groups in science, especially through after-school programs and financial support through higher education.

TABLE OF CONTENTS

List of Figures

List of Tables

Acknowledgements

Many are the people and institutions that made this work possible. First and foremost, I thank Ruth Maria Diogo, my mother and cheerleader. Thanks for the support, the love, and all the care packages. I would like thank Felicia Moore Mensah, my advisor and guide through the academic world in the United States. I cannot thank you enough for the hard work on the editing of this dissertation. I would like to thank my dissertation committee of Janet L. Miller, Felicia Moore Mensah, O. Roger Anderson, Erica Walker, and Alondra Nelson. Thank you for the thorough reading, thoughtful questioning, and caring comments. I also thank the Brazilian government through CAPES, the Fulbright Program, Comissão Fulbright Brasil, and the Office of Diversity at Teachers College, for the financial support. I am also grateful for all the friends that made my stay in New York City feels like home. A special thanks to my Fulbright family, and to my great friend Stefanie Macaluso. Lastly, I would like to thank the participants of this study: Allyson, Betty, Christa, Esther, Jane, and Shanna. They opened their lives with me, shared precious time, and are, ultimately, the reason this study was possible.

Dedication

Para minha mãezinha, sempre, sempre, sempre!

CHAPTER I

INTRODUCTION

> "(…) being poor, of Color, and also a woman results in daily experiences that create a systematically different relationship to knowledge [including its production, comprehension, and integration]." (Hurtado, 1996, p. 372)

In spite of the globalization phenomenon, women of African descent have distinct cultural experiences according to their ethnic origins. These experiences are intrinsically participating in their understanding of the world, and therefore constitute elements that shape those women's images of science and scientists. Consequently, those women relate to science in distinct ways. This work is a result of my trajectory not only academically but also personally; it investigates the experiences of Black women who pursue a career in the sciences, specifically in physics.

I grew up in southern Brazil where the majority of the population is of German or Italian descent, and so, being a Black female, I was always of minority status. Therefore, when studying physics in my college years, it did not surprise me that I had no Black professors. For my master's degree, however, I moved to northeastern Brazil to the state of Bahia. Salvador, the capital, has nearly three million inhabitants of whom 80% are of African descent (IBGE, 2010). It shocked me to find only one Black professor at the Physics Institute. I earned a degree in History and Philosophy of Science and Science Education and started working as a visiting professor in the physics department of a large public university. I was the only Black woman faculty in the physics department, and we were four women among twenty-six faculty.

As a combination of my living environments, my work experience, academic studies, and political views, the issues of Black women in science arise. As a Black woman physicist, with a background working with social movements, and sensitive to issues of inequalities, I feel it is my responsibility to question the absence of Black women in science in Brazil. Similar to the demand for recognition of the particularities of Black women inside the feminist movements (Collins, 2000), it is reasonable to examine Black women within the discussions about women in science.

Although the motivation for my research sprung from the status of Black women in science in Brazil, this is a study about Black women in science in the United States. In the first section of this dissertation, I present a discussion of the status of Black women in science in Brazil as a means to explain why I engaged in this research topic and to disclose my intellectual journey to arrive in the research questions that guide this investigation. A more detailed treatment of the topic is presented in a review of literature related to the broader questions of the study in subsequent sections of the dissertation.

Black Women in Scientific Careers in Brazil

Discussions about the inclusion of women in science are not a new topic in Brazilian literature (Leta, 2003), but it is still incipient and it is not integrated in the research in science education (Megid, 1998; Rosa, 2008). A review of the top five impact index Brazilian science education journals published between 1997 and 2011 revealed only one article with a focus on gender and science education. The article (Rezende & Ostermann, 2007) presents a literature review on gender in science education. The authors find that, initially, scholars developed studies in gender and science education from a biological perspective; they focused on the search for cognitive factors that explain possible differences in educational achievement between boys and girls. Currently, scholars address these issues as cultural and discuss them in a socio-cultural framework. The authors also report that in Brazil the discussion is scarce or nonexistent in science education journals; the scenario is even worse in physics education.

Rezende and Ostermann (2007) mention the role of an ethnic affiliation when reporting Chinn's (2002) study on Asian scientists. Chinn conducted interviews with four Asian women to understand what influenced their choice of scientific careers. This study proved revealing in regards to the influences that family and school can have on the career choices of women. The interviews focused on questions about family, childhood memories, school experiences, social factors related to teachers, family and community, gender and ethnicity, professional identity, and expectations for the future. While analyzing these results, Rezende and Ostermann discussed implications for the Brazilian scenario. They highlighted the traditional and chauvinist culture of the country. Although reporting ethnic discussions, they did not address issues of race and ethnicity in their work. This reinforces the role of the researcher when analyzing research from an ethnic perspective.

Despite the lack of debate within the science education community in Brazil regarding gender in science, scholars recognize the underrepresentation of in the sciences and that it is important to study the factors that lead to this exclusion. Moreover, it is necessary to find alternatives to address this exclusion and to reverse the situation.

However, in regards to the discussion of low representation of Black people in the scientific world, the debate does not exist at all in that country.

The Brazilian National Council for Research and Development (Conselho Nacional de Pesquisa e Desenvolvimento - CNPq) publishes biannually a census of the national scientific production, and gender is one of the categories present in the census. However, the census ignores race or ethnicity. Racial inclusion in the sciences does not seem to be a relevant question within the Brazilian scientific community, or at least is not a priority. It is hard even to make any quantitative analysis of the presence of Black people in the Brazilian scientific production, as there is a lack of data precluding the use of an empirical basis to justify the discussion.

The only educational data that includes race as a category comes from the Brazilian Institute of Geography and Statistics (IBGE). This institute offers extensive data on the levels of education, literacy, retention, and repetition, but only for the basic school system, which is equivalent to grades K-12 in the United States. The Atlas Racial Brasileiro[1] reveals educational differences between White and Black women, the former being generally more successful than the latter (Atlas, 2005). These data suggest that there may be differences also in the presence of Black women in the scientific world. Therefore, it is important to recognize the need of studying the low representation of Black women in the sciences in Brazil.

While thinking of racial and ethnic minorities as something new in Brazil, this is not the case in the international arena. In the United States, in comparison, the literature

[1]Atlas Racial Brasileiro (Brazilian Racial Encyclopedia) consists in a database available electronically. It is the result of a study developed by the United Nations Development Program (PNUD) in a partnership with the Centro de Desenvolvimento e Planejamento Regional (Center for Regional Planning and Development), from Federal University of Minas Gerais, using data from the IBGE census from 1991 to 2002.

largely addresses this issue – even though there is a severe underrepresentation of Black women in sciences (and physics) in the United States. Nevertheless, the understanding of the few successful cases of Black women in physics in the United States can contribute to the understanding of the exclusions experienced in Brazil, and foster the inclusion of women of African descent in the sciences.

Purpose and Research Questions

The purpose of this study is twofold. First, to describe the lived experiences of Black women physicists from the United States, focusing on their academic trajectories. Second, investigating how these women develop their scientific identity throughout the years. This study uses a qualitative research framework to understand how Black women build their identities as physicists. The study answers the following research questions:

1. How does a Black woman physicist describe her experiences towards the construction of a scientific identity?
    a. What are the personal and professional trajectories of this woman?
    b. What factors, experiences, and contexts she attributes to her career choices?
2. How do Black women physicists negotiate their multiple identities?
3. What do Black women physicists identify as obstacles in their career paths?
    a. What strategies do they use to overcome these obstacles?

Significance and Implications

The investigations on underrepresented groups in science have received significant attention; however, there is still a gap in the literature related to the success and experiences of Black women in physics. Thus, it is necessary to build a framework for understanding how Black women choose, and then pursue, careers in the sciences. In addition, the understanding of the life experiences of women of color in physics in the United States can serve as a baseline for studies of marginalized populations in the sciences in other countries.

Structure of the Dissertation

First, I introduce a discussion about women in scientific careers in Brazil and the United States, showing what scholars investigated and uncovering gaps in the literature. Second, I present the approaches that help me developing a theoretical framework for this research. Next, I discuss my methodological choices and summarize the data collection procedures. The core chapters of the dissertation are two stand-alone articles. The first article, chapter four, is the life story of Christa, one of the Black women physicists interviewed in this study. The chapter offers a detail recount of Christa's experiences towards the development of her identity as a physicist, and addresses my first research question. The second paper, chapter five, provides an aggregated data analysis with all the six participants of the study and discussion of the emergent themes found from the data, addressing research questions two and three. Following, I summarize the findings, outline the limitations of the study, and discuss final considerations. I close the work with a personal statement telling the researcher's story.

CHAPTER II

REVIEW OF THE LITERATURE

Considering that research on Black women in scientific careers is nonexistent in Brazil, my rationale was that it was necessary to search for sources outside the country to gather a better understanding on this area. Because researchers in the United States have been concerned with the underrepresentation of particular groups in science (Lewis, 2003), I focus on the experiences and literature produced in this country. In this chapter, I review works on the status of Black women in scientific careers in the United States, followed by a critical discussion of significant contributions to the literature that connects gender, ethnicity, race, and science. Finally, I discuss a conceptual framework that emerges from my personal worldviews aligned with feminist and critical race theory perspectives.

Black Women in STEM in the United States

The number of Black people that have received bachelor degrees in Science, Technology, Engineering, and Mathematics (STEM) fields has increased by 34% between 1995 and 2004 (Perna et al., 2009), which shows progress. However, the underrepresentation of this racial/ethnic group remains high. In 2004, while Black people were 12% of the overall population in the United States (U.S. Census Bureau, 2010); they represented only 7% of the bachelor degree recipients in science and engineering fields in that year. The situation worsens as the degree level increases. In the same year, Black people were responsible for 3.3% of all masters' and 1.9% of all doctoral degrees awarded in science and engineering (Perna et al., 2009).

As an expected consequence of the low level of doctoral degree production, there are very few people of African descent[2] occupying faculty positions. Of all full-time faculty at four-year institutions in engineering, only 4.9% were of Black people in fall 2003, and in the same period only 3.4% of all full-time faculty at four-year institutions in the natural sciences were of African descent (Perna et al., 2009).

The situation of Black people, in general, in STEM fields in the United States is of underrepresentation; however, Black women suffer from a double jeopardy (Sidanius & Veniegas, 2000), that is, they are racially/ethnically discriminated against, and amongst the Black population, they suffer from gender discrimination. There is a considerable gender gap within Black people in STEM fields. For example, Black women received only 36% of all bachelor's degrees awarded to Black people in engineering in 2001 (Perna et. al, 2009). The only scientific field where African American women (and women in general) are overrepresented is in the biological sciences, where 72% of bachelor degrees were awarded to Black people in biological sciences in 2001 (Perna et al.).

These numbers provide a panoramic view of the insertion of Black in scientific careers in the United States, but they cannot give information about what happens on the individual level. For an account of the struggles, perceptions, and experiences of Black people pursuing scientific careers it is necessary to check the qualitative research produced in this area. I classify that research into two types according to their approach.

---

[2] The terms Black people and people of African descent will be used interchangeably along this text. The terms African American and people of color will be used in quotations when the original authors have adopted the term. All the six participants in this study identified themselves as Black or African American. I identify myself as a Latin American Black Brazilian woman and reserve the term American for all the peoples of the Americas.

There are investigations that concentrate on the reasons of failure of minoritized groups in the sciences (e.g., Johnson, 2007; Love, 1993; Oakes, 1990, 1990a; Powell, 1990; Seymour & Hewitt, 1997; Steele, 1997), and there are works that focus on the successful cases that seek to understand their histories (e.g., Massey, 1992; Maton, Hrabowski & Schmitt, 2000; McCauley, 1988; Moore, 2001; Townsend, 1994; Walker, 2012). This study focuses on the positive perspective. Even though I recognize the relevance of revealing and understanding the reasons that exclude Black people from the sciences, I believe it is also important to look at the experiences of those who have overcome the challenges they faced.

In this direction, the literature indicates that at the individual level strong pre-college science experiences, family support, teacher encouragement, intrinsic motivation, and perseverance as critical factors for the success of minoritized students in scientific academic programs (Brown, 2002; Carlone & Johnson, 2007; Russell & Atwater, 2005). Although the literature gives some clues to explain the success of minoritized students in scientific careers, Carlone and Johnson (2007) argue that it is necessary to build a richer theoretical framework that takes into consideration “the complex interplay between structure and agency and the ways these tensions play out over time” (p. 1188). These authors developed a grounded model of science identity aiming to “provide a theoretical and methodological springboard for other researchers who concern themselves with identity and the problem of underrepresented groups in science” (p.1189).

Scientific Identity

Carlone and Johnson (2007) designed a prototype theoretical model of science identity. They describe a person (female scientist) who would have a strong science identity as someone who:

> [...] is competent; she demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world scientifically. She also has the requisite skills to perform for others her competence with scientific practices (e.g., uses of scientific tools, fluency with all forms of scientific talk and ways of acting, and interacting in various formal and informal scientific settings). Further, she recognizes herself, and gets recognized by others, as a 'science person.' (p. 1190)

Their model shows three dimensions of science identity: competence, performance, and recognition; these dimensions overlap, as shown in Figure 2.1.

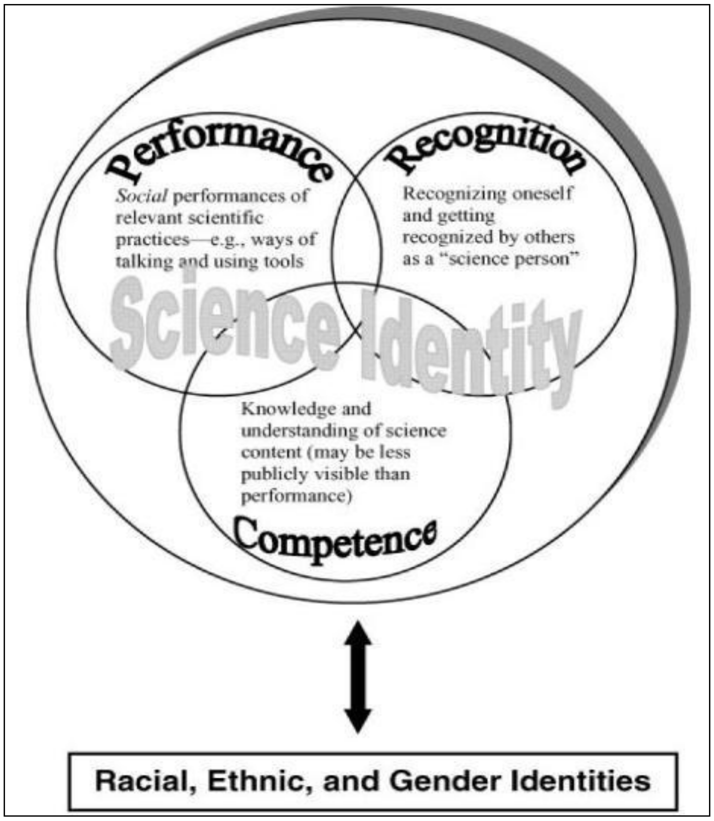


Figure 2.1: Prototype model of science identity (Carlone & Johnson, 2007).

They grounded this model on data obtained from 15 women who majored in scientific fields, and participated in an ethnographic study on female students of color in science programs. The participants of the study included four Latinas, four Black women, four American Indians, and four Asian Americans.

Carlone and Johnson's (2007) contribution is not only in the development of a theoretical framework, but also in making explicit a connection between science identity, gender, race, and ethnic affiliations. They claim that their "science identity model is based on an assumption that one's gender, racial, and ethnic identities affect one's science identity, a connection hinted at, but not made explicit, in previous literature" (p. 1191). Coherently, the authors explicitly discuss their assumptions about identity, ethnicity, and race:

> *Identity is not* [emphasis added] simply what an individual says about her relationship to, abilities in, or aspirations regarding science [....] In our conceptualization, science identity is both situationally emergent and potentially enduring over time and context [....] The women in this study all identify themselves as women of color, a term with both ethnic and racial components. *By ethnicity* [emphasis added], we mean systems of meaning shared among a group. *By race* [emphasis added], we mean what students, at first glance, 'look like'. (p. 1192-1193)

However, they do not explicitly state their assumptions about gender and science.

Even though a gender discussion is relevant, I will restrict my analysis to their lack of an explicit reflection on science. Because the development of a model for scientific identity is the goal of the authors, and since they made an extensive discussion on the concept of identity, I would expect to see at least some discussion on the concept of science in Carlone and Johnson's work. Nevertheless, the lack of discussion about the science itself leads to a problem with the data the researchers used to ground their theory.

First, Carlone and Johnson (2007) conducted a study with 15 women that had majors in Molecular biology (7), Biochemistry (2), Psychology/population biology (1), Kinesiology (2), Anthropology (1), Chemistry (1), and Population biology (1). Two questions arise from this sample choice: what areas the authors considered as science, and women's overall representation in their chosen scientific fields. Anthropology is usually considered a social science in the humanities, but a woman with a major in anthropology was used to ground a theory as if anthropology had the same epistemological status of chemistry and physics. Therefore, the discussion of what accounts for science is not just necessary but fundamental. The second issue from the sample choice is that the majority of the participants were not from an underrepresented group in science; in fact, it was quite the opposite: Biology is the only scientific field where women in general, and those of African descent in particular, are over-represented (Perna et al., 2009).

Carlone and Johnson (2007) discuss the rigor in their research validation process that included triangulation and member checking. However, the lack of a deeper discussion of science compromises the research results in spite of their methodological efforts. They claim to have "…placed more trust in findings that emerged from several different data sources" (p. 1196), and "…had already tentatively grouped students into identity categories when [they] discovered that all women in the research scientist identity category were pursuing PhDs in science research [...] this provided strong support for [their] groupings" (p. 1196). However, in their sample, only two women were pursuing Ph.D.'s (Table 1, p. 1194). One of those had a major in Molecular Biology, not an underrepresented field, and the other pursued her degree in Medicine, which some scholars arguably do not categorize as a science (Rudnick, 2004; Vasconcellos & Pignati, 2006). In addition, Carlone and Johnson (2007) affirm in their findings "almost every woman in this study made statements associating her interest in science with her altruistic career goals" (p. 1209). From that they suggest that an emphasis in the relationships between science and altruism "could encourage more women of color to enter health professions" (p. 1209), which is a valid argument, yet different from their initial assumptions and goals that were linked to underrepresented women in science fields, not only in health professions. At this point, the authors talk about health professions not scientific professions.

Finally, from a more positive aspect, Carlone and Johnson's (2007) study constituted a relevant shift in the investigations on underrepresented groups in science. Their merit consisted in explicitly considering the relationships between identity, science identity, gender, race, and ethnic affiliations. However, the study still leaves a gap in the literature, namely, a framework for understanding how a woman of African descent might choose, and then pursue, a career in the sciences.

In this dissertation study, I propose another framework to analyze the participation of underrepresented groups in science, which emerges from an inquiry into the data that I collected that is grounded on feminist, identity theories, critical theory, and critical race theory.

Conceptual Framework

Part of my journey to design a research study to investigate Black women's scientific identities involved the search for a conceptual framework that could help me to make sense of the world I was about to enter. Grounded in social constructivist beliefs, and influenced by a perspective of epistemological skepticism, the scheme in Figure 2.2 shows a sound conceptual framework to approach this study's research questions; it synthesizes feminism, identity, critical theory, and critical race theory. These approaches combined seem to offer a valuable ground to listen to Black women's voices, and are coherent with my worldviews.

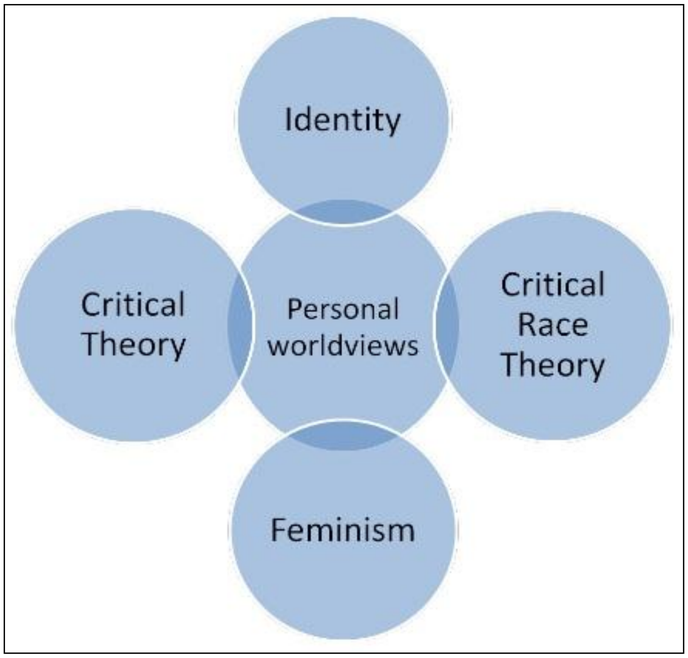


Figure 2.2: Conceptual framework

Feminist Perspectives

Feminist perspectives (feminist theory) have been influencing the debates about women in science, especially in science education. In my attempt to form a conceptual framework to understand the underrepresentation of minoritized groups in science, I see that feminist perspectives have a very important contribution in the realm of science education and its role for the enculturation of women in science. Therefore, my intention is to bring the influences of feminism in science education from the classroom and at the institutional level into my research.

James B. Conant (noted scientist, university educator, and administrator) brought the issue of education for girls to public attention in 1959 when discussing the differences in years of study of talented boys and girls (Conant, 1959; Bybee, 1997). Despite the awareness of the science education community of gender issues, little was made explicit in educational reforms to address this question. Berryman (1983) produced a special report for the Rockefeller Foundation addressing the questions of minorities and female representation in science and mathematics. At that time, the report findings showed that the underrepresentation of women Ph.D. degree holders in science was "partly attributable to their underrepresentation at the Ph.D. level itself" (p. 4). The report suggested that the key for underrepresentation of women in science was related to familiar motivational factors, through pressures during adolescence to resolve sexual identities and career preferences.

Due to the contribution of feminist theories, however, scholars have revised studies on science education. Thanks to women such as Evelyn Fox Keller, Sandra Harding, and Nancy Brickhouse, scientists, and particularly science education researchers, have been paying attention to such questions. Barton (1998) directly recommends a feminist science education when arguing that a feminist pedagogy is more than inclusive teaching. She said it was not simply about teaching for all, and it was not just about good teaching, but it was about political and social engagement and a commitment to teaching science and challenging "the ideologies that justify power inequalities" and using this knowledge to "construct different realities" (p. viii). The feminist science educator is committed to a liberatory agenda. Kelly (1987) pointed out that it was not just a matter of shaping girls into science habits of mind, values, and practices, but that bringing girls to science is also about changing science and its structures. The literature usually bases this debate on what girls need to overcome and what they need to change in order to understand science.

Barton (1998) analyzes the influences of the three waves of feminism in science education. The first wave would have brought attention to the underrepresentation of women in science, fostering studies that showed the lack of women role models in the scientific endeavor. As products of this first wave influence, there were after-school programs as incentives for girls to enter into science and teaching strategies to develop girls' skills in science. The second wave focused on the science itself, questioning its nature and practices. In science education, this questioning of reasoning led to the incorporation of marginalized ways of knowing, and a gender-inclusive teaching, assuming caring, cooperation, and compassion as women values, and that these should be encouraged in science, science learning, and science teaching. The third wave brought the idea that race, gender, and class can only be seen situated socially and historically. As a result, for science education this approach led to a review on how science is situated in schools, the role of students, and teachers. An argument resulted from the third wave influence is that science teaching and science researching are political and activist.

Brotman and Moore (2008) map the debate around girls and science by reviewing the published literature on science education from 1995 to 2006 and identify four themes in which scholars categorize the discussions. The categories they elaborated were equity and access, curriculum and pedagogy, reconstructing the nature and culture of science, and identity. In a way, these categories follow the pattern of the waves of feminism, being the third and fourth themes contemplated in the third wave discussions. Initially, the research in science education related to curriculum and pedagogy, and girls in science were basically about how to adjust the curriculum to girls' way of learning and their experiences (Brotman & Moore, 2008), assuming that girls are more cooperative than boys and that they look for deeper "conceptual understandings and active learning experiences" (p. 14). Curriculum experiences that seek to be gender-inclusive had adopted these orientations. The studies analyzed by Brotman and Moore suggested that girl-friendly curricula are beneficial for both boys and girls, which indicates that a science curriculum influenced by feminist perspectives is more inclusive and beneficial for teaching and learning of science as whole.

Gilbert (1994) discussed curriculum implementations that were a response to the literature debate on feminism in science education. She analyzed an intervention in New Zealand that intended to be girls-inclusive. The author showed that the underrepresentation of girls in science was a problem officially recognized since arguments for the importance of girls studying science appeared in publications of the Department of Education. Because of this recognition, the author argues that all the curriculum documents produced in New Zealand during the mid-late 1980s incorporated elements from the women in science discourse.

Although a great part of the feminist literature that addresses the question of women in science, the literature does not explicitly talk about Black women. The issue of race and ethnicity is present in the feminist discussions that happened especially in the recent decades, with the growth of the Black feminist movement. In 1993 Sandra Harding, a renowned feminist, organized a number of essays that examined the role of racism in the construction and use of science. In one of those articles, Shirley Malcom (1993), a Black scientist denounced in the 1970’s that the American Association for Advancement of Science (AAAS) left out “minority women” in their equity initiatives. The Office of Opportunities in Science of that association published in 1976 an inventory of programs listing over 300 nationwide efforts intended to affect American Indians, Black people, Mexican Americans, and Puerto Ricans. At that time, Malcom was a research assistant in that office. Later, she returned to AAAS and found a Project on Women in Science to increase the participation of women in science. Malcom, however, noticed that either the minority projects or the women projects targeted minority women. In the end of the 1970's, AAAS held a conference that had as a subject "the special problems faced by minority women in science and engineering" (p. 250). Malcom highlighted that although women's educational achievements increased, "the problems for Black women in science and engineering were and are still subtle and pervasive" (p. 251).

The contributions of feminist perspectives in relation to the education of women have been beneficial in exposing areas of contention regarding women in science. The discussions on women in science can only gain effectiveness if explicitly addressed in teacher training programs, official documents, and in the materials teachers use. As an analogy to the debate on inserting the nature of science in the curriculum (e.g., Lederman, 1999), discussions on gender in science need to be made explicit in all levels of the educational process.

Finally, feminist perspectives also contribute on a political dimension. It was in the figure of a Black woman scientist that more attention was paid to the issue of underrepresentation of minority women in the sciences in AAAS, for example. Analogously, by better understanding successful Black women physicists, I can have an active role in bringing more attention to the issue of underrepresentation of minority women in the sciences in the Brazilian academic context.

Identity

Because I want to understand how Black women form their scientific identity, it is crucial to include an identity component in my theoretical framework. Identity is an extremely complex concept that is in constant re-definition and analysis; it can be a field of study in itself. There are several theories on identity and the self, and there are several journals dedicated solely to this topic. Identity studies can be found in the realms of sociology, anthropology, psychology, and philosophy, to name a few. I focus on the social constructions of identity.

Lave and Wenger (1998) coined “communities of practice” that refers to a group of people who share concern or passion for something they do, and they learn through regular interaction with each other on how to improve their practices. A community of practice involves three basic components: the people that are interacting, the domain of interest that they have in common, and the practices in which they engage together. Communities of practice seem to put primacy in the environment on the construction of one’s identity.

Although not discussing solely professional identity, Holland, Lachicotte, Skinner, and Cain (1998) bring a significant contribution to the discussion of identity as a personal construct versus a social product through the analysis of several case studies. They consider both the environment and the individual in the construction of one’s identity. The authors use Leontiev’s notion of activity to explain the processes of the identity construction. The theory of activity has this aspect of motion, engagement, and negotiation of constructs and values, which seems to fit well to develop an idea of identity that combines this negotiation of self and social.

Holland et al. (1998) discuss the notion of positional identity, the relation between one's social position within a specific context; that is, how the individual positions herself or himself in different social contexts, and how the person's actions within these contexts is what forms one's positional identity. Therefore, depending on the contexts and on how one behaves within a context, people different identities. Similarly, Moore (2008) discusses positional identity in the following way:

> Positional identity is directly related to an individual's life experiences, which are lived in culturally constructed worlds, such as gender, class, race, ethnicity, age, and religion, to name a few. As individuals experience life, they generate perspectives that allow them to live, function, behave, interact, and be in the world, and the lenses they use to understand their worlds reflect how specific contexts shape voice and identity. (p. 685)

Indeed, identity itself is a complex concept, but more than that, one's identity is not a singular, cohesive construct.

The participants in this research study are women, particularly Black scientists; they are mothers, daughters, sisters, and wives; they are religious, middle class, and heterosexual; they are political activists, immigrants, multilingual. The people I hope to include in the future may have parents or relatives from Europe, Africa, Latin America; they also have physical disabilities, come from a rural area, or have a home-schooling history. Therefore, women physicists can belong to several domains, and yet they may have some things in common (i.e., sex, race, professional career), but they might have even more aspects that distinguish them amongst themselves; thus women of similar backgrounds may have different views of the world (Parsons & Mensah, 2010).

All these social markers are part of the identity constitution of the physicists that are participants in this current study. Their positional identities influence their construction of their scientific identity in one way or another, with more or less impact. As a researcher trying to understand these women's views about themselves, it is crucial to consider the multiple aspects that constitute a person, "these aspects of the individual should not be ignored in communicating results [...], nor should context be overlooked for understanding individuals in society" (Moore, 2008, p.684); therefore, I believe that it is essential to adopt an identity component in my framework.

Critical Theory

Skepticism can be characterized for its constant questioning-- a questioning of everything. Skepticism defines one of the central problems of epistemology; it relies in the need to show how it is possible to justify a belief (Grayling, 2002). For example, skepticism affirms that there are no reasons, rational criteria, to justify the choice of a scientific theory over another. Therefore, when scientists chose a theory, they dismiss another theory, equally valid, or even several others that may be equally valid (Grayling, 2002; Popkin, 2000; Porchat Pereira, 1993; Smith, 2004). My influences, drawn from my own skepticism, led me to the critical theory of the Frankfurt school.

The Frankfurt school had an approach to analyze culture that was analogous to the skepticism argument, since they rejected "any notion of some firm foundation - empirical, moral, methodological, or otherwise - on which cultural critique might proceed" (Surber, 1998, p.128). I believe a constant vigilance and moral standing, methodological, or otherwise, is essential for a researcher to develop a work that can talk about the world and serve the people; ideally, research is to promote a conscious change.

In addition, this perspective provides me with the ground to validate the voices of the unheard – Black women scientists. The underrepresentation of Black women in scientific careers does not happen by accident; it is result of several factors that perpetuate instances of power. In my research, I am not concerned on "why so few"[3], but in subverting the construction of power by understanding how these few are successful Black women physicists.

A critical theory approach allows me to enlarge the agenda of mainstream science education research, and to think from a point of those that the majority often leaves out. More particularly, if in Brazil Black women in science are not a concern in academia, I want to use my research to open that space and bring Black women into science discourse. Since current studies of underrepresented minorities in the sciences downplay physicists, and Black women physicists, then my goal is to highlight these women and share aspects of their lives to offer ways in which to understand their identities as women scientists.

Critical Race Theory

Considering Black women in science, in the light of critical theory, and with particular attention to the intersections of race, gender, and social class, critical race theory emerges as a potent theoretical framework to discuss social issues. Critical race theory reviews the dominant White hegemonic discourse and power (Donnor, 2003). In its origins, critical race theory was a result of critiques inside the critical theory movement, and "urged that [critics'] work could be improved by the practice of looking

---

[3] "Why So Few?: Women in Science, Technology, Engineering, and Mathematics" is the title of the American Association of University of Women (AAUW)'s report (2010).

to the stories and viewpoints of persons of color who have experienced racism" (Delgado, 1995, p. xvi).

Critical race theory (CRT) and CRT methodology were born out of the legal scholarship, and have "five elements that form their basic insights, perspectives, methodology, and pedagogy" (Solórzano & Yosso, 2002, p. 25). First, CRT rests on the centrality of race and racism in the United States and the recognition that racism is permanent and structural in this society. Second, CRT challenges claims of colorblindness, objectivity, and meritocracy, which are instruments to perpetuate the power of dominant ideology. Third, there is a commitment from CRT scholars to social justice, in the sense that works emerging from a critical race perspective intend to be a "transformative response to racial, gender, and class oppression" (p. 26). The fourth basic tenet stands for the centrality of experiential knowledge and the importance of telling the stories of lived experiences of people of color. Moreover, critical race scholars recognize that the

> … experiential knowledge of people of color is legitimate, appropriate, and critical to understanding, analyzing, and teaching about racial subordination. In fact, critical race theorists view this knowledge as a strength and draw explicitly on the lived experiences of people of color by including such methods as storytelling, family histories, biographies, scenarios, parables, *cuentos*, *testimonios*, chronicles, and narratives. (p. 26)

Finally, the fifth basic CRT tenet challenges ahistoricism and claims for a transdisciplinary approach to research and analyses in general.

CRT goes beyond considering race in cultural analysis. It challenges the very conceptions of race and racism, and how those constructs are employed. Additionally, in order to make a comprehensive analysis of racialized people, critical race theory incorporates theoretical perspectives like feminism, Marxism, and post-structuralism. These views make CRT a perspective that is coherent with the other theoretical choices of this study, and can easily dialogue with them, helping to build a richer conceptual framework to face questions involving race and ethnicity along with gender and its relations to scientific identity. Donnor (2003) affirms that CRT works “toward the elimination of racial oppression with the goal of ending all forms of oppression” (p. 233), which resonates with my personal history as a social movement activist.

CRT also borrows notions of intersectionality from feminist theories (Collins, 2000) to talk about the complex system of oppression that affects women of color. Crenshaw (1991) introduced the term intersectionality when discussing experiences of violence against women of color. Furthermore, intersectionality was used through data analysis of participants’ interviews in science education. For example, Moore (2008) and Mensah (2012) looked at intersectionality in science education and examined how “multiple social variables simultaneously interact and influence each other” (p. 690, 2008) in the lives of teachers of color and students of color. Therefore, intersectionality carries the notion that social systems of oppression work together to subordinate individuals in an intersection of constructs such as race, gender, class, and ethnicity (Collins, 2000). Not only is race foregrounded, but other constructs add to the complexity of race understandings.

In this direction, critical race theory also has implications to science education for Black women. As Ladson-Billings (1999) suggested, CRT is a powerful framework to analyze the discourse and practices in multicultural education, or teaching science for diversity populations. Black women are considered to be ‘diversity populations.’ Grounded on CRT perspectives, Ladson-Billings discussed how education constructed diversity, showing that in the 1960’s educators examined what they called “culturally deprived or disadvantaged” children; these children were essentially not White and middle class. In the 1980’s, there was the discourse of teaching students “at-risk,” mostly because of the report *A Nation at Risk* that was released in 1983 by the Commission on Excellence in Education. The report stated that the entire nation was in risk in several aspects, including educational. The label “at-risk” ended up not identifying the entire nation but only a group of children, and it “became synonymous with being a person of color” (Ladson-Billings, 1999, p. 218). The author stated that teachers refer to diverse or multicultural settings when they actually want to refer to people of predominantly African descent or Latino schools. Ladson-Billings argues that the “construction of difference is a central discursive practice for justifying our need to “prepare teachers for student diversity” (p. 216).

Therefore, the articulation of these four perspectives: feminism, identity, critical theory, and critical race theory, provided a robust ground to understand and interpret the life history of Black women physicists. The following chapter offers a methodological design developed within the framework discussed above, with the objective to contribute to the discussions of minoritized groups in science, filling the gaps analyzed in the literature review.

CHAPTER III

METHODS

In order to understand how the research participants make meaning of who they are as scientists, as women, and as being Black, it was necessary to collect data deeply and richly about the real life of these women, in real settings, and in a process towards an interpretation of their feelings, thoughts, and experiences. To use a qualitative approach was a natural choice in this case because the "central characteristic of qualitative research is that individuals construct reality in interaction with their social world … [and] the researcher is interested in understanding the meaning a phenomenon has for those involved" (Merriam, 2009, p. 22).

In addition, life history is a traditional qualitative approach, inspired in the work of anthropologists (Bogdan & Biklen, 1994) that can show complex relationships amongst different categories. For example, through the construction and analysis of a life history it is possible to unveil patterns of Black women scientists' trajectories that would be relevant through this approach. One of the formats used in this study to discuss life history is through storytelling. I chose storytelling for its power to connect the reader with the character, and for its methodological emancipatory role within critical race theory (Solórzano & Yosso, 2002).

Participants

As an operational definition, Black women physicists were considered those women who defined themselves as Black or African American and held a Ph.D. degree in physics or related field (e.g., astronomy). The National Society of Black Physicists

(NSBP) congregates Black physicists in the United States since 1977. This organization gathers Black scientists throughout the country and provides a resourceful space for conducting the investigation. Through NSBP and its conferences, it was possible to recruit some participants for this study.

The sample was purposefully chosen, and sought to represent different sectors of physics and careers in physics. The procedure was in two steps: an initial survey to identify potential participants, and secondly the selection of a purposeful sample from this set, partially by using specified criteria as presented below. Initially, I sent an exploratory survey to locate as many Black women physicists as possible and to obtain their contact information. To identify these women I used the National Society of Black Physicists database on Black female physicists. In addition, I made use of online social networks such as LinkedIn and Facebook, but used mostly the professional associations like American Physical Society and NSBP. Finally, I made use of “word-of-mouth,” or snowballing through email sent to a variety of professional associations related to women in science, Black women professionals, physicists, astronomers, engineers, and other STEM fields, and asked them to pass along the message to identity colleagues, peers, or associates whom they knew. NSBP’s list, last updated in 2008, had 57 names (two were deceased). The American Institute of Physics (AIP) Statistical Research Center reported 42 African American women that received a Ph.D. in Physics between 1977 and 2006. I collected data on 14 women with Ph.D. in Physics, of those, only four were not in NSBP’s list.

My final list represented a population of 59 Black women physicists in the United States. Probably there are women who received a Ph.D. in physics but are not in NSBP’s list, nor did I reach in my search for participants. Still, considering the number of African Americans who earned Ph.D.'s in physics in ten years, between 1995 and 2006 (33) (figure 3.1), I estimate the total population of Black women physicists in the United States in 2012 to be not larger than a 100 scientists.

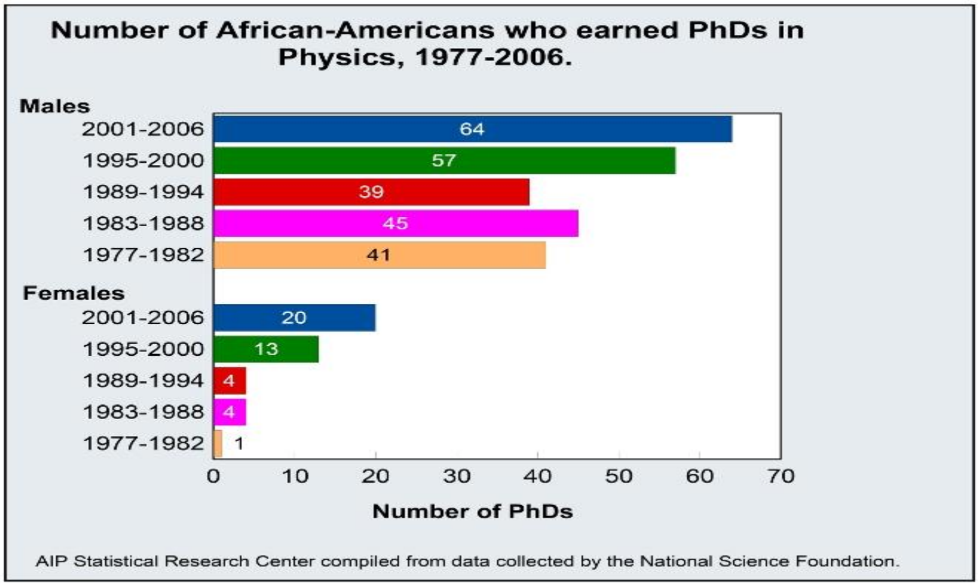


Figure 3.1: Number of African-Americans who earned PhDs in Physics, 1977-2006, by gender.

I hosted the initial survey (Appendix A) at Surveys @ Teachers College, Columbia University, a service provided by the university to collect survey data. The survey was available at the URL http://rio.tc.columbia.edu/surveys/Katemari/index.cfm and I sent it through the contacts described above (direct email, social networks, and professional associations). The purpose of this initial survey was to gather general information about my available population, and use these data to select the informants for the in-depth interviews[4]. The survey covered, for example, questions about the academic

---

[4] IRB Approval: Rosa Protocol 11-195 - IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.

background, ethnic affiliation, and current work status. In addition to the survey, I also recruited participants for the study during a NSBP conference, approaching women directly or by recommendation of peers that were aware of my study.

In the second stage of the research, I selected participants for in-depth interviews using the following criteria: they needed to hold a Ph.D. degree in physics, astronomy or related field (assessed on an individual basis); identified themselves as Black or African American; and were willing to participate in in-depth interviews. Because I was looking for physicists in diverse types of institutions, I initially considered women who worked in three main areas: academia, research centers, and industry. Considering most of the women are employed in universities (NSBP, 2008), my initial design called for six participants of which four would work in universities, one in a research center, and one in an industrial setting. Within academia, I initially considered private and public universities, as well as research universities, liberal arts colleges, and community colleges. In addition, the selection of the six participants was restricted to those who had most of their education in the United States. Overall, my study participants consisted of six women selected according to the following scheme (Table 3.1):

Table 3.1: Sample selection by type of institution

Type of institution			**# of participants**
Work in academia			4
	Private university		
		Research university	1
		Liberal arts	1
	Public university		

Community college	1	
Research university	1	
Research center		1
Industry		1
Total		**6**

However, once I gathered the information from the initial survey I chose to send an invitation to join the study for all 11 women who had answered they would agree to participate in in-depth interviews. Given that I had funding from a grant to do the travels, and all the participants were in the continental US, I decided to interview all the respondents that would like to join the study. From the initial survey, 67% of the women were working in the private sector and the distribution of Black women scientists was as follow (Table 3.2):

Table 3.2: distribution by industry, from initial survey[5]

Industry or Private Sector	Secondary or High School	College or University	Government or Research Institute	Self Employed	Other
18.18% (2)	9.09% (1)	45.45% (5)	45.45% (5)	0.00% (0)	9.09% (1)

Although eleven women agreed to participate in the interview phase of the study, I was only able to interview five of them, for various reasons such as schedule conflict, or lack of response to the contacts I made. In the end, my sample constituted of six women,

[5] The sum adds up to 14 and not 11, the number of respondents, because they could select multiple choices. For example, work in industry and teach in high school.

five recruited from the initial survey and one from my attending the NSBP meeting. Table 3.3 shows the participants, their undergraduate and graduate degrees (masters omitted), current position, and sector of current employment.

Table 3.3: Summary of participant's profiles

	Race/ ethnicity	Degrees	Current Position	Sector
Allyson	African-American	B.Sc. Physics Ph.D. Material Science & Engineering	Research Scientist	Government
Betty	African-American	B.Sc. Electrical Engineering Ph.D. Physics	Research Analyst	Government
Christa	African-American	B.A. Physics Ph.D. Physics	Assistant Professor of Physics	Private Liberal Arts College
Esther	African-American	B.Sc. Applied Physics Ph.D. Applied Physics	Assistant Professor of Physics	Public HBCU
Jane	African-American	B.A. Physics Ph.D. Applied Physics	Research Associate	Public Research University
Shanna	African-American	B.Sc. Physics Ph.D. Physics	Electrical Engineering	Government

This sample has half of the participants working in the government sector and half in college or universities, a make-up similar to the pool from the initial survey, where these sectors made 46% each of the pool. These six women constitute a sample that considers women in physics careers in diverse settings, but not just in academia, the most traditional placement for physicists in general. Finally, they are physicists in different moments in their careers; their age varies from late twenties (20's) to mid-fifties (50's) years old.

Data Collection

The main source of data collection in this investigation was the in-person interviews with the participants (Seidman, 1991). Obbo (1997) recommended that someone working with narratives must be familiar with three things: rapport, listening, and writing. I opted for interviewing because interview methods allow the researcher to develop detailed descriptions, integrate multiple perspectives, describe processes, and learn how they interpret events, bridge intersubjectivities, identify variables and frame hypotheses for qualitative research (Weiss, 1995). Weiss said that interviews can "give us a window on the past" (p. 1). Through interviewing participants, a researcher can have a recount of past events, learn about one's experiences, and collect stories from the people who lived them. Interviews can provide information about families, exclusive organizations, and personal background. Obbo, who conducted narrative research with Black women, advised that "one of the best research habits to acquire is writing […] even with a good memory or recording devices, written notes are indispensable in keeping the record straight" (p. 62). Therefore, in addition to the use of interviews, I kept a personal journal where I took notes throughout the study.

The interviews were audio recorded when the women physicists were interviewed in various locations across the United States. A professional transcriber then transcribed the interviews. I shared the files with the transcriber through an online share and storage service. The files were accessible only by the two of us, and the transcriber deleted the files and all the records of the transcriptions when the service concluded. I used the same interview protocol (Appendix B) for all six participants; however, I made refinements for the interview questions during the interview process, building upon the information I was collecting from previous interviews.

The interviews ranged from two hours to a little more than three hours. They took place in participants' offices and residences, or at hotels, providing quiet and private places. All of the participation in the study was voluntary and I did not provide compensation. Before the interview, I informed all the participants about their rights and on the day of the interview, I explained their rights again and offered time to settle any questions. Finally, all the participants signed a consent form (Appendix C).

Data preparation. The interviews had been audio recorded in digital format and sent to a professional transcriber who transcribed both the interviewer and the informant. The transcriber made minimal notes for moments where there were laughs or long pauses, and for moments that the audio was not clear or she was not sure about a word or acronym.

Then I altered the transcripts to change all the participants' names and replaced them with codenames, or pseudonyms. The participants' names were randomly generated using data from the US Census through the online name generator service Kleimo; an obscurity factor of 15 was used, where 1 = Common, 50 = Not so common, and 99 = Totally obscure. In addition, I changed names of people, institutions, cities and states to codenames or masked to protect the participants' privacy. For example, I would mask University of Texas to University of South Central, so the reader can have an idea of geographic location but not an identification of the specific institution.

The Analysis Process

In this section, I describe in detail how the analysis process took place for one code and theme, thus serving as an example for the overall analysis process I developed. I used individual concepts and themes as the units of analysis. I obtained a theme or concept using a word, sentence or paragraph. That is, I noted any part of the interview transcripts that could represent a concept or an aspect relevant to talk about Black women physicists' scientific identity construction for developing concepts and themes.

The coding scheme that I used derived mainly from the data as in vivo coding. I did that by using the participants' own words and language to generate a code. For example, I generated the code "summer program" from the transcripts once I noticed this expression appeared repeatedly in the experiences of the women participating in this study. Additionally, there were codes that I derived from the theoretical framework. For instance, the code "family support" derived from the literature that indicates one of the factors influencing the number of underrepresented groups in scientific careers is the family support they receive.

I assigned a chunk of text to a particular code as follow. Initially I created a code that related to the theme of the text. Then as other parts of the transcripts showed a connection with that theme, I coded the subsequent text and compared the texts to check for consistency on what could represent that theme. For example, here I code the first time Christa talks about a summer program:

> [...] the physics teacher got this information about a summer program called [Program] at NASA […] that was for minorities in science, and she said I was the

> only minority she knew and she didn't know if I was interested, but since I was the only one, she just gave it to me. (Christa)

Then in the following transcript, she does not use "summer program" but she makes reference to how she spent her summers in science related programs, which I now code as *summer program*: "And that was the summers of my junior and senior years of high school, and then the summer after my first year of college" (Christa). I expanded the code "summer program" to incorporate the mention REU's, which were Research Experiences for Undergraduates (REU), a program funded by the National Science Foundation (NSF) usually for undergraduate students during the summer.

I continued this process for all the codes that I assigned to chunks of text. When analyzing a transcript of another participant, I applied the same code for texts that presented the same theme, and compared the texts from different participants, in search of coherence between the quotes that I assigned under the same code. For example, I cite an instance still using the "summer program", which was developed into a code that refers to *academic or research experiences related to science undertaken during the summer, as a special program in which the participants were funded to develop STEM research expertise, content knowledge, or practices.*

During the process of interviewing I learned more about summer programs, and for subsequent interviews I probed to get more information to clarify whether certain experiences mentioned would have the characteristics of what I identified as a "summer program" or explore the differences between summer programs, promoting an interrelation of the data collection process and data analysis (Corbin & Strauss, 1990).

Next, I combined codes that were related conceptually to each other but did not refer to the same types of event, thus creating categories. For example, the combination of "summer program", "scholarships and funding", "math performance", and "choice of major" led to the category "conditions to choose physics as a career".

The process as described for creating the "summer program" code was extended to my entire coding scheme. I accounted for slight variances on how the concepts emerged, if entirely from data, or informed by the literature review. But then again, the construction of the interview protocol was informed by the literature review; therefore, it is expected to see concepts emerging from the data that would follow the literature review pattern.

I assigned simultaneous codes in some single transcript quotes, if more than one concept was present in the same quote, a usual practice in qualitative research (Tesch, 1990). In these cases, looking for general patterns across the participants was helpful in describing and giving substance to the categories and themes from the study. For example, I coded the following quote under each of the following: "opportunities", "role of a teacher", "being a minority":

> And so really it was, it was my teachers in high school, my math teachers who really told me about like schools, like they had-how I got to [My College] was, you know, they had a minority weekend and they must have contacted the teachers, like the [city] club, alumni club, and then they told me about it and suggested that I go, and I went. So it was really my teachers. Not so much the guidance, the college advisor-counselor because I don't think they expected much from me, but it was really my teachers. Teachers played a big part, so I think, so I

really went to college-- my object was to go and get a math degree so I could do business (laughs) and make some money! (Jane)

For organizing the codes and themes, I developed a color scheme and used a multi-step approach to reduce to larger categories. I organized them using excel spreadsheets. Examples of the coding tables are in Appendix D.

Using critical race theory framework as a guide through the analysis process, I created stories based on the data collected, and on my interpretation of the data. The counterstories that I construct in the following chapters are a result of my interpretative lenses; they are not the counterstories that the scientists told, they are the counterstories that I heard.

Validity and Rigor

For the coding process, I used the qualitative content analysis software Atlas.ti, where I organized each interview transcript as a primary document (P-Doc). This allowed me to compare effectively quotes from different transcripts because the use of constant comparisons "assists the researcher in guarding against bias, for he or she is then challenging concepts with fresh data" (Corbin & Strauss, 1990, p. 9).

Other elements of rigor used were peer debriefing (Spall, 1998) with a group of graduate students and a faculty member whose shared expertise was in critical race theory. The group gathered once a month for one semester to discuss our projects and research. I discussed my analysis and findings with the group, who helped me identifying biases and underlying themes. In addition, we engaged in discussions related to the assignment of codes to specific quotes. I was able to put my coding system under a test with samples of the transcripts. We worked on it collectively, and this process helped me to have consistency on the coding process. Furthermore, I revised the coding scheme after I coded all P-docs in order to increase consistency.

Finally, thinking critically about rigor and validity (Aguinaldo, 2004), this study also aimed to challenge conventional ways of analyzing data by employing a non-traditional form of analysis and report, through storytelling. Science educators mostly use storytelling as a way of teaching science (Hammond, 2001; Martin & Brouwer, 1991; Martin & Miller, 1988; Roach & Wandersee, 1995; Yulianty & Premadi, 2010) not as a research method. Although the use of naturalistic methods in science education research has been defended (Smith, 1982) and its use has been increasing (Carlone et al., 2008), it is still fair to say that storytelling is not a popular method of research in science education, particularly in physics education. Consequently, to use storytelling methods in science education research is to challenge conventional ways of analyzing data and doing research in this field. The ways of thinking about rigor and validity in our research community require, then, a new approach.

In the legal scholarship, storytelling has served as a way to tell stories of marginalized, silenced, and oppressed groups as a way to offer a different account of dominant narratives. Delgado (1989) called these non-dominant narratives counterstories. In this study, I used interviews to collect the counterstories of Black women physicists in the United States, bringing storytelling as a research method in science education.

The use of storytelling as a research method may pose a challenge for the search of rigor and validity. Juravich (2010) said on a book review that the author's prose "balances academic rigor and storytelling," which shows that storytelling is still viewed by some as not an academic rigorous style of research. It is not to say that storytelling does not yield to valid knowledge, but that one needs to keep in mind what these concepts represent and the historical context in which the research is inserted (Guba & Lincoln, 1994). The use of storytelling emerges from the critical race theory; Lincoln, Lynham and Guba (2011) discussed the implications of critical theories on practical issues of naturalistic research.

The quality criterion here does not rely on triangulation (Denzin, 1978) or statistics, but on taking into account that the research is historically situated (Lincoln, Lynham & Guba, 2011). In addition, I disclose my position socially, culturally, ethnically, and as a woman researcher. I also had particular care with ethics issues on the matter of a fully informed consent (Lincoln et al.) and in taking measures to protect the identity of the physicists in the study.

Finally, in search for external validity the aim is not to generalize the results to be applied to any other setting, instead the findings discussed in this study take into account a "mix of social, political, cultural, economic, ethnic, and gender circumstances and values" (Guba & Lincoln, 1994, p.114) that are similar across settings. Therefore, they are situated in a historical context, and their meanings are expected to be transformed over time, depending on the knowledge we create and accumulate in the field. Finally, readers can evaluate the goodness of the study on its "ability to impact action for the creation of a more fair society" (Lincoln, Lynham & Guba, 2011, p. 108).

The findings chapters were organized as two stand-alone papers in which one (Chapter 4) is dedicated to the findings and analysis of the experiences of one physicist in the study, Christa. It is a deep account of her life story. This chapter focuses on the use of storytelling to talk about the experiences of a woman of color scientist. There is a rich description of the life story of one physicist and the process of developing an identity as a scientist. This chapter focuses on addressing the first research question on the described experiences towards the construction of a scientific identity, the physicist's personal and professional trajectories, and her career choices.

I chose Christa's story because although unique, she offers experiences that are common to the other participants, such as pre-college experiences in science after-school programs, good math performance, microaggressions (Pierce et al., 1977) in different moments of her academic life, family and religious support, as well as substantial financial support throughout the years. I also chose Christa for this chapter because her interview was the only one that showed a more conflicting sense of self as scientist, or a less confident scientific identity. Christa was the only physicist I interviewed twice (the second interview was ten months after the first one) because she was in a particular transitional moment in her career when the first interview happened, and I wanted to assess how the process she was going through would interfere, if ever, in her identity as a scientist.

The second findings chapter (chapter 5) is dedicated to the findings from the experiences of all six participants in the study. The chapter focuses on the research questions two and three on how do the physicists negotiate their multiple identities, what do the they identify as obstacles in their career paths, and what strategies do they use to overcome these obstacles.

CHAPTER IV

A STORYTELLING OF CHRISTA'S LIFE

Abstract

In this paper, I tell the life story of Christa, a Black woman physicist. Grounded in critical race theory, I present a counterstory of her educational and professional experiences towards the construction of a scientific identity. The findings showed that a support network (parental, religious, and marital), self-efficacy, funding, and expertise recognition were essential to enable Christa's scientific identity development. In addition, the use of counter storytelling helped to unveil how racism operated in this process of science identity construction.

Introduction

In this paper, I focus on storytelling to discuss the scientific identity construction of Christa-Marie Jackson, a Black woman physicist. I use storytelling to address the following research questions: How does a Black woman physicist describe her experiences towards the construction of a scientific identity, what are the personal and professional trajectories of this woman, and what factors, experiences, and contexts she attributes to her career choices? First, I talk about the importance of storytelling within a critical race theory perspective to analyze the experience of racially (and gendered) marginalized groups. Second, I tell the story of Christa. Finally, I summarize the findings and discuss implications for the field of physics education. In the legal scholarship, storytelling has served as a way to tell stories of marginalized, silenced, and oppressed groups as a way to offer a different account of dominant narratives. Delgado (1989) called these non-dominant narratives counterstories. Storytelling is in the core of critical race theory (CRT), legitimizing the lived experiences of people of color (Delgado, 1989). One of the foundational ideas of CRT, however, is the notion that racism is structural to the society in the United States, and that it is present in people's every day experiences. Ladson-Billings (1998) pointed out that the field of education can benefit from CRT scholarship because "states generate legislation and enact laws designed to proscribe the contours of education" (p.17) in this country. Another point of interest for educators is because CRT "sees the official school curriculum as a culturally specific artifact designed to maintain a White supremacist master script" (p.17). Grounded in the CRT framework and its implications for educations, I use storytelling in this chapter to talk about the experiences of a Black woman physicist, using storytelling as a research method in physics education.

I present Christa's story, which is a counterstory because it challenges hegemonic narratives about women of color in science. Christa's story is a story of success. Hers is the story of a Black young girl who performed well in school, who was fascinated by the natural sciences, and who grew up to become a physicist. It is not the story of "low educational achievement and attainment of students of color" usually told "within the context of racism" (Solórzano & Yosso, 2002, p. 26). The story told here is chronologically organized -- from Christa's childhood, with a characterization of her personality, family, and upbringing; her young life and K-12 experiences; through her adulthood with academic and professional choices, and ends with her current status and future plans.

Methods

This paper functions also as a methodological exercise to use storytelling to talk about identity as an emergent phenomenon; thus, identity as result of a complex interaction among several domains that affect each other, where an isolated analysis does not provide a better understanding of the final interaction[6]. The use of storytelling, in this case, gives an account of the intertwined relations between gender, class, upbringing, schooling, race, geography, among other factors, and the formation of an identity as a scientist. In critical race theory and feminist theory, scholars conceptualize these complex interactions as intersectionality (Crenshaw, 1991; Ludvig, 2006).

I use storytelling in this paper as a methodology to weave different markers and identities (Lugo-Lugo, 2008) in the self-reported experiences of a Black woman physicist. I collected the story through audio-recorded semi-structured interviews; and conducted two interviews, the first was an in-person interview with a little over three hours of duration, and the second one was a phone interview of about 40 minutes. The two interviews were about 10 months apart from each other.

It might be hard to identify when the researcher is speaking and when it is the interviewee speaking. For example, when I say, “Christa does not talk much about her father,” that is a piece of analysis from the times Christa has mentioned her father during the interview. When I say, “she and her brothers were mostly raised by their mother,” I am paraphrasing Christa’s words “my mom was the one who mostly raised us”; and when

[6] In the sciences, that is equivalent to say that identity can be characterized as a complex system (Joslyn & Rocha, 2000).

I say, “what she learned growing up is just a tenacity, learning how to solve problems, learning how to figure that out,” that is a direct quote from the interview. I use quotation marks for direct quotations, but in some instances, I directly quote Christa without quotation marks. For example, when describing Christa’s personality, I say she “was a very introverted child,” which was a direct quote from the interview but there is no indication in the text that this is a direct quote. In other moments, however, I want to make sure it was clear that I mix my voice with Christa’s voice. For example, when I talk about Christa’s relation with religion, I say “mostly because [she] knew that’s what [her] parents wanted”, [7] using quotation marks and making use of parenthesis to indicate I altered the original quote. I could have simply paraphrased this part, but that would be hard to tell whether that was fruit of my analysis or Christa’s analysis of her own choices. Thus, my purpose is not to disguise data from analysis but to offer a story that brings it all together without breaking the flow of the narrative. That is, precisely, one of the strengths of storytelling.

Finally, one important note to make about the story and the data for creating this story is that Christa is one person. The character is not a composite from the experiences of different participants melded into one study. I chose to tell Christa’s story because although unique, she offers experiences that are common to the other participants, such as pre-college experiences in science after-school programs, good math performance, microaggressions (Pierce et al., 1977) in different moments of her academic life, family and religious support, as well as substantial financial support throughout the years. I also chose Christa for this chapter because her interview is the only one that shows a more

---

[7] The original quote from the interview says “mostly because I knew that’s what my parents wanted.”

conflicting sense of self as scientist, or a less confident scientific identity. Christa is the only physicist I interviewed twice. In her second interview, Christa is more confident about her role as a scientist. The story that follows is a rich description—long and detailed—of the lived experiences of one physicist and the process of developing her identity as a scientist. In addition, the story that is told of Christa is presented in a format that conveys story and interjects moments of discussion where needed, particularly at the end of each major division of her life—childhood, college and career. The life of Christa ends with a short conclusion to highlight major parts of her story.

The Life of Christa

Early Childhood

Legend has it that a five-year old girl was flipping through the pages of a dictionary when she saw a word, pointed to it, and asked her mother what that word was:

“Paleontologist,” the mother said.

“What does that mean?”, the little girl inquired.

“It’s a person who digs up dinosaurs.”

“That’s what I want to be when I grow up!”

Christa, the little paleontologist wannabe, grew up to be a physicist. That is her story…

From a family of the Mid-Atlantic region of the United States, Christa Jackson was a very introverted child. When she was not watching her five-year younger brother, or attempting to have a fair Lego playtime with the older brother, who was five years older, she would be by herself, doing schoolwork, reading, or immersed in her thoughts. She did not really have any friends. Bullying was a constant part of her childhood; she was the girl kids usually picked on, and nobody liked to play with her.

It is always amazing what school can do to someone, how it can affect our lives, foster our dreams, or shut our curiosities down. The first distinct memory Christa had of science was in her third grade. She had just switched schools, and her parents had gotten a set of *Encyclopedia Britannica*, which she was flipping through one day. It was then that she found herself deeply interested in fireflies. The little girl was amazed by them, and wrote a twenty-page paper with diagrams, illustrations, and all the information she could gather on fireflies. She was so proud of her work. She handed it out to Mr. Phillips, her teacher. He lost it. He never read it. More than that, Mr. Phillips put on Christa's report card a "C" in socialization: "She is not socially engaged and probably won't amount to anything," he wrote.

Yet, the quiet girl who sat in the back and did not interact much with the other children liked to play school, not Barbies. Besides school activities, Christa spent a good part of her time at church functions. She was the "typical church to Bible kid" and proudly knew all the Bible answers. She became a Christian very early, "mostly because [she] knew that's what [her] parents wanted." She would go to church every Sunday and attend Sunday school at church, the evening worships, and the Wednesday activities. The Jackson family frequented a predominantly Black United Methodist church in the inner city, when the kids were young.

"This looks like a circus to me!"

"There are people jumping up and down and screaming, and I don't know what is going on."

These were little Christa's impression of the church. So the girl would crawl underneath the pews at church, scared. But she got used to that. The family was very religious and by the time she went to high school, she was going to a predominantly White church where she and her brothers were the youngest people at the time her family started attending there. She was about ten and the next youngest person older than her, besides her parents and brother, was in their fifties. The church then hired a youth pastor just for her and her brothers, to try to change the character of the church, and attract more youngsters.

In her church community as a young girl, Christa was surrounded by adults for a long while. That was not much different from her other circles. The quiet girl did not have friends in general, let alone friends of her age. She recalled, "I wanted to do everything right and everything right was what my parents wanted and they wanted me to be a Christian and they wanted me to be good and they wanted-and so that's what I tried my best to be."

A Counterstory about Parents and School

Christa's parents were from a humble background; her father's father was a gardener for a wealthy family for as long as Christa could remember. Her mother grew up in the projects of a large urban city in the East, and although she has an associate degree, Christa says she is not academically smart, but extremely street smart: "what she learned growing up is just a tenacity, learning how to solve problems, learning how to figure that out." Christa speaks proudly and enthusiastically about her mother. She does not talk much about her father though, who was not very present. Their mother mostly raised Christa and her brothers.

The family lived in a for-profit planned town. The town was divided into villages, and each village had its own facilities, such as grocery shopping, sports center, and schools. Because it was a for-profit planned town, it was run by some sort of association, which collected dues and managed the town. Christa's parents, however, could never afford to pay the association dues, and so whenever they wanted to use the facilities in the town, they had to say they were guests from outside. "We couldn't even afford to live in the town that we lived in! So it was a very interesting experience," she says. So the Jackson family would use the town's facilities sporadically, just so no one would notice that they were actual residents of the town.

Christa had access to resources that were actually beyond the means of her family. They would use the pool occasionally and spend something like twenty-five dollars per visit, instead of what would be around fifteen hundred to pay the annual fees. Besides the pool, the family had access to the school system the town offered, which was also an experiment in alternative education, for the better and the worse:

> …and so especially in the Seventies [1970's], when they were trying out all kinds of crazy ideas, they--each school had its own stuff that it would choose and try to implement and see what would happen. And so, so some of the educational experiences I had in schools were very interesting (laughs). Most of them didn't work, and by the time of the late Eighties [1980s], early Nineties [1990s], they were getting rid of all of them!

The Jackson family was very clear about some of the things they wanted for their children's education, and they did participate in their school life. One time, in one of those Back to School Nights, when some schools organize a night having the parents coming over and meeting all of the teachers and things like that, Christa felt really embarrassed in front of her peers and teachers. It was in the gymnasium of the school.

There was that big open room with lots of people and tables, and everything was going well until the Jacksons got into an argument with the math teacher, arguing with each other and with the teacher. The reason was that Christa's parents did not want her using a calculator; not at home, and not at school. So all the other kids in the class used a calculator, but Christa was not allowed to use a calculator until her senior year of high school, when she was taking calculus, and still, she could not use it on exams or homework. Therefore, when her teacher was doing an activity in class using it, then she could use it, otherwise, no calculators for her: "I think that was something that was extremely important that my parents did, that they fought for."

Mr. Jackson used to work as an engineer for the same family his father worked for as a gardener. He designed things for that affluent family until he found out that other people were taking credit for his work, so he quit. For Christa, her father was her only family connection with the sciences. Not that they used to talk about it, because he was already the long-distance driver when she was growing up, but she knew he originally had a background in science. Although one might think that Mr. Jackson's science background could have set up a science-learning environment for Christa, the truth is that they did not connect that much in those matters. For example, her dad would do things around the house and sometimes she would ask to help him, but it seemed like whenever he needed help, he would go to her brothers first, who were not interested in it at all.

It was Mrs. Jackson, with her tenacity of trying to get out of the inner city and exploring things to broaden her children's horizons that fostered Christa's explorations in the world of science. She would tell the children: "Okay, well, you're interested in this. We'll have to figure out. You know, you're not going to get the latest and greatest and newest stuff, but we'll figure out ways for you to get the experiences you need in order to decide [what you are interested in]."

The three children were not exactly spoiled kids, but whatever they were interested in their parents would do their best to provide and to engage them in whatever activities so they could decide if the activity was something they wanted to do. Because Christa showed some interest in science and mathematics, Mrs. Jackson would always carry the three kids to activities and programs somehow related to science and mathematics. This happened until one day the boys were old enough and said they did not want to tag along.

Christa was lucky to be geographically close to many colleges, universities, and museums. One day her parents heard about a famous paleontologist that would be in the area. They put little Christa in the car and drove her to the talk and sat there, next to her, listening about dinosaurs and excavations. At the end of the presentation, they bought her books on the topic and Christa would read about dinosaurs for weeks.

Like many kids, Christa wanted to go to camp during the summer, but she did not want just to go to a camp, she wanted to attend a dinosaur camp! However, her parents could not afford to send Christa, now in fifth grade, to one of those paleontology-like camps. So Christa's mom, always resourceful and trying to foster her daughters' curiosities, started looking for free activities and discovered that there was an archaeologist in the area who ran an archaeology summer program that was free to basically anyone that was interested. And so from the time Christa was about nine years old until she was about fifteen years old, she spent her summers at this camp doing archaeological digs: "It's like paleontology but you dig up people instead of dinosaurs!", her mother said.

When Christa was sixteen, she had just finished physics in high school, and her physics teacher got some information about a summer program at NASA that was for minorities in science: “Christa, you are the only minority I know, and I don’t know if you are interested or not but… Well, since you are the only minority I know, I’m giving this to you.” Christa picked up the brochure and just threw it in her backpack, forgetting about it. Later on, Christa was at home and heard her mom saying:

“You should apply to this,” the vigilant mother had found the brochure in the backpack.

“But I’m not interested in astronomy. I want to be a paleontologist.”

“Fill it out anyway!”

Then the young girl filled the form out and a few weeks later, she got a letter saying she had been rejected from the program. Christa did not tell her mother about the letter because even though she was not interested in the program, she did not enjoy getting a rejection letter. She put the letter away and went to bed.

It was around ten o’clock that night when Christa’s mom came into her bedroom, all excited, speaking loudly:

“You got into the program! You got into the program!”

“Mom, stop joking.”

Mrs. Jackson, with her artistic mind and spirit, was well known for being a practical joker. Christa was upset, for her mother was making fun of her rejection.

“No, I’m not joking. They just got a call, they got more funding, and your name was at the top of the list, so you got into this program at NASA.”

What a turn of events for Christa! Because of that increase of funding for the NASA program for minority students, she got to spend the following three summers working at NASA. Christa can proudly say her first job was at NASA, at sixteen. There she worked at a space center, making connections and gathering good experiences. The truth was that she was not interested in the space thing. She was very good at mathematics and science, so she excelled in her job during her junior and senior years of high school and the summer after her first year of college, but while she was in high school, all she could think of was the whole paleontologist thing.

Middle and High School Teacher Influences

Christa’s times during middle and high school were very interesting. Her middle school offered a Gifted and Talented Program and a regular mathematics class. Although Christa had the highest grade in general mathematics class, and should have gone into the algebra/trigonometry class, the school placed her in the regular pre-algebra class. Christa was conscious of her misplacement, but she is not the type that complains about things. She liked pleasing not only her mom, but the teachers as well. She commented, “I was bored. But I didn’t tell my parents and so they couldn’t, they couldn’t fix it.” And the young girl did well nevertheless.

However, when she got into high school, her mathematics grades dropped dramatically, and she failed most of her tests. She resigned to find she was not that good in mathematics after all, but her teacher was very confused:

> I don’t understand. You’re the--as far as I can tell-- you’re the best student in the class. Your homework is great. When you do things on the board, they’re, you know, perfect, you know, except for maybe minor mistakes. But you always fail

the test and I don’t understand. If you know the concepts, you can talk about it, I don’t understand!

There was another moment in Christa’s life where a teacher was of great influence. This teacher went over Christa’s exams and noticed that the young girl had actually answered all the questions correctly, but she had not transferred the answers properly to the answer sheet. The issue was that, in high school, the school changed the format of testing so that teachers would give the students the exam on one piece of paper, the students would do their work on a different piece of paper, and record their answers on an answers’ sheet. The teachers then would just go through and check or grade the students’ answer sheet. What Christa’s mathematics teacher found out was that Christa had a problem transferring answers from one sheet to another. She was then diagnosed with “learning issues.” This information went to her records and from that point on, all the teachers knew they had to apply a special format of assessment for Christa.

The mathematics teacher not only found this problem out but she went back and checked all older Christa’s exams. She shared this information with the other teachers who checked all of Christa’s old tests. It turns out that Christa had gotten all the correct answers. So the mathematics teacher went back and corrected Christa’s grades in ninth grade mathematics, and the corrected tests for the mathematics graded ended in Christa receiving A’s: “So I thought, I actually thought that I was really bad in math when it turns out I was really good in math,” she laughs.

Christa was somewhat lucky because she had the chance to join a science fair in middle school, where she built a volcano. This was a good experience because she was also bored during her science classes at that time. She never took biology; she had chemistry, AP chemistry, and physics. In high school, she enjoyed her physics classes, particularly because she was concomitantly taking calculus, and could make the connections between the subjects. Mathematics and science were her favorite subjects for sure. Apart from that, there was little much from her school science experiences that Christa enjoyed.

Christa's school experiences were a constant up and down, in regards to her science and mathematics teachers. In high school, she had a very bad experience with Mr. Lawrence. He was a chemistry teacher that would just sit in the back of the classroom and have students teach a section of the textbook to their peers. He would let the students write homework assignments and grade them. Nevertheless, that was not the real bad part: "Let's just say he was arrested for sexual misconduct issues; […] he would sit in the back of the classroom and play with himself." Looking back to that experience, Christa analyzes: "Yeah, it was creepy. And probably if it wasn't for him, I might have ended up being a physical chemist." From all her science and mathematics teachers in high school, there was no one Christa would hold good memories of, no one that she felt had inspired he that she wanted to emulate.

In middle school, Christa continued to show interest in the world of science, and sought the school space to appease her curiosity. She found in her backyard this thing that she did not know what it was, and so she put it in a bag and took it to her teacher, Mrs. Harris, to ask what it was. The teacher never got back to her. Sometime later Christa saw a bag sitting in the corner of the class and thought that it was probably "her bag." So she went over to the bag, and it was a good thing that she did. In the sealed bag were praying mantis' eggs and they had hatched, and so the entire bag was filled with praying mantis, little baby ones: "Wow, they are still alive!" Christa ran out back to let them outside.

Mrs. Harris never acknowledged any of this.

Christa's Early Life as Discussion

It is common to find in the literature reasons why students of color fail (Cummins, 1986, Ladson-Billings & Tate, 1995). Research also points out that lack of parental support and school involvement are predictors for students' failure in school. These stories may be true and focus on negative views and experiences of students of color, and others choose to build a collective and positive image associated with students of color viewed not from a deficit perspective. Christa's school experiences, in contrast, show an engaged mother, and parental active participation in the school life. Brewster and Bowen (2004) found that the importance of teachers in affecting student's school engagement is greater than parents' engagement, and yet Christa's counterstory presents teachers that dismiss her attempts to engage in science, in spite of her mother's constant support.

Christa also offers another story on how her behavior in class is evaluated. Finn (1993) reports that there is an association between school achievement and student's class participation. He argues that some behaviors may detract students from learning. Example of these behaviors are students that "generally sit in less visible locations in the classroom" and "avoid interacting with the teacher," or that are disruptive, creating "disturbances that interfere with other youngsters' work or with the teacher's efforts to manage the classroom" (p. 8). The author says, however, "withdrawn youngsters had even lower achievement levels than those who [are] disruptive" (p.8). In a dominant story, Christa's quiet behavior is an indication of a problematic child, and that in fact echoed in her teacher's perception of her future. The same quietness, however, when heard from Christa's perspective, is a merely characteristic of her introvert personality.[8]

Factors that Influence College Choice

For this second set of stories that cover college, Christa was the only daughter of a long-distance bus driver, who was never home when she was a kid. Growing up she realized she would not like to have a job that would put her away from her family. Everything Christa learned about the paleontologist profession would lead her to either leaving for long periods or having to move to the middle of nowhere in the desert. Those were reasons enough for Christa to abandon her paleontologist dream: "Okay, then what? What am I going to do? Well, I'm certainly going to college…"

Christa was just "one of those kids" that everyone knew was going into college. She was a good student, quiet, and never gave her parents or teacher a hard time. There was the expectation not only that Christa would go to college, but also that she would do well:

"I need something easy to major in in college…"

Because "physics was easy," Christa decided to major in physics.

"Yeah, it's not because I like it but because I [can] do it; maybe be a physics/math major," she pondered.

Her decision to study physics was not a surprise though. Her family just wanted her to do something she was interested in, and her few friends, most of them were in their fifties-sixties range, and they were just happy for her to go to college. There was only one person that had a strong opinion about Christa's choice, her pediatrician:

---

[8] Brickhouse, Lowery, and Schultz (2000) point out that "one of the common features of high-achieving Black girls is they work hard and are silent," and that "silence has been described as having the effect of passing as a White female" (p. 444). They note all girls face issues of coming to voice but that "they are expressed in different ways depending on race" (p.444).

“I’m not going to become a doctor but I’ll probably become a scientist,” Christa said.

“It’s not a doctor but it’s still okay,” her pediatrician compromised.

When it was the time to apply for different institutions, Christa used a unique approach. She picked the institution that spelled her entire name correctly. For her, that was a sign that the institution was approachable, that they would treat her as a person, and not just one more student. To spell her name correctly in the letters, the school would have to manually insert it, since the SAT system does not have space to put her entire name. Therefore, if a school was using her name just by copying from the SAT system, without even checking her name, that meant a letter straight to the trash for Miss Christa-Marie Jackson. By using this selection criterion, Christa rejected MIT’s offer. There was one college that spelled her name mostly right, they just missed the hyphen, so Christa considered this one. Nevertheless, when she visited their campus, she noticed only one other Black family, and she felt that they were ignored by the school. She already had an idea that she wanted to be somewhere that was smaller and personable. She ended up choosing a not so renowned college, which spelled her name properly, hyphen and all. Even during the application, Christa did not really want to apply to MIT or other big, well-known schools. These other institutions were not amicable places to be. But her parents insisted:

“You’re smart. You can--you should be able to go anywhere, and so you should apply to Harvard and Yale and MIT…”

“You know, it’s going to cost sixty dollars to apply here and a hundred dollars to apply here and fifty dollars here,” Christa alerted her parents.

"We can't afford that and so you'd have to pick one."

"I don't want to go to any of these schools. You pick one." Her parents picked MIT.

That is how she ended up applying for that school, and receiving an award letter from MIT. Many people did not understand why she declined MIT, but they were fine with that. Christa's pediatrician, however, was very upset when he learned Christa had turned MIT down for a smaller school; he, who hoped she would become a doctor one day, stopped talking to her.

Christa attended a small liberal arts college, which had passed her "they care about me" test. She initially enrolled as a physics/mathematics major. However, she did not like the people in the mathematics department, and was unhappy with her economics classes. She stated, "The professor was just really mean, not very nice at all!" So she went to the physics department and said, "I want to do an independent study where physics destroys economics." Thus, Christa did an independent study where she helped rebuild a laser, but the goal of this project was to burn a hole through her economy book. This was Christa's first exposure to optics. By the end of the project, she had burned a hole through the book: "I didn't completely destroy it," she laments. But she did destroy the laser in a big explosion.

College proved to be a friendlier and richer learning environment than her K-12 experiences. For example, her department had a weekly event in which physics majors and professors would get together and do things such as build a potato cannon using liquid nitrogen, then go out to the baseball field and launch the potatoes across the field. Students and faculty would meet and do random things together. Afterwards, they would gather for Physics Band, where one of the physics professors would teach people how to play guitar. The students could also bring another instrument, sit around and play Beatles' songs; or just really sit and enjoy each other's company. That was a very different experience for Christa, not only in terms of socialization, but also in terms of socialization in an academic setting.

Christa enjoyed her physics classes and aced quantum mechanics, but she did not really believe in any of it. That was the first time she was exposed to the idea of uncertainty, that nature was not deterministic. It was something she did not buy. Her strong religious beliefs somewhat clashed with her new physics knowledge. She did not allow this to bother her so much, and learned to live with the clash. She did not have to believe in all the teachers taught to her. As long as she could do the calculations and solve the problems, Christa was fine. For Christa, it was all a game, the academic game, and she learned how to play it, and play it well. Christa learned the rules of the game. With her analytical mind and during K-12, she learned how to behave and provide the right answers in mathematics classes, and she played accordingly. Perhaps there is a pleasure in knowing how to play the game and being good at it that can compensate for the fact that she did not care that much for physics itself.

"Don't get me wrong, physics was hard. But it was easier than the humanities, which I couldn't keep up with. So I spent a lot of hours in the physics department, a lot of time asking questions and trying to understand, but that was easier than trying to read, you know, a three-hundred page book in a week."

Christa's Early College Life as Discussion

Perhaps Christa's lack of support from her teachers – except for the mathematics teacher who corrected all her grades – developed in her a sense of what type of treatment she could expect from educational institutions. This treatment led to her strong conviction about going to an institution that was "personable." Christa suffered microaggressions (Pierce et al., 1977) in school from both teachers and students throughout the years. For example, teachers dismissed her attempts to engage in independent studies, and her peers bullied and isolated her. Racial microaggressions are everyday interactions that send harmful messages to people of color; they are subtle, constant, and insidious racist attacks (Rollock, 2011). Storytelling, in this case, is central in CRT to highlight episodes of racism in everyday life, particularly microaggressions (Delgado & Stefancic, 2001).

Christa desired an engaging learning environment in science at an educational institution she felt would see, hear, and support her interests. She just had to find such an institution—one where she could belong. Christa was not thinking about "microaggressions." They are hard to identify for their subtleties, but she looked for a place that would offer more chances of treating her well. In that direction, it was not enough for the MIT to award her an acceptance letter; they had long ago lost her. They lost her through Mr. Phillips, Mrs. Harris, and the colleagues that isolated her. The MIT and all other prestige institutions lost Christa. As they lose many other great students, not only because they have built an image of unattainability, but because the entire educational system had already contributed to make great students like Christa, that do not fit the racial and socio economic make up of prestige institutions, to "learn their place," to learn they will not be comfortable in such institutions. Sue (2010) analyzes how "microaggressions operate systematically" (p. 235) in education, and suggests that women are underrepresented in science and engineering probably because of the discrimination they suffer.

Rollock (2011) argues that acts of microaggressions are “one of the ways in which Whiteness” is manifested, and that “much of the power of Whiteness lies in the fact that it is often disguised [...] as the morally acceptable, as normal, as natural” (p. 2). The microaggressions at educational settings are a powerful tool to enculturate students in a stratified society and its systems of power and knowledge. By the end of high school, Christa was supposed to know where she belonged. She knew she would not “amount to anything,” as Mr. Phillips suggested, she knew she was “the” different one, because all the other kids picked on her, and she knew that known prestigious institutions would not treat her well.

To counterbalance that, Christa also knew she was “one of these kids that everyone knows that go to college,” because that is how her family and church community saw and thought about her, as this quiet, good kid, that would certainly succeed. In addition to that, the girl who was belittled at school was valued at NASA during the summers. That was a different world, where she made good connections and where people treated her differently from school. Moreover, she had the good grades; in spite of episodes that could have shut her down, she performed well academically, working to make her teachers proud. She was still a people pleaser.

It is plausible to think that this combination of family and religious community support, allied with the environment and opportunities that Christa had at NASA, helped her to overcome the challenges life put her through during her school years, leading her to college, unlike most of her family and friends.

Christa’s Early Career as a Physicist

In this third set of stories, we look beyond the college years and into her early emergence of a physicist's identity. Even though Christa opted for an undergraduate degree in physics, it was not until she finished college that she realized she liked physics. Until then she liked mathematics, chemistry, and mostly the humanities. However, as much as she was interested in reading and discussing books and writing about them, she could not do it at the pace that those things were required to be done: "I'm a very, very slow reader!"

Like most physics department in the country, there are few if any women professors that Christa had exposure to, but the department had recently hired Dr. Williams into a tenure-track position. During that time, Christa watched Dr. Williams struggle for tenure and thought how awful a process that was for Dr. Williams; however, Dr. Williams was a person who helped Christa a lot during her undergraduate years.

Dr. Williams fought for Christa to go abroad to learn another language and culture, and also encouraged her to do other summer activities, which led Christa not only to spend one semester abroad, but to spend a summer in another university, during her sophomore year in college doing physics education research as an REU. [9] In addition, the summer after her junior year, she went to another university and did an REU with a Nobel Prize winner. Christa was moving forward in her career in becoming a physicist. She had Dr. Williams directing her career path, as well as Dr. Clark, from NASA. Christa really was not thinking of physics as a career. She was just playing a game and not realizing the opportunities that were in front of her:

I had no idea what I wanted to do and I still wasn't, you know, [sure]. I was doing

[9] REU (Research Experience for Undergraduates) is a National Science Foundation supported program, where a group of undergraduates work in research programs at host institutions.

> physics but I wasn’t interested in physics, so I wasn’t looking at people in that particular way. I wasn’t looking-I was sort of wandering around and that wandering happens to look like a career, but it was mostly me just, I guess, not, not realizing the opportunities that were in front of me, and later on reflecting back and allowing those interactions to guide me.

Other faculty members in her department were insightful in different ways, with one who reassured her that she could do science, another that she could do engineering, and yet another that she could do anything she wanted. Finally, another faculty member made her realize she could go to graduate school, something Christa had never thought before, “Graduate school?”, Christa questioned. Christa had ever heard or knew anything about graduate school:

> My parents, because of their art background, it wasn’t anything that they knew to tell me anything about, which is probably why I wandered so much. I didn’t know it was out there and what opportunities were available. And so I hadn’t thought about graduate school and, and I was definitely being groomed by the faculty […] to go to graduate school.

Christa’s parents were so proud of her-- the first of their kids to go to college! They kept telling everyone about how Christa was going to graduate summa cum laude. Christa was also happy, she was all on track for her summa cum laude degree, and her grades were fine; those were happy times in the young woman’s life.

All was going well, with the usual ups and downs one can have during their college years, like studying hard for exams, the lack of time, one struggle here and there, but overall, Christa’s life was going quite well until a series of events led to a critical episode in her life.

It was autumn. Christa had returned from her semester abroad for her senior year at college. Within the first month of the semester, her best friend had three people who were close to her to die for different reasons; one was old age, one committed suicide, and one was murdered. These happenings were all very close to each other and Christa was trying to help her friend through this time, which brought up some fundamental questions about life. Christa realized she could not answer those questions from a physics perspective or a religious perspective either. The young woman was struggling to try to understand who she was and what she believed in.

Her Young Earth strong religious beliefs, that were really her parents' beliefs, had been shaken once she started to learn more about science and the evidences about the age of earth. In addition, her physics beliefs had been shaken when she learned that the world was not deterministic. So far, Christa had been playing the game without major problems, but her approach was not being helpful to comfort her friend's losses. Christa went back to her comfort zone, investing as much of her energy as she could in physics to try to solve problems: "If I can, if I can understand the physics, then everything will be okay and I can just ignore this other stuff."

At that time, Christa was taking electricity and magnetism, and she did not understand the concepts. She was having a hard time with the courses and her attempt to compartmentalize, ignoring the external world, was not working; her grades started to drop. Christa went back to calculate her GPA, foreseeing lower grades, to see whether she could still make it to graduate summa cum lade, as her parents were expecting her to. Nevertheless, with the poor performance in electricity and magnetism Christa would not be able to graduate summa cum lade. The prodigy daughter saw her entire world completely falling apart: “I couldn’t please my parents, I couldn’t help my friend, I didn’t know who I was, I didn’t know what I believed, and I had nothing.”

Feeling isolated and hopeless, Christa stopped eating, sleeping, and drinking; she had a mental breakdown in the electronics lab, the same lab she had spent her entire sophomore year working. She now found herself on the floor, crying underneath the bench, inconsolable. One of her physics teachers entered the lab and found her there, shaking, in tears, and got Christa to the health center, where they managed to calm her down. Christa then went back to her room on campus and sat on the floor with a razor blade in the dark. She decided to kill herself. She was quiet; she had made up her mind, she was worthless, inferior… and she felt something saying, “No, don’t do it.”

A couple of days went by and Christa went home for Thanksgiving break but she did not tell her parents what was going on. The only thing she told them was that she wanted to talk to their pastor at the church. The very religious girl that had stopped attending church after entering college was now going back to her foundational roots, looking for the family pastor, in an attempt to resolve her spiritual conflicts.

“If God isn’t real, I’m going to kill myself,” were the first words Christa told the pastor she had not seen in a long time.

“Let’s talk about what’s going on,” he suggested.

“You know, I don’t-I, I’m not sure that I believe all of this stuff that I’m hearing in church and, because it doesn’t agree with science and science is testable, and I don’t see how these reconcile, and I don’t know who I am or where I’m going.”

The pastor then recommended the reading of a book by a Christian astronomer named Hugh Ross, about integrating science and faith. That was for Christa the start of a long quest over the next couple of years where she started investigating many other religions. She read other holy books, such as the Bible, the Koran, and the Bhagavad Gita, in search of fundamental answers to questions such as “is there truth, is there God, and is there any way that we could know? How would we go about doing this?” Eventually, she came back to Christianity, in what she considers her own faith, rebuilt from scratch, critically questioned, and not simply adopted as her parents’ beliefs to please them.

The tipping point was an accumulated series of things that broke the equilibrium of a system for Christa. In this case, it was the system of beliefs, behaviors, and psychological well-being. Her religious beliefs, her science explorations, and people’s expectations combined with her inability to comfort or to please others culminated in a situation where she was unable to conciliate everyone’s needs, and she was forced to think about herself, her needs, her faith, and her wishes.

All this turmoil happened November and December of Christa’s senior year. She was emotionally fragile, and with the help of her academic advisor, she dropped all classes that were not essential for her to graduate. She took just one class during that semester, which was all she needed to remain a full-time student. That was not the only decision Christa took.

In spite of her professors’ disapproval, and disappointment, she decided not to go to graduate school. They were particularly upset because she would be their first Black student to graduate from the physics department, and their first to go to graduate school. It was more of an institutional concern than a care about Christa’s well-being. Christa’s advisor for her senior project was mad that she decided not to go to graduate school, to the point that he stopped talking to her and did not read her final project at all. He and the other faculty were broken hearted because they had so many hopes for Christa. She felt that she was letting them down, but Christa was changing; she had changed. Her emotional breakdown was the spark to rebuild her faith. She learned how to say no, to learn what her interests were, and to prioritize them, letting go of her people-pleasing personality.

A New Start: When Interests Converge

Coming out of college, Christa decided to teach. She got a teaching position at a K-12 private school. That was when she put her life back together. That was also when she realized that she really liked physics and that she wanted to do more physics. Then, she decided to go to graduate school, “I felt that God was telling me that I should go to graduate school and I didn’t know why […], well, if God wants me to go, He has a plan, and so I will just go…” Christa was in her second year of teaching when she made this decision. She knew she would have to teach herself physics that she had not taken in college, because she went abroad and did not have all the coursework for graduate school. She realized that teaching K-12 requires a great deal of time and energy, and this posed a problem in that she could not study for the physics GRE if she continued teaching. Her decision was, then, to obtain a nine-to-five job in order to have time to study. She activated her contacts at NASA and said she needed a job because she wanted to go to graduate school. She got a job. While working at NASA, Christa studied for the

Physics GRE and applied for a NSF IGERT grant. [10] This specific grant is part of a program to train U.S. Ph.D. scientists and engineers with interdisciplinary backgrounds, and to improve "diversity in student participation and preparation." Christa got the grant, and then had to decide where to go for her Ph.D.

During one of her REU, Christa had worked at one institution that was now a NSF IGERT site. She had already some experience of working in that location. Though she was familiar with people there and, because of these relationships, she did not want to go to that university. During her REU, Christa witnessed how the principal investigator mistreated his students, and she had promised never work for someone like Dr. Matthews, who now was the responsible for the IGERT grant at that site and he was looking for people to work in his lab.

Christa found that this time around Dr. Matthews was a completely different person. He no longer yelled at his graduate students. He was nice, reasonable, and courteous. Christa learned that Dr. Matthews had been through a hard part of his life when she first met him, and she thought this could justify his behavior before. As part of the IGERT program, Christa had to rotate in different labs before deciding where she would stay, and she actually enjoyed her experience with Dr. Matthews this time around. She decided to give the lab a chance, starting her Ph.D. program in this institution.

Christa had a very good time with her new colleagues. She was part of network of graduate students that supported each other and would meet regularly; they were sometimes from the same labs, sometimes from different labs, and they would study together. She had one particular close friend with whom she would meet every Friday

---

[10] NSF IGERT – Integrative Graduate Education and Research Traineeship Program: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=12759&org=DGE&from=home

and just talk about how things were going in the lab. In her second year, Christa discovered the National Society of Black Physicists meetings and decided she wanted to go, but Dr. Matthews said, “Well, I think it would be much more valuable for you to be in the lab working, that that’s going to be a better experience for you.”

Christa was very upset. First, because she felt that he knew she had always been in a predominantly White environment and was very comfortable in this type of setting. Second, because he was the chair of the Physics Department Diversity Committee in their university, she expected more support from him to attend an event like that. She completed her work in the lab and wrote Dr. Matthews a letter: “These were the deadlines that I’d set for my accomplishments in the lab. I have met them early and I have my own funding, so I’m going to go to the conference.” She felt victorious. Later she learned that Dr. Matthews respected her quite a bit for standing up for herself and meeting their work deadlines. However, as time passed by, and Christa got to know more and more of her advisor, she realized he was a selfish person. For example, he thought education was important, but when Christa wanted to go and take half a day to volunteer and help in an after-school program, he would deny it.

“No, it’s more important for you to be in the lab,” he stated.

“But you just said that we need to be doing this and our graduate students need this experience.”

“No, you need to be in the lab.”

In addition, when Christa tried to engage in activities for broadening her career, opportunities and her knowledge, he would also object.

“I want to take this course over in Electrical Engineering. That’s-I think it’s a really good optics course," Christa argued.

"No, you need to be in the lab."

Christa had a tough time during graduate school, as she was completing her program. Two months before her scheduled defense, she finally had gotten her system to work to the point that she could take data. She had a crystal in the system that was not the best crystal, but it was working, and it was better if she could take data with that crystal before changing to another one. Dr. Matthews, in fact, told her always to take data before changing something otherwise there will not be a way to know if the change was actually making the system better or not. Christa had everything set and wanted to take data before switching out the crystal. Her adviser shows up:

"No, I have a crystal. You should-we should switch it out," he suggested.

"No, I don't want to switch it out. I want to take data," Christa said.

"I have-I know the crystal and I'm going to get it," he stated.

Then took the crystal out of her system for two weeks, meaning she could not do anything, she could not run her experiment.

Six weeks before the scheduled dissertation defense, Christa still did not have her crystal back. She was so angry that, at four o'clock in the morning, she sent Dr. Matthews a not-so-polite email that said, "If you do not put this thing back or something back in my system, I'm going to raise hell!" The next morning, around nine o'clock, when Christa arrived in the lab, Dr. Matthews was there, putting the crystal back in the system. He actually put a different crystal that ended up working better, and Christa got the data she needed two weeks before her defense.

For the defense, most of her committee did not read the thesis. She knew that one committee member read it, because he met with her and went page by page through her thesis. The other members did not provide any comments on her work that would indicate that they have read it.

"Do you have feedback on my thesis?" asked Christa.

"I don't like your font on that equation," answered one of the committee members, standing in front of Christa, while flipping through the pages of her work. It was a frustrating experience, making Christa doubt about herself and her work as a scientist:

> I came out of grad school feeling like I don't know how to communicate my work, I don't know how to present it in a way that's understandable, and, you know, maybe I didn't get my experiment to work. Maybe my advisor, when he put the crystal in, maybe he was the one who got it to work and I don't really know how to get things to work. I don't know.

During all this, there was only one thing that kept Christa going-- God. She had gone to graduate school with the understanding that she was going to graduate, though it was not something that she initially wanted to do. It was something God wanted her to do. Through all of her struggles, she knew God wanted her to go to graduate school and to finish.

After finishing her Ph.D., Christa wanted to go back to teaching K-12 and get published. She did not want to pursue an academic career, because the life of her peers was not something she wanted—working odd hours, having physics as her only life and conversation topic. She wanted more. Nevertheless, her advisor tried to convince her to work as a faculty member:

> Hmm, okay, maybe. But I don't want to be a professor at a Research I institution. I'll consider it, but it's going to be at a small liberal arts college. The focus is on teaching and not research because I look at your life and there's nothing about that that I want to emulate.

Christa would have to overpass another hurdle in order to get published. After her doctoral defense, Christa started working on publishing the results of her research. Every time she would take a draft for her advisor to approve, he would say it was not good, or that he did not like the audience of that said journal, or something else. She wrote and rewrote articles for four different journals. She tried to get an opinion about her articles from other people, and even journals editors, and always got good feedback. However, in her doctoral institutional policies, she is not allowed to submit a paper unless her advisor agrees with it. Therefore, the young scientist kept trying, without success, to get her name out there, and have her work shared with the physics community.

Christa should have at least five articles, consisting of her work and in collaboration with others, but she had zero publications from her doctoral work. The department started putting pressure on Dr. Matthews about Christa, especially when one of his recent graduate students got published. From eight or ten of his graduate students, Dr. Matthews's did not help any of them to publish. He in turn publishes with colleagues at other institutions and not the work from his lab. After trying for more than five years after graduation, Christa gave up.

As a graduate student and later as a post-doctoral fellow, she had no power to fight. She felt frustrated, doubting of her skills as a scientist. To obtain the highest degree in her field, a Ph.D. in physics, Christa did not feel like a physicist. She wanted the approval and recognition of her peers through publications and feedback from others. On one occasion, Christa presented a poster communication at the American Physical Society conference, in which she did not interact much with people, therefore did not get much feedback. However, she got good feedback in oral communications she did in the National Society of Black Physicists meetings, but she partially dismisses these positive responses because she finds the society of Black physicists is more forgiving or more receptive than the society of physicists at a large. Still she feels unsure of her identity as a physicist:

> I have lots of uncertainties of what my capabilities are. […] I don't--I feel like, you know, if I can just get that first paper out, then I'll feel more confident in my abilities as a physicist, that people under--that I can communicate my work, that people appreciate my work, that it's good work, that it's thorough.

Christa's Early Physics Life as Discussion

One of the tenets of critical race theory is the principle of interest convergence that states, "the interest of [B]lacks in achieving racial equality will be accommodated only when that interest converges with the interests of whites in policymaking positions" (Bell, 2004, p.69). I analyze the presence of a Black woman in a physics department as a case of interest convergence because of the underrepresentation of women and Black people in STEM fields and the country's need to produce more scientists.

Perna et al. (2009) argue that "numerous reports assert that the United States must increase its production of highly educated workers [in STEM] fields in order to be competitive in the global marketplace" (p. 1), at the same time that universities are expected to increase the diversity of students, faculty, and staff. During her undergraduate studies, Christa was the first, and only, Black student the physics department had ever had. Many expectations were put on her. She studied in a predominantly White institution (PWI) and received a full-scholarship for her entire bachelor's degree. That was good for the department, because it increased its diversity in terms of both gender and race with just one student. It was also good for Christa, who was fully funded, which was important for a family with limited financial resources; and it was good for the country, increasing the workforce in a strategic field for the development of the economy.

Many institutions have departments or committees specifically to address issues of diversity. That was no different at Christa's graduate physics department. In fact, her advisor was the chair of said committee. Even though he held a position where he was supposed to support diverse students, he vetoed Christa's participation in a conference that could offer her support through a professional network of other Black physicists. In order to attend the conference, Christa had to increase the amount of work she did at her professor's lab to keep with the deadline they had initially set. Therefore, when there was no gain for the lab, Christa's prospective personal gain was denied. Similarly to African-American football student athletes, where their personal education interests are neglected (Donnor, 2005), Christa's personal academic and professional needs were put in second plan in favor to the needs of the department, the lab, and her advisor.

Searching for (Self-)Acceptance

Two weeks after her doctoral defense, Christa was hired into a Visiting Professor position to work in the institution that she had previously networked from the NSBP meetings. She worked there two terms out of a trimester system. Those seven months, were great, and she had the chance to get to know the college and the professor's life. The college wanted her to stay, but she felt she needed a break. Christa decided to live on her savings for four months, just doing things she wanted to do and to enjoy life. She went abroad, did whitewater rafting, and other non-academic activities. After this time, she went back to academia for as a post-doctoral fellow. She started a two-year post-doc in the same institution where she obtained her Ph.D., but this time she went to work in Electrical Engineering, doing physics and collaborating with chemical and biological engineering colleagues, far from her previous adviser.

Christa met her husband during her post-doc. It was very hard for her to consider starting a relationship when the chances were that she might be moving at the end of the year or whenever. As a result, they got married very quickly-- in ten months. Eleven months later, she started her tenure position. Christa stated, "I always knew that I wouldn't marry a physicist because I've interacted with lots of physicists and I like them and all, but they just talk about physics all the time, and I have a much broader range of interests," Christa married a young White man, who was concerned about how to introduce his new girlfriend to his parents. He worried that they would be upset about Christa being Black. When he told his parents, a radio deejay and a stay-home mom, that he was dating a Black woman who had a Ph.D. in physics, they promptly asked:

"What do we talk to her about?"

"She's a normal person; you can talk to her about anything!"

Christa was learning how to balance the image of a scientist and expectations people outside academia created about her for being a physicist.

Every family gathering is the same. Everyone looks up to the physicist in the family because she was the first in her family to graduate from college, the first in her generation to get a bachelor's degree and a Ph.D., and in physics! One thing that constantly frightens Christa relates to her ability to communicate science in such a way that she does not alienate her family and friends. She struggles with the view that people might have of her as being this very smart and unapproachable woman:

> I can have conversations about the weather, I can have conversations about, you know, the latest sporting event. I could talk with them about science if they're interested, but I don't push that if that's not what they're interested in. And so it's really important to me to try to stay connected to my family, even though many times society, especially if you have a Ph.D. and then a Ph.D. in physics, they want to say, 'Oh, you're unapproachable. You don't know how to speak English.' …because certainly I have a Ph.D. in physics and my mom has an Associate's degree in art, right? And so there is definitely a very real possibility that I've become basically super smart and completely alienate my family.

One of Christa's brothers materializes her fears when he uses Christa to impress his friends, saying, "I might be a screw-up, but look at my sister: she has a Ph.D." This really upsets her because it puts her on a very different level, when deep inside all she wants is to be able to tell them "I'm just like the rest of you; I just happen to know a little bit more in this particular area," and connect with her brother friends', being part of the same circle.

Christa's husband is "extremely supportive" of her work, and he actually quit his job to move with her when she was offered a tenure-track position because it was a great opportunity and he did not want to take that away from her. Their plan, if they have children, would be for him to be a stay-at-home dad. He does not have a job yet, and he looks for it, but not too seriously. The couple lives in a hundred-year-old house and he has a lot of work to do around there.

In her mid-thirties and going through a tenure process, Christa was afraid to wait until too late to have a pregnancy with fewer risks of complications and fewer chances of birth defects, and so on. The tenure process is so stressful that she suspects all this stress would negatively interfere with pregnancy, if she decided to have a child now. Last, there is the fact she enjoys being married without children, as she would like to enjoy the couples' life for a bit more before adding the children. "And I don't even know if I want kids! Maybe it's already too late… I don't know. I probably think about whether or not I want to have children at least once a day."

A year had passed since Christa started her tenure-track position, and soon members from the review board would start to sit her in class to evaluate her teaching. She was about to enter this period in which her teaching and scholarship would be officially evaluated. She was getting herself psychologically prepared for the scrutiny, as well as assuming more responsibilities in the institution, teaching more classes, and sitting on more committees. Although she enjoyed her work, she felt that the academic job promise was misleading. After all academia is supposed to give you freedom! But no:

"Oh, when you get your sabbatical, then you get a year off. It's not a year off!!! It's a year off from teaching," she complains.

"You have to reinvigorate your research, Christa."

"But I want a year off. I want to be able to do those things, those that I put off, that I've put on hold for seven years."

Christa wants to go out and see the world, try glass-blowing, pick up another instrument. She felt like she had been denying herself pleasures in favor of doing "things amazingly well" in the academic realm. This made Christa feel frustrated because she could not see a way out of this circle. She was pressured to continue to excel in her career, and this might be a new challenge that Christa would have to deal with. Fortunately, she was now a much stronger person than she was in college and could step back to analyze her situation from another perspective-- "maybe there's a way that I can [do it all]…I just haven't found it because I'm too early in my career."

In addition, Christa found herself spiritually: "I'm deeply religious, but I'm very deeply thoughtful." She implies that being religious is not being critical, generally, and she highlights how truly religious she is, at the same time she does not see herself as a typical religious person because she is thoughtful and inquisitive:

> I'm not the type of person that just because a pastor says it, I agree with it and believe it. I am (pause) I read--I don't just want to read the Bible in English. I want to read it in the original language. I want to read all of the possible translations, not just the one that you translated this way because it's the words that you think best fit your interpretation and form my own conclusions. So I would say I'm, I am definitely Christian, and I would say I'm a very Bible-believing Christian, but I wouldn't say that I belong to a particular denomination because denominations have particular opinions on certain things, and I form my own opinions and it's not along a denomination.

It is this spirituality, combined with her perseverance and experiences throughout childhood, which transformed Christa into a different person. However, she was still a woman struggling to define her identity as a scientist. The ghost of her Ph.D. advisor haunted Christa, interfering in her ability to feel secure about her science and about herself as a physicist.

> I think the perseverance that I observed as a child allows me to persevere now. I definitely feel less confident now than I felt as a child doing--I mean, I wasn't--I was, you know, still mostly in paleontology mode and things like that, but I feel very insecure. But I know that most of that is--I mean, I can even hear the messages in my head from my advisor. I can hear his voice saying, 'You don't know how to write. Nobody understands what you're saying.' And it drowns out the other voices that I've heard that say, 'You know what? I've never heard anybody explain this particular concept in physics this clearly. Thank you for doing that.' Which is frustrating, because there are more of those voices than there are of my advisor's, but his is the one that I hear the most and it causes a lot of doubt. But I think that the earlier part of my history allows me to persevere through.

The tenure process continued. The college analyzed Christa's classes and her entire work was under scrutiny. That was a bit enervating, in the beginning when she thought about it, but once people actually sat and observed her class she did not even notice they were there. She found herself so comfortable and confident in the classroom. Christa did not receive critiques on her teaching and that triggered her low confidence button. She checked with friends who had passed through this process, and looked for the teaching center at her institution, for a second opinion on her teaching evaluations. Everything was fine. The tenure process moved smoothly and the recognition from her institution along with the feedback from her students boosted Christa's confidence.

Currently, Christa is an Assistant Professor of Physics in the Astronomy and physics department of a liberal arts college, a primarily undergraduate institution. In her work, Christa is expected to have a research program for the undergraduates, to write and do scholarly work, such as writing papers and presenting at conferences, writing books, and to participate in several committees in the college in general and in the physics department in particular. The college does not expect her scholarly work to be necessarily in physics; it can be in education. Since she loves teaching, she might be looking into producing research on physics education in the future.

Christa's current institution understands her "publication situation" because they are aware of Dr. Matthews's practices, so they were willing to hire her even without any publications. Still Christa is facing a situation in her new position. Because NSF has a policy that if a researcher does not have publications, they cannot get funding. Finding herself in a catch-22, Christa is trying to get funding to expand her lab so she can work and publish. In the lab, Christa is responsible for four research students. She is very happy that her undergraduate research students are excited about science because of the experience they have had with her. One of her students now wants to go to graduate school, and focus on optics. The student is trying to decide whether he wants to do physics or electrical engineering. This interest is a direct result of interacting with Christa.

> And so that's like, wow, that's really cool. And it's a White male, you know? And I was always taught-well, not always. But I remember when I was working at NASA, I was taught that White men are the enemy and I found them to be--you

know, [my advisor at NASA], who's a White male, was extremely supportive and instrumental in my career, and so that was a very positive experience.

Christa's Physicist Identity as Discussion

In this entire journey, Christa never felt excluded from science. She also never saw herself as a Black person doing science. She just did what did. She just did science. She never thought of attributing any of the bad, or good, things that happened to her to the fact that she was a Black person, or a woman: "The last thing that I am tempted to do is to attribute it to my race or my gender. And maybe that's just a safety mechanism, I don't know"[11]. After a long pause, she reticently says, "Yeah. I'm not sure".

In this constant movement, oscillating between a strong and weak physics identity, the tenure process and the responsibility of earning this distinction gave Christa the final strength she needed to claim the identity of a physicist. "I don't actually think of myself as a woman," she laughs, "although I certainly think of myself as a woman before I think of myself as Black -- kind of a physicist, then woman, then Black woman." As a physicist, as a Black person, and as a woman, all that Christa wants now is to focus on her teaching and to remain engaged in education. Aside from this, she wants to go to China, New Zealand, do glass-blowing, and whitewater rafting.

Unlike popular perception that women of color are not interested in science (Johnson, 2006), Christa offers a counter narrative of a Black girl who likes science and tries repeatedly to engage in science in school. She likes science, but endures a long

[11] Derrick Bell said one of the rules of the racial standing was that complains about racism from Black people are taken less seriously and as biased (Lee & Lee, 1993). This suggests that Black people experience a continuous process that implicitly teaches that we should not focus on race and ethnic background to analyze our experiences in society, because we are biased, and our complaints are repeatedly dismissed anyway. This might explain why Christa says that "the last thing [she is] tempted to do is to attribute" her hurdles in the science world to her race or gender.

journey to find if science likes her back.

Christa could have been a paleontologist as that profession fascinated her, but her view of self-versus-paleontologists (or the image she has about them) made her less interested in following that profession. Similarly, Christa could have decided to work as a professor in a research institution, as her advisor and other faculty in her department expect her to, instead of going to work in a liberal arts college. However, her view of self-versus-other-physicist makes her decide not to follow their steps. These data are consistent with Lee (1998) findings on perception of self and likelihood to become a scientist.

The process of becoming a scientist involves more than the learning of scientific concepts and skills, it requires the development of sense of self as a scientist and the recognition of others (Carlone et al., 2008; Carlone & Johnson, 2007). Christa does not get the recognition she expects from her advisor, a figure of authority in the field she wants to be recognized as a professional. She has her work presented and well received in the National Society of Black Physicists conference, but she doubts herself because that is a “nice audience.” Would have she felt more confident about her work had she presented it in a mostly White conference? Ladson-Billings (1996), an academic African-American woman, discusses about how Whites and non-Whites audiences react differently to her conference presentation. Because there is a difference in the audiences, it is possible that Christa have internalized that the White male audience validation is more important than the Black audience validation (that is always nice).

Minority women are “less likely than White males to enjoy a successful academic career” (Trower, 2003, p.1), in general, and in a White male dominant field as physics, that is definitely a fact. As a faculty of color, Christa has higher chances of facing inappropriate questioning of her authority or credibility from the students (Tuitt et al., 2009) and it is precisely the approval of her students and the institution's recognition of her work that Christa suggests being helpful to improve her confidence and acceptance of her role as a physicist.

Conclusion

This paper focused on the described experiences of Christa towards the construction of a scientific identity. I use counter-storytelling to present, discuss, and analyze Christa's personal and professional trajectories as a physicist, as well as her career choices. In this chapter, counter-storytelling shows how the construction of a scientific identity is a multifaceted process and that it is hard and limiting, to talk about fixed categories that compose scientific identity. That is not to say that one cannot identify larger themes that play a part in the construction of scientific identity, for one can see in Christa that a support network (parental, religious, and marital), self-efficacy, funding, and expertise recognition are essential to enable Christa's scientific identity development. Counter-storytelling, however, besides offering a platform to talk about identity as a result of complex interactions among these domains, helps unveiling how racism operates in this process of science identity construction.

Christa counters the mainstream story of parents absent in the schooling experiences of students of color. Her narrative unveils how microaggression can influence everyday behavior and major life decisions, such as the college choice. Looking at Christa's story, one can see how episodes that personally benefit her as a woman of color in physics happen as a trade that largely benefits those that already have privileges (e.g. advisor, university, science community). In the end, it is impossible to dissociate Christa's experiences towards the construction of a scientific identity, her opportunities and struggles during this journey, from her gendered and racialized experiences in a society where racism is prevalent and normal.

CHAPTER V

SCIENTIFIC IDENTITY IN THE MAKING

Abstract

This paper examines the lived experiences of six Black women physicists and addresses how do these women negotiate their multiple identities, what do they identify as obstacles in their career paths, and what strategies do the scientists use to overcome these obstacles. The findings suggest there was a pattern through which the scientists went through in their careers. In addition, it reveals that college recruitment and funding were fundamental for these women to choose physics over other STEM fields. The data analysis shows that Black women experience unique challenges of socialization in STEM and that physics departments should provide a more integrating environment to support Black women in science.

Introduction

This research is conceptualized using critical race theory (CRT) and a feminist standpoint. CRT has five tenets that serve as lenses to guide this study: (a) counter-storytelling, (b) the permanence of racism, (c) Whiteness as property, (d) interest convergence, and (e) the critique of liberalism (Decuir & Dixson, 2004). The first tenet refers to the centrality of experiential knowledge, arguing that the experience of people of color is legitimate and an integral part to analyze and understand racial inequality in society; and I use counter-storytelling as the main method to convey this experience. The second tenet states that racism is structural, and a permanent component in the United

States' society. The third tenet brings the notion of Whiteness as a property in the sense that, because of the history of race and racism in the United States, Harris (1993) considers being White a property interest. For example, Whiteness as a property in the educational enterprise is manifest in the obvious fact that the majority of White students have been almost the only ones to have access to high-quality curricula and advanced placement courses (Ladson-Billings & Tate, 1995). The fourth tenet suggests that civil rights gains occurred merely because they "converged with the self-interests of Whites" (Decuir & Dixson, 2004, p. 28). Finally, the fifth tenet challenges the dominant ideology and its claims of neutrality, objectivity, colorblindness, and meritocracy.

Within a feminist standpoint (Collins, 2000), in combination with CRT, emerges the concept of intersectionality. Crenshaw (1991) presents "intersectionality as a way of framing the various interactions of race and gender in the context of violence against women of color" (p. 1296). She argues that this construct can be used in different contexts, though, as a mediator to the tensions between "assertions of multiple identities and the ongoing necessity of group politics" (p. 1296). Intersectionality, then, becomes the intersection of distinct sets of identities, distinct groups that can overlap in some parts of a space of possible identities. Crenshaw's work focuses on women of color, discussing how gender and race come together to limit, or shape, specific experiences of women of color. She also intersects gender and race with social class in many points, exploring how this other set of identity constricts, again, the experiences of women of color.

The word intersectionality is a direct reminder about Set Theory, a foundational part of mathematics that studies sets, its properties and relations. Sets are collection of abstract objects, and other domains borrow this mathematics language to refer to collections in general. Set Theory allows for binary operations on sets, such as union, difference, and intersection. The intersection of two sets A and B is the set that contains all elements of A that also belong to B, or vice versa. The intersection of A and B is written "A ∩ B". One can have an intersection of many sets, for example A, B, C (A ∩ B ∩ C). Another way to represent sets is shown in figure 5.1.

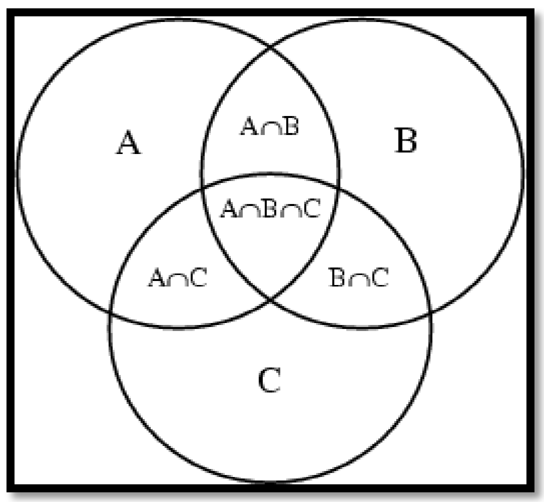


Figure 5.1: Graphic representation of Intersection of sets A, B, and C

When we look at intersections, there is a set A and there is a set B independently of each other. An intersection of A and B form another set, A ∩ B that is not A and it is not B, but shares elements with A and shares elements with B. Not surprisingly, an image search for intersectionality using a search engine would come up with images like those in figure 5.2. [12]

[12] Images from http://ecx.images-amazon.com/images/I/41WZh5mmz8L._SL500_PIsitb-sticker-arrow-big,TopRight,35,-73_OU01_SS500_.jpg, http://occupydenver.org/wp-content/uploads/2012/10/IntersectWeb.jpg, and http://farm5.static.flickr.com/4146/5052980396_d5e6497f03.jpg , respectively

Figure 5.2: Graphic representations of intersectionality

Therefore, implicit in the term intersectionality is the idea of the existence of a set Gender, a set Race, a set Class, and so on; because intersectionality argues that there is, for example, an intersection (set) between Gender and Race. That is to say, that Gender and Race exist independently of each other. Perhaps as an unintended consequence, intersectionality implies the existence of essentialized categories of race and gender. [13] An intersection of Race and Gender is a set that contains elements of Race that share membership with Gender. The great contribution of intersectionality within critical race theory is not only to recognize the influence of multiple categories such as gender and social class to understand the experiences of people of color, but to emphasize that these multiples elements are fundamental to this understanding. However, the idea of intersection does not seem to problematize the essentialized notion of race and gender.

However, to what extent can one view women of color as an intersection of being women and being of color. Is it possible for a woman of color to have formed her identity

[13] Through a different argument, Delgado (2011) arrives to similar critics to intersectionality.

as a woman without her race playing essential part on that very construction? As a physics educator, I propose an analogy using the history of physics to illustrate the nature of race and gender that guided me through this study. For some time, scientists conceptualized the nature of light as being a particle. It behaved like a particle; it could be studied like a particle. One could make calculations as if light was a particle. Then the nature of light was... a particle. Later, scientists proposed that the light behaved like a wave. For a while, people debated whether light had a particle or wave nature. Then many scientists settled for the idea that they could study and analyze light as particle or as a wave, and that light showed a behavior that complemented each other, therefore it had a wave-particle nature (i.e. the Copenhagen interpretation). However, other scientists said light was a wave (e.g. Heverett's many-worlds interpretation), [14] and others said it is a particle and a wave (e.g. de Broglie-Bohm's hidden variable interpretation). [15] Scientists know particles very well, and know waves very well; we can use mathematical models, build technologies, and have a good understanding of how to manipulate light, using the mathematical tools for particle or wave, even though scientists might disagree about the nature of light a fundamental level. Light itself could be more than wave/particle but a third thing that we fail to identify for we know how to operate with the wave and particle. Leaving the realm of physics and translating its debate around the nature of light (wave or particle, wave, or wave and particle) to think about gender and race, I argue that maybe we are so used to working with the categories of gender and race that we might

---

[14] For a discussion on the Copenhagen interpretation and the many-worlds interpretation: Murphy, K. (2007). The many worlds interpretation. Available at: http://www.phy.ohiou.edu/~murphy/talks/misc/manyworlds.pdf

[15] For a discussion on the de Broglie-Bohm's interpretation: Brown, H. & Wallace, D. (2005). Solving the measurement problem: de Broglie-Bohm loses out to Everett. Foundations of Physics, 35, 517-540.

fail to think about racialized gender/gendered race. In other words, we might consider thinking of racial and gender identity formation not as an intersection of two groups, but as a group in itself.

However, as it happens with the phenomenon of light, in physics, where we analyze particle and wave behavior separately, it can be helpful to analyze gender, race, social class, etc., as separate, for the sake of systematization. Intersectionality becomes, then, a methodological way to group a system that was compartmentalized because of its intrinsic complexity.

In this direction, when talking about intersection of race and gender in this work, I am not assuming an independent idea of race from gender. I am subscribing to the notion that race and gender identity are intrinsically connected (Spillers, 1987), and look at this connection in relation to scientific identity formation. This paper addresses the research questions of how do Black women physicists negotiate their multiple identities, what do they identify as obstacles in their career paths, and what strategies do the scientists use to overcome these obstacles. In the sections that follow, I present the methods used to collect and analyze the data, followed by the findings with a characterization of the participants of the study. Next, there is the discussion of the data collected, and the themes that emerged in the investigation. Last, I present conclusions, as well as a discussion for the development of prospective studies on the topic.

Methods

In order to identify Black women physicists in the United States, I made available an online survey to gather initial information on possible participants. I distributed the link for the survey among the members of the professional associations such as the

National Society of Black Physicists (NSBP) and the American Physical Society, as well as social networks[16]. In addition, I sent the survey link directly to the scientists that are in the NSBP Black Women Physicist database (which includes not only their members). The purpose of this initial survey was to gather general information about my available population, and to use this data to select the informants for the in-depth interviews. The survey covered, for example, questions about academic background, ethnic affiliation, and current work status. In addition to the survey, I recruited participants during a NSBP conference.

In the second stage of the data collection, I selected the participants for in-depth interviews using the following criteria: they held a Ph.D. degree in physics, astronomy or related field (assessed on an individual basis); identified themselves as Black or of African American; and were willing to participate in in-depth interviews. In addition, the selection of the participants was restricted to those who had most of their education in the United States. I sent an invitation to join the study to the eleven women who had answered that they would agree to participate in in-depth interviews. Although eleven scientists agreed to participate in the interview phase of the study, I interviewed only five of them. For various reasons, such as schedule conflict, I did not interview the remaining six women. In the end, the sample constituted of six women, five recruited from the initial survey and one on the NSBP meeting site. These six women constituted a sample of Black women in physics careers, working in diverse settings (i.e., the government sector and half in college or universities, a make-up similar to the pool from the initial

[16] LinkedIn, Google Plus, and Facebook.

survey, where these sectors made 46% each of the pool). The participants' ages vary from late twenties (20's) to mid-fifties (50's) years of age.

The interviews were audio recorded in person, in various locations across the United States. The interviews ranged from two hours to three hours for each participant. One participant, Christa, had two interviews. Her second interview was ten months after the first encounter, and it was audio recorded via telephone; it lasted about forty minutes. Two other participants, Allyson and Shanna, were contacted after the interview, through email, for clarification on her stories. The other interviews did not require further clarifications. The same open-ended questions interview protocol was used for all six participants; however, refinements for the questions were made as the interview process continued, building upon the information that was collected in previous interviews. I coded the interviews and analyzed the data to allow for emergent themes.

Grounded in critical race theory, the lived experiences of Black women physicists were analyzed using counter-storytelling (Solórzano & Yosso, 2002). Counter-stories can be "personal, composite stories or narratives of people of color" (Hiraldo, 2010, p.53). For analysis, I utilize personal narratives of the physicists in search of emergent themes (e.g., federal agencies support) and reported experiences that relate to the research questions.

Findings

This section presents short stories from the life of each physicist in the study. The stories serve to introduce the Black women physicists by highlighting their current position, and then going backward to include stories of their upbringing and educational experiences. Following these individual case stories, I discuss how the physicists negotiate their multiple identities, what obstacles they face during their trajectory, and how they overcome these obstacles.

Black Women Physicists Profiles

Allyson. Allyson holds a bachelor degree in physics and a Ph.D. in material science and engineering. Allyson is a first generation Ph.D. degree holder of a middle class family from the Southeast. Her parents raised their two daughters to develop very strong mathematical skills and science. Her father was an electrical engineer. Growing up in the suburbs, Allyson faced early on the differences between people of color and Whites in her neighborhood. In her school, there was a disparity in the number of students of color in the accelerated classes, and even in the treatment she received from some of her teachers. Teachers would challenge her presence in Advanced Placement classes and not offer the same support they would for the White students.

Allyson grew up very involved in Baptist church community. She was an usher, sang in the choir, and was a youth missionary. She was also involved in several extracurricular activities such as the Girl Scouts, the step team, ballet, and the marching band. In addition, Allyson had the opportunity to participate in initiatives that fostered mathematics and science skills and targeted students of color. She attended summer programs and got tutoring in mathematics, biology, chemistry, and physics through these initiatives.

Allyson followed the steps of two of her cousins who were pursuing bachelor degrees in the sciences at the same Historically Black College and University (HBCU) Allyson did her studies. At this institution, the students were of color but the faculty was not, and she found that curious. Nevertheless, Allyson felt a great support from her academic community. However, when moving to the doctoral level, Allyson felt a great difference from the supportive HBCU environment to the hostile Predominantly White Institution (PWI). She did not see many people of color, unless they were working as janitors or on the custodian staff. Even though Allyson had a good relationship with her advisor, who was friends of her college advisor, she had some hard times with her colleagues. They could not understand why she was there and not at home taking care of children and a husband, like their wives. Allyson got married during her doctoral studies, and although her husband is very supportive of her work, she recognizes that it was a challenge to juggle graduate school and marriage. Over time, the relationship with her graduate colleagues evolved, but Allyson had challenges with them until they achieved peace. Allyson is in her first job, working for the government, and plans to have children in the future. As a researcher, she works on developing science and technology for the United States government.

Betty. Betty holds a bachelor degree in Electrical Engineering, and a masters and Ph.D. in Physics. Betty grew up in a large urban environment in the Midwest of the United States. She had a very loose connection to the church when growing up, and her parents were not particularly religious, although they did go to Catholic mass every now and then. Betty described her overall environment as more spiritual than religious. Her parents were greatly involved in activist circles, which provided Betty an environment to engage in social justice and Black movements that were strongly present in her upbringing.

None of her close relatives was in a scientific field. What brought Betty into the sciences was really her love for mathematics. She liked multiplication tables and figuring out the patterns of relationships between numbers. She always studied in public schools and participated in many after-school programs. Betty attended a top-rate quality magnet high school in which she focused her studies on science and mathematics and took as many Honors and AP classes she could.

After participating in a few programs that aimed to recruit minority students for STEM disciplines, Betty went to engineering school because she was already familiar with what she thought the profession was, and familiar with the institution she selected. College years were demanding, but not particularly challenging. During graduate school at a HBCU, Betty did not have much guidance from her advisors, but was given a lot of responsibilities and autonomy to build a lab and run it. She had a rare opportunity as a Ph.D. student to manage a laboratory in every single aspect of it-- to teach people to work in the lab and to give reports to the lab sponsors. Later, Betty shifted her career with a post-doctoral fellowship doing physics education research, followed by developing work in policies for STEM education.

She got married later in life, and is in a point of her career where it is hard to find mentors because it is difficult to find people that do the type of work that she does and has the interdisciplinary expertise that her profession requires. Currently, she is a Research Analyst doing largely qualitative analysis and getting involved in issues of either conceptualization or quality control for both qualitative and quantitative projects.

Esther. Esther is the youngest daughter of five, a wife, a mother of four, and the grandmother of six children. Being the youngest child of five, three girls and two boys, she was separated from her siblings when she was two years old. At that time, Esther's mother passed away and the family decided that the grandparents would take care of the children, so the girls went under the care of her mother’s parents, and her brothers stayed with her father’s parents.

Esther was raised in a rural area, her grandfather raised hogs and her grandmother worked as a cook – bringing all the leftover food to the hogs. Esther's grandparents were very involved in her school and in the church. At the school, her grandfather was the president of the Parent-Teacher Association, and her grandmother worked as a cook. In the church, her grandfather was a deacon and along with his wife, sang in the church choir. Esther says she “grew up in the church, of course,” and that her family would “feed the preacher every Sunday, so we’d get up in the mornings early and make dinner for the preacher and the elders, and they all would get the big piece of chicken, we’d get a little piece of chicken.” Esther also was a very active participant in the church life; she “sang in the choir, served on the usher board, Baptist training union, all of that.” The church was a central part of her life at that time and continues to play an important role in the present.

When growing up Esther played ball, cards, and board games. She said that her “favorite toys growing up as a girl was dolls,” highlighting the gendered character of her toys during childhood. She did not have chemistry sets or any other toys that people would consider science related. In fact, she cannot really relate her experiences at a young age with science. It was just later in school that she had contact with science classes. When Esther transitioned from a segregated to an integrated school, her grandmother made sure to remind her that she was a good student and that she should not feel intimidated in the new school. Esther could do the calculations and answer the problems, but she did not really know what was that good for, and was not interested in science, until one of her teachers told her she was doing really great on her exams, while her colleagues were failing the tests. He said she would make a good physics major, and so she did, because he believed she could do it.

Esther married young and had her children while getting her physics degree. After finishing college, she worked for a while and then decided to spend more time with her children. At this time she home schooled them for six years. Then she decided they were grown and that she wanted to be a college professor. A college professor would need a Ph.D. degree, so she returned to school. Graduate school was a great experience for Esther, except for the hard work. She has no negative remembrances of graduate school. She had great support from her family and particularly from her husband, who would sleep on the sofa of the lab to keep her company. Now Esther is mostly concerned with physics education research, and in mentoring students of color, supporting them, and making sure they know they can be whatever they want. Currently, Esther works as an Assistant Professor in the physics department of an HBCU. She is the only Black woman in that department.

Christa. Christa holds a bachelor and a Ph.D. degree in physics. Christa was the daughter of a long-distance driver who was mostly away during her childhood, so their mother, a very creative woman who would do everything possible to enable her children’s dreams, mostly raised her and her two brothers. Christa was part of a religious family that frequented the church building regularly. Christa spent great amount of time involved in church activities. She and her siblings were the only children in their church. Consequently, Christa spent a lot of time among adults in her religious community.

Christa was an introverted child that did not have friends at school. She did not have a particularly stimulating science experience at school, but she always excelled in mathematics. In spite of financial difficulties, Christa encountered several educational opportunities during her childhood, through summer programs related to science, or access to free science museums. The combination of high mathematics performances and summer program experiences led Christa to a major in physics in college. During her undergraduate years, Christa developed a larger social network both in the physics department and in the institutions where she did summer research programs.

As the first member of her family to go to college, and the first Black student in her physics department at her undergraduate institution, Christa had a lot of pressure to excel. This pressure, in combination with some faith struggles, contributed to a physiological turmoil towards the end of her degree and a consequent departure from academia. After teaching high school physics for a while, Christa returned to academia and completed her Ph.D. She wanted to learn more physics and return to teaching high school. She got married; contrary to what she initially envisioned for her career, she became a faculty member in a physics department, and is currently running her own laboratory. Christa is an Assistant Professor of physics in the astronomy and physics department of a liberal arts college.

Jane. Jane holds a bachelor’s degree in physics and a Ph.D. in applied physics. Jane grew up in a large urban area in the Northeastern United States. She is a first generation daughter of immigrants from the Caribbean, where her parents were teachers. For this reason, Jane’s parents would push her education, and her mother would go to the PTA meetings. They wanted Jane to be a medical doctor. Her parents were very strict and deeply religious; her father was a minister. She was the only daughter and had five brothers. As children of a minister, Jane and her brothers were not allowed to go to the movies or to listen to secular music.

Jane did not grow up thinking about being a scientist; however, she remembers having a Black male as a science teacher in junior high school. She was also impressed when she had a young female physics teacher that seemed fragile in Jane's eyes, but was "tough" in her urban high school. These two teachers affected Jane for their unusualness. Jane did not have any relatives or friends of the family with a science background, but she liked mathematics. In fact, she was on her school's mathematics team. One of her mathematics teachers told her about college; he suggested her to go to a minority weekend that a college was promoting. Jane eventually completed her undergraduate studies there, at this woman's college. Her parents were supportive of her academic choice for the bachelor degree, even though her father did not understand very well what she was doing, but when graduate school came, they did not understand why it took so long, and kept asking her when she would get a job. Their expectations were for her to be a medical doctor, or a lawyer, or maybe a teacher, but the type of career she was pursuing was not familiar to them. She first intended to major in mathematics, but her institution only had pure mathematics, and she liked applied math; she even tried economics, but she did not like that either. One of her professors, however, offered her a summer research opportunity to work in another professors' physics lab, and Jane fell in love with physics research.

Jane did not want to do a Ph.D. in physics. She left academia and worked as a research assistant in the health field for a year, until she decided to go back to school and obtain a Ph.D. This program took her eight years, three qualifying exams, and some isolation in the beginning, for being the only Black female in physics at her institution. She concluded her program, and during her academic trajectory, she always had a good relationship with professors and advisors. She remains in contact with some of her professors and advisor, and even works with others. Currently, Jane is a research associate in a large public research university. She is responsible for managing the laboratory, training graduate students, and conducting research.

Shanna. Shanna holds a bachelor degree in physics, as well as a master's degree and Ph.D. degree in the same field. She is the only child of a single mother; she grew up in the house with her grandmother and her youngest aunt. From an urban area in the Northeastern US, Shanna lived in the projects her entire life until she went off to college. Her mother worked for the school district and was very supportive of Shanna's education. Religion did not play a strong role in Shanna's upbringing. Her family was not really religious, and they would go to church maybe a few times a year.

Shanna attributes part of her personal trajectory to the influence of her, almost ten years older "very smart" aunt. Shanna's aunt seems to have opened paths for her. They both went to the same elementary school. Her aunt won an important mathematics competition at the school. Because of her aunt's achievements, the school's principal wanted the aunt to go to the best junior high school in the city but he was never able to get Shanna's aunt to that school. Shanna attributed her aunt's non-admission to racism in that time. However, when it was Shanna's turn, the school's principal was successfully able to advocate for her. In junior high, she was part of a science club, and enjoyed it.

She also liked to play with Legos, but her family did not allow her to do so; "No, those are for boys. You have to have pink things, things that are for girls," she was told.

Also during junior high, and high school, Shanna was in a summer program to increase the participation of minorities in engineering. Every summer she would go to a different college campus and take preparatory classes for the fall school classes. She performed well in mathematics and with most of her friends also being part of these summer programs, the choice for a science field as a major in college came almost naturally. She picked physics because of the college package she received from the university. Shanna attended an HBCU and had research opportunities every summer. For her, to continue to graduate school was not a choice. It was the necessary path of the physicist's career. Her graduate times, however were not such a breeze, and she found herself isolated and with lack of support in a PWI. She failed her qualification exams and had to change institutions. It turned out that her advisor gave her an excellent recommendation, and she went to a top institution to work with a prestigious science group. Shanna's relationship with her advisor there was very traumatic, and her experience with academia overall was very painful. She decided she did not want to build a career in academia. Nevertheless, she is very successful in her field, working for a governmental agency, and continuously works in outreach activities to support other underrepresented groups in science. Shanna works for a governmental agency in the United States, where she analyzes electrical engineering projects and products.

Emergent Themes

The life stories of these scientists are dissimilar in many ways. However, they have some experiences in common. The analyses of the physicists' stories leads to five emergent themes: negotiating multiple identities, communities of support, invitation to engage in science, communities of practice, and isolation in the academy. In this section, I explore these themes analyzing the physicists' narratives.

Negotiating Multiple Identities

The first large theme to explore was of identity. Overall, the participants talked very similarly about performing as a woman and as a physicist, while their racial and ethnic identity was of less emphasis in their discourse. Quotes that were part of the code "Being a Woman", for example, involved notions of self as well as of other. The physicists talked about what women in general are or do, dissociated from the participants' connection with being a woman. Specifically, the participants talked about themselves as women and how that related to their science. They connected being a woman with views of the self as being strong and persistent, nurturing and fair, as well as being the person who deals with the parenthood dilemma. Conversely, the participants associated themselves with more humanist practices as women physicists. They report characteristics as nourishing or respect to others as connected to their role as women. For example, Esther highlighted how often women were more nurturing: "I think that as a woman, I think that I am--and I could be wrong. I just think that females are wired differently than males, and I think that there's a nurturing aspect to females that is not inherent in men." Similarly, Betty stated,

> As a woman. I mean, I think part of it, I guess, is the way that I express thoughts. The way, I guess there is--I mean, it's hard to say there are nurturing men in the world, but there's a nurturing way that often that women approach, although there's also some very not nurturing women. I don't know. (Betty)

They did show some ambivalence, though, and recognized that men could also be nurturing. Still, they emphasized that this was a women's characteristic and related themselves with that trait.

The physicists also talked about how others' perceived their gender performance:

> It's interesting because lately they [her colleagues] say I use my feminine wiles to get my way, and one thing I realize with guys is their ego. They're so fragile, right? So now going back to technicians, I realize that if you're nice to people, they'll be nice to you. So I'll just be nice, you know, just nice, like I'll treat-- 'cause I think sometimes some scientists have this, what's the word -- snootiness about them?, Like, 'I have the Ph.D. and you're just like a Bachelor's, so you're beneath me' kind of thing. And so sometimes I don't do it that way, though. (Jane)

Jane's words brought the two sides of being a caring woman; one in the way she saw herself, as someone nice, and another way in how her male colleagues classified her behavior, as being flirtatious. "But I don't think I'm flirting," Jane justified, as almost defending herself. In a man's world, being nice and nurturing is still synonymous with weakness and femininity. In addition, if a woman of Jane's professional stature treats the technicians that fix equipment in her lab with respect; her colleagues saw that as a sexualized behavior.

The informants reported this sexualized component in different ways. They discussed about how their peers saw the women scientists' bodies as an insult. They were requested to dress "less feminine" in order to fit in the group, or were advised to not wear make-up. These comments happened in a specific time, during their college years, precisely when they were being initiated in the physics community. Half of the physicists felt others perceived their dressing attire as provocative or too dressed up. This sort of commentary came both from other women and from men. In addition, the informants also reported sexual advances from male professors, specifically in Historically Black Colleges or Universities (HBCUs). For example, Betty talked about her experience:

> So sometimes being in an all-Black context like an HBCU, the sexism is crazy. So I've had, you know, everything from the professor who's essentially chasing you around the desk. I've had a formal complaint against me for wearing a mini skirt to an exam by a fellow graduate student, which is just stupid. As an undergrad, I had a professor that failed me because I wouldn't sleep with him. (Betty)

Part of the process of identifying themselves with the group they were entering involved a negotiation between an unspoken dress code and body type that seemed to be necessary to be a physicist. None of the participants conceded in adjusting to the attire requested. Instead, their body was an instrument of rebellion and identity affirmation. This rebellion did not come without ambivalence, though. This continuous process of identity affirmation was also a reason for constant doubts of belonging to that space that did not resemble those women. Esther beautifully exemplified this struggle:

> And again, all these old White men… and there I am, you know, they look all shabby, whatever. I got on my--I had on a Lily Anne suit, and I got it from my sister-in-law because I said I'm going to present, I want to look nice, you know? And I didn't have many professional clothes then [...] I wore this black suit and I had my hair pulled back. I wanted to look like a female, you know? And I remember feeling so odd, you know? I just didn't feel like I fit in at all, and that

> was one of those times when I was, you know, I guess those were the early years when I was thinking that maybe this isn't a field for a female because I don't recall seeing another female, I really don't. So maybe I did, but I just couldn't remember it, you know. (Esther)

Esther made a choice to dress in a suit from a specific brand, arrange her hair in a specific style, and even move (as her gestures during the interview indicate) in a certain way to "look like a female," although the gestures were unlikely to be a conscious choice. Butler (1990) characterizes those body acts as performance. In this case, Esther was performing as a Black woman in opposition to the "White men" she knew she was going to find in the room. Esther had a socially constructed idea of what being a Black woman was, as she had an idea of what White men physicists in a conference wear, and although she did not want to perform like them, she wanted others to see her as a physicist.

The participants that talked about how their dressing etiquette bothered those around them at the university seemed to have rejected what Ong (2005) called gendered passing. Instead, they engaged in bodily projects of rejecting practices that conform to the prevalent images of White male physicist, in favor of multiplicity. Unlike Ong's (2005) report, in which women of color in science displayed either stereotype manipulation or performances of superiority, the participants in my study used the dressing code and make-up as simple statements of non-conformation. They did not manipulate a stereotype to exacerbate the expectations of the physics community in relation to Black women. Neither had they necessarily benefited from performances of academic superiority. Although some of them excelled overall in academia, there were the women who failed in steps along the way (e.g. Jane and Shanna). For those, reaching success and establishment in a career happened more through persistence than because of outstanding superior academic performance, as was the case with Ong's (2005) informants.

Still in a White male world, Shanna talked about how her body was unexpected in the physics community; her account is about how these women can notice that their presence causes surprise. Shanna explained:

> Yes, until I go to the conference and I'm standing in front of them, they're like, 'What?!' They just--the assumption is not that you're going to be a woman or an African American, my name doesn't give it away, so that benefits me because when I would apply for things, they don't automatically know from my name to be biased for or against me [as an African American woman]..

Furthermore, Esther talked about how uncomfortable it was to be in this environment: "I remember sitting in this little room and it was like a room full of White men, and I'm thinking, oh, I just feel so out of place. And I was just thinking, oh God, just get me through!"

A feeling of being out of place was shared by other students, even other White male students, but Black women, or women of color in general, cannot use the blending-in strategy that other students could incorporate. Their bodies were exposed to the aggression in a way they could not escape. All of the women in the study felt this unease: "I don't look like everybody else, and I'm not one of those people who could blend in and quasi-look like everybody else" (Jane). Jane showed evidence that there was an attempt to blend in and to not be seen as different. She said,

> So you know, it felt weird being the only one and I used to try to hide until a friend-someone said to me a couple years ago, 'Jane, you cannot hide. You're a

> tall, big Black woman. You cannot, you cannot hide. There's no way you can hide.' [...] so it took a long time to get used to-- to like being visible. (Jane)

Therefore, the way the Black women physicists dealt with being in a White male world of physics was mostly through the support of non-academic communities. Most of them relied on family, friends or religious communities to enact other identities in a way that the aggressions they experienced in the academic environment could be dealt with. For example, Christa talked about the support of her family and how her position as a scientist is validated through her family. She said, "my family is very supportive of what, of what I do and the fact that they understand, I mean even if it's on a basic level, they understand what I do and can communicate that to other people," suggesting her science authority was extended to other people through her family. Christa assumes the position of scientist in the family context, without doubting of her authority: "They will call me and say, 'I heard about this. Can you help me? I don't understand about this or that.' And so I've become a resource for my family" (Christa).

I attribute the support from these other circles to the strength that these women built to endure the microaggressions in the university and to protect their still in formation sense of self as scientists.

Communities of Support: The Role of Church

The literature indicates that at the individual level strong pre-college science experiences, family support, teacher encouragement, intrinsic motivation, and perseverance are critical factors for the success of minoritized students in scientific academic programs (Brown, 2002; Carlone & Johnson, 2007; Russell & Atwater, 2005). Family support is reported by all the women in this study, corroborating the literature, but the second theme that emerges from the interviews, and that yet remain unexplored by the literature is the role of religious communities (church) as support network for Black women in science.

For the second theme, four out of the six women physicists talked about growing up in an environment where religion was an important component of their lives (Allyson, Esther, Christa, and Jane). More than a fundamental part of their system of belief, religion played a social role in the life of these Black women. There was a strong social connection with these women growing up. For example, for Allyson the church represented a place for practicing her faith as well as for her social connections; she says, "I was definitely involved in church, just about any and every activity. I can kind of like run down a few, but yeah, definitely church and the community. That was really important." For Esther, family and church were closely related:

> So we, we grew up in the church, of course. We had to go to Sunday School and then had to go to midweek service, and we had to go to services after Sunday. We fed the preacher every Sunday almost because my grandfather, again, he was the type that loved to do that, so we'd leave church and the preacher would come to our house. So we'd get up in the mornings early and make dinner for the preacher and the elders. (Esther)

While Jane's father is a minister and she grew up in an "extremely strict" family, Betty's family had a more social connection with church. Betty explains that in the Midwest "there's several big, like large Black Catholic churches, so it was more of a, you know, the community you're kind of in. But I would say they [her parents] were more, they were more part of activist circles than they were really religious."

Epistemologically, relationships between science and religion did not pose a problem for the scientists-to-be. For all the participants that reported having strong religious beliefs, they talked about science and religion as not interfering in each other, and that these two views, the religious and scientific, were not only not conflicting, but dealt with different domains, different questions, and complemented each other. For example, Esther's understanding of science and religion started in a "two-worlds approach", which states that science and religion are complementary but independent forms of knowledge (El-Hani & Sepulveda, 2010):

> Well, I remember when I was in the science classes, you know, you have little pockets of things that you remember. And I remember even early on that I could accept what I was being taught in the classroom as far as science, as far as evolution, as far as different theories, but I just always believed what I learned in my church. (Esther)

Looking back, Esther did not talk about having conflicting ideas, and in some way, she had reconciled science knowledge and religion beliefs in an "interdisciplinary approach", where science and religion form an integrated lens to see the world (El-Hani & Sepulveda, 2010). She added, "So I figured, now I have a more, I guess, mature way of thinking of it than I did then, but now I can--in my mind, I can see how, what scientists are trying to observe and understand-- it's just what God created, so I never had this disconnect between my scientific teachings and my religious beliefs. It just never bothered me." Similarly, Allyson saw science as a way to learn how "God created things in general," indicating an integrated view.

The religious communities offered a support to the women in this study throughout their trajectory in becoming physicists. Allyson talked about when she was still in school and her mom would tell her “before any tests or quizzes, there’s something that you don’t know, you know, just turn it over to God and, you know, you just let Him lead you.” Christa looked for her pastor in a moment of doubt about her beliefs in God, physics, and life; she attributed her decision to pursuing graduate school to God.

> You know, it wasn’t a pure decision to go to graduate school. It was I felt that God was telling me that I should go to graduate school and I didn’t know why, which is why I was like, well, if God wants me to go, He has a plan, and so I will just go. (Christa)

Betty, who said having a more social than religious connection with the church, remembers the church support by the end of her doctoral program. She said, “I attended a large Black Catholic church in [the Southern United States]. I had two priests at my dissertation defense.”

Apart from a belief system foundation, the religious practices of these women constituted important tools of socialization and construction of self-image. They had engaged in leadership positions within their church or religious communities while growing up and during their college years, when they were building and defining their scientific identity. As they continued to frequent these religious communities as young adults, the religious communities constituted an important part of these women’s support network.

Invitation to Engage in Science

The third theme that emerged as a common experience amongst the women in this study relates to how they started their participation in formal science programs. Their experiences followed a pattern that started with attending science related after-school programs, college cooptation by physics departments, and engagement in summer research programs during college.

Most of the physicists (five out of six) attended after-school or summer school programs related to science, being exposed to a science environment in early ages. For example, Shanna was part of a science club in junior high; she said, “that’s one of the things that I remember about like really being into science, being in that Science Club.” Still in junior high, and later in high school, Shanna participated in a program targeted to introduce minorities to engineering. In this program, she would go to a different college campus and take preparatory classes for the fall school classes. “And so I was surrounded by a bunch of kids who were interested in math and science and engineering, at least outside of regular school,” Shanna pointed out.

These programs also exposed the students to science research. Allyson talked about her first physics research experience happening in high school. She said,

> when I was in high school, I did a lot of summer programs that were in math and science. And I would say junior year of high school, I went to the [University], and I did a physics program. And there were tons of experiments that we did, and that was like my first research experience, even though I was a high school student. (Allyson)

Jane was part of a math team in high school, and Betty felt like she was coopted by math competition programs:

> So one of the things that happen when you show early promise in these areas, at least at that time-and I was in public schools, is you quickly get sucked into the, it used to be called Math Counts searches. They were basically sophisticated standardized tests, and they were looking for people who were prodigies and had special talent in certain, in certain areas, and so they would do everything from testings that were far above your-what you could have known at that age, and just test for things that you were curious about. The best thing I ever got out of them was just I became fearless with regard to testing because I did so much of it. (Betty)

Betty also did a summer at a national laboratory, engaging in science research. Christa had experiences in national laboratories, as well; she spent two summers working at NASA when she was still in high school.

After these experiences, the physicists say they were already in the mindset of choosing a major in science when they chose to go to college. First because they had already experienced it, and second because their friends were also part of these science communities. As Shanna illustrates, it was not much a matter of what major to choose but one that was decided for her because of pre-college program participation and picking one of the STEM areas: “And so we all were brainwashed that ‘You must major in engineering or science.’ It’s not a matter of ‘if’ -- it’s just picking which one” she says.

In addition to the community building sentiment, these programs also helped to inform the students about science-related professions. Betty's comment exemplifies both of these aspects:

> There's a way in which if you achieve at a certain level, you know, you sort of end up in the same kind of places. You do the same kind of programs. You get recruited by the engineering schools a lot, especially these kind of programs that are looking to increase the students of color in these disciplines. And you know, I guess I knew what an engineer was because I had been in lots of programs. (Betty)

All the physicists chose their majors for at least one of the two following reasons: more intense exposure to practices in physics in comparison with other fields of science and/or more attractive financial pack offer to major in the field in comparison with other areas. For example, Betty says,

> I always wanted to understand the sort of atomic level understanding of how electricity worked. So it was just probably having spent time in programs like this where you get to kind of play around with ideas and see what you like [that made me choose my major]. (Betty)

Financial reasons weighted more for Jane. She compared the packages from different programs and even though she preferred to do engineering, the physics financial support was better:

> One of the reasons was because of their financial package, right? Right, because I had applied to another [school]. That actually was the other-that's the one I really wanted to go to because I really wanted-actually I'm thinking about it now, I

> really wanted to go into engineering. And I thought, but you know, you know, I- but their package was more loans than grants. And [her] College was more grants. That's the only way this is possible, financial assistance, you know? Financial assistance is just a dream, right? (laughs) Who could afford, except for people who come from wealthy family, you know? Who can afford this kind of education? (Jane)

Although financial reasons are also decisive for Shanna's choice, she adds that she wanted to be different from her friends:

> I did not want to be an engineer because <u>everybody</u> wanted to be an engineer and I had to be different. So I was like, okay, I picked physics for two reasons. One, it's different. […] And I got a full scholarship to college predicated on me majoring in physics, because everybody's majoring in engineering, so if you're applying for scholarships, now you have ten thousand people applying for engineering scholarships. Nobody's applying for the physics scholarship (laughs). If you're crazy enough to want to go into physics, they will throw money at you. (Shanna)

Allyson's experience mirrors Shanna's sentiment that there are more funds if one decides to major in physics. Allyson says she went to university "on a full scholarship, which was truly a blessing because [she] went as physics major, but it was an NSF-sponsored program. […] and you had to either go into physics, chemistry or mathematics, and that was it." She was on a track to major in engineering, giving she was participating in a program to attract minorities into engineering, but she went to physics because she also received a scholarship that was attached to majoring in specific science related fields, and physics was the closest path or the “foundation for engineering,” as she put it. The NSF-funded program that Allyson mentions aimed to increase significantly the number of students in STEM fields in HBCU’s. From the six physicists in this study, four attended historically Black colleges and universities.

Communities of Practice: Science Research Programs

Similar to the invitation to engage in science, which greatly influenced the choice of major for the physicists, there is a moment in their trajectories in which they engage in communities of science practices along with their academic training. The characteristics of these communities of science practices are as programs held in institutions different from where the physicists were getting their training, that is, they would go to different universities, research institutes, or national laboratories, for example. These programs happened during the summer and were fully funded.

All the physicists in this study report attending summer research programs in undergrad. These experiences influenced the career choices they made later on, either for helping them choose a field of physics they found interesting, learning about post-doc opportunities, or deciding the type of institution they wanted to work at. For Christa, the summer research programs helped her assess the environment of a potential post-doc,

> So I did the REU at the [University], and Mr. Jay was one of multiple groups doing cold atom research [there]. […] And even though I wasn’t in his group and I didn’t work with him, I vowed that if I was going to graduate school-which I didn’t know at that point-and if I went to [that university], that I would never work for that man. He was mean. He was not a nice person at all. (Christa)

Some summer research experiences aim to offer training with perspective of job placement after the student's graduation. That was Esther's experience. She worked at NASA during the summers, "when I was doing my undergrad work, I co-oped at NASA […], and the purpose, of course, to do that was that they would offer me a job upon my completion" but she found out that it was not the type of environment she would like to work in the future. She said, "over the time of going, I think I went three times [to co-op positions at NASA], two summers and one semester. I just did not like the environment, so I didn't take that job."

In addition to the work environment, the scientists learned about different fields of physics that they might enjoy. For example, Jane talks about her summer experiences as a place to try research in fields different from those in her department:

> I went to [research lab]. I didn't like that program, but it was interesting. Actually, all of them made me realize-it's funny because I went to explore other areas within physics. I was like, okay, I did this ____ and laser stuff, let me see what else. So part-I realized I didn't want to do particle physics, cosmology, not that, and then the other one I worked at (pause) I worked at [an institute]. They hire, but they do mostly modeling and I realized I didn't want to do that. (Jane)

Jane brought up another important aspect of summer research programs, that they are funded opportunities; Jane said, "the summer research program. I got paid for that, yeah […] Yeah, and that continued, and that made like every summer." In a way, these programs constituted a financial aid for the students during their college years.

Finally, none of the physicists had complaints about the summer research programs, on the opposite: "all of my summer research experiences were wonderful. I've learned a lot and still use some of the things, the knowledge that I gained during those experiences," Christa added.

Isolation in the Academy: The Study Groups

The last emergent theme in this study relates to the isolation experienced by the physicists in graduate programs through what I call the study group phenomenon.

During graduate school, the site of isolation was the study groups. The physicists talked about feeling isolated from their colleagues in the physics department and having difficulties entering the study groups. While some fields rely heavily on reading and writing, STEM requires students to work on mathematical exercises and problem solving. Students in these fields dedicate a considerable amount of their study time solving exercises and problems repeatedly. The support of study groups for this activity is extremely important, because students can share not only the final response of the problems, and check if they are in the right track, but share how to solve the problems. While in other fields sharing answers and process may be seen as something close to cheating, in STEM fields, that is part of the learning process. Besides, there is a tradition of students to share their material with students of another semester; there is a social network of problem solving. Shanna explained, "you know, like the Chinese kids have solutions to the textbook written in Chinese." It is not hard to imagine then, that is important for a student to enter this network. Shanna continued, "so you gotta like figure out who's got what, figure out what's going to work for you, that kind of thing, and socialize outside of your comfort zone." For her, her comfort zone would have been other African American student, but she said, "I was the only one, so I'm already out of my comfort zone" (Shanna).

The physicists talked about how hard it was to integrate these study groups. Jane shared, “people would not-or they’ll tell me, oh, they’re not studying and find out they’re studying together, so I was studying on my own and having a hard time. So yes, I was excluded, especially in graduate school I was excluded.”

Shanna described her experience with study groups going from an HBCU to a PWI for graduate school:

> And so it was difficult for me to break into a study group because-and you had to have study groups in grad school in physics because I wasn’t going to get in with Russians, I wasn’t going to get in with the Chinese kids, and basically all I had was the Americans and the Americans were still trying to figure out what happened. Like we were very smart at our respective state schools and now we’re getting C’s because you have all these international students who have studied a lot more, you know? The requirements are different. If you’re-you have to be like the top Russian kid to come all the way over to America and get into a top school, so it was difficult for me to get into study groups there. (Shanna)

Shanna had graduate school experience from two institutions, because she failed her qualifying exams in the first university. In the first institution, she found out she would have to go out of her comfort zone. She said “you want to have a study group with people who you feel like you have something in common with, and until you actually get to know someone, all you have to go on is what you see and,” and all that she saw was “very tall” Russian students. “[T]here were a lot of Russians in our department, they would all study together and they would all speak in Russian and they all knew [each other], you know, went to the same schools and stuff,” Shanna contextualized.

In the second institution, where she went already with a master's degree from the previous school, she realized she had to be more proactive in order to join the study groups.

> But when I started at [second school], I already knew. All right, I gotta break into these study groups, I have to make friends, I have to go to the Happy Hours. I have to go to-I have to do these social activities because it builds these bonds. So I was quite a social butterfly when I was at [second school]. I was department representative, I was in lots of groups and organizations and all that stuff. And it helped me to be more included, but even now, I still feel excluded. […]
> Like so if we're at cookies and tea and they're talking about a study group, I'm like, "Oh, you guys are studying Tuesday at two? I'm going to come." See, I didn't have to ask, "Will you invited me?" I'm not going to wait for that. I'm going to come, I'm going to show up (Shanna)

Besides improving their social participation by attending happy hours and other social activities in the department, the physicists said that another strategy to break into the study groups was to invite themselves to the meetings. For example, Shanna says she "just bulldozed [her] way in"; she "refused to be excluded." Shanna pondered, "I'm going to find out when the study group is and I'm going to show up." Shanna used her master's degree to leverage her entrance in the groups; she explained: "It helped that I had a Master's from [previous school] when I got to [second school] because then it's like, well, maybe she does know something and can be of benefit."

Jane talked about how this experience of exclusion from the study groups affected her confidence:

> It was very hard for me because I was struggling and I was feeling I was stupid, I couldn't get it, and they're getting it and not understanding how they're getting it. Or they're getting it because they had access to previous tests, homework solutions, you know, from previous years from previous students (Jane).

Jane said she learned the other students had all these resources only a year afterwards, and then she realized "it's not that they're smarter than [her], but they had the resources," and she was by herself, "sitting there trying to figure out on her own." Allyson talked about how she felt the transition from a "nurturing and supportive" environment in an HBCU to an "extremely competitive" PWI. For her, that was a hard experience and required adaptation. Similarly to Jane, Allyson identified her colleagues had resources she lacked of, and she said people tried to exclude her from science, for example by "having lab mates withholding information, resources from experiments and classes that [she] needed."

Jane and Allyson used a strategy of forming a group of their own, unlike Shanna, who tried to integrate with the other students. Jane formed a study group of her own, with other minority students, from different disciplines.

> And that's when I was so happy when these students came along because even though-I mean, the only thing that united us-we were Black, but we were struggle-we all felt that, so we all had to like work together. Or not even that. Also there was this Hispanic student from [Latin America]. Because we were isolated, we were two in the lab so we worked together because we only had each other to work together. We didn't have anybody else. (Jane)

Jane talked about how she gathered with international students from Latin America and Africa because her White compatriots would exclude her; she also talked about the relationship with the few other women in the program:

> […] and so interestingly in this program, I didn't have any females. There were- the one female that came, she left for a Master's, or you may have Asian females but they tend-Chinese females, but they tend to stay in their own, you know, own group, you know. But in terms of us and the American students, you know, I wasn't part of their club, you know. As much as I tried, I just couldn't, I couldn't get information out, out of them, so in terms of, you know-so really like [the Latin American student] and the two African students, we ended up being-we kind of built our own support group to make it through the program. (Jane)

Allyson summed up saying that "in order to be successful in graduate school" it was necessary to develop a network, an "academic posse." She had a support network formed by students of color that were also recipients of her scholarship. When she felt she needed their help, Allyson would look for them: "I'm going to be smart about this. I'm going to call of my support group. I'm going to call on my academic posse, and I called them. They have a nickname, 'The Black Mafia," she said. They were in different programs, but faced some similar situations in graduate school, and they supported each other.

Discussion

This discussion section of the findings focuses on addressing the questions about: (a) how the physicists negotiate their multiple identities, (b) what are the obstacles the scientists face during their trajectories, and (c) what are the strategies they use to overcome these obstacles. The stories alone do not tell much about how the participants make sense of identity, but their stories provide a bigger picture from which we can look further into identity and science for Black women and people of color in general in the sciences.

Identity and the Black Body

For Black women physicist the constant reminder that they are unusual in the science spaces are instances of microaggression (Solórzano, Ceja, & Yosso, 2000). Pierce, Carew, Pierce-Gonzalez and Wills (1977) argued that microaggressions are the main channel for proracist behaviors. They defined microaggressions as the “subtle, stunning, often automatic, and non-verbal exchanges which are ‘put downs’ of blacks by offenders. The offensive mechanisms used against blacks often are innocuous” (p. 65). Just by the fact of being surrounded by White and Asian men, which is mostly the case, these women face the burden of having their work, behavior, and bodies under the scrutiny of others in a way that constitutes a non-verbal aggression, and contributes to their self-image construction of what a physicist is or looks like. This image does not resemble them. Nevertheless, the women in this study developed a scientific identity over time, and were able to enact their multiple identities through a negotiation in different spaces.

Before seeing themselves as scientists, the participants share experiences as Black women and women in the Black body. The embodiment of this identity conflicts with the ordinary body of science and scientists—in terms of the physical and the field. It is evident in the experiences of all the participants of this study that they develop a sense of who they are as women and as Black women in science. Their experiences reflect a physical body at odds within the body or field of science. They negotiate how to be a physicist and remain who they are as Black women. I discuss the negotiation of self with others as an Identity Protective Belt[17]-- a hold where the scientist-to-be engages different identities of self (such as a Black woman) in a way to protect her scientific identity (physicist).

This identity protective belt (IPB) becomes a safe space for scientific identity enactment for the Black women physicist who work and interact in a predominantly White male science environment. The components of the IPB are by auxiliary communities of religion (church), family support and academic programming (after-school and summer research programs). The IPB components start early and become major influences for the women physicists, from early school through their professional placements in government and academia. The auxiliary communities provide professional development, build and sustain their belief system, provide motivation, and ease the degree of stress as Black women physicists. Furthermore, the family community is a safe space to enact their scientific identity. They feel like scientists when among their family members, which is not the same when their science identity is challenged outside these auxiliary communities.

Other communities identified as part of this IPB are the summer research programs. As part of the identity protective belt, the summer research programs (SRP) functioned as the site where the scientists-to-be have the chance to disconnect temporarily from the environment where they have negative experiences during the year,

[17] Overtly inspired by Lakatos' research programs nomenclature. Lakatos, I. (1970). Falsification and the methodology of scientific research programs. In: Criticism and the Growth of Knowledge, I. Lakatos and A. Musgrave (eds.), Cambridge University Press, Cambridge, pp. 91-196.

and immerse in a community of practice for the entire summer, doing science. The participants these programs as spaces that require putting their expertise in practice. It is also a place where they are treated professionally. The physicists start to think about these places as possible future job sites, they position themselves as professionals. The dynamics of the communities in summer research programs is such that it legitimizes the identity as a scientist for these women; therefore, I classified these communities as part of the identity protective belt.

The SRP are very special places in this process of scientific identity construction because they are genuine communities of practices (Lave & Wenger, 1998); moreover, they are communities of science practices. The identity negotiations of self in the social and academic spaces of the SRP are positive experiences and the women share fond memories of learning in SRP. While they talk about uncomfortable situations and microaggressions in their home universities or conferences they attend, they do not talk about negative experiences in SRP.

Perhaps in regards to the experiences in their home universities, being extended and much more contentious, the SRP experiences are remembered as better overall, and the women dismiss or forget bad experiences over time. Likewise, is it something about how SRP are structured that they provide a more diverse setting for these scientists-in-the-making? Analyses of the Meyerhoff scholars program[18] show that there are organizational characteristics of community settings that can promote the empowerment of its individuals (Maton & Salem, 1995). Examples of these characteristics are “a

[18] The Meyerhoff Scholars Program “was developed in 1988 in response to the low levels of performance of well-qualified African American science, technology, engineering and mathematics (STEM) majors, with a special interest in enhancing the performance of African American males”(Maton, Hrabowski III, & Özdemir, 2007, p.127).

support system that is encompassing, peer-based, and provides a sense of community" (p. 631). Some of these SRPs are specifically designed for underrepresented students in science; therefore, it is possible that some SRP sites offered a diverse setting that improved the sense of belonging to those communities. These communities in the IPB are essential for the development of a scientific identity of Black women, for they constitute social spaces in which these women can not only affirm themselves as scientists, but also be fully recognized as such.

Federal Support for Science and Students of Color

Very much related to auxiliary support is to comment on the role of federal agencies such as the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA). These institutions and the programming they fund start and support the academic and professional trajectory of the scientists in this study. Funding from NSF, in the earlier stages of their training, during college, or graduate school is vital to the women's careers. These funding opportunities from NSF specifically target underrepresented groups in science, and support grants to the scientists already established in their careers. In its turn, NASA scholarships and funding initiatives specifically for underrepresented groups supports the women as well. Five of six participants in this study were funded by NASA at some point, with programs ranging from high-school to college, and funding ranging from four months to three years (such as their participation in three consecutive summer programs).

This study focuses on stories of success; therefore, I cannot talk about what happens to those who started the process of becoming a physicist but did not finish it. However, the life experiences of successful women of color gathered in this study show that federal funding is a common factor in their trajectories. Their stories of success from receiving the benefits of federally funded programs targeted to underrepresented groups in science are critical in their successful careers.

To make another connection, studies have shown factors that influence on choice of an academic major (Ehrenberg, 2010; Maple & Stage, 1991; Simpson, 2001), mostly drawing results from test score data, socioeconomic status (SES), parents' education, and high-school courses enrollment. Some studies reported self-efficacy as an important factor for enrollment in STEM fields (Post, Stewart & Smith, 1991), but little has been said about the role that university recruitment initiatives play on making a decision about a college major, particularly for students who go into STEM fields after participating in federally supported science programs.

Because fewer candidates wanted to study physics in comparison, for example, to engineering, the financial aid tended to be more generous for those who selected physics as a major. Funding is an aspect that we cannot leave out of the equation when analyzing the presence of underrepresented groups in STEM degrees. It is a reality that people in these groups are more likely to face financial hardships and that is part of the reason why so few Black students succeed in STEM (Maton, Hrabowsky III & Schmitt, 2000). Science can be interesting, engaging, and passionate, but many families and individuals of color also yearn for financial security. Guaranteeing existent and improving future funding for pre-college programs or research experiences during college can be the deciding factor between increasing the number of underrepresented groups in STEM fields, or continuing to keep us away.

Overcoming Obstacles

The counter narratives of the physicists revealed a mechanism of isolation by the means of study groups' formation. In these groups, students exchanged list of problems and their solutions, which could lead to the learning of physics and mathematics. Students from previous semesters passed their problems lists to incoming students, creating a network of problems lists' solutions. Entering study groups, and this network consequently, becomes an asset to academic achievement for students in STEM. An obstacle that the Black women physicists faced during their academic training relates to the barrier they encountered to enter the study groups.

The racial and ethnic positionality seemed to affect more their integration in study groups than their gender positionality. Even though they said being a woman was more of an issue than being Black in the physics departments, when it came to integrating study groups they talked about the other students being White Americans, Asian, or White Europeans more than about the fact they were men. Similarly, Shanna talked that the few other women in her program were Asian and did not socialize with them.

White and Asian students seem to have automatic membership in these groups. They form an exclusive club in which the concept of Whiteness as a property is extended to Asian students, who represent "honorary Whites" (Bonilla-Silva, 2010, p. 179), for they are not underrepresented in STEM and benefit from the same privileges of White students (NSF, 2006). The closeness of the study groups to Black women in STEM departments is detrimental to the learning process and to the self-efficacy of these women. Consequently, their academic achievement is compromised.

Social integration is a factor associated with academic achievement (Saenz, Marcoulides, Junn, & Young, 1999), and this is even more important for the study groups' dynamics in STEM fields. The feelings of isolation and alienation of minority students in PWI institutions can be associated with uncomfortable feelings with the social environment (Saenz et al., 1999). The physicists in this study used two approaches to resolve this situation.

The first approach was to force themselves into the study groups by finding out when their colleagues were meeting and showing up or by inviting themselves to the meetings. This approach was preceded by a socialization effort in other instances than the study groups. To deal with the isolation overall, the physicists needed to join events that happened in the STEM departments such as happy hour or cookie-and-tea time. They had to reach out to the other students, try to connect, and show to the other students how they could benefit from the women's presence in the study groups. For example, Shanna used her previous master's degree from a prestigious institution to leverage her entrance in a study group, in what I identity as an interest convergence in the study group phenomenon.

The second approach was to find racial minority students from other programs and form a group for support. Saenz et al. (1999) said that some minority students in PWI's "choose to associate primarily with students from a similar ethnic or racial background to provide security and racial identity." This "choice", however, seemed to be due a lack of choice. When White and Asian students got together and shared answers from problems' lists and the Black women were left behind and out of the group, the permanence of racism was clear. When this situation repeated regularly, they constituted instances of microaggression. After trying to socialize with White and Asian students and failing, the Black women tried to form a support network with other ethnic minorities outside their program. It is plausible that their first choice to socialize would be other Black students, for they constitute their comfort zone, as they put it, but they were the only Black students in their STEM departments.

Implications and Conclusion

Overall, the data suggest there is a process by which Black women physicists develop their identity as scientist. This process starts during school years, when these women are invited to participate in after-school programs that focus on academic performances or scientific practices. When focusing on academic performance, these programs create an environment that privileges hard, steady work, problem solving, and excellence on tests and exams. The programs that focus on scientific practices provide an environment that promotes science skills, collaborative work, and experimental scientific processes. In these initial stages the women may or may not have a personal identification with science; it is not necessarily something they like, it is just something they do well, in the case of academic performance, that they enjoy the social activities, in the case of the scientific practices, or that an authority figure recommended, usually a teacher. Either way, they start this cycle of engaging in these science activities and continue to do so for a few years, until it is time to enter college.

By the time the scientists-in-the-making decide to go to college, they decide to apply for a physics major because they know they perform well and because they receive a good financial package. The participants in this study may not particularly have liked physics, but all of them liked math and performed well in that subject. For them, a physics degree was not a challenge since they were already used to the strict problem solving content aspect of the degree. Self-efficacy, then, played an important role for the choice of major. In addition, the institutions that promoted recruitment specifically targeting underrepresented groups in STEM fields, offered attractive financial aid for these scientists-in-the-making.

This is not to say that money is the ultimate factor in these women's decision making, since their academic pre-college experiences play an important role, but the data clearly points to financial aid as a strong contribution to put Black women in the physics path to build a scientific identity. Once they are on track, it is their love for physics that helps them to continue.

Although some of the participants report they did not like physics that much, every time they talk during the interviews about content, specific events in the laboratory, or their research, they speak for longer periods of time and with great enthusiasm. The affective connection these women develop with the content area and/or the lab practices is undeniable. They talk about love, joy, pleasure, and fun, while describing their relationship with specific concepts in physics.

By the end of this study, I am very intrigued by the findings on summer research programs during college; particularly I would like to know how they are structured and how do these experiences for women of color help to shape their identity. I believe it is unlikely that these are truly neutral spaces in regards to practices of exclusion for people of color, given that these science research programs are a microcosm of scientific training. My expectation is that they would mimic what happens in science institutions at a large. Nevertheless, I would like to know more about how these spaces support them in developing interest and identity in science, no less STEM fields. It is possible that there is a flaw in the interview protocol, since I did not look specifically about SRP experiences. However, it looks like this is a promising area for further research, giving it is a unique space for the negotiation of identities for women of color in STEM fields.

CHAPTER VI

CONCLUSION AND IMPLICATIONS

It is powerful to collect and recount stories from the experiences of people of color, especially those who are successful. The format applied in this study was helpful in that care was taken not to lose the complex connections that are at stake when it comes to identity formation in science for women of color. Thus, the methods allowed for a rich analysis, without falling into ordinary categorizations and systematizations of traditional knowledge production in education research.

In this chapter I look back to the initial research questions that guided this investigation, summarize the findings, and present a discussion of the major findings. I designed this study to answer the following research questions:

1. How does a Black woman physicist describe her experiences towards the construction of a scientific identity?
    a. What are the personal and professional trajectories of this woman?
    b. What factors, experiences, and contexts she attributes to her career choices?
2. How do Black women physicists negotiate their multiple identities?
3. What do Black women physicists identify as obstacles in their career paths?
    b. What strategies do they use to overcome these obstacles?

To discuss the interconnected aspects of the personal and professional trajectories of a Black woman physicist, counter-storytelling tells Christa's perspective on her trajectory, showing her idiosyncrasies and offering a detailed account of the life experiences of a Black woman in the world of science (Chapter 4). In portraying all six stories, the women in the study have distinct personal and professional trajectories; however, there are common elements along the course of their careers (Chapter 5).

Trajectories of Black Women Physicists and Scientific Identity Construction

The life experiences that physicists in this study describe suggest there is a pattern through which they develop their scientific identity and identity as physicists. This process starts in early ages, continues through their preparation in college—undergraduate to graduate to post-doctoral, and culminates with the early years of their careers.

First, the future physicists are invited to participate in science through school opportunities. They excel in mathematics and engage in communities of scientific practices, mostly through after-school and summer programs. In these programs, they enjoy the science and math activities and start building a sense of community with colleagues that share the same joy for science and math. These results concur with Walker's (2012) findings; Walker stresses the importance of mathematic episodes and experiences in early ages to the identity development of professional mathematicians. By the time the future physicists finish high school, they have under their belts the experience of actively participating in communities of scientific practices and have an idea of what professions in STEM look like.

In a second moment, STEM college recruitment programs, with the goal to attract students from underrepresented groups, invite these future scientists to join their universities. These programs offer the students substantial financial aid packages. In these programs, formal training and preparation to become a physicist begins.

Third, the scientists-in-the-making continuously engage in communities of scientific practices through research summer experiences, leaving their home universities to work in different institutions during the summer. They interact with a variety of research groups and get practices in several areas of physics. During this time, the physicists in HBCU's face overt sexism, while the ones in PWI's report racism in their experiences.

Identity formation, and science identity in particular, is a continuous process that becomes even more evident when there are changes in ones' life such as school changing, marital status, geographic moving (Ryan & Deci, 2012). Yet, "the major struggles of identity fall upon adolescents, for whom the establishment of secure identities is critical for passage into the adult world" (p. 226). It is during this critical moment that the physicists are greatly exposed to science practices in after-school and summer programs, and are initiated in the academic environment. Thus, interventions and experiences that happen in this phase of Black women's lives seem to be fundamental for the process of developing a scientific identity, and are a common thread from the physicists in this study.

Factors that Contribute to Career Choices of Black Women Physicists

The scientists attribute their career choices to several factors, experiences, and contexts. Although they might be intrinsically motivated to engage in science in early ages, this engagement requires "definite environmental affordances and supports if they are to be sustained over time, and over life's natural obstacles" (Ryan & Deci, 2012, p. 228). In this direction, opportunities that invite Black women to STEM appear to be among the necessary conditions for these women to think of these fields as a career option.

Their college choice is mostly a combination of recruitment from universities that were looking to increase the number of students from underrepresented groups in their science programs, with attractive financial aid packets, building on their previous exposure to scientific careers through after school programs in high school. In that respect, HBCU's play an important role, recruiting most of the Black women for STEM – four out of the six physicists in this study. In addition, self-efficacy is a factor that counts for these women, for they present good performances in mathematics pre-college, and feel physics is a course they could perform well in, with respect to the content. They have strong family support; their families view education as a fundamental asset and are diligent with these women's school obligations.

Negotiating Multiple Identities: Gender, Race, and Science Profession

The Black women physicists talk about gender performance in a male-dominated field, and complain about different treatment they have for being a woman. They do not elaborate on what it means to be a Black woman physicist, but emphasize the hurdles in regards to gender, downplaying their racial and ethnic identity. This suggests that the physicists, like other people of color, learn over time not make statements about their racialized experiences, because of claims that they lack objectivity (Lee & Lee, 1993; Rollock, 2011). This way, their first response is to separate gender and race and explain the burdens of negative experiences by the fact that they are women.

The scientists share their stories, verbalize their views of physicists as being arrogant, careless, White men who wear shabby clothing, and live for the lab. This is conflicting with their views of self. They position themselves as being nurturing Black women physicists, who take good care of their appearance, have a variety of interests, and enjoy time with their family and friends. They are, nevertheless, physicists, and see themselves as such. Thus, the overall question of investigation in this study is a discussion of a science identity of Black women physicists, which contrasts sharply from the typical, traditional, prototypical image of the scientist.

For these individuals, the exercise of a positional identity in relation to their racial and ethnic background and their gender performance happens before they start developing their professional identity as scientists. Cobb (2004) for example argues that the students' development of a mathematics identity involves "changes in their more enduring sense of who they are and who they want to become" (p. 336), that is, to develop a mathematics identity the students have to negotiate who they see themselves to be with the images they have of what a math person is. Similarly, the development of a scientific identity involves a negotiation among the identities the scientist-in-the-making performs. Because "identities can be focused on […] the person one expects or wishes to become, the person one feels obligated to try to become, or the person one fears one may become" (Oyserman, Elmore & Smith, 2012, p. 69). Black women physicists can find themselves in an identity dilemma. They want to be physicists, but they see physicists as, for example, arrogant; yet, they see themselves as nurturing and different from the image they have of physicists. This dilemma seems to be resolved with a compartmentalization strategy (Showers & Zeigler-Hill, 2012), in which the physicists realize their negative views about physicists but dissociate the negative images from themselves.

The embodiment of an identity as a Black woman conflicts with the ordinary body of science and scientists. The women of color in this study develop their scientific identity in spite of predominant images and traditional science environments. They negotiate the self and others in relation to self through an identity protective belt, consisting of communities where the scientists-to-be engage in different identities in a way to protect their scientific identity in construction. This identity protective belt (IPB) works as a safe space for scientific identity enactment; it is composed by auxiliary communities outside the space of formal training for the scientist-to-be. For example, even though the scientist-to-be has her presence challenged in the physics and scientific spaces of school and workplace, she always has other spaces, such as family, home and church, where she can be seen, treated, and made to feel like a scientist, without losing her identity as a smart, Black woman. Specifically, family becomes a safe space to enact a scientific identity. The women can feel like scientists when among their family members. They do not have their scientific identity challenged in that space; they are the authority in science. I argue that this balance over time protects the scientific identity to be shattered, and allows it to flourish.

Other communities that are part of this IPB are the summer research programs. These programs offer spaces in which the scientists are required to put their expertise in practice; it is also a place where they are treated professionally. The dynamics of the communities in summer research programs is such that it legitimizes the identity as a scientist of the women that attend these programs; therefore, I include these communities in the identity protective belt. Communities of scientific practices, in the form of summer programs, science clubs, and research opportunities, can provide a space to build and strengthen scientific identities.

Overcoming Obstacles

There are many obstacles that Black women physicists face over time in order to succeed in their careers. For example, they might experience lack of resources in their schools (May & Chubin, 2003), unfriendly school environments in advanced placement classes (Nunn, 2011), lack of support of their advisors in college (Robinson & Franklin, 2011; Schlosser, Talleyrand, Lyons, Kim, & Johnson, 2011), and isolation in the workplace (Frazier, 2011). This study unveils yet another obstacle Black women face in STEM: a mechanism of exclusion through the study groups phenomenon.

Study groups reveal to be more than a site of peer support but an essential part of the learning process in STEM, and in developing the science identity. To be part of these study groups means to enter a network that promotes the sharing of solved exercises and problems lists amongst students. Members of these groups are mostly White or Asian men and Asian women. The Black women physicists in this study find it difficult to enter these networks and therefore have limited access to resources that contribute to their academic performances. Consequently, they feel isolated in their departments, and experience a decrease in their self-efficacy (Bandura, 1986), which is one of the factors for success of minorities in STEM. The decrease of self-efficacy happens when the scientists perceive their colleagues, given the same resources, can perform better than they can. They feel the other students are learning the material, solving the problems lists, and doing better on the exams while they are struggling with the same materials. Because they are not part of the study groups, they do not realize the other students have more studying aids (e.g. answers to problems' lists), and therefore are in advantage.

In addition, these scientists are usually one of the few women in their departments, making it harder to socialize with other women. The presence of other Black students in the science departments of these women is small or nonexistent and socialization for these women with other students that share their racial background is not possible. This environment, combined with the exclusion from the study groups, makes Black women physicists feel isolated. The intersection of race and gender hinders the social integration of Black women physicists in graduate school and exposes the racism amongst students in STEM departments. There are no possibilities to shift the racialized gender experiences in this instance to solely gender experiences. The study groups' phenomenon makes explicit the results on the physicists' lives of an intricate nature of race and gender.

To overcome these obstacles, the scientists increase their participation in social activities as a means to break into the study groups, and look for allies outside of their departments to overcome isolation. One of the findings in this study is that it is a common practice in physics departments to have regular social gatherings such as tea-and-cookie hour, physics band, and happy hour. The physicists find that increasing their participation in these social gatherings can help making their ways to the study groups. They realize the need of leaving their comfort zone, and the need to make extra effort to socialize with their colleagues. With this approach, the physicists could find out information about time and location of the study groups and would then simply show up in the meetings.

The other strategy the scientists use is to deal with the isolation is to form a support group with other minority students in their institutions. These other students are from a variety of academic backgrounds (i.e., they are not physics students) but they share a racial or ethnic membership with the physicists, or at least the ethnic minority status on campus. This group might not help with integrating the physicists into the problems' list network, but external social groups and networking provide emotional and academic support (e.g., studying together or watching each other's' presentations), integrating Black women into an academic community, even if it is not the physics community.

Scientific Identity Forming Trajectory

In conclusion, there is a process for Black women physicists to develop their scientific identity. This process begins when they are invited to participate in science and mathematics activities, allowing the young students to engage in communities of scientific practices early on. Later, these students are contacted by colleges, particularly HBCU's, through recruitment programs targeted to underrepresented groups in science or STEM fields. These programs offer attractive financial aid packages for the students who excel in mathematics and science and are already familiar with the science (physics) content and some laboratory work from their summer school programs. Once in a science major, there is a process of negotiating their multiple identities, finding when and how to perform them, as well how to conciliate these identities. During this process, they continuously engage in communities of scientific practices through summer research experiences and working with advisors and on collaborative team projects. Over time, they increase their recognition of their science persona through the validation of their advisor, a successful tenure process, positive feedback from students, attractive job offers, and grants approval, for example.

Finally, the results in this study concur with Carlone and Johnson's (2007) work in which they identify performance, recognition, and competence as key elements for the construction of a scientific identity. Still, the findings from this dissertation extend their work by analyzing the experiences of women of color in a science field in which they are severely underrepresented (physics). In addition, this study examines how racism operates in this process of scientific identity construction for Black women in the United States, and unveils the closed form of the study groups as a pernicious mechanism to exclude Black women in physics, but also acknowledges how outside communities of support provide a protective belt for their identity formation as physicists.

Implications and Recommendations

The results of this study present implications for the physics education community, policymakers, and physics community as a whole. These implications go beyond borders, and reconnect with my initial motivations for carrying out this investigation. Implications and recommendations can be extended for understanding Black people in scientific fields in Brazil and the improvement of Black people in science in that country as well as more broadly in societies where racial inequality has been a hindrance. With this study, I expect to contribute to the body of literature on scientific identity, particularly on the experience of women and people of color in the sciences. I also expect to develop future work continuing to expand the knowledge produced in science education, specially, to explore the use of critical race theory and counterstory to think about science education in the Brazilian context.

This study however is not without limitations. Given the qualitative nature of the study and the storytelling methodology, the number of participants is relatively small.[19] In addition, positionality as a researcher influences the data collection and my analysis of the data (Moore, 2008). Another limitation of the study relies on my relationship (or lack of) with the participants, which interferes with the quality (depth and extension) of the interviews. I tried to minimize these limitations with procedures such as peer debriefing, in-depth interviews, as described in the methods section (chapter 3).

For the Physics Education Community

Giving voice to students has been a concern for educators across different disciplines (Abrahams, Rowland & Kohler, 2012; Farrel, Peguero, Lindsey & White, 1988; McElroy-Johnson, 1993; Sheared, 1994). In this direction, from a classroom perspective, teachers and teacher educators can make use of storytelling to unveil and validate the experiences of students of color in science (Mensah & Jackson, 2012). Similarly, physics educator researchers can use this tradition as a methodological tool to expand the community's knowledge on the experiences of people of color in scientific fields. Furthermore, this study shows the role of teachers in counseling students in relation to career options and providing them with information about after school and summer programs in science is extremely valuable in starting a science trajectory for students color, and is certainly the impetus for the Black women physicist in this study.

For The Physics Community

It is not enough to think about the education of physicists only within the physics education community because, ultimately, physicists are trained and enculturated by

[19] It is worth mentioning that I estimate the total population of Black women physicists is a relatively small number of about one hundred women, and I interviewed six of them.

other physicists that may or may not have educational concerns or a mentoring mentality in regards to students of color. Therefore, it is important to educate physicists overall. Specifically, physicists need to be aware that current practices in the laboratory and in physics departments might affect people of color differently and fail to provide an inclusive and fertile environment for researchers of color. Even professional organizations for students and early career faculty of color can provide a community of support among emergent scholars of color (Rivera Maulucci & Mensah, 2012). Accordingly, physics departments and physicists should provide students of color access to professional associations such as the National Association of Black Physicists, the National Society of Hispanic Physicists, and the Committee on the Status of Women in Physics (of the American Physical Society). Likewise, they should encourage students to join these associations and present their physics research in their conferences. By doing so, the physics community validates the physics production of women of color, and students of color in general.

For Policymakers

Institutions and policymakers have to take into account the role federal support (i.e., science programming and financial aid) has to attract underrepresented groups into STEM fields, particularly to physics. The results of this work suggest that current initiatives of that sort should be maintained and extended. The contributions of marginalized people in the production of the scientific knowledge are necessary to increase awareness of their contributions and public policies targeted to attract underrepresented groups in science early in school. Specifically, funds should be allocated to afterschool programs and summer research opportunities with funding to support STEM majors.

Future Work: Things I Want to Learn More About

When a dissertation study concludes, many more investigations emerge. Considering the emergent character of scientific identity and its complex nature, I am interested in exploring in future work the use of a complex system approach and apply complex system theories (Rocha, 1999) for scientific identity formation, ultimately to enable the modeling of this process. For example, complex system theories in general are derived from the field of 'complex system' science. Studies in this area examine systems that have a complex behavior or emergent behavior that is nonlinear or exemplary of dynamic systems, etc. Bruun (2012) uses complex system theories to analyze types of social interactions in connection with physics learning. Given the model of identity protective belt I developed in this study, it strongly connects with interactions within different communities; therefore, I am curious to use an approach similar to Bruun's to gather more understanding of the identity protective belt. Related, an examination of summer research programs is especially interesting. I would like to see what happens during those programs because the physicists talk in a positive way about these programs, while their formal academic institutions represent the site of stressful situations and denial of their belonging into science.

An additional site to research is the beginning of career scientists in laboratory and classroom settings. As my study evidences, working in a laboratory, mentoring other science students (Christa), and teaching can strengthen the scientific identity of women of color. Therefore, works that focus on the practices of faculty members and professors during their initial years of setting up a lab and teaching can illuminate relationships between student-teacher interactions that contribute to the development and stabilization of scientific identities. Both may contribute to the importance of laboratories for the scientific community and physics education community.

Although all these studies interest me deeply, my main research goal in the future will be to contribute to the analysis of the experiences of Black people in the sciences in Brazil, using the expertise I developed throughout this study conducted in the United States. And based on the results to identify Black women physicists in Brazil. The collection of stories of their lives and development of a larger study connecting the experiences of women of the African diaspora in the Americas are research endeavors that I am passionate to conduct.

However, the transfer of findings from one context—from the United States to Brazil — poses yet a limitation. Hence, I will need to discuss critically the findings of the study in light of the cultural, historical, and social distinctions between these two countries. Yet, an understanding of the experiences of Black women in physics in the United States promotes a framework to understanding how to foster the insertion of Black women in the sciences in Brazil. Although distinct, women of the African diaspora in these two countries share similarities and differences that invite interesting discussion. Experiences of racism in their daily lives as a structural reality and dismissal of active participation in intellectual production of science present theoretical and methodological challenges and possibilities to discuss science, the use of technology, and the construction of scientific knowledge in Brazil. As a result, this dissertation study offers a ground to look at the experiences of women of African descent from the diaspora across multiple frontiers.

CHAPTER VII

CODA

"We don't see the things as they are; we see them as we are"

Anäis Nin

At the end of this dissertation, there is yet a story to be told: my story. My story is the premise for my interest in conducting the current study on Black women physicists.

I have a bachelor's degree in physics and a master's degree in history and philosophy of science and science education. I grew up in a working class family in an urban area of Southern Brazil. I am the only person in my immediate family to have a college degree (and I have one male cousin with a bachelor's degree). Most of the women in my family are domestic workers, and my mother always highlighted the importance of school as a means to achieve better job positions.

Going back to my childhood, I was raised by my mother, who always worked full-time. Because of that, I spent a lot of time in daycare, and later on, by myself. I would equally play with dolls and toys that were considered to be for boys, such as Playmobil. I remember being "that kid" that would challenge adults when told that a girl should behave like this or like that.

As for my science experiences in early years, I cannot remember anything unless it happened in connection my school experiences. I cannot tell, for instance, how old I was when my grandmother passed away, but I remember I was in my second grade. Similarly, I remember I was in third grade when I decided to become a physicist. I know it was in third grade because, years later, I found a school yearbook where I answered that I didn't like Portuguese, loved mathematics, and wanted to be an astronomer.

When I went to High School, I attended a technical school and received professional training for becoming a secretary. I studied in a prestigious public technical school as part of the Federal system that was connected to the university and physically located on the university campus. This environment exposed me early on to higher education settings. I started working at the age of 15, first at the university, and then for city hall. In my second year, I commuted to school, studied in the morning, had lunch on campus, worked five hours off-campus in the afternoon, and rushed back to the campus for dinner and my evening job. Although I was in an environment with mostly socioeconomic privileged students, [20] my experiences differed from most of my colleagues.

Because I was physically in the university, I was privileged with access to information and opportunities that high school students usually do not have. For example, my school was next to the planetarium, and I would sneak in and attend sessions there regularly. Also, I learned from the inside about the assistantships that the university offered (e.g., admissions test fee exception, work-study, reduced price meal),[21] and I was eligible even as a high school student. Another opportunity I learned about was that the

---

[20] Public universities and to some extent federal technical schools are considered elite schools in Brazil for its test-based admission system. Generally, students that go to public schools do not pass the high standard admission exams of public universities, leaving these universities for middle class and upper middle class families that can afford private pre-college education.

[21] In Brazil, a public school or university will not charge anything from the students. We do not pay any fees at all, but one needs to pay for the admission test (called *vestibular*, in Portuguese).

physics department had a free-of-charge after school program. In my third year, I spent four hours a week, every week, in the Institute of Physics, doing hands-on experiments.

When I went to college, I first studied mathematics for one year in a private university, while working full-time during the day. After that, I passed the admission exam and began my physics degree in a public university. During college, I was very active in local social movements, created an educational NGO with a group of fellow educators, and went for an internship in a physics department abroad. I carried my activist and academic work side by side. At that time, most of the social discussions in or outside academia were centered on socioeconomic inequalities, and although race was present, it was definitely minimized. I worked mostly with adult education, with influences of Paulo Freire, Emilia Ferreiro, and other Latin American scholars. I like to believe that part of my activist work influenced the way I see and do physics, and pushed me to study epistemology of physics.

For my master's, I moved to the Northeastern area of Brazil, and while living in Salvador I joined local social movements groups. There, discussions and actions were centered on issues of racial inequalities. While Porto Alegre, my hometown, has approximately 20% of the population of African descent, Salvador has 80%. In addition to that environment, there were the professional experiences. I was teaching physics and physics methods classes at the university when one of my students asked me to help her to develop a study on women in physics. We ended up presenting this work together in a physics education conference in North Africa.

My experiences to this point inspired the research questions that guided this dissertation.

I came to New York City to find a myriad of experiences that would help my carrying out this research. My overall academic experiences at Columbia University and Teachers College contributed to my learning and formulating new lenses through which I now see the world. Specifically, the discussions provided by the Institute of Research in Women and Gender (IRWAG) at Columbia helped me to look at gender (e.g., Butler), race (e.g., Spillers and Wade), and human rights (e.g., An-Na'im and Merry) in new ways. I have studied and systematically discussed about gender and race relations in Brazil at IRWAG more than I have ever discussed these topics when back in Brazil. At Teachers College, through the critical race theory group, I found people that challenged my views on racial relations, and provided an environment for great debates. Living in a multicultural city such as New York and interacting with people in a second language (Portuguese being my first language) enabled me to think more about my identities and how consciously or not I wear different hats in multiple contexts.

During this research, I consciously used my Fulbright scholar status and Columbia as a cachet to approach professional institutions to share my research survey amongst their members.[22] I also used my physicist credentials, and being a woman, when contacting the scientists by email. Some of the scientists realized that I was a Black woman when they first met me in person.[23] I see that my membership as a Black woman

---

[22] I ended up receiving an email to answer my survey. It was a message forward by someone, to someone else, and so on. In the message, there was a conversation-- someone asked whether I was legitimate, and someone else said I was a "Fulbright scholar from Brazil", and that they had called TC IRB to ask about the study.

[23] Betty told me that other scientists have asked her about me, and she said that after the interview she felt more comfortable at soliciting participation of others to participate in my study because she said, they usually get suspicious when there are people they do not know who are asking about them.

with a background in physics, attending a prestigious university was helpful to secure other women physicists as participants of this study. However, I often made use of my “foreignness” to probe for clarifying questions during the interviews.

Therefore, entering into, conducting, and doing analysis for this dissertation study was influenced by many factors. For example, as an agnostic living in New York City, and interacting with people from a variety of religious beliefs, I became more sensitive to the multiple ways religion can be present in people’s lives, and the important influence this was for some of the women in my study. Also, the discussions with the critical race group were fundamental to help my identifying possible episodes of microaggressions that the women in the study experienced, yet did not actually communicate them.

Alternatively, I was influenced by the results of this study. For example, living daily with the voices of the scientists, listening and reading their interviews, inspired me to continue working in moments of adversity. In addition, this work motivated me to think about a career in policy for science education. Finally, I come out from this doctoral process wanting to learn even more about race, gender, and the lives of those who make science; I came out of this study learning more about me—as a Black woman physicists and researcher.

In conclusion, I identify myself, among other things, as a Latin American, Brazilian, working class, physics educator, agnostic, Portuguese speaker, Black woman. All these identities and social markers influence the way I navigate in the world and interact with people. The study I present here is the result of a long and continuous learning process, and the way I present myself today, is partially a result of this study.

References

Abrahams, F., Rowland, M. & Kohler, K. (2012). Music Education behind bars: Giving voice to the inmates and the students who teach them. *Music Educators Journal, 98*, 67-73.

Aguinaldo, J. (2004). Rethinking validity in qualitative research from a social constructionist perspective: From "is this valid research?" to "what is this research valid for?". *The Qualitative Report, 9*, 127-136. Retrieved from: http://www.nova.edu/ssss/QR/QR9-1/aguinaldo.pdf

Atlas Racial Brasileiro. (2005). Retrieved from: http://www.pnud.org.br/Atlas.aspx?view=atlasracial Viewed: 12 October 2012.

Bandura, A. (1986). *Social foundations of thought and action.* Englewood Cliffs, NJ: Prentice-Hall.

Barton, A. (1998). *Feminist science education.* New York: Teachers College Press.

Bell, D. (2004*). Silent covenants: Brown vs Board of Education and the unfulfilled hopes for racial reform.* New York: Oxford University Press.

Berryman, S. (1983). *Who will do science? Trends, and their causes, in minority and female representation among holders of advanced degrees in science and mathematics.* (A Special Report). New York: The Rockfeller Foundation.

Bogdan, R. & Biklen, S. (1994). *Investigação qualitativa em educação*. Porto: Porto Editora.

Bonilla-Silva, E. (2010). *Race without racists: Color-blind racism & racial inequality in contemporary America.* Lanham, Maryland: Rowman & Littlefield.

Brewster, A. & Bowen, G. (2004). Teacher support and the school engagement of Latino middle and high school students at risk of school failure. *Child and Adolescent Social Work Journal, 21*, 47-66.

Brickhouse, N., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journals of Research in Science Teaching, 37*, 441-458.

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*, 971-1002.

Brown, H. & Wallace, D. (2005). Solving the measurement problem: de Broglie-Bohm loses out to Everett. *Foundations of Physics, 35*, 517-540.

Brown, S.W. (2002). Hispanic students majoring in science or engineering: What happened in their educational journeys? *Journal of Women and Minorities in Science and Engineering, 8*, 123.

Bruun, J. (2012, August). Identifying community structure in multiple networks: Academic and social aspects of learning behavior. Invited poster symposium session presented at the *Annual Meeting of the Physics Education Research Conference*, Philadelphia, PA.

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

Bybee, R. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Carlone, H., & 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*, 1187-1218.

Carlone, H.; Cook, M.; Wong, J.; Sandoval, W.; Barton, A.; Tan, E. & Brickhouse, N. (2008). Seeing and supporting identity development in science. International Society of the Learning Sciences. *Proceedings of the 8th international conference on international conference for the learning sciences*, *3*, 214-220.

Chinn, P. (2002). Asian and Pacific Islander women scientists and engineers: A narrative exploration of model minority, gender, and racial stereotypes. *Journal of Research in Science Teaching. 39*, 302-323.

Cobb, P. (2004). Mathematics, literacies, and identity. *Reading Research Quarterly, 39*, 333-337.

Collins, P. (2000): *Black feminist thought: Knowledge, consciousness, and the politics of empowerment.* New York: Routledge.

Conant, J. B. (1959): *The American high school today: a first report to interested citizens.* New York: McGraw-Hill.

Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology, 13*, 3-21.

Cummins, J. (1986). Empowering minority students: A framework for intervention. *Harvard Educational Review, 56*, 18-37.

Decuir, J., & Dixson, A. (2004). "So when it comes out, they aren't that surprised that it is there": Using critical race theory as a tool of analysis of race and racism in education. *Educational Researcher, 33*, 26-31.

Delgado, R. (1989). Storytelling for oppositionists and others: A plea for narrative. *Michigan Law Review, 87*, 2411-2441.

Delgado, R. (1995). Introduction. In R. Delgado (Ed.), *Critical race theory: The cutting edge* (pp. xiii-xvi). Philadelphia: Temple University Press.

Delgado, R. (2000). Storytelling for oppositionists and others: A plea for narrative. In R. Delgado & J. Stefancic (Eds.), *Critical race theory: The cutting edge* (2nd ed., pp.60-70). Philadelphia: Temple University Press.

Delgado, R. (2011). Rodrigo's reconsideration: Intersectionality and the future of critical race theory. *Iowa Law Review, 96*, 1247-1288.

Delgado, R. & Stefancic, J. (2001). *Critical race theory: An introduction*. New York: New York University Press.

Denzin, N. (1978). The research act: a theoretical introduction to sociological methods. New York: McGraw-Hill.

Denzin, N. & Lincoln, Y. (2005). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage Handbook of Qualitative Research* (3rd ed.), pp. 1-33. Thousand Oaks, CA: Sage.

Donnor, J. (2003). Learning from Black folk(s): Race, technology, and society. In G. Ladson-Billings (Ed.), *Critical Race perspectives on social studies: The profession, policies, and curriculum* (pp.231-46). Greenwich, CT: Information Age Publishing.

Donnor, J. (2005). Towards an interest-convergence in the education of African-American football student athletes in major college sports. *Race Ethnicity and Education, 8*, 45-67.

Ehrenberg, R. (2010). Analyzing the factors that influence persistence rates in STEM field, majors: Introduction to the symposium. *Economics of Education Review, 29*, 888-891.

El-Hani, C. & Sepulveda, C. (2010). The relationship between science and religion in the education of protestant biology preservice teachers in a Brazilian university. *Cultural Studies of Science Education, 5,* 103-125. DOI 10.1007/s11422-009-9212-7

Farrel, E., Peguero, G., Lindsey, R. & White, R. (1988). Giving voice to high school students: Pressure and boredom, ya know what I'm sayin'? *American Educational Research Journal, 25*, 489-502.

Finn, J. (1993). School engagement & students at risk. *National Center For Education Statistics Research and Development Reports.*

Frazier, K. (2011). Academic bullying: A barrier to tenure and promotion for African-American faculty. *Florida Journal of Educational Administration & Policy*, 5, 1-13.

Gilbert, J. (1994). Beyond girls can do anything: The deconstruction and reconstruction of feminist approaches to science education in New Zealand. Retrieved from http://www.aare.edu.au/94pap/gilbj94082.txt in November 23, 2009.

Grayling, A.C. (2002) Epistemologia. In N Bunnin & E. P. Tsui-James (Eds.), *Compêndio de filosofia* (pp.39-63). São Paulo: Edições Loyola.

Guba, E. & Lincoln, Y. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage.

Hammond, L. (2001). Notes from California: an anthropological approach to urban science education for language minority families. *Journal of Research in Science Teaching, 38*, 983-999.

Harris, C. (1993). Whiteness as a property. *Harvard Law Review, 106*, 1707-1791.

Hiraldo, P. (2010). The role of critical race theory in higher education. *The Vermont Connection, 31*, 53-59.

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

Hurtado, A. (1996). Strategic suspensions: Feminists of color theorize the production of knowledge. In N. Goldberger, J. Tarule, B. Clinchy & M. Belenky. *Knowledge, difference, and power: essays inspired by women's ways of knowing* (pp.372-392). New York: Basic Books.

IBGE (2010). Uma análise das condições de vida da população brasileira 2010. Instituto Brasileiro de Geografia e Estatistica (IBGE). *Síntese dos Indicadores Sociais*.

Johnson, A. (2006). Policy implications of supporting women of color in the sciences, *Journal of Women, Politics & Policy, 27*, 135-150.

Johnson, A. (2007). Unintended consequences: How science professors discourage women of color. *Science Education, 91*, 805-821.

Joslyn, C. & Rocha, L. (2000). Towards semiotic agent-based models of socio-technical organizations, *Proc. AI, Simulation and Planning in High Autonomy Systems (AIS 2000) Conference*, Tucson, Arizona, pp. 70-79.

Juravich, N. (2010). How communism shaped New York – literally. New York Observer, 9 June 2010.

Kelly, A. (1987). Why do girls don't do science. In A. Kelly (Ed.), *Science for girls?* (pp. 12-17). Open University Press: Philadelphia.

Ladson-Billings, G. (1996). Silences as weapons: Challenges of a Black professor teaching white students. *Theory into Practice, 35,* 79-85.

Ladson-Billings, G. (1998). Just what is critical race theory and what's it doing in a nice field like education? *International Journal of Qualitative Studies in Education, 11*, 7-24.

Ladson-Billings, G. (1999). Preparing teachers for diverse student populations: A critical race theory perspective. *Review of Research in Education, 24*, 211-247.

Ladson-Billings, G. & Tate, W. (1995). Toward a critical race theory of education. *Teachers College Record, 97*, 47- 68.

Lave, J., & Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York, NY: Cambridge University Press.

Lederman, N. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*, 916–929.

Lee, D. (1998). Which kids can "become" scientists? Effects of gender, self-concepts, and perceptions of scientists. *Social Psychology Quarterly, 61,* 199-219.

Lee, P. & Lee, M. (1993). Reflections from the bottom of the well: Racial bias in the provision of legal services to the poor. *Clearinghouse Review, 27,* 311-322.

Leta, J. (2003). As mulheres na ciência brasileira: Crescimento, contrastes e um perfil de sucesso. *Estudos Avançados, 17,* 271-284.

Lewis, B. (2003). A critique of the literature on the underrepresentation of African Americans in science: Directions for future research. *Journal of Women and Minorities in Science and Engineering, 9,* 361–373.

Lincoln, Y., Lynham, S. & Guba, E. (2011). Paradigmatic controversies, contradictions, and emerging confluences, revisited. In Denzin, N. K., & Lincoln, Y. S. (Eds.), *The SAGE handbook of qualitative research* (4th ed.) (pp. 97-128). Thousand Oaks, CA: SAGE Publications.

Love, B. (1993). Issues and problems in the retention of Black students in predominantly white institutions of higher education. *Equity and Excellence in Education, 26,* 27–36.

Ludvig, A. (2006). Differences between women? Intersecting voices in female narrative. *European Journal of Women's Studies, 13*, 245-258.

Lugo-Lugo, C. (2008). So you are a Mestiza: Exploring the consequences of ethnic and racial clumping in the US academy. *Ethnic and Racial Studies*, 1-18. DOI: 10.1080/01419870701568882

Malcom, S. (1993). Increasing the participation of Black women in science and technology. In S. Harding (Ed.), *The "racial" economy of science*: *Toward a democratic future* (pp. 249–253). Indiana University Press.

Maple, S. & Stage, F. (1991). Influences on the choice of math/science major by gender and ethnicity. *American Educational Research Journal, 28,* 37-60.

Martin, B. & Brouwer, W. (1991). The sharing of personal science and the narrative element in science education. *Science Education, 75*, 707-722.

Martin, K. & Miller, E. (1988). Storytelling and science. *Language Arts, 65*, 225-259.

Massey, W. (1992). A success story amid decades of disappointment. *Science, 258*, 1177–1179.

Maton, K., Hrabowski III, F. & Özdemir, M. (2007). Opening an African American stem program to talented students of all races: Evaluation of the Meyerhoff scholars program, 1991-2005. In G. Orfield, P. Marin, S. M. Flores, & M. L. Garces (Eds.), *Charting the future of college affirmative action:Legal victories, continuing attacks, and new research*. Los Angeles: The Civil Rights Project at UCLA. (pp. 125–155).

Maton, K., Hrabowski, F., & Schmitt, C. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching, 37,* 629–654.

Maton, K. & Salem, D. (1995). Organizational characteristics of empowering community settings: A multiple case study approach. *American Journal of community Psychology, 23*, 631-656.

May, G. & Chubin, D. (2003). A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education*, *92*, 27-39.

McCauley, D. (1988). Effects of specific factors on blacks' persistence at a predominantly white university. *Journal of College Student Development*, 48–51.

McElroy-Johnson, B. (1993). Giving voice to the voiceless. *Harvard Educational Review, 63*, 85-104.

Megid, J. (1998). *O ensino de ciências no Brasil: Catálogo analítico de teses e dissertações - 1972 - 1995.* Campinas: UNICAMP/FE/CEDOC.

Mensah, F.M. (2012). Positional identity as a lens for connecting elementary preservice teachers to science teaching in urban classrooms. In M. Varelas (Ed.), Identity construction and science education research: Learning, teaching, and being in multiple contexts, (pp. 107-123). Rotterdam, The Netherlands: Sense Publishers.

Mensah, F. M., & Jackson, I. (May, 2012). (Re)visions of science and science teaching: Students of color transforming their ideas of teaching science in urban schools. Critical Race Studies in Education Association Conference, New York, NY.

Merriam, S. (2009). *Qualitative research: A guide to design and implementation.* San Francisco: Jossey-Bass.

Moore, F. (2008). Positional identity and science teacher professional development. *Journal of Research in Science Teaching, 45*, 684-710.

Moore, J. (2001). Developing academic warriors: Things that parents, administrators, and faculty should know. In L. Jones (Ed.), *Retaining African Americans in higher education: Challenging paradigms for retaining students, faculty, & administrators* (pp. 77–90). Sterling, VA: Stylus Publishers.

Murphy, K. (2007). *The many worlds interpretation*. Available at: http://www.phy.ohiou.edu/~murphy/talks/misc/manyworlds.pdf

NSBP. (2008). *Black women in physics.* National Society of Black Physicists. http://www.nsbp.org/bwip

NSF. (2006). National Science Foundation. Scientists and engineers statistical data system. http://www.nsf.gov/statistics/wmpd

Nunn, (2011). Classrooms as racialized spaces Dynamics of collaboration tension and student attitudes in urban and suburban high schools. *Urban Education, 46*, 1226-1255.

Oakes, J. (1990). *Lost talent: The underparticipation of women, minorities, and disabled students in science.* Santa Monica, CA: The Rand Corporation.

Oakes, J. (1990a). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science*. Santa Monica, CA: The Rand Corporation.

Obbo, C. (1997). What do women know?... as I was saying! In K. M. Vaz (Ed.), *Oral narrative research with Black women: Collecting treasures* (pp. 41-63). Thousand Oaks, California: Sage.

Ong, M. (2005). Body projects of young women of color in physics: Intersections of gender, race, and science. *Social Problems, 52*. 593-617.

Oyserman, D., Elmore, K. & Smith, G. (2012). Self, self-concept, and identity. In M. R. Leary & J. P. Tangney (Eds.), *Handbook of self and identity* (2nd ed), pp. 69-104. New York: Guilford Press.

Parker, L., Lynn, M. (2002). What's race got to do with it? Critical race theory's conflicts with and connections to qualitative research methodology and epistemology. *Qualitative Inquiry, 8*, 7-22.

Parsons, A., & Mensah, F. (2010). Black feminist thought: The lived experiences of two Black female science educators (pp. 13-24). In K. Scantlebury, J.B. Kahle, & S.N. Martin (Eds.), *Re-visioning science education from feminist perspectives: Challenges, choices and careers*. Sense Publishers.

Perna, L., Lundy-Wagner, V., Drezner, N. D., Gasman, M., Yoon, S., Bose, E., & Gary, S. (2009). The contribution of HBCUs to the preparation of African American women for STEM careers: A case study. *Research in Higher Education, 50*, 1-23.

Pierce, C., Carew, J., Pierce-Gonzalez, D. & Wills, D. (1977). An experiment in racism: TV commercials. *Education and Urban Society, 10*, 61-87.

Popkin, R. (2000). *História do Ceticismo de Erasmo a Spinoza*. [The history of scepticism from Erasmus to Spinoza]. Rio de Janeiro: Francisco Alves.

Porchat Pereira, O. (1993). *Vida comum e ceticismo*. [Common life and skepticism].São Paulo: Brasiliense.

Post, P., Stewart, M. & Smith, P. (1991). Self-efficacy, interest, and consideration on math/science and non-math/science occupations among Black freshmen. *Journal of Vocational Behavior, 38*, 179-186.

Powell, L. (1990). Factors associated with the underrepresentation of African Americans in mathematics and science. *Journal of Negro Education, 59,* 292–298.

Rezende, F. & Ostermann, F. (2007, February). *A questão de gênero no ensino de ciências sob o enfoque sociocultural*. [The question of gender in science education through a sociocultural perspective]. Paper presented at Simpósio Nacional de Ensino de Física, São Luis, Brazil.

Rivera Maulucci, M., & Mensah, F. (2012). NARST equity and ethics committee: Mentoring scholars of color in the organization. In J.A. Bianchini, V. L. Akerson, A. Calabrese Barton, O. Lee, & A. J. Rodriguez (Eds.), *Moving the equity agenda forward: Equity research, practice, and policy in science education*. (pp. 295-316). New York, NY: Springer.

Roach, L. & Wandersee, J. (1995). Putting people back into science: Using historical vignettes. *School Science and Mathematics, 95,* 365-370.

Robinson, S. & Franklin, V. (2011). Working against the odds: The undergraduate support of African American women. *Diversity in Higher Education*, *8*, 21-41.

Rocha, L. (1999). Complex systems modeling: Using metaphors from nature in simulation and scientific models. *BITS: Computer and Communications News. Computing, Information, and Communications Division*. Los Alamos National Laboratory. November 1999.

Rollock, N. (2011). Unspoken rules of engagement: navigating racial microaggressions in the academic terrain. *International Journal of Qualitative Studies in Education,* 1–16. DOI: 10.1080/09518398.2010.543433

Rosa, K. (2008, May*)*. Gênero e etnia no ensino de Física: o cenário da investigação brasileira. [Gender and ethnicity in physics education: the Brazilian research scenario], Paper presented at *VI Encontro da rede Brasileira de estudos e pesquisas feministas* - REDEFEM, Belo Horizonte, Brazil.

Rudnick, A. (2004). An introductory course in philosophy of medicine. *Med Humanities, 30,* 54-56. doi: 10.1136/jmh.2003.000154

Russell, M., & Atwater, M. (2005). Traveling the road to success: A discourse onpersistence throughout the science pipeline with African American students at a predominantly white institution. *Journal of Research in Science Teaching, 42*, 691–715.

Ryan, R. & Deci, E. (2012). Multiple identities within a single self: A self-determination theory perspective on internalization within contexts and cultures. In M. R. Leary & J. P. Tangney (Eds.), *Handbook of self and identity* (2nd ed), pp. 225-246. New York: Guilford Press.

Schlosser, L., Talleyrand, R., Lyons, H., Kim, B. & Johnson, W. B. (2011). Multicultural issues in graduate advising relationships. *Journal of Career Development, 38,* 19-43.

Seidman, I. (1991). Interviewing as qualitative research: A guide for researchers in education and the social sciences. New York: Teachers College Press.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Sheared, V. (1994). Giving voice: An inclusive model of instruction—a womanist perspective. *New Directions for Adult and Continuing Education, 1994*, 27–37.

Showers, C. & Zeigler-Hill, V. (2012). Organization of self-knowledge: Features, functions, and flexibility. In M. R. Leary & J. P. Tangney (Eds.), *Handbook of self and identity* (2nd ed), pp. 105-123. New York: Guilford Press.

Sidanius J. & Veniegas, R. (2000). Gender and race discrimination: The interactive nature of disadvantage. In S. Oskamp (Ed.), *Reducing prejudice and discrimination: The Claremont symposium on applied social psychology*, pp. 47-69. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Simpson, J. (2001). Segregated by subject: Racial differences in the factors influencing academic major between European Americans, Asian Americans, and African, Hispanic, and Native Americans. *The Journal of Higher Education, 72*, 63-100.

Smith, M. (1982). Benefits of naturalistic methods in research in science education. *Journal of Research in Science Teaching, 19*, 627-638.

Smith, P. J. (2004). *Ceticismo*. [Skepticism]. Rio de Janeiro: Editora Jorge Zahar.

Solórzano, D. & Yosso, T. (2002). Critical race methodology: Counter-storytelling as an analytical framework for education research. *Qualitative Inquiry, 8*,23-44.

Solórzano, D., Ceja, M., & Yosso, T. (2000). Critical race theory, racial microaggressions, and campus racial climate: The experiences of African American college students. *The Journal of Negro Education, 69*, 60-73.

Spall, S. (1998). Peer debriefing in qualitative research: Emerging operational models. *Qualitative Inquiry, 4*, 280-292.

Spillers, H. (1987). Mama's baby, papa's maybe: An American grammar book. *Diacritics, 17*, 64-81.

Steele, C. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613–629.

Sue, D. W. (2010). *Microaggressions in everyday life: race, gender, and sexual orientation.* Hoboken, New Jersey: John Wiley & Sons.

Surber, J. (1998). *Culture and critique: An introduction to the critical discourses of cultural studies*. Boulder, Colo: Westview Press.

Tesch, R. (1990). *Qualitative research: Analysis types and software tools*. New York: Falmer Press.

Townsend, L. (1994). How universities successfully retain and graduate black students. *Journal of Blacks in Higher Education, 4*, 85–89.

Trower, C. (2003). Leveling the field. *The Academic Workplace, 14*, 1-15.

Tuitt, F., Hanna, M., Martinez, L., Salazar, M. & Griffin, R. (2009). Teaching in the line of fire: Faculty of color in the academy. *Thought & Action*, *25,* 65-74.

U.S. Census Bureau. (2010). 2004 American Community Survey. Available at: http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=01000US&-ds_name=ACS_2004_EST_G00_&-_lang=en&-_caller=geoselect&-format=

Vasconcellos, L. C. F. & Pignati, W. A. (2006). Medicina do trabalho: subciência ou subserviência? Uma abordagem epistemológica. [Labor medicine: sub-science or subserviency? An epistemological approach]. *Ciência & saúde coletiva, 11*, 1105-1115. doi: 10.1590/S1413-81232006000400031

Walker, E. (2012). Cultivating mathematics identities in and out of school and in between. *Journal of Urban Mathematics Education, 5,* 66-83.

Weiss, R. (1995). *Learning from strangers: The art and method of qualitative interview studies*. New York: The Free Press.

Yulianty, Y. & Premadi, P. (2010). Teaching science using storytelling method. *Proceeding of the Conference of the Indonesia Astronomy and Astrophysics*, 29-31 October 2009. http://astronomy.itb.ac.id/HAI2009/procee/articles/28_Yulianty-et-al.pdf

Appendix A

Initial Survey

surveys @ TEACHERS COLLEGE COLUMBIA UNIVERSITY

Cover Page 1 Page 2 Page 3 Page 4

Gender, ethnicity, and physics education

Understanding how Black women build their identities as scientists

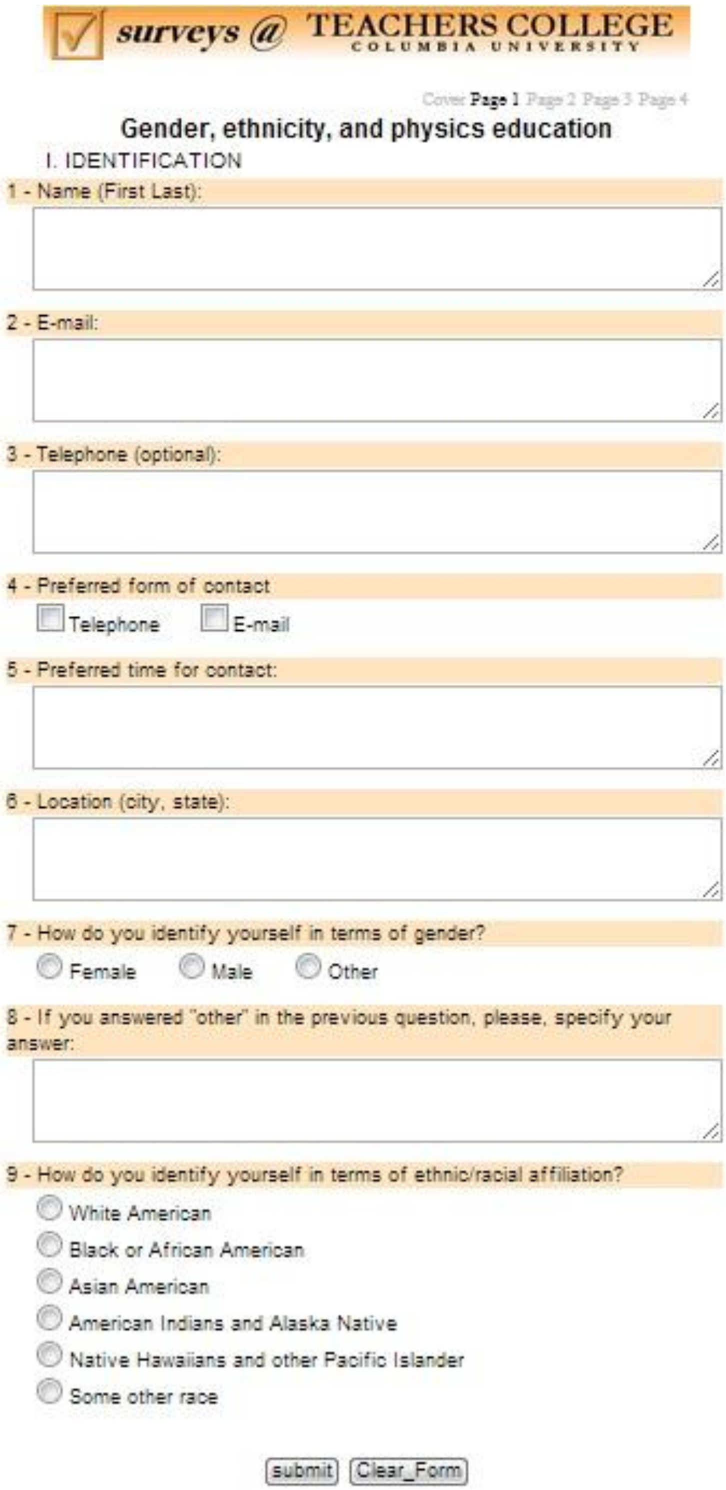
Welcome to the Black Women in Physics Survey!

There are few women of African descent in scientific careers, particularly in the physical sciences. This study aims to understand how Black women navigate their careers in the sciences, and the paths they have taken to become a physicist. This survey is intended to develop a broader picture of the status of Black women physicists in the United States. It has been developed by Katemari Rosa, supported by a CAPES/Fulbright-Brazil fellowship. Thank you in advance for participating in this study!

Your responses to this questionnaire are not anonymous; however, your data will be kept confidential and the results will only be released in aggregated statistical form. Individual level information will not be shared or made available. If you have any questions or comments about this questionnaire, please contact me (Katemari Rosa) at kdr2109@tc.columbia.edu or my academic advisor, Dr. Felicia Moore Mensah (moorefe@tc.columbia.edu).

Also, if at any time you have comments, or concerns regarding the conduct of the research or questions about your rights as a research subject, please contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, you can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.

Start_survey



surveys @ TEACHERS COLLEGE COLUMBIA UNIVERSITY

Cover **Page 1** Page 2 Page 3 Page 4

Gender, ethnicity, and physics education

I. IDENTIFICATION

1 - Name (First Last):

2 - E-mail:

3 - Telephone (optional):

4 - Preferred form of contact

- [ ] Telephone
- [ ] E-mail

5 - Preferred time for contact:

6 - Location (city, state):

7 - How do you identify yourself in terms of gender?

- ○ Female
- ○ Male
- ○ Other

8 - If you answered "other" in the previous question, please, specify your answer:

9 - How do you identify yourself in terms of ethnic/racial affiliation?

- ○ White American
- ○ Black or African American
- ○ Asian American
- ○ American Indians and Alaska Native
- ○ Native Hawaiians and other Pacific Islander
- ○ Some other race

[submit] [Clear_Form]

surveys @ TEACHERS COLLEGE COLUMBIA UNIVERSITY

Cover Page 1 **Page 2** Page 3 Page 4

Gender, ethnicity, and physics education

II. ACADEMIC BACKGROUND

1 - What is your highest completed degree?

- Ph.D./Other doctoral degree
- M.S./Other masters degree
- B.S./Other bachelors degree

2 - In what field have you completed the following degrees, and in which year?
For example:
Doctoral - Physics, 1992
Master - Mathematics, 1987
Bachelor - Engineer, 1985

3 - Have there been any significant breaks or interruptions in your doctoral studies?

No Yes

4 - If you answered "yes" in the previous question, please explain:

5 - Have you pursued any part of your education outside of the United States?

No Yes

6 - If you answered "yes" in the previous question, please, tell us in which years and in which countries:

7 - Did you attend a Historically Black College or University?

No Yes

8 - If you answered "yes" in the previous question, please tell us in which school:

submit Clear_Form

surveys @ TEACHERS COLLEGE COLUMBIA UNIVERSITY

Cover Page 1 Page 2 Page 3 Page 4

Gender, ethnicity, and physics education

III. PROFESSIONAL INFORMATION

1 - Are you currently employed in a job that requires the knowledge or skills that you received in your physics education?

- No
- Yes

2 - In what type of institution are you currently employed?

- Industry or Private Sector
- Secondary or High School
- College or University
- Government or Research Institute
- Self Employed
- Other

3 - If you answered "other" in the previous question, please explain:

4 - If you are currently working in an educational institution, is it

- Private
- Public

submit Clear_Form

surveys @ TEACHERS COLLEGE
COLUMBIA UNIVERSITY

Cover Page 1 Page 2 Page 3 Page 4

Gender, ethnicity, and physics education

IV. IN-DEPTH INTERVIEW

In a second phase of this study we would like to collect in-depth information about your experiences as a Black woman scientist. We would appreciate so much if you could contribute to the understanding of how Black women physicists build their careers.

There is a chance that you might be contacted within the next two months to participate in an in-depth, face-to-face interview.

1 - Please indicate if you would like to participate in an interview.

- ○ Yes, I wouldn't mind being contacted.
- ○ No, please, don't contact me in any way.

[submit] [Clear_Form]

Appendix B

Interview Protocol

Understanding how Black women build their identities as scientists

Interviewee Name: ____

Institutional affiliation: ____

Job Position: ____

Interviewer name: ____

Date of interview: ____________Time of interview:___________

Location of interview: _____________________________________

Notes on identifiability:

Setting description:

Thank you so much for joining me today. As you know, this study is entitled Gender, ethnicity, and physics education: Understanding how Black women build their identities as scientists.

The purpose of this study is to understand the lives of women of African descent in relation to science and the construction of their identities as physicists.

In today's interview, which will last about two hours, I will be asking about your childhood, family, school, and work experiences to help me to write about successful physicists like you.

I will treat the content of this interview, including the recordings, all notes, and any other documents with the strictest confidentiality. The data will be kept in a safe location that is not accessible to anyone except me. All copies of the audio and digital data from the interview will be deleted on the defense of my dissertation, which can happen no later than August 31, 2014.

Your name will never appear in the class report of this study. If I should use your words in my class report, I will refer to you only with a pseudonym. I also will never reveal the names of individuals whom you should mention.

Only I, as the interviewer, will have access to your real name. The results of the study will be used for the main investigator dissertation, in conferences, meetings, publications in journals, and used for educational purposes.

As we proceed through the interview today, I would like to invite you to stop me at any time to point out issues or concerns that you want me to mask or otherwise to keep "off the record."

Finally, I want to be sure that you know that your participation in this study is completely free and voluntary. You may refuse to respond to any questions. You also may discontinue the study at any time.

With your permission, I would like to record this interview in order to have a comprehensive record of our conversation. Is that acceptable to you?

_____YES _____NO

If YES: If at any time you would like to stop the recorder, you can reach over and press the stop button, or ask me to do so.

If NO: If you would prefer not to be recorded I'll be happy to take notes by hand as you speak.

Do you have any questions at this time?

This form [show the consent form] details what I just told you about confidentiality. Could I ask you to read this form at this time, and let me know if you have any questions? I will give you a copy for your records.

[After signing: Give interviewee a copy of the consent form – which includes the Participant's Rights and the Investigator's Verification of Explanation]

Okay, thank you – do you have any questions for me at this point?

I. Background

I'd like to start by confirming some of your information.
1. What is your current position at [name of organization/institution]?
2. What are your main responsibilities in this position?
3. I understand that you are a physicist, is that right?
    3.1 In what area were your undergraduate and graduate degrees?

II. Family & Environment

Great! Now I would like to go back a little bit and ask you questions related to your first contacts with science.

4. Please, talk about your upbringing; did you grow up in an urban/rural/other area?
    4.1 Please, tell me more about this environment. How would you describe your contact with science in that setting?
    [IN OTHER WORDS: How do you describe that this urban/rural/other setting related to your experiences with science when growing up?
5. How do you remember your first contact with science?
    [IF NEEDED: was it playing with friends and family, TV, at school? How do you remember it?]
6. How did your family support your interests in science during your childhood and adolescence?
7. Did you engage in activities that were related to science with your friends?
8. Did you have toys or games that you think that are connected to science?
    [IF YES]
    8.1 How do you think they were connected?
    9.1. Please describe one or two of these activities.
10. Looking back, do you remember how your friends reacted with your academic choices in the sciences?
11. What about your family, how did they react with your academic and professional choices in the sciences?
12. Do you have relatives or friends who are in scientific fields?
    [IF YES:]
    12.1. In what areas?
    12.2. How do you describe your relationship with this/these person/s?

12.3. How would you describe this/these person/s influence in your interest in science?

13. Still, thinking about your upbringing, was your family religious at that time?
14. What about yourself?
    14.1 How would you describe your religious practices at that time?
    [IF NECESSARY:]
    - Did you frequent a church?
    - Did you belong to a religious group or community?
    - Did you engage in religious activities?

[IF THE PERSON MENTION BELONGING TO A CHURCH OR RELIGIOUS GROUP, ASK QUESTION 15, IF NOT, SKIP TO QUESTION 16]

15. What religious denomination did you belong to?
16. Still thinking about when you were growing up; how would you describe your religious practices and beliefs and your relationship with science at that time?

III. Academic

I would like now to ask you now to think about your school times. Let's talk about your school experiences.

17. What do you remember from your initial school experiences with science?
18. What was your favorite subject back then? Or favorite teacher?
    18.1. Why did you like ___________ the most?
19. What do you remember from your science teachers?
    19.1. How was your relationship with your science teachers?
    [IF NECESSARY: Please, describe your relationship with your science teachers.]
20. Is there any particular class, activity or episode in school related to science that you still remember today?
    20.1. Please, describe how this experience was.
21. Now, thinking about your time as an undergraduate student. How you decided to major in physics?
22. Did you have mentors when you were a student or in college?
    [IF YES:]
    22.1. Describe the relationship you had with your mentors?
    22.2. What influence do you think they had, if any, in how you navigated in academia, or in finishing your degree (undergraduate, masters, doctoral)?
23. How was your relationship with your advisor during your doctoral studies?
    23.1. What influence do you think your advisor, if any, had in how you navigated in academia?
24. Who or what most encouraged you in your doctoral studies?
    [PROBE:
    Partner or spouse

Other family members
Your neighborhood or community
Teachers, professors or mentors
Other students
Your own determination, will power and hard work

25. How would you describe your overall training in physics?
[PROBE:
Did you have the chance to publish while a student?
Attend conferences?]
26. Did you have financial support from the university or other agencies?
27. How would you describe your support network during your doctoral studies? Were you part of the National Society of Black Physicist at that time?
[IF NECESSARY: Were you part of some kind of student association?]

IV. Professional

I now would like you to tell me more about your professional trajectory.

28. Not always we start our first job in the same field we end up working. I would like to know more about your previous job positions. What was your first job?
28.1. When was that?
28.2. How did you get this position?
29. What was your first job/position related to science?

[IF THE INTERVIEWEE WORKED IN DIFFERENT FIELDS BEFORE, THEN ASK 30]

30. How did this shift happen, from a job in _____________ (not scientific field) to your position as __________________ (the scientific field)?
[IF NECESSARY:]
30.1. How did happen that you decide to go for a scientific career?
31. Can you remember when exactly you decide to go for a scientific career?
[IF YES: What happened?]
32. How do you see your career choices in relation to decisions about marriage or children?
[IF PARTICIPANT MENTIONS TO HAVE A PARTNER, ASK QUESTION 33, IF NOT: So, do you currently have a partner?]
33. How do you describe your partner's support of your career choices? Is your partner in the science field or in academia? Please, tell me more about that?
34. Ok, now tell me more about your current job as a _________. Please, describe your activities here.
35. Why did you choose to work in a university, research center or industry?
[IN OTHER WORDS: How it happened that you ended up working in a university, research center or industry?]
36. Tell me more about your trajectory to this position. How did you get this job?
37. Do you have mentees, or are you advising and mentoring others in science and/or on your job?
37.1. Why?

[IF YES:]

37.2. How is your relationship with your mentees?

38. What are the differences you see from the mentoring when you were a student and now in the present?
39. Do you have mentors now, or models that inspire you?

[IF YES:]

39.1. How do they inspire you?

40. How do you feel you have contributed to the field of science?
    40.1. And how do you feel you have contributed in your area in particular?
    40.2. Do you feel that your work is well-received and respected by your colleagues, where you are now?
    40.3. Do you feel that your work is well-received and respected in the field in general?

V. Beliefs and motivation

Okay so now I would like to make some questions specifically about how you view science and your motivations to keep working on the field.

41. If you now had to explain to a fourth grader what science is, how would you do it?
42. What about what physics is? How would you explain it?
43. And, ultimately, how do you explain about what you do?
44. How do you think that your identification as a woman influence the way you view and do science?
45. How do you define yourself racially and ethnically?
46. How do you think your racial and ethnic affiliation interfered or interfere in your experiences in the sciences?
47. How do you think that your history, your personal experiences influence the way you view and do science?
48. I know I have asked before about your religious beliefs while growing up, but now I would like to ask you thinking about the present. How do you identify yourself in terms of religious beliefs?
49. How do you think your religious beliefs interfere in your science career?

VI. Perseverance

I know this is a long interview, and you have been great. We are now approaching the end and this is the last section of this interview. I would like to learn more about your motivations to get to where you are now in your career.

50. Did you ever feel excluded from science?
    50.1. How was that so?
    50.2. When did that happened? And where?
51. How did you deal with the situations and feelings of exclusion?

[IF NECESSARY: What strategies did you use?]

52. This might be a difficult question, but I would like you to tell me about bad memory you have from your contact with science. Please, describe some upsetting situation or feeling that you remember being associated with as you moved along your science career path.
53. Tell me about good memories you have from your contact with science - 20 years ago, 2 years ago, or even 2 hours ago, it doesn't matter when, just mention some pleasant memories, moments, or something nice that happened in regards to science in your life.
54. Finally, could you please talk about your future career goals?
55. Is there anything else you would like to add in this interview, any information you think it might help me to understand more about your career trajectory?

THANK YOU VERY MUCH FOR PARTICIPATING IN THIS INTERVIEW AND SHARING ALL THOSE EXPERIENCES.

Appendix C

Consent Form

Teachers College, Columbia University

INFORMED CONSENT

DESCRIPTION OF THE RESEARCH: You are invited to participate in a research study on Black women physicists. This project aims to understand how a woman of African descent chooses a career in the sciences, and the paths taken to become a physicist. You will be asked questions about your childhood, school, and work experiences, for instance. You will be asked to answer a written questionnaire; you may be interviewed with the use of audio-recording, and your answers may be published in papers and presented in scientific meetings. The audio-recordings will be safely stored and all the material will be coded so your name will not be in any of the tapes or questionnaires. The research will be conducted by the main investigator. The interviews can be conducted in person at a location of your convenience; however, if face-to-face is not possible, telephone conversations may be used.

RISKS AND BENEFITS: The risks and possible benefits associated with this study are that you might feel some discomfort by remembering past events that happened in your life. If you could be identified, there would be the social risks as retaliation at work; however, all the data will be coded and identifiable information will be changed.

There are also the risks in the case that you might have your confidentiality breached, unintentionally, for example, in the logistics, with data handling) or by virtue of the investigation method (qualitative study using narratives and life history). It is possible that people who know you very well could identify you when reading the study's results (e.g., journal publications, conference presentations). In any case, the breach of confidentiality could cause some level discomfort in your professional environment.

The benefits of participating in this research might be to encourage more women like themselves to pursue careers in science, to help Black women gain visibility in physics, to provide science educators with information that can improve their practices in the classrooms to help girls participate and pursue careers in physics.

In the case you are unable to participate in all aspects of this research, alternative means will be provided such as e-mail, voice chat, telephone, letter, or other communication that could enable you to participate at your convenience. There will be no consequence to you if you decide not to participate or to participate only partially in the research.

PAYMENTS: There are no payments to participate in this research.

DATA STORAGE TO PROTECT CONFIDENTIALITY: The data will not be collected anonymously. All data that is collected will be coded and you will be assigned a pseudonym. Only the main investigator will have access to the codes. The material containing data will be stored in locked files, physically or electronically with password known only by the main investigator.

By the end of the interview, the identification sheet will be separated from the interview protocol, kept safely separated from other documents, and then stored in the main investigator's locked file. Later, a pseudonym will be assigned to each participant and during the study and after that, when communicating its results, only the participants' pseudonym will be linked with the date. In addition, I will try to mask your information (e.g. changing name of geographic locations) to avoid the risk of breaching the confidentiality by people that might know the participant very well.

TIME INVOLVEMENT: Your participation will be approximately two to twelve months, where we will start with a short questionnaire and have two interviews in person, depending on your availability, in a total of approximately five hours in these twelve months.

HOW WILL RESULTS BE USED: The results of the study will be used for the main investigator’s dissertation. Papers and/or presentations at conferences, meetings, publications in journals may be written of the findings of the study. Findings will be used only for educational purposes.

Teachers College, Columbia University

PARTICIPANT'S RIGHTS

Principal Investigator: Katemari Rosa

Research Title: Gender, Ethnicity, and Physics Education: understanding how Black women build their identities as scientists

- I have read and discussed the Research Description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding this study.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at his/her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue to participate, the investigator will provide this information to me.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's phone number is (347) 867-8905.
- If at any time I have comments, or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, I can write to the IRB at Teachers

College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.

- I should receive a copy of the Research Description and this Participant's Rights document.
- If video and/or audio taping is part of this research, I ( ) consent to be audio/video taped. I ( ) do NOT consent to being video/audio taped. The written, video and/or audio taped materials will be viewed only by the principal investigator and members of the research team.
- Written, video and/or audio taped materials ( ) may be viewed in an educational setting outside the research
  ( ) may NOT be viewed in an educational setting outside the research.
- My signature means that I agree to participate in this study.

Participant's signature: ________________________________ Date:____/____/____

Name: ________________________________

Teachers College, Columbia University

Investigator's Verification of Explanation

I certify that I have carefully explained the purpose and nature of this research to ______________________________________ (participant's name) in age-appropriate language. She has had the opportunity to discuss it with me in detail. I have answered all her questions and he/she provided the affirmative agreement (i.e. assent) to participate in this research.

Investigator's Signature: ____

Date: ______________________

180

Appendix D

Coding Tables

CODES-PRIMARY-DOCUMENTS-TABLE
HU: [C:\Users\Katemari\Documents\PhD\Tese\Analise de dados\coding 2011.hpr6]
Code-Filter: All [111]
PD-Filter: All [6]

	51 Being a woman	55.1 Being a physicist	52 Being Black	55 Being a scientist	25 school	22.2.1 Adviser	5 IDENTITY	12 Family	43 Career	22 Graduate school	31.1 Religion	33 VOS	38 Mentors	36 Expectations	82 Struggle	53 Being a minority	12.1 family support	45 The Lab	35.0 Support network	41 job	42 current position	01 Family profile	14.1 Microaggression	57 Being a role model
P 1: Christa_Entrevista 1.rtf	12	24	11	29	11	30	18	27	24	12	14	8	10	24	6	8	15	13	5	5	10	8	8	12
P 2: Ester_Entrevista 2.rtf	18	16	14	8	8	4	5	14	9	4	5	5	4	5	1	7	10	0	0	4	3	7	0	8
P 3: Betty_Entrevista 3.rtf	8	11	5	6	10	6	11	0	8	4	5	11	5	1	5	2	3	5	4	4	6	6	2	2
P 4: Jane_Entrevista 4.rtf	22	15	14	5	6	1	12	5	1	7	9	7	16	4	10	6	3	6	10	11	3	6	17	1
P 5: Shanna_Entrevista 5.rtf	17	14	19	6	13	15	6	5	5	12	5	5	3	5	12	8	2	4	6	4	6	1	0	4
P 6: Allyson_Entrevista 6.rtf	7	1	5	6	9	1	2	1	2	6	4	6	4	3	3	6	3	3	5	2	2	1	1	1
TOTALS:	84	81	68	60	57	57	54	52	49	45	42	42	42	42	37	37	36	31	30	30	30	29	28	28

	41 academia job	23.1 Summer program	22.1 Choice of major	31 Beliefs	23 scholarship and funding	41.3 Conferences	55.2 Being an advisor	12.2 mother	35 Motivation	56 Being smart	41.1 Teaching	15.1 opportunities	39 NSBP	25.1 Role of teacher	25.1.0 Science teacher	22.0 Choices	35.1 Lifestyle	11 childhood	22 College	35.2 Family planning	02 Upbringing profile	13.1 science exposure	4 PROFESSIONAL	21 first contacts with science	31.1.1 Church	22.2 Choice of institution	24 Math performance	34 perseverance	12.9 Husband	15.2 NASA
P 1: Christa_Entrevista 1.rtf	14	8	6	14	5	3	4	8	7	17	17	8	9	9	5	8	7	11	9	6	6	4	9	6	7	8	9	9	0	10
P 2: Ester_Entrevista 2.rtf	12	3	6	2	7	9	6	4	7	3	6	6	2	7	3	2	4	4	2	2	5	5	8	7	2	2	1	2	6	4
P 3: Betty_Entrevista 3.rtf	0	5	3	0	2	3	6	6	0	0	0	1	2	0	3	3	3	2	1	2	0	2	0	1	3	1	1	0	6	1
P 4: Jane_Entrevista 4.rtf	0	4	3	5	4	6	5	1	7	1	1	1	4	5	6	3	4	2	3	6	4	3	2	0	3	4	5	4	0	1
P 5: Shanna_Entrevista 5.rtf	1	2	4	3	3	2	3	3	2	2	0	3	5	1	0	5	4	1	3	2	3	1	1	2	2	2	2	2	1	0
P 6: Allyson_Entrevista 6.rtf	0	5	5	2	5	2	0	2	1	1	0	4	1	1	5	1	0	1	3	2	2	5	0	3	1	1	0	1	3	0
TOTALS:	27	27	27	26	26	25	24	24	24	24	24	23	23	23	22	22	22	21	21	20	20	20	20	19	18	18	18	18	16	16

	4.3.1 Tenure	1.0 Marriage/Relationships	4.1.2 Publication	3.9 NSF	1.2.4 Siblings	1.3 environment	1.2.7 Friends	8.1 Excluded from science	4.8 The Future	8. Critic Episodes	1.2.3 Father	1.5 Resources	9 Fields of work/experience	3.1 Physics education	4.0.1 Pleasure with job/career/position	3.7 Depression	2.0 Academia	2.1.0 Favorite subjects	2.5.3 Performance	0 profile	2.4.1 Like/dislike physics	2.4 Physics performance	2.5.2 Tracking	4.9 Contribution to science
P 1: Christa_Entrevista 1.rtf	12	9	8	7	6	6	5	1	5	9	6	6	3	6	4	10	9	3	3	6	8	5	2	0
P 2: Ester_Entrevista 2.rtf	2	2	4	0	4	1	0	3	2	0	2	1	2	4	5	0	0	0	4	0	0	3	1	0
P 3: Betty_Entrevista 3.rtf	1	4	1	3	2	4	3	1	1	0	0	2	4	1	0	1	0	4	1	0	0	0	2	1
P 4: Jane_Entrevista 4.rtf	0	0	1	0	3	0	2	1	3	0	2	0	1	0	1	0	2	0	1	2	1	0	0	4
P 5: Shanna_Entrevista 5.rtf	1	1	1	0	0	2	2	6	1	0	0	3	2	0	1	0	0	2	1	0	0	1	2	2
P 6: Allyson_Entrevista 6.rtf	0	0	1	6	1	2	2	2	2	5	4	1	1	0	0	0	0	2	1	1	0	0	2	2
TOTALS:	16	16	16	16	16	15	14	14	14	14	14	13	13	11	11	11	11	11	11	9	9	9	9	9

	2.3.1.0 REU	1.2.5 Relatives in science	2.2.2.1 Faculty	5.9 Being a wife	8.4 Strategies to overcome obstacles	3.2 Values	5.1.1 Sexism	1.2.1.1 Family involvement in school	2.1 degrees	3.9 AFS	4.0.2 Not enjoying what she does	5.8 Being a mother	5.4 Being poor	2.5.2.1 Desegregation	2.1 Colleagues - students	8.3 Happy moment	4.1.1 occupation	9.2 Laser, Optics	3.1 being a minority	3.8.1 Role models	2.7 type of institution	1.3.1.1 Museum	1.2.8 Other people - not friends or family	4.3 Colleagues - work	9 Scholarship	0.3 School profile	1.2.6 Grandfather	2.2.2 HBCU or PWI	2.5.4 Learning disabilities - find better word	2.1.1 Least favorite subjects	2 ACADEMIC	1 FAMILY AND ENVIRONMENT	3 BELIEFS AND MOTIVATION	TOTALS:	
P 1: Christa_Entrevista 1.rtf	8	2	4	1	0	2	2	3	1	1	1	2	0	0	2	0	2	0	1	2	2	2	2	2	0	1	1	0	1	0	0	0	0	771	36%
P 2: Ester_Entrevista 2.rtf	0	1	2	3	0	1	0	0	1	1	1	2	0	3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	355	16%
P 3: Betty_Entrevista 3.rtf	0	2	0	0	3	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	234	11%
P 4: Jane_Entrevista 4.rtf	0	0	0	1	0	1	0	1	1	1	1	0	0	0	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	328	15%
P 5: Shanna_Entrevista 5.rtf	0	0	0	1	0	1	2	0	1	1	1	0	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	283	13%
P 6: Allyson_Entrevista 6.rtf	1	3	1	0	3	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	187	9%
TOTALS:	9	8	7	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1	0	0	0	0	2158	

	Being a woman	Being a physicist	Being Black	Being a scientist	school	Advisor	IDENTITY	Family	Career	Graduate school	Religion	VOS	Mentors	Expectations	Struggle	Being a minority	family support	The Lab	Support network	Job	current position	Family profile	Microaggression	Being a role model	academia job
Allyson	7	1	5	6	9	1	2	1	2	6	4	6	4	3	3	6	3	3	5	2	2	1	1	1	0
Betty	8	11	5	6	10	6	11	0	8	4	5	11	5	1	5	2	3	5	4	4	6	6	2	2	0
Christa	12	24	11	29	11	30	18	27	24	12	14	8	10	24	6	8	15	13	5	5	10	8	8	12	14
Ester	18	16	14	8	8	4	5	14	9	4	5	5	4	5	1	7	10	0	0	4	3	7	0	8	12
Jane	22	15	14	5	6	1	12	5	1	7	9	7	16	4	10	6	3	6	10	11	3	6	17	1	0
Shanna	17	14	19	6	13	15	6	5	5	12	5	5	3	5	12	8	2	4	6	4	6	1	0	4	1
TOTALS.	84	81	68	60	57	57	54	52	49	45	42	42	42	42	37	37	36	31	30	30	30	29	28	28	27

	Summer program	Choice of major	Beliefs	23 scholarship and funding	4.1.3 Conferences	5.5.2 Being an advisor	1.2.2 mother	3.5 Motivation	5.6 Being smart	4.1.1 Teaching	1.5.1 opportunities	3.9 NSBP	2.5.1 Role of teacher	2.5.1.0 Science teacher	2.2.0 Choices	3.5.1 Lifestyle	1.1 childhood	2.2 College	3.5.2 Family planning	0.2 Upbringing profile	1.3.1 science exposure	4 PROFESSIONAL	2.1 first contacts with science	3.1.1.1 Church	2.2.2 Choice of institution	2.4 Math performance	3.4 perseverance	1.2.9 Husband	1.5.2 NASA	4.3.1 Tenure	1.0 Marriage/Relationships	4.1.2 Publication	3.9 NSF
Allyson	5	5	2	5	2	0	2	1	1	0	4	1	1	5	1	0	1	3	2	2	5	0	3	1	1	0	1	3	0	0	0	1	6
Betty	5	3	0	2	3	6	6	0	0	0	1	2	0	3	3	3	2	1	2	0	2	0	1	3	1	1	0	6	1	1	4	1	3
Christa	8	6	14	5	3	4	8	7	17	17	8	9	9	5	8	7	11	9	6	6	4	9	6	7	8	9	9	0	10	12	9	8	7
Ester	3	6	2	7	9	6	4	7	3	6	6	2	7	3	2	4	4	2	2	5	5	8	7	2	2	1	2	6	4	2	2	4	0
Jane	4	3	5	4	6	5	1	7	1	1	1	4	5	6	3	4	2	3	6	4	3	2	0	3	4	5	4	0	1	0	0	1	0
Shanna	2	4	3	3	2	3	3	2	2	0	3	5	1	0	5	4	1	3	2	3	1	1	2	2	2	2	2	1	0	1	1	1	0
TOTALS.	27	27	26	26	25	24	24	24	24	24	23	23	23	22	22	22	21	21	20	20	20	20	19	18	18	18	18	16	16	16	16	16	16

Continues...