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Female Students and Achievement in Secondary School Mathematics

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ACCEPTANCE

This dissertation, FEMALE STUDENTS AND ACHIEVEMENT IN SECONDARY SCHOOL MATHEMATICS, by BARRY P. SHILDNECK IV, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chair, as representatives of the faculty, certify this dissertation has met all standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

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ABSTRACT

FEMALE STUDENTS AND ACHIEVEMENT IN
SECONDARY SCHOOL MATHEMATICS
by
Barry P. Shildneck IV

Achievement and the experiences of women in secondary school mathematics have been well documented in the research literature (e.g., Benbow & Stanley, 1980, 1983; Tartre & Fennema, 1995; Sherman, 1982; Ryckman & Peckham, 1987; Keller & Dauenheimer, 2003). With respect to achievement, the research literature primarily focuses on how women are deficient to men (e.g., Benbow & Stanley, 1980, 1983) and the roles affective attributes (e.g., Sherman, 1982; Fennema, Petersen, Carpenter & Lubinski, 1990) and stereotype threat (e.g., Quinn & Spencer, 2001; Steele & Aronson, 1995) have played in women's deficiencies. Despite the perspective and nature of this research, there are, however, women who have achieved at extraordinarily high levels in the secondary mathematics classroom.

It is important to examine this historical research as it has impacted the views of teachers, researchers, and media with regard to female mathematics students' opportunities. By reflecting upon the research literature and its far reaching impacts, high-achieving women in mathematics can begin to reverse the perceptions that limit their opportunities. Thus, the purpose of this study was to explore, through the experiences and stories relayed by the study's participants, how young women might

negotiate the (historic all male) mathematics domain. Employing a qualitative research designed within a phenomenological framework and analyzed through a combination of postmodern and standpoint feminisms, I examined the stories of four undergraduate female students who were identified as being high-achieving in secondary school mathematics. These young women, by reflecting upon their secondary school experiences, and by reflecting upon their experiences within the context of the existing research literature, not only identified the aspects of their lives they felt had the greatest impact upon their opportunities but also examined their personal definitions of success and the impacts their gender had on their (socially defined) achievements within secondary school mathematics.

INDEX WORDS: Achievement, Female Students, Gender, Phenomenology, Postmodern Feminism, Secondary School Mathematics, Standpoint Theory, Success

FEMALE STUDENTS AND ACHIEVEMENT IN SECONDARY SCHOOL MATHEMATICS

by
Barry P. Shildneck IV

A Dissertation

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ABBREVIATIONS

ACT	ACT Achievement and Reasoning Test
AP	Advanced Placement
AVID	Advancement Via Individual Determination Program
GPA	Grade Point Average
MBA	Master of Business Administration
MPA	Master of Public Administration
MBTI	Myers-Briggs Type Indicator
NCLB	No Child Left Behind
PAGE	Professional Association of Georgia Educators
PSAT	Preliminary SAT/National Merit Scholarship Qualifying Test
SAT	SAT Reasoning Test
SMPY	Studies of Mathematically Precocious Youth
SOAR	Survey of Achievement Responsibility
STAR	Student Teacher Achievement Recognition Program

CHAPTER 1

INTRODUCTION OF THE STUDY

I begin this chapter by sharing recollections from my personal experiences that influenced my decision to pursue this research project. I then share a brief description of the young women who agreed to participate in the study. Following this description, I provide a rationale for the pursuit of the research project, providing the problem statement and the associated research questions that guided and narrowed the focus of the exploration.

Background

My initial thoughts about education have always been concerned with subject matter and the classroom experiences of teacher and students. Therefore, as I undertook the commitment of becoming a mathematics teacher, I reflected upon the practices of those classroom teachers that impacted me most. Having a sister that is 8 years younger also afforded me the opportunity to observe and realize the possible impact that teachers have on their students. While I may sound biased, my younger sister is very intelligent. She never struggled in school and was constantly challenged, not only by the gifted programs and courses in which she was enrolled but also by an older brother who held the highest of expectations. There came a point, however, in her secondary mathematics program where she did finally begin to struggle. I had the opportunity to, on occasion, directly observe some of her struggles in the mathematics classroom. I noticed that very

few female students at her school chose to take the calculus course in which my sister was enrolled. It appeared (from my perspective as a mathematics teacher) that her calculus teacher was impersonal and used outdated methods. The atmosphere of the classroom and the demeanor of the teacher could easily be compared to the atmosphere of a “male locker room.” This description, however, lacks much of the important detail that is meant by the phrase. On occasions when I had the opportunity to observe the student interactions in the classroom, male students seemed to dominate most of the conversations. From my perspective, it didn’t seem to matter whether the conversations were mathematical or jovial, but even when the latter, the conversations pertained to material that would traditionally be considered male in nature. Female students appeared to make up the majority of the “questioners” in the classroom. This characteristic, however, seemed to indicate to the instructor and indirectly to the male students (I suppose) that the female students lacked the ability to handle the required mathematics curriculum. From my perspective, as the brother of one of these female students, I came to believe that these attitudes made female students feel un-welcomed and as if they did not belong in the course. Unfortunately, in large part, the ultimate consequence that resulted from these feelings was that my sister chose to give up on her mathematics career and drop the course.

When I became a mathematics teacher, one of my goals was to ensure that young women in my classroom did not suffer the same fate as my sister. I searched for and reflected upon teachers that impacted me (although I am male) and that seemed to have success with all students. The most important attitude that I think that I have brought to

my classroom is that each student is an individual with her or his own method of learning and understanding. I consciously have created a setting where students are treated differently, but on an individual basis, rather than the basis of gender, ethnicity, or other cultural factors. I have designed my classroom to be a place where students, as individuals, might come and learn mathematics together without the fear of an instructor who has prejudged them on the basis of these from stereotyped characteristics. By treating each student as an individual, valued as both a person and a learner, I have been able to create a classroom atmosphere in which students, regardless of their previous level of success in mathematics, feel they are being taught and have the opportunity to learn. By founding my classroom upon this concept, I have consistently enjoyed success with not only female students but also students of all backgrounds. It is for these reasons that I have developed an interest in gendered mathematics, and specifically, how female secondary mathematics students can achieve at high levels.

The Participants

There were initially 5 young women who agreed to participate in the research project. Early on, however, one of the young women was forced to drop out as a result of the time commitment required during her current and future semesters for her major field of study. The 4 remaining young women who participated in the study were all former students who passed through my most advanced pre-calculus course. Each had been successful within this course, earning grades of A in both semesters. Furthermore, each participant met criteria that were set forth at the outset of recruitment. These criteria include: minimum grades in upper-level mathematics courses, and scores on highly

recognized standardized tests. While in high school, each of the women had greatly exceeded the minimum requirements for both of these criteria. All of the research participants were, at the time of this study, undergraduate students. The participants, Farah, Samantha, Sophia, and Clara, were a senior, a sophomore, and two freshmen, respectively. A detailed account of each participant's background as well as a detailed summary of each of their stories is shared within the data collections and findings chapter. As a precursor to this chapter, I share here a brief description of each participant.

Farah, the senior, was a young woman at a large technical university in the Southeastern region of the Unites States. Upon reporting this study, she will have completed her requirements for graduation with a major in microbiology. She had recently been accepted to graduate school at another large southeastern university where she intends on majoring in pharmacology or pharmacokinetics. She had moved to the Unites States from Nigeria when she was 12 years of age. As a result, her story varies greatly from the other participants. While in high school, this young woman participated in numerous extracurricular activities. Upon completing her high school requirements she was an honors graduate and the Star Student[1] for her graduating class.

Samantha, the sophomore, was the only participant that was majoring in a traditionally mathematics related field, choosing to pursue a degree in actuarial science. She was attending a large southeastern university within her home state. While in high

[1] The Professional Association of Georgia Educators (PAGE) website describes the Student Teacher Achievement Recognition (STAR) as a program that honors Georgia's outstanding high school seniors and the teachers who have been most instrumental in their academic development. Students earning this recognition are required to have the highest score (in one sitting) on the SAT and be in the top 10% of graduates in their school's graduating class.

school, she was also an honors graduate. While she was not the Star Student for her graduating class, she did earn the highest score on the mathematics section of the SAT in her school—a perfect 800. She also participated in numerous activities both in and outside of the school setting.

The first of the 2 freshmen, Sophia, chose to attend a prestigious university in the Southwestern region of the United States. She has chosen to major in classical studies and anthropology. While in high school, she participated in numerous clubs and activities. She was also an honors graduate and earned the second highest SAT score in her graduating class. She moved to the United States from Brazil with her mother and step-father while she was in middle school. Her schooling experiences in Brazil were greatly influential on the type of learner she became. Within her recollections she readily shares her comparisons between the schooling systems in each country and their influences upon her.

The final participant, Clara, is a freshman in a highly selective university in her home state. She chose to attend this university as a result of its prestige and her previous relationship to it through her father, who works for the university (at a separate campus). This young woman was extremely selective in her choices of extracurricular activities in high school. Rather than participating in numerous activities, she focused on those that would also help her academically. Her focus in high school was solely on grades and high test scores. As a result, she was her graduating class's Star Student and Salutatorian.

The multiple backgrounds from which this group of young women has come assisted me in analyzing and synthesizing how their stories might be related. Because

these young women had such varying histories, but with all experiencing astounding success in mathematics, I was able to reject data that could have otherwise been considered common among the participants as a result of having similar upbringing and familial experiences. Thus, I found the lack of similarity among the participants' pasts, previous to beginning their secondary education, to be extremely advantageous when analyzing the data.

Purpose of the Study

The gender gap in mathematics, whether perceived or real, has been well documented in the research literature (Benbow & Stanley, 1980, 1983; Boaler, 2002a; Burton, 1995; Reyes & Stanic, 1988; Morrow & Morrow, 1995; Tartre & Fennema, 1995; Sherman, 1982; Lesko & Corpus, 2006; Ryckman & Peckham, 1987). While research regarding gender in mathematics has continued to evolve, the stigma of early studies such as those of Benbow and Stanly (1980, 1983) continues to permeate mathematics classrooms. Although more recent studies show that girls are consistently performing as well as, and often outscoring, their male counterparts on standardized mathematics tests (Hyde, Lindberg, Linn, Ellis, & Williams, 2008), there continues to be an acceptance that boys are more analytical than girls, and as such more prepared to learn mathematics. Furthermore, as educational policy is informed and driven by the findings of studies regarding the learning of mathematics, the essentialist nature of failure-oriented research (in mathematics) has had a far reaching impact not only on the perceptions of female mathematics students but also on decisions that have directly affected the educational opportunities for young women.

As a secondary mathematics teacher, I have come to understand that there are numerous young women that outperform young men in the mathematics classroom. Now studies, such as that done by Hyde et al. (2008), are beginning to provide "validation" to my experiences as a mathematics teacher for the past 11 years. The question, then, is how are young women able to achieve at such high levels in mathematics in light of the perceptions held by many that girls should be held to lower expectations than their male classmates.

The purpose of this study is to examine how young women, having been socially defined as mathematically successful (as detailed in chapter 4), view the impact of factors from their personal histories and from their previous experiences on their achievement in high school mathematics. Through this study, I attempt to allow these young women to inquire about what traits, beliefs, and ideas are/were held by themselves and those around them that led to their opportunities to be successful within the (male?) mathematics domain.

Rationale

The overarching question that guides my research is: "How do high achieving young women interpret their success in high school mathematics?" By asking young women to reflect on those experiences that they believe directly impacted their secondary

mathematics experiences, I identify the affective traits[2] that girls attribute to their success. I investigated sociocultural factors[3] as well as traits of teachers, schools, and curricula that might be attributed as having impacted female students' mathematics achievement.

Guiding Questions

Using a qualitative phenomenological methodology, I investigated the affective traits and sociocultural factors that a selected group of undergraduate female students identified as having impacted their opportunities in the secondary mathematics classroom. By analyzing participants' recollections through both postmodern and feminist theoretical frameworks, I examined each participant's story as individual in context and meaning. I began the study with two major research questions. As the study progressed, however, singular themes emerged that gave rise to a third question that was of particular interest. The research questions that were addressed included:

1. To what factors do high-achieving female mathematics students attribute their success?
2. Do these students, defined as mathematically successful by common social standards,[4] as indicated in the methodology, identify themselves as "high-

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[2] Reyes (1984) defines affective variables to be students' feelings, aspects of the classroom, or themselves that impact their learning. She limits her definition for her specific inquiry but indicates that affective variables may include perceptions of difficulty, usefulness, and appropriateness of subject matter.

[3] Yoong, Taha, and Veloo (2001) define sociocultural factors as locally situated, including the historical backgrounds, cultural mores, major political events, national education structures and aims, and language policies that impact the education of a student.

[4] While "common social standards" can be seen as problematic, for the sake of this study, the phrase is meant to identify a set of criteria that, when met, any student would be

achieving"? What definition or personal significance does "high-achieving" hold for these participants?

3. How do these participants define gender as it functions in their lives? What relationships do they perceive between their gender and their success in secondary mathematics?

By providing my participants a research space in which to explore these questions, I gained insight into how these young women were able to achieve within the secondary mathematics domain. As a result of conducting the study, I developed (and redevelop, i.e., the participants are all past students of mine) relationships with my participants in which the discussion of needed transformations within the mathematics arena might begin. I believe that young women need opportunities that allow them to become seen as mathematically successful within their own social-cultural groups and by other groups before the dogma of male domination may be changed. Without women's direct involvement, this change, I believe, can never take place. Thus, by allowing this small group of women the opportunity to discuss their experiences and to have their stories documented, I hope that the questions we, as mathematics educators and researchers, ask change from "Why are boys better than girls at math?" and "Why don't more girls do math?" to "If she can do it, why can't others?" and "What can be learned from these women that might assist mathematics teachers in providing opportunities for all young women to find success in the mathematics classrooms (if they so choose)?"

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politically defined as successful. Political success in this case indicates that a student achieved high test scores on standardized assessments such as the SAT, ACT or PSAT and completed their required (and elective) schooling with a grade point average of higher than 3.5 on a 4.0 scale.

CHAPTER 2

PHILOSOPHICAL AND THEORETICAL FRAMEWORKS

As I began to think about what theories addressed my research, I was compelled to contemplate the study in two ways. First, I was forced to consider from which theoretical positions the research questions were conceived as well as the design and implementation of the study. Second, I found it necessary to develop a theoretical framework that enabled me to analyze the data that was to be provided while acknowledging my participants' multiple stories as women as well as me having been their (male) teacher.

When considering the research design, I felt obligated to reflect upon my personal understandings of myself as not only a researcher but also as a teacher, husband, parent, and a man. I found that it was through these lenses that I see and question the complexities and constructions that make up the perceptions and beliefs held within and about my society. Thus, it was also through these lenses that I composed my research questions and the design of the research project. As I have reflected about the ways in which I view my world as an educator, I found myself consistently drawing upon the concept of praxis and elements of postmodernism. Thus, I first introduce, as the philosophical framework from which the study was designed and implemented, an integration of praxis within postmodernism.

Second, as a theoretical framework through which the analysis of data was completed, I follow with a description of a blending of postmodern and feminist theories. In order to ensure that I, as the researcher, was continually aware of the influences that I might have had both as a man and my participants' former teacher, I used tenets of postmodern feminism. With respect to my interpretations and sharing of my participant's stories, I chose to incorporate feminist theories regarding women's standpoints and situated knowledge. It is through these philosophies that I attempt to understand (analyze) the information that was provided by the women that chose to share their histories.

A Philosophical Framework: Praxis and Postmodernism

Praxis

The concept of praxis[5] greatly influenced my beliefs about mathematics education. That is to say, my teaching practices are guided by the integration of theory and experience. Furthermore, as I have developed as a teacher, I have continued to instruct using methods that emphasize the use of what is learned both within the class and for future use. By understanding my philosophical role as an educator, I have learned to highlight not only the curricular material that is required but also the methods of learning and analysis that might serve students outside of the formal mathematics classroom. Furthermore, by designing a learning environment in which students work as teams to investigate new and previous concepts, my classroom models the experience of collaboration that is required for success in many modern occupations.

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[5] Praxis is the concept of theory "in action," typically through social discourse.

Praxis stresses the relation of theory to action. This relation emphasizes the importance of the practical use of knowledge. For William James (1906) theory is not absolute. Rather, theories become cognitive instruments that propel us forward. James also redefines "ideas" as parts of our experience that are true just in so far as they help us relate to other experiences. Thus, the importance of knowledge is based in its practical usefulness in relation to theoretical development; in particularly, its usefulness in understanding ones' situation and role in society.

Patti Lather (1991) utilizes the idea of praxis for social research. Praxis, according to Lather, "is the self-creative activity through which we make our world" (p.11). To be "praxis-oriented," she states, is to adopt a "research paradigm openly committed to critiquing the status quo and building on a more just society" (p. 172). Praxis in research, then, is interactive and reciprocally shapes theory and practice. For Lather, this concept is at the center of emancipatory social science. She argues that "for praxis to be possible, not only must theory illuminate the lived experience of progressive social groups; it must also be illuminated by their struggles" (p. 55). Research grounded in postmodernism theory thus raises questions that require researchers to move toward a transformative form of praxis (Lather, 1991).

Postmodernism

Postmodernism is a theoretical movement typically attributed to the ideas of philosophers and authors such as Michel Foucault, Jean-Francois Lyotard, Jacque Derrida, and Gillez Deleuze. "Postmodernism" in the philosophical sense refers to a theoretical tradition that takes up a radical shift in the critique of the substantive

doctrines, values, and practices underlying modernity. Traditionally, postmodernism opposes the ideas of foundationalism, essentialism, and realism. Modernism is described by Peters and Burbules (2004) "as a movement sustained by a belief in the advancement of knowledge and human progress, made on the basis of experience and scientific method" (p. 9). In this way, the modern position is aligned with a search for scientific *T*ruth and thus, empirical positivism.[6] Bogdan and Biklen (2007) further explain that modernism is based on "beliefs in human progress through rationalism and science; the idea of a stable, consistent, and coherent self; and positivist approaches to knowing—beliefs that have held sway in the West since the enlightenment" (p. 21). Modernist perspectives, as a result, rely on the assumption that there exists a scientific and observable truth regardless of the societal or cultural constructs surrounding the object of inquiry.

The postmodern, in response, rejects the modernist view of science as value free and objective. Usher and Edwards (1994) maintain that "the significant thing is that in postmodernity uncertainty, the lack of a centre, and the floating of meaning are understood as phenomena to be celebrated rather than regretted" (p.10). Postmodernism, thus, challenges the absolutes about human (empirical) knowledge and questions claims

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[6] Lather (1991) summarized four assumptions of positivism:

1. the aims, concepts and methods of the natural sciences are applicable to the social sciences;
2. the correspondence theory of truth which holds that reality is knowable through correct measurement methods is adequate for the social sciences;
3. the goal of social research is to create universal laws of human behavior which transcend culture and history; and
4. the fact/value dichotomy, the denial of both the theory-laden dimensions of observation and the value-laden dimensions of theory create the grounds for an "objective" social science. (p. 172)

of objectivity. As a result, postmodern philosophy necessarily rejects the idea that knowledge as an accurate representation of reality, rejects truth as correspondence of reality, and, opposes the existence of transcendental standpoints. Furthermore, postmodern critiques are based on questioning claims of neutrality and the privilege of (empirical) reason. Postmodernism also conceptualizes the world as socially constructed. As a result, postmodernists argue that one can only know something from a certain constructed position. Donna Haraway (1988) described the modernist position as a "view from nowhere," because subjects can not and do not formulate ideas outside of their historic context. The assertion that knowledge is contextual challenges the possibility of knowing what is true, through the use of scientific reason. Thus, postmodern philosophers continually examine the cultural relations of power, both in practice and in text, in an effort to reveal the "truth" of foundationalist paradigms. Postmodernism is thus defined (at least in part) by its break with totalitizing, universalizing metanarratives and the humanist view of the subject. As "humanism posits the subject as an autonomous individual capable of full consciousness and endowed with a stable self," the postmodern is contingent on the subject as ever changing, dynamic, "messy," and unexplained (Lather, 1991, p. 5). As stated earlier, to accomplish these tasks postmodern philosophers draw upon the works of authors such as Lyotard, Foucault, and Derrida that questioned well-entrenched positivist paradigms.[7]

[7] The philosophers listed, with the exception of Lyotard, never claimed to be a postmodernist or the label of any related philosophy such as structuralist or post-structuralist. Lyotard claimed to be a postmodernist with his publication of *The Postmodern Condition* (1984).

Lyotard (1984) described "modern" as the set of grand narratives (metanarratives) that societies tell themselves in order to justify their sets of beliefs, practices, and institutions. In other words, a metanarrative is a story that provides a rationale for a unified certainty about knowledge and the meaning of experience. Furthermore, in order to achieve its objective status, this meaning is removed from its historic or personalized significance.

Postmodernism, in turn, as Lyotard (1984) defined it, is the "incredulity toward metanarratives" (p. xxiv). Thus, postmodern philosophers are skeptical of the grand narratives through which a society defines itself. Lyotard, however, was not opposed to modernism. Rather, he described postmodernism as not the end of modernism, but as a continuation by less conventional means. In this way, postmodernism defines a "new" school of thought for regarding the grand narratives that define a culture. It is through these new lines of investigation that the postmodern philosopher attempts to understand her or his societal contexts.

Derrida described "postmodern" inquiry as a critique of modern culture through the deconstruction of the language, authority and societal practices. First, deconstruction offers an active interpretation of, resistance to, and reevaluation of humanist (positivist) views based on the *sovereign subject*.[8] By questioning the binaries surrounding the privilege of the sovereign subject, in comparison to other subjects, Derrida begins to deconstruct the authoritarian relationships that are at play within society. This deconstruction is done by delegitimizing authority so as to examine the consequences of

[8] The sovereign subject can be defined as the predominant forms of pedagogy existing in contemporary institutions, theories, and practices (Peters & Burbules, 2004, p. 68)

replacing the privileged subject with the other. According to Lather (1991), deconstruction is “impossible to freeze conceptually” (p. 13). She goes on to explain the process of deconstruction in three steps:

1. identify the binaries, the oppositions that structure an argument;
2. reverse/displace the dependent term from its negative position to a place that locates it as the very condition of the positive term; and
3. create a more fluid and less coercive conceptual organization of the terms which transcends a binary logic by simultaneously being both and neither of the binary terms. (p.13)

Lather further contends that by doing so we demystify the realities that have been created by and within society. “The goal,” she states, “is to keep things in process, to disrupt, to keep the system in play, to set up procedures to continuously demystify the realities we create, to fight the tendency for our categories to congeal” (p. 13). Furthermore, deconstruction disrupts the logic that ranks subjects in an implicit hierarchy that has been established by the language. By dismantling this rank order, the characteristics and complexities of society are revealed and can be examined. Research conducted within postmodern frameworks acknowledges the convoluted nature of multiple possibilities and hierarchies surrounding the deconstructed subject. The courage to think and act within such an uncertain framework is the hallmark of a transformative praxis (Lather, 1991).

Foucault also manifested new lines of inquiry within the relationship between knowledge and power and the power relations of discursively formed subjects. Foucault developed an approach for inquiry into the development of knowledge that treated

systems of thought as discursive formations. "'Discourse' in this sense is taken to mean a group of statements that form a unity by virtue of their relation to one another" (Peters & Burbules, 2004, p. 61). The notion of discourse is powerful enough to simultaneously constitute and exclude objects as subjects. Power, for Foucault, is productive. It exists in every aspect of society and is intimately related to the formation of knowledge. Discourse might, in this way, be understood as a system of possibility (Usher & Edwards, 1994). As such, it is through discourse that a field of knowledge is made available.

For Foucault (1972), knowledge is not objective or value-free. Rather, it is inextricably linked to relations of power. Power produces knowledge. Foucault defines "power–knowledge" as the knowledge that is formed within the discourses of society. Thus, power–knowledge is a discursive formation that functions on the basis of societal practices and, as a result, are affected by forms of repression. Furthermore, as knowledge is not value free or neutral, knowledge can not be understood outside of its relationship to power. The activity of the subject, according to Foucault is not what produces knowledge. Rather, the processes and struggles that traverse the relationships between power and knowledge determine the forms and domains of knowledge. This view of the relationship between power and knowledge underlies postmodern philosophy. While Foucault did not label himself a postmodernist, his ideas regarding the critique of discursive formations and how knowledge is produced within the contexts of these discourses has been instrumental in the use of postmodern philosophy as a theoretical framework for investigations into educational issues (Peters & Burbules, 2004).

Postmodern philosophy[9] provides me with a language to discuss the current discourses within the historical context and to further investigate the alternate conceptions and conclusions without presuming that there is a "right" answer that replaces my previous understandings. A postmodern analysis allows me to question the perceived "truths" that exist within the current educational realities. By adopting postmodern theory one rejects the perspectives of modernism and empirical positivism. Postmodern philosophers do not search for patterns or structures that define human phenomena. Rather, through its movements which continually intersect, contradict in both idea and action, postmodern gives rise to something new (Lather, 1991). This awareness further allows one to accept who an individual is at the moment and in the current historical and social contexts. As a postmodern educator,[10] then, I must also be aware that a student may be someone quite different at one time and within one setting than she may be at a different moment or within other social contexts. In other words, based on what discourses[11] are currently acting upon the individual, she may be someone quite dissimilar from one social setting to the next.

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[9] The terms *postmodernism* and *poststructuralism* are often used interchangeably in the literature. There are, however, acknowledged differences in their strict definitions. For the purposes of this discussion, *postmodern* is used as an umbrella term under which both postmodernism and poststructuralism are placed (Kincheloe & McLaren, 1994).

[10] For me, a postmodern educator is a teacher who understands that the world is socially constructed by the individual through the sociocultural and sociohistorical discourse available to the individual. In the classroom, then, a postmodern understanding that learning is based on the current and historical contexts of individual students is imperative to providing meaningful educational experiences for all students.

Postmodernism also provides a framework in which to deconstruct[12] the discourses surrounding the binaries that define marginalized peoples. Marginalized subjects can be defined as those people found on the right side of power relations such as male/female, white/non-white, or rich/poor. Power is inherent within all interactions (Meaney, 2004). These discourses regarding power relations, then, exist within societal constructs (Freire, 1970/2005). Thus, in order to work with students who exist within structures of marginalization, teachers must first deconstruct the cultural practices; that is, we must first disrupt the hierarchies that are present with regard to the students. When we discuss deconstruction we must remember it "is not about tearing down but about rebuilding; it is not about pointing out an error but about looking at how a structure has been constructed, what holds it together, and what it produces" (St. Pierre, 2000, p. 482). With deconstruction in mind, and within the context of this study, I am not concerned with how students or mathematics have been defined and constructed. I am not interested in picking apart previous research, practices, or philosophies for their mistakes in overlooking possible lines of inquiry that could have contributed to the construction of a better mathematics educational system. Rather, my interest is in the unknown, the unheard story of teachers and students that participate in the mathematics domain. It is through this lens, then, that I view mathematics and mathematics education.

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[11] Foucault (1972) defines *discourse* as a "group of statements that belong to a single system of formation" (p. 107). Thus, discourse can be thought of as a system of structures and practices through which one's reality is constructed by language.

[12] Deconstruction is a critical practice that aims to "dismantle the metaphysical and rhetorical structures which are at work, not in order to reject or discard them, but to reinscribe them in another way" (Derrida, cited in Spivak, 1997, p. lxxv).

For researchers, postmodernism provides a framework for analysis (through deconstruction), that brings language and discourse to the forefront, and challenges the formal theoretical certainties to which traditional (quantitative, generalizable) research subscribes (Edwards & Usher, 2001). Where traditional forms of research seek to determine *T*ruth, the postmodern researcher understands that through investigation, at best, we will be provided with *a* truth which provides a way of seeing the world differently (Usher & Edwards, 1994). Postmodern frameworks thus open new and different spaces for investigation. Traditional research, being based in modern quantifiable practices, is limited in both scope and technique. By framing studies in a post (new) framework, researchers have alternative viewpoints, methods, and questions to explore. Postmodern analyses are concerned with the historical conditions, assumptions, and power relations that allow certain discourses to exist (St. Pierre, 2000). Research within a postmodern frame, then, provides a framework for examining the existing discourses that ultimately are replaced (in light of discovered truth*s*) by newly developed discourses.

As I began to reflect upon my philosophy, beliefs, and educational practices, I find it necessary to critically analyze these beliefs within a theoretical structure that allows me to not only adhere to those principles that ground my teaching practices but also allows me to grow and advance as an educator. Reflection into my teaching practices allows me to progress as a teacher. By reflecting on my teaching, I further my professional practices so as to incorporate techniques and strategies that allow me to provide opportunities for students to learn mathematics in meaningful contexts;

frameworks in which students will be able to progress and use mathematics in their lives. Postmodernism, on the other hand, gives me an opportunity to reflect upon my beliefs and practices and begin to develop a theoretical framework that is appropriate for exploring the factors surrounding high-achieving women in secondary school mathematics. Adopting a postmodern framework for education research is about adopting an attitude: "Such an attitude is a critical position expressed through [the] commitment to the examination of the dominant constructs and ways of generating knowledge that define [mathematics]" (Valero, 2004, p. 36). As I begin to frame my research, I find that I must adopt such an attitude and question the discourses around those factors that motivated, in part, my decision to become a mathematics teacher. Throughout these reflections, I find myself asking: "Why did I want to teach?" As I investigate my feelings and thoughts about my desire to be an educator, I also question why I decided to teach mathematics specifically. Postmodernism has presented me with a forum to investigate these questions as well the implications of my answers. Thus, postmodernism has given me a *new* language to discuss my goals and beliefs about education, and, in particularly what I believe about mathematics education.

A Theoretical Framework: Feminism

As I am a male researcher, conducting a study in the area of gendered mathematics, I find that feminist philosophy must inform the frameworks for, development of, and analysis of this study. I find it impossible to begin to develop an inquiry into the lives of female mathematics students without becoming versed in the various theories that have been used to describe my participants' social and political

existences. Feminist research, then, may be best understood, for this project, as an interpretive lens through which I will view my research.

Feminism

The term "feminism" has developed over time to encompass both philosophical theory and political action. While feminism in either form seeks social justice for women and the end to sexism, there are many different kinds of feminisms that approach these goals in different ways. Investigations conducted and observations made through a feminist lens provide for a range of perspectives on social and political phenomena. Topics that do not directly relate to gender are also theorized from feminist perspectives as views of any topic might be based in the experiences of one's gendered self.

Different forms of feminism have brought a variety of ideas to philosophy, including claims regarding social and political difference, new approaches for asking (and answering) questions, critiques of traditional philosophies and research methods, and new lines of inquiry. The work of feminist philosophers has impacted traditional philosophies as well by examining the relationships between traditional and feminist philosophies. Topics that concern feminists include issues that arise from investigations into gender, sex, sexuality, and forms of social injustice.

Although the term feminism in the United States has typically referenced the women's suffrage movements in the late 19th and early 20th centuries, ideas regarding women achieving equitable status had long been developing. The effort to obtain equal political freedoms during this period is often seen as the first major form of "Western feminism" (Tuana, 2007). In the latter half of the 20th century, however, the focus of

feminists changed from this quest for political rights to the struggle for greater equality in general. Areas of concentration for feminist theory began to include equality in education and equal pay in the workplace. More recently, movements in feminist thoughts have centered about the critique of previous forms of feminism. Patricia Hill Collins (2005), for example, points out that earlier forms of feminism often ignored the intersecting relationships of oppression based on traits such as gender, race, and sexuality. Generally speaking, the goal of feminism is to end the oppression of women. Many feminists, however, now argue, like Collins, that women are oppressed not just by sexism or as a result of their gender, but at the same time in multiple ways (as a result of their class, race, age, sexuality, to name a few examples). Thus, many feminists also contest that the goal of feminism is to end any oppression that affects women (Haslanger & Tuana, 2004). Furthermore, by criticizing their lack of attention to these other forms of difference, feminists have developed new lines of inquiry that are based on race, ethnicity, class, nationality, religion. These "new" theories assert that personal identity is the central location for identifying and questioning the impact of gender.

Feminist philosophy

"Feminist philosophy is the West's most recent tradition" (Tuana, 2007, p. 21). As compared to the political action of feminist movements, feminist philosophies might be defined as sets or systems of beliefs and theories that through methods of analysis and authorship develop an awareness of inequity and initiate resistance. While feminist philosophy has emerged from a commitment to the pursuit of equal rights for women, it is also attentive to the ways in which gender structures oppress people on multiple bases.

In fact, feminist philosophy has developed as a tradition "that works within and very frequently across all of the mainstream traditions within Western philosophy" (Tuana, 2007, p. 21). Feminist philosophy is an approach in which feminists analyze, develop ideas, and make conclusions about intersecting issues such as gender, power, societal hierarchies, sexuality, race, economic status, and political equality. To achieve these analyses, feminist philosophy, according to Haslanger and Tuana (2004), incorporates two central inquiries. The first challenges how women *should be* viewed and treated based on concepts of social justice. The second questions how women *are actually* viewed and treated as members of their society. As a result of these intellectual pursuits, feminists argue that women are disadvantaged when it comes to political and societal equality.

Feminism, however, does not conform to any encompassing or blanket theory when it comes to issues of equality, the impact of gender, or even methods for exploring issues within feminist ideas. Disagreements among feminists can and do occur as a result of all or any part of the theories that are presented. For example, feminists might differ on their definitions of what it means to be oppressed or disadvantaged. They might also disagree on what it means to have achieved equality. Many disagreements among feminists, however, lie in the ideas surrounding the role of men within feminism, and the application of "outside" philosophies to topics of gender and sexuality. Nonetheless, feminist philosophy, at its core, is based in the belief that the structures of society, in some way(s), disadvantage women. Karen Offen (1992) explains:

> Feminism is necessarily pro-woman. However, it does not follow that it must be anti-man; indeed, in time past, some of the most important

> advocates of women's cause have been men. Feminism makes claims for a rebalancing between women and men of the social, economic, and political power within a given society, on behalf of both sexes in the name of their common humanity, but with respect for their differences. (p. 75)

Feminist traditions

As mentioned above, there is considerable debate as to what constitutes feminism and feminist philosophy. Questions as to what should or should not be considered are among those most debated. Because women experience injustice in numerous forms, their experiences are constituted by a complex system of social structures that cannot be ignored. These complexities, in turn, have given rise to some feminists' further critique of more general forms of feminism. As a result, some theorists have attempted to claim or even define their own particular brand of feminism.

The passages that follow are an attempt to briefly describe a number of these "brands" of feminism. I begin by presenting a summary of the ideas presented within liberal feminism, (feminist) phenomenology, psychoanalytic feminism, Black feminism, theories of performance and gender, and post-colonial theory. As stated before, there are a number of feminist theories. Needless to say, at times, feminist philosophers within each of the following traditions also disagree upon intrinsic details and specific intended outcomes. Thus, a detailed history and analysis of each of the feminist traditions shared here is outside the scope of this project. Furthermore, I have addressed only a limited number of these traditions. This survey of feminist philosophy should not be taken as an encompassing account of current feminisms; rather, it is a highlight of some of the critical feminist theories.

As the final two forms of feminism that I address, postmodern feminism and standpoint theory, are vital to the analytical framework of this study, I provide a much more detailed and in-depth account of each philosophy. Hopefully, by introducing the survey of feminisms prior to those of postmodern feminism and standpoint theory I have provided the means for understanding these two traditions that are so critical to my theoretical framework within the broader philosophical context.

Liberal Feminism. Liberal feminists conceive that their feminist beliefs emerge from pioneer feminist philosophers and activists such as Mary Wollstonecraft and John Stuart Mill (Baehr, 2007). They believe that both women and men have the right to freedoms due to their status as individuals. Liberal feminists also believe that the source of oppression for women is government. Feminism's role for the liberalist is political. In particular, they effort the elimination of laws that limit women's freedoms. A primary belief of liberal feminists is that societies, in general, are patriarchal and thus are the source of oppression.

The focus for liberal feminist philosophy, however, is the individual (Brown, 2003). Thus, female experience is the primary unit of analysis for the liberal feminist. By exploring the women's backgrounds, contexts, and actions within society, liberal feminists believe that they are able to better understand how women are constituted by the structure of patriarchal societies. "Female experience," says Brown (2003), "is more concrete and less abstract than that of the male, but patriarchal culture socializes women to share men's mistaken belief in the individual as self determined" (p. 20). As a result, those who hold that the perspective of the individual is of the utmost importance also

hold that women are active subjects who give meaning to themselves and their world. Thus, the primary concern of the liberal feminist becomes one of agency[13]—can "human individuals be free to create their world" (Brown, 2003, p. 11).

Phenomenology. The view of woman as "embodied" is essential for (feminist) phenomenology. Drawing upon the work of Husserl and Heidegger, phenomenologists such as Simone de Beauvior (1949) and Iris Marion Young (2005) perceive that women's experiences, in society, are integral in their understanding of what it means to be "woman." Furthermore, they question what being a woman as subject looks like, as well as how such a transformation might occur. By recognizing the duality of woman as both subject and object within an oppressive society, phenomenological feminists developed the idea of feminine consciousness. de Beauvior (1949), however, concludes her analysis by stating that for a woman to become autonomous would require that men also accept the change of status of women from objects to subjects. She further argues that if women are to "gain understanding, we must get out of these ruts; we must discard the vague notions of superiority, inferiority, equality which have hitherto corrupted every discussion of the subject and start afresh" (p. 15). To do this, Young (2005) argues that women must be interpreted through the lens of lived experience. Thus, both de Beauvior and Young suggest that feminists look at the concepts of feminine and masculine, female and male, through a phenomenological lens in which we come to understand the

[13] Agency in this sense can be thought of as one's ability to recognize one's cultural contexts and disadvantageous settings so as to act within and upon the sociocultural operators that result in oppression.

individual, within their situation, historically defined and ultimately equal in their autonomy.

Psychoanalytic Feminism. Psychoanalytic feminists borrow ideas from the "science" of psychology to interpret human sexuality and its impact on the female psyche. Feminists such as Irigaray (1985) define their theory within the psyche developed throughout a woman's life based primarily on her perception of biological differences. These biological differences are integral in the ways that masculine society objectifies women. Women are thus the objects of men. Women, as objects, have been "trained" to become passive; even though, as pre-adolescents they had the same desires and the same natural active interests as their male counterparts. Also, women, according to Irigaray (1985), have multiple areas of the body from whence they can experience pleasure. This multiplicity is also different than men, who have only one. She equates this difference with women having multiple selves. Therefore, Irigaray (1985) says, women cannot be seen on interpreted or in singular ways like men. They speak their own language and have their own culture apart from the male dominated culture.

Wittig (1992) also draws upon the mythification of human sexuality to provide a framework for discussing systems of power. By deconstructing the myth of "woman" and the social reality of "women," Wittig argues that female human beings exist in part to argue against the classification "woman/women." The myth of "woman" she further argues, exists only as part of the oppressive society developed by "man." Thus, women should not be seen as a "natural" group. She further argues that the classification of

"woman/women" would disappear if the class of "men" ceased to exist. Thus, for Wittig, the oppressive state of women is based in the language of the structure of society.

Black Feminism. In *Black Feminist Thought*, Collins (1990) outlines what it means for a Black woman in the United States to possess their own version of feminist theory. For her there are six distinct aspects to Black feminist though, the "overarching purpose" of which is to "resist oppression" and empower African American women to fight against social injustice (p. 22). The first characteristic that Collins explains is that Black feminism exists in a dialectical relationship. She defines Black feminism as a social critical theory of social justice that responds to the contradiction that exists between the "promises" of the founders of our nation and the "actual" circumstances in which we live. Carby (1997) furthers this idea by insisting that "political race" has surpassed "biological race" in importance for structures of oppression. Second, Collins says that while all African American women have different backgrounds and circumstances, they all face similar socio-political challenges. As a result, there exist patterns in society from which they, as a group, can develop a collective standpoint. Third, Black feminist thought exists within a dialogical relationship that occurs as a result of one's wish to understand their oppression. As a result, the goal, for Carby (1997), is to reshape society by fighting injustice utilizing the group's solidarity. Fourth, Collins believes that there exists an "intellectual" class within the group that should lead the fight against oppression. These leaders, typically members of the academy, are the ones who understand and can interpret the arguments made within the oppressive state. As a result, their goal should be to lead the entire group towards solutions to issues of injustice. Fifth,

Collins believes that Black feminist thought must continue to evolve. As social situations change rapidly, so must Black women's knowledge of oppressive structures. Theory must be dynamic to keep up with developing structures. Finally, Collins believes Black women must share their ideas with and learn from other oppressed groups. "Black feminism," she states, "requires searching for justice not only for U.S. Black women, but for everyone" (p. 43).

Performance. Judith Butler (1990) has worked to continually develop a theory of gender based on what gender does—its performance. First, Butler argues that any socially constructed identity scheme is regulatory. These schemes are made up of categories such as women, men, homosexual, heterosexual, Black, White, and so forth. She argues that the categorization is normalizing based on structures of power. Furthermore, she believes that these schemes are stumbling blocks to autonomy and as such, it is her duty to "trouble" these categorizations.

In *Gender Trouble* (1990) Butler argues that categories such as "women" are continually restructured by the very structures of power from which they seek emancipation. In her eyes, theories regarding liberation with regard to gender are problematic based on the fact that gender is seen as an irrefutable biological fact. As a solution, Butler "troubles" the concept of gender. Rather than "women" or "female" to define a universal identity for a group possessing the same biological qualities (sex), Butler defines "gender" to be an action. As such, it is a social construction through which human beings of one biological type (sex) are marginalized. She further argues that the concept of gender is science's way of replacing the biological differences into socially

normalizing categories. The danger of this process is that these biological categories have become normalized to the point where they are naturally associated with gender perceptions (stereotypes). For Butler, however, the label of gender signifies a performative act. Gender, according to Butler, is not fixed in the same way sex is. The gender and sexuality of a person is "called into question by the cultural emergence of … gendered beings who appear to be persons but who fail to conform to gendered norms of cultural intelligibility by which persons are defined" (Butler, 1990, p. 23). Thus, gender can be understood to be "in flux." As such, for Butler, the gendered subject (as now perceived) did not exist before the action (of gender) was taken. By conceiving of gender as a social construction, Butler believes that she is more able to deconstruct the discursive practices that are constituted by "normal" people (those people in power) in the pursuit of recognizing structures of oppression.

Post-Colonial Theory. Postcolonial feminists emphasize that women in what is typically termed "first world" countries fail to consider contexts of women who live in third world societies. As a result, feminists tend to focus on the impacts gender has within their own societies. Furthermore, when Western feminists do address issues of oppression of women in third world countries, they take much the same form and use the same methods of analysis as they would use when doing the same in their own (Mohanty, 2004). Upon investigating forms of oppression within different cultures, one can easily see that women's experiences within different cultures vary greatly. For example, one typical "struggle" for women in the United States is equitable pay for the same job performances as men. While struggles for women in third world countries might also be

of the same essence, quite often they are based on atrocities, such as female genital mutilation, foot binding, dowry burnings, and female infanticide, that women in first world countries do not have to be concerned with. As a result, Mohanty (2004) urges feminists to move past analyses done "across classes and cultures" that situate women as a single homogeneous group based solely on biology. Rather, she argues that feminist take up a post-colonial attitude that characterizes women not on their sameness or shared oppression (which is fundamentally that they are women), but on their "material and ideological specificities that constitute a particular group of women as 'powerless' within a particular context" (p. 23).

Theoretical Framework: Postmodern Feminism and Standpoint Theory

As noted above, feminist theory concerns itself with the aims and concerns of women. To say that a study is "feminist" is to acknowledge that gender is the central lens through which the inquiry is conducted and analyzed (Anderson, 2007). As Lather (1991) states, "feminist researchers see gender as a basic organizing principle which profoundly shapes/mediates the concrete conditions of our lives" (p. 71). Feminist theory is a lens through which I can look to focus on my participants as sexed, historically, and culturally situated women. The concentration of this project should, thus, include feminist epistemology, ethics, and social philosophy as these are of particular interest to the field of gendered education.

While there is no single feminist theory, all feminist theories evolve from objection to the same basic principles (Tong, 2006). Feminist theories challenge traditional philosophies in two ways. First, feminist philosophers believe that traditional

(masculine) philosophies fail to regard women's interests, identities, and issues. Feminist theories regard traditional philosophies as patriarchal (Brown, 2003). An historical evaluation of traditional philosophies reveals a lack of recognition of women and their philosophical beliefs. According to Brown (2003), this disservice has great social ramifications, including the devaluation of women's knowledge and social roles. Thus, the second objection is that, by not recognizing women's ways of knowing and being, traditional philosophy places greater value on the male point of view (Belenky, Clinchy, Tarule, & Goldberger, 1997).

As stated earlier, there is no one feminist framework. Harding (1986) classified feminist epistemological theories into three classifications: feminist empiricism, standpoint theory, and postmodernism. Over the past 2 decades, however, the distinctions between these frameworks have been blurred. More recently, Harding (1993) and others see these categories as ways to understand the multiplicity of feminisms and not mutually exclusive classifications. The blurring between standpoint theory and the postmodernism has been difficult for me to traverse. As I have continued to develop my personal theoretical framework, however, I find myself "theoretically migrating" (Hartsock, 1998, p. 237) between aspects of postmodern feminism and feminist standpoint theory.

Postmodern Feminism

The postmodern tenets of feminist theory are important to this study. In particular, the discussions regarding and the understandings of the historically and socially situated self, subjectivity, forms of domination (power), and gender relations were important for the development, procedures, and analysis of this study (Trinder, 2000). Giroux (1991)

acknowledges that postmodernism and feminist theories are internally contradictory. He posits that the interconnections between them offer grounds for being mutually correcting. He also states that while each of the frameworks is individually inadequate, by conjoining the two, the weaknesses of each might be strengthened by the other's strengths. By doing so, Giroux believes that we "provide a political and theoretical discourse which can move beyond a postmodern aesthetic and a feminist separatism in order to develop a project in which a politics of difference can emerge within a shared discourse of democratic public life" (p. 6).

As a male researcher, and as one of the participants' former mathematics teachers, I must consider the impact of power and power relations during the study as well as those relations participants may choose to discuss from previous experiences. As Walshaw (2001) points out, "a Foucauldian[14] analysis is focused on the effects of power rather than on offering explanations" (p. 482). Such analysis focuses on the effects of power rather than on explaining them (Walshaw). Postmodern feminism, in turn, attempts to understand the broader workings of power by examining how it functions as a result of knowledge production (Giroux, 1991). While the postmodern recognizes that power produces knowledge, postmodern feminism takes this acknowledgement further by inquiring as to whether the knowledge produced has positive or oppressive effects. By considering the participant–researcher relationships through tenets of postmodern

[14] Foucault, Michel (1926-1984): A French philosopher and historian of thought who focused on psychology and developed the frameworks of Marxism and existential phenomenology. Along with Derrida and Lyotard, Foucault is thought of as one of the foremost postmodern philosophers. It is important to note that neither Foucault nor Derrida claimed the label of postmodernist or poststructuralist (see Rajchman, 1987).

feminism, I was better prepared to reflect upon and examine the possible biases and powers at play as the study progressed. Furthermore, "individuals are positioned within a variety of 'subject positions'" (Giroux, 1991, p. 43). As a result there are no consistencies as to how people actually make choices, communicate, relate, or promote resistance to oppression. Thus, rather than focusing solely on questions of gender difference, in order to understand the truth*s* about my participants, I needed to examine the discursive[15] practices surrounding them, paying attention to how concepts of power, knowledge, government and practices of the self inscribe them as subjects (Walshaw, 2001).

Postmodern feminists, like most postmodern philosophers, believe that reality is discursively formed (Foucault, 1972). Thus, postmodernists view individuals as being constituted by their social contexts. Identities, such as gender, are socially imposed. Because one has multiple social identities (woman, mother, daughter, student), however, she has opportunities to disrupt the discursive systems that construct her. Women possess "multiple forms of consciousness constructed through available discourses and practices" (Giroux, 1991, p. 43). These identities, however, are at all times open to interrogation through personal analysis. Postmodern feminism provides a framework for such analysis. As Collins (1998) states: "Postmodernism can foster a powerful critique of existing knowledge and the hierarchal power relations they defend. … Postmodernism destabilizes what has been deemed natural, normal, normative, and true" (p. 124). Within feminism, then, postmodernist ideas have been deployed against theories that are

[15] "'Discursive' stresses the ways in which all practice are bound up in systems of knowledge. The playing out of these 'knowledge producing' systems, which infuse everyday activities, shape the experience of being human" (Hardy, 2004, p. 106).

essentializing to women. The claim that gender is socially constructed and that it can be disrupted finds its home in postmodernism (Butler, 1990).

Lather (1991) argues that postmodernism offers feminists ways to work within and challenge dominant discourses. For the postmodern feminist, language is defining, binaries are questioned, and discussions about what is “real” change to discussions about discursive formations and the reflections of authoritarian positions. In these ways, within postmodern feminism, our understanding of how knowledge is acquired and (re-) structured is formed. From this understanding, postmodern feminism provides a means to critique cultural dogma and reductionist societal constructions. Thus, postmodern feminism provides a route from which we can move from deconstruction toward empowerment (Trinder, 2000).

One criticism of postmodern feminism, however, is the belief in this permanent plurality of perspectives. Critics argue that such situatedness forms a philosophical perspective from everywhere and nowhere (Crasnow, 2008). Crasnow characterizes this position as relativist and not epistemic. This characterization implies that postmodern feminists can only see theory as it is related to their gender construction. This view is dangerous as it suggests that women can only see themselves from the primary position of being gendered. Postmodern feminists, such as Haraway (1988), however, argue that people are not epistemically trapped by their cultured, gendered, racial identities. They can choose to think from and actually view their world from multiple perspectives. Women are able to see themselves and each other from a multiple contexts and situations. Women may regard themselves as mother, spouse, professional, athlete, and so on. As a

result, knowledge(s) are formed from within any one or a multiplicity of these views. Thus, given that women have a plurality of perspectives, their formation is constantly evolving, adapting and adding components to their multiple identities, and there is no static relationship between a woman and her perspective.

This emphasis on difference within postmodern feminism gives some theorists pause. As Giroux (1991) shares, they "raise questions as to how differences are to be understood so as to change rather than reproduce prevailing power relations" (p. 40). In general, the postmodern sense of difference diffuses the concerns by utilizing defined terms such as man, woman, and subjectivity (Giroux, 1991). Postmodern feminists take understanding difference to a transformative level by focusing only on "differences that make a difference." In doing so, the center of inquiry changes from difference to the constitution around that difference. In other words, the focus becomes equality and inequality. By re-focusing the direction of inquiry in this way, postmodern feminists have provided a process through which they might reconstruct difference within a transformative set of practices.

A second critique of postmodern feminism is that while it provides an analytic tool to critique oppressive systems of knowledge, it lacks the framework for producing an activist platform. Postmodern feminists do not necessarily claim the role of political activists. Postmodern feminism, however, does offer the possibility for self-representation and social reconstruction (Giroux, 1991). As such, postmodern feminism, in critiquing oppositional binaries categories such as "man" and "woman," produces a "political transformation of the key concepts… which are strategic for [the development

of a social and political activism]" (Wittig, 1999, p. 346). "This means there cannot any longer be women and men, and that as classes and categories of thought or language they have to disappear, politically" (Wittig, 1999, p. 346). Postmodernism thus develops a sort of "universalizing sameness" that allows individuals who share similar oppressive experiences to band together and take an active stance against the oppressive structures that produced such experiences (Alexander & Mohanty, 1997). It is this universalizing sameness that allows for the development of theories that regard knowledge as multiple and situated within one's perspective and the development of one's standpoint.

Feminist Epistemology

Feminist theories regarding epistemology consider the ways in which gender influences conceptions of knowledge, the knower, and inquiry (Alcoff & Potter, 1993). These theories seek to identify ways in which dominant epistemologies disadvantage women. Feminist epistemology is therefore built upon the premise of challenging hierarchical modes of creating and distributing knowledge (Hesse-Biber, Leavy, & Yaiser, 2004). Thus, feminist epistemological positions hold that dominant conceptions of knowledge exclude women from inquiry, deny them epistemic authority, denigrate feminine cognitive methods of acquiring knowledge, produce theories of women that represent them as inferior, and produce theories of social phenomena that render gendered power relations producing knowledge that is not useful for people in subordinate positions and that reinforces social hierarchies (Anderson, 2007).

An epistemological position shapes the entire research process. A feminist epistemology begins with research questions that are rooted in women's lives. By

focusing on women's experience, researchers are able to focus on issues of difference, questioning social power, and resisting scientific reason. The assumption that knowledge that is true for men is also true for women is relinquished. This "truth" is a major belief of "hard," objective, science. Feminist theory, however, emphasizes the knowledge that is produced through interpretations and feelings. There has long existed a bias opposing this "soft" social science. Wider acceptance of ideas such as Foucault's "subjugated knowledges" has added value to perspective epistemological positions (Hesse-Biber, et al., 2004).

Because epistemology is concerned with knowledge, as a philosophical theory it is fundamentally based in considerations of who can be a knower and what can be known (Harding, 1987). The central claim of feminist epistemology is that a knower is situated in her own social and cultural context (Haraway, 1988). The knowledge formed, then, is also situated: knowledge that reflects the particular perspectives of the subject. Feminist philosophers are concerned with how gender situates the knower within the learning process. As knowers are situated within relations to what is known and to other knowers, what is known and how it is known is based on the knower's perspective of her situation. Damarin (1995) states, "knowledge is always situated by the standpoint of the knower; from a feminist standpoint, knowledge begins with women's lives" (p. 247). Here, then, one should also consider the number of ways different subjects can have knowledge of an object. Each particular knowledge constructed about an object is based on one's personal experience with that object. For example, a soldier, participating in a military action, and a person in the southern United States watching a story about the same action on her

television both have knowledge of that action. Their experiences, though, having been very different means that their knowledge (which includes the emotions and attitudes with regard to their experiences) about the action are also very different.

Standpoint Theory

Hartsock (2004) uses Marx's critique of the social classes as a basis for the development of her feminist standpoint theory. Hartsock equates the relationship between the proletariat (dominant) class and the labor (oppressed) class to that which exists between modern patriarchal Western society and women. For her, the division of labor that existed between the proletariat and the labor classes is similar to the division of labor (and difference in product) that can be found between women and modern culture. "Feminist Marxists and material feminists more generally have argued that the position of women is structurally different from that of men" (Hartsock, 2004, p. 36). She further argues that these feminists have yet to give sufficient attention to the epistemological consequences of this claim. By addressing the epistemological considerations surrounding the societal structural differences for women and men she believes women are in an advantageous position, a position "that makes available a particular and privileged vantage point on male supremacy, a vantage point which can ground a powerful critique of the phallocratic institutions and ideology which constitute the capitalist form of patriarchy" (Hartsock, 2004, p. 36). Jaggar (2004) states that women's social class and position gives them "a special epistemological standpoint which makes possible a view of the world that is more reliable and less distorted than that available to… men" (p.56). Furthermore, the distinctive social experiences women have can

generate insights that are incompatible with men's interpretations of reality. The struggles women experience is the basis for a feminine standpoint. This standpoint, then, must be developed through a "collective process" that examines the collective struggles of women (p. 57). Women thus can understand society's perverse dominant schemes from both within and outside of the ruling class (patriarchal culture). For Hartsock (2004) a feminist standpoint focuses "on the institutionalized social practices and on the specific epistemology and ontology manifested by the institutionalized sexual division of labor" (p.40).

The concept of a standpoint structures epistemology in a particular way. It posits a duality of levels of reality, of which the deeper level includes and explains the appearance, and indicates the logic through which the appearance and the deeper reality are deconstructed (Hartsock, 2004). Within such an epistemology, to arrive at an adequate representation of reality, it is important to begin from the proper standpoint (Jaggar, 2004). In class societies the accepted knowledge is that from the perspective of the ruling class. As a result, members of the ruling class are reinforced by their own belief systems. Oppressed groups, on the other hand, are subjugated by the same system. Their oppression, however, is the means through which inequities are revealed. Thus, the standpoint of an oppressed group is epistemologically advantageous: "It provides a view of reality that is more impartial than that of the ruling class" (Jaggar, 2004, p. 57). It is also more comprehensive. Jaggar (2004) argues that the standpoint of the oppressed includes and can explain the standpoint of the ruling class, while the converse is not possible.

Strong Objectivity and Situated knowledge(s). Standpoint theorists expands on the definition of situated knowledge to include the role a person's identity plays as well as the social context of learning. Thus, for the standpoint feminist, social context includes social locations, social identities, social roles and relationships. This perspective is important in *knowing* how society defines gender difference: the different roles, norms, and meanings assigned to men and women on account of their sexual characteristics (Haslanger, 2000). The impact gender roles and norms have on learning is what feminist epistemologists find important to question. Society has traditionally defined roles and traits as either "masculine" or "feminine." It is from within these traditional identifiers that members of society locate themselves to acquire knowledge.

The assumption that knowledge is objective, without being impacted by masculine and feminine traditions, is another belief that feminist epistemologists reject. Standpoint theorists argue that rational and objective knowledge, as traditionally defined, is limited. Harding (1993) redefines *objectivity* as it pertains to feminist epistemology; for her, the idea of traditional (*weak*)[16] objectivity is outdated. Rather, she offers a definition of *strong objectivity*. Strong objectivity is based on the notion that there are certain social situations that tend to generate the *most* objective knowledge claims (Anderson, 2002). In much the same way that standpoint theory emphasizes starting with the experiences of those who have been omitted from consideration in who produces knowledge, strong objectivity relies on acknowledging the impact of a subject's culture and experiences in

[16] Weak objectivity is defined by Harding (1991) as traditional objectivity that is thought of as value-free from the rational, scientific point of view. She considers this objectivity as weak because it fails to account for the role of the subject in the production of knowledge and the context within which knowledge was created.

knowledge production. Beginning with the lived experiences of women (and others) that have been traditionally excluded from privileged positions, truly objective knowledge can be produced. Harding (1991) describes strong objectivity as a sort of maximum objectivity that brings background experiences and beliefs (both personal and cultural) to the forefront. Objectivity claims in the past have traditionally omitted these notions as they have been believed to be irrelevant:

> In an important sense, our cultures have agendas and make assumptions that we as individuals cannot easily detect. Theoretically unmediated experience, that aspect of a group's or an individual's experience in which cultural influences cannot be detected, functions as part of the evidence for scientific claims. Cultural agendas and assumptions are part of the background assumptions and auxiliary hypotheses that philosophers have identified. If the goal is to make available for critical scrutiny *all* the evidence marshaled for or against a scientific hypothesis, then this evidence too requires critical examination within scientific research processes. In other words, we can think of strong objectivity as extending the notion of scientific research to include systematic examination of such powerful background beliefs. It must do so to be competent at maximizing objectivity. (Harding, 1991, p. 149)

As stated earlier, Jaggar (2004) argues that knowledge produced from the standpoint of subordinated groups is more comprehensive and impartial than "traditionally objective" knowledge. Thus, situated knowledge(s) offer a more objective form of knowledge due to the group's motivation to understand the perspectives of those in privileged positions. A social scientist who conducts research by exploring the situatedness of her or his participants also approaches the research process in a pursuit of strong objectivity. Such researchers are interested in producing outcomes that might be used to reveal the relations of power that are disguised in traditional knowledge claims.

Harding's (1991) strong objectivity also perceives the relations between subject and object as important sources of knowledge. As Harding notes, gender difference is an important resource for knowledge as it

> starts research in the lives not just of strangers or outsiders but of 'outsiders within,' from which the relationship between outside and inside, margin and center, can more easily be detected. It starts thought in the perspective from the life of the other, allowing the other to gaze back 'shamelessly' at the self who had reserved for himself the right to gaze 'anonymously' at whomsoever he chooses. It starts thought in the lives of people who are unlikely to permit the denial of the interpretive core of all knowledge claims. (p.150)

Thus, by incorporating experiences, cultural assumptions, and allowing for interpretations into differences in gender, the use of strong objectivity opens up new areas for inquiry that focus on knowledges based on personal experience and contextual understandings.

The goal for Haraway (1988), then, is to develop a useful form of objectivity. For Haraway, objectivity in the traditional sense does not exist. Rather, objectivity is based on position and perspective. Feminists need "a doctrine of embodied objectivity that accommodates paradoxical and critical feminist science projects: feminist objectivity means quite simply *situated knowledge*" (p. 580). By equating objective knowledge with situated knowledges, Haraway indicates that women have unique positions and perspectives through which they understand their experiences. Each of these perspectives, she argues, has the characteristic of being partial: "Only partial perspective," she argues, "promises objective vision"; a vision that is understood only through the social perspective within which knowledge was acquired" (p. 581). Feminist objectivity, specifically, is "about limited location and situated knowledge, not about transcendence

and splitting of subject and object" (p. 582). Such a doctrine of objectivity, then, is about social positions, local perspectives.

Haraway (1988) also discusses the splitting of situated knowledges. She indicates that no one person is situated within a single perspective. Nor can any one person understand each of their knowledges as situated within every perspective. Thus, because no one person is able to understand herself as in all of her classifications at any singular moment, she must "split" her knowledges from within a multiplicity of perspectives. Furthermore, she argues, the holder of knowledge should be thought of as an actor within the context of a situation: "Situated knowledges require that the object of knowledge be pictured as an actor and agent, not a screen or a ground or a resource, never finally as slave to the master that closes off the dialectic in his unique agency and authorship of 'objective' knowledge" (p. 589). The accounts of the real world, then, depend on the social relation this actor has in their "conversations" with their social situations (p. 589).

In order to obtain the most accurate (objective) knowledge(s), then, feminist scholars need to understand what others know, think, and feel (Fricker, 2006). Thus, for the feminist epistemologist, emotion, intuition, attitudes, interest, values, and perception all play important roles in how people know and how they understand what they have learned (Fricker). Attitudes and interests structure the cognition of those who hold them. Therefore, women are conscious of their world differently than men; given that both have acquired knowledge through those structures appointed to them by the social roles that are considered appropriate. The "ideological goal of feminist research," then, "is to correct both the invisibility and distortion of female experience in ways relevant to

ending women's unequal social position [and access to knowledge]" (Lather, 1991, p. 71). Feminist (standpoint) epistemology is therefore concerned with investigating and raising women's consciousness about the conditions of self-understanding and the social settings in which they live (MacKinnon, 1989).

In order to investigate what has impacted successful young women to achieve in the mathematics domain, I find it necessary to question not only how society defines success but also how society defines female (mathematics) learners. I further find it necessary, through the lens of postmodernism, to question what I believe about learning and my own understanding of these terms. In order to successfully inquire about the experiences of young women it is necessary to adopt a framework that incorporates feminist theory. As there are multiple feminist theories to work from within, I have chosen to overlay postmodern and standpoint feminist theories. The purpose of adopting both postmodern and standpoint feminism into my personal framework is to incorporate aspects of each that I feel important for this study. Primarily, postmodern feminism has been included to ensure that I, as the (male) primary researcher, remain aware of aspects of power and subjectivity during the study. Postmodern analysis provides a lens through which to question the effects discourses of power, positionality, and subjectivity have on women in secondary mathematics. It is from this viewpoint that I developed the guiding research questions and developed and analyzed the questions and responses throughout the research process.

While standpoint feminism utilizes many of the same principles as postmodern feminism, I believe that standpoint feminism provides a more personal analytic lens for

my individual participants. Whereas, I am concerned with hearing their stories and analyzing/understanding those stories with regard to how relations of power have played a role, my participants will obviously see themselves differently than I see them. Their understanding of their situation, their development, and their knowledge is based on their individuality—historically and gendered. Furthermore, while the agenda of postmodern feminists is to simply expose modern discourses as fiction (St. Pierre, 2000), standpoint feminists seek to cause an awareness regarding how women's social position is unequal and how this inequity may be remedied (Collins, 2000). This conscious raising is a secondary effect that will hopefully occur as my participants develop into co-researchers,[17] thus, furthering the discussion of successful women in secondary mathematics.

Why a Multiple Framework?

Being a male teacher and researcher, exploring the impact of gender in mathematics, might be troubling to some. Many people may ask how a man can ever truly understand the role being a girl plays in society, much less a field that has maintained its identity as male dominated. At no point have I, or will I, claim to be able to understand the relationship gender plays for women in these areas. I am not a woman and I can never make that claim. As a man and a teacher who looks at the world through a postmodern lens, however, I always have and will continue to question the relations of

[17] Participatory inquiry as defined by Garaway (2004) can be characterized as a reflexive process that allows the participants of a study to become co-researchers as well as subjects within the investigation. In comparison to "simple-participation" studies, the participants are given opportunities for self-reflection where she can see herself as "making action," not just as a studied object (Stinson, 2004).

power that are at play in our society and especially in our schools. Being male (and white) affords me opportunities to question inequities, and be listened to, within the contexts of our current societal frameworks. For this reason, I maintain that it is not only important but necessary that men join the conversation, asking and exploring important *new* questions with regard to gender and education. Furthermore, I believe that men must attempt to share a common understanding with women. As a result, I also believe that men can acquire a basic knowledge of what feminism is. In *Feminist Theory: From Margin to Center*, hooks (1989) suggests that men must play a primary role in ending sexist oppression:

> Men should share equally in the resistance struggle. In particular, men have a tremendous contribution to make to feminist struggle in sexism of their male peers. When men show a willingness to assume equal responsibility in feminist struggle, performing whatever tasks are necessary, women should affirm their revolutionary work by acknowledging them as comrades in struggle. (p. 83)

hooks' argument for men's shared responsibility in feminist endeavors is made possible by men being provided opportunities within a patriarchal society that women are not. The kinds of subject positions that are offered to men differ greatly when it comes to understanding pro-feminist theory and political action. These viewpoints, however, can help to identify the strengths and limitations by analyzing the perspectives of men's forms of feminism (Harding, 2004). Furthermore, contributions to feminist thought made by men can result in distinctive feminist men's standpoints. These standpoints, in turn, can be utilized by men, no less than women, to identify and resist sexist and oppressive biases.

Furthermore, Harding (2004) argues, men "can learn to exercise their critical thinking more rigorously" when it comes to pro-feminist ideas (p. 181). They become aware of the need to understand the ideas surrounding rational (scientific) thought and (traditional) objectivities. They also begin to develop a consideration for women as gendered, not by their biology, but through their histories, oppressions, and ideas.

By incorporating a feminist standpoint position into my framework, my analyses start off from my participants' lives. By doing so, I was able to examine how they fared within a historically patriarchal society.

Also as the study progressed, as I came from a unique (within the context of this study) standpoint, I was able to provide a perspective to the analysis that my participants were unable to provide. Even as much as traditionally defined standpoint theory privileges the views of the oppressed, the political relations maintained by men provide a scientific and epistemic advantage for those who set out to resist male supremacy (Harding, 2004). By taking the stance of resistance to male authority, men develop similar struggles, albeit with each other, from which gaps in experience, similar to (but not the same as) those of women that provide them the advantageous standpoints that allow them to understand both their views and those of those in power. In this way, feminist standpoint theory "offers men opportunities to produce distinctive feminist subject positions of their own that find resources in men's feminist opposition to patriarchal politics and thought" (Harding, 2004, p. 190).

Feminist standpoint theory, from its assertion that we begin with women's experiences, decreases the partiality and distortion of our (possibly) objective views of

social relations. From the researcher's perspective then, social positions with respect to gender, culture, race, class, and sexuality are revealed. Researchers are thus required to reflect upon the implications of their social position for both their motives for undertaking the research and the consequences of conducting the research (Pease, 2000). While some standpoint theorists have argued that standpoint theory articulates a fundamentally different theoretical and political position to that of feminist postmodernism, Pease (2000) argues that "more recent interpretations have located women's experience in concrete, historical, and discursive contexts" (p. 140). As a result, postmodern turns in some forms of standpoint theory have led to the rejection of a single female perspective and led to the acceptance of multiple female perspectives. Pease continues his argument by making a distinction between feminist postmodernism and postmodern feminism (which is from where he believes developments in standpoint theory are derived): "While the tenets of feminist postmodernism are certainly in conflict with the emancipatory aims of standpoint epistemologies, I believe that postmodern feminism can use deconstruction to allow marginalized voices to be heard" (p. 140).

One example of method that Pease (2000) proposes to achieve this deconstruction is participatory research for the purposes of consciousness-raising. Consciousness-raising as a method, he argues, is a method that allows researchers to both conduct a postmodern analysis and adhere to a form of activism. By conducting this type of research, I intend to raise awareness of three groups: the researcher, the participants, and those related to the research community (including those who make policy). This critical use of postmodernism grows out of the commitment to emancipatory discourse, but is still

engaged by postmodernism to try to use it in the interests of emancipation (Lather, 1991). Lather (1991) continues by stating, “It is at the intersection of postmodernism and the politics of emancipation that I put at the center of my attempt to explore what it might mean to generate ways of knowing that can take us beyond ourselves” (p. 2). It is at this intersection of postmodernism and standpoint theory that I find myself residing for the purposes of this study.

By utilizing a combination of postmodernism, postmodern feminism, and standpoint theory, I have not only provided a framework through which I analyzed the information that was provided by the young women who participated in this study, but I also created a mirror in which I could reflect upon my maleness and my privileged status (both as a man and as a teacher) throughout the course of the investigation. From within my male standpoint, I was able to reflect upon my interpretations of the stories that I collected. Furthermore, I was able to bring to the study insights from both a man’s perspective in society, and from that of a mathematics teacher. In this way, the interpretations and the analyses that followed were conducted from within a perspective that provided me guidance and forethought that helped me to continually reflect upon myself and the data so as to ensure the “authenticity” of my participants’ histories.

CHAPTER 3

REVIEW OF PREVIOUS LITERATURE

This chapter begins with a discussion of feminism in mathematics. Feminist theories have impacted mathematics in numerous ways. Utilizing theorists such as Becker (1995) and Jacobs (1997) I consider the impact of feminism on the learning and instruction of mathematics. I also draw from investigations such as those conducted by Leder (1995), Reyes (1984), and Reyes and Stanic (1988), that investigate the impact sociocultural factors have on mathematics education; such factors include sex, race, and socioeconomic status. Furthermore, employing the theories of Burton (1987, 1995), Mura (1995), and Boaler (1996, 2002), I discuss gender imbalance, the development of a pedagogy of fairness, and how each of these have helped lead to ideas for curriculum reform with respect to females' learning of mathematics.

Second, I review a sample of research studies that have previously been conducted with regard to gender in mathematics education. Before the review, an explanation is provided for the analysis of historical research being conducted in chronological order. This chronology, however, produced not only an historical framework of gendered studies in mathematics but also resulted in a naturally occurring thematic organization. Thus, while the review is generally presented in chronological order, it is presented through those themes that in many ways surfaced or "emerged" as a result of the analysis. Themes included in the research consist of theories regarding

gender deficiency, affective attributes, stereotype threat, and the participation of females in post-secondary mathematics. I conclude the review with an analysis of the methodologies that have traditionally been used when studying the relationship between gender and mathematics education.

Feminism in Mathematics

It is deeply ingrained, even within the feminist community, that mathematics is an alienating experience for women (Morrow & Morrow, 1995). Mathematics, for many young women, is simply a subject that must be taken in order to move on to the next level (whether it is the next course, level of school, or career). Many adults, educators included, have helped to perpetuate these perceptions. Traditional research in the field, I believe, has done little to remedy the outlook of women when it comes to the learning of mathematics. Thus, feminist researchers in the field of mathematics education have been charged with (a) exploring ways in which women choose to pursue and continue their pursuit of mathematics, and (b) uncovering ways young women might be successful in their pursuit of learning mathematics.

A discussion of feminist theories' impacts on the learning and instruction of mathematics must begin with how "women" come to "know" (Becker, 1995; Jacobs & Becker, 1997).[18] Numerous studies have been conducted regarding how women learn and whether it is different than the ways men learn (Benbow & Stanley, 1980, 1983; Ai,

[18] Given my poststructural (postmodern) sensibilities, as I use concepts such as "women," "to know" and others throughout this review, I also "trouble" them. That is to say, I put them under erasure. Professor Stinson, building from the work of Derrida and others, suggests that we are not forever "doomed" by language as long as when we use delimiting concepts that we also place them under erasure (D. Stinson, personal communication, May, 2005).

2002; Sohn, 1982). Through an analysis of previous research, Becker (1995) determined that it is (societally) acceptable for women to proclaim their voice differently than men when it comes to moral issues. Her findings, however, also indicate that "it is far more dangerous for women to have a 'different voice' with regard to cognition" (p. 164). Her determination is that women (meaning most women) do learn differently than men, although it is less acceptable with regard to male dominated domains such as mathematics. Becker defines the way (most) women come to know through a series of seven stages.[19] Her breakdown of knowledge acquisition is not meant to be a developmental sequence through which women pass. Rather, the stages are an unordered series that "represent a progression from dependence to autonomy, from uncritical to critical [reasoning]" (p. 165). Becker extends this concept to pedagogy as she encourages a model for teaching mathematics that she terms "connected teaching." Aspects of connected teaching suggest that it is social in nature. Learning for women, Becker states, best takes place when done in a collaborative setting. The focus of the interaction should be in the context of application and experiential in nature. Furthermore, she stresses the importance of sharing and explanation, as well as an atmosphere that welcomes alternative explanations and solutions. In such a classroom setting, the learners become co-teachers and are encouraged to grow, mature, and develop into autonomous and critically minded mathematics students.

[19] The seven stages identified by Becker (1995) are Silence Knowing, Received Knowing, Subjective Knowing, Procedural Knowing, Separate Knowing, Connected Knowing, and Constructed Knowing.

Becker's (1995) work, although it relies on older speculations that affirm the possibility that genetic differences in cognition exist, is important. Her findings indicate that even if one were to admit differences between boys and girls in cognitive abilities, there is a dynamic and social aspect to the ways women learn. These social and contextual factors, then, must be considered when exploring the mathematics education for women.

One such investigation was conducted by Reyes and Stanic (1988) who explored the relationship between race, sex, and socioeconomic status (SES) have with the learning of mathematics. By first analyzing the extensive research regarding issues of race, gender, and SES, Reyes and Stanic developed a framework through which to investigate these relationships. Their model considered social influences, teacher and student attitudes, school curricula, and achievement-related behaviors. While they were able to document the fact that differences exist within the mathematics classroom (especially in the case of gender), they were not able to determine the possible causes of these differences. Thus, Reyes and Stanic believe that further research (even outside of mathematics education) may provide insight into these causal factors.

The effects social factors such as parent, peer, and teacher influence have been discussed at length when it comes to student differences in the classroom (e.g., Hoover-Dempsey & Sandler, 1995; Stevenson & Baker, 1987; Flanders, 1960; Olson, 1981; Hallinan & Williams, 1990). Leder (1995) investigated the effect that the media has on societal factors regarding gender. Leder found that media often included stories regarding women's opportunities. Typically such articles confirmed that women were

disadvantaged: politically, socially, and educationally. Although there are articles published that discussed the advantages women have in some areas, more articles were found that perpetuated the traditional stereotype that women "can't." As these articles were perceived to confirm these stereotypes, they were also found to have an impact on the ways parents and teachers influence female students.

Mura (1995) further addresses the gender imbalance[20] of the mathematics classroom by analyzing the themes in gender research. In an effort to develop a better understanding of the motivations, aims, and effects of various theoretical viewpoints, Mura identifies four perspectives from which research has been conducted. The intervention perspective emphasizes the goal of increasing participation of women in mathematics. In such interventions, changing the attitudes of young women toward the practice of mathematics is the most recognizable outcome. The segregation perspective, such as that promoted by Morrow and Morrow (1995), asserts that boys and girls should be taught separately. Researchers that encourage segregated classrooms believe that boys and girls learn differently and thus, should be taught using different techniques and even a different curriculum. Many segregationists also believe that this separation would solve the problem of inequitable supply of resources (which is perceived to exist in favor of male students) as each group would require its own (differing) sets. The discipline perspective, on the other hand, asserts that mathematics itself is to blame for the gender

[20] Gender imbalance in this sense is not necessarily based in performance. Rather, it is based on the sense that "all feminists would agree that women suffer certain disadvantages in comparison with men" (Mura, 1995, p. 155). Thus, the imbalance(s) of which Mura speaks, I believe, are any perceived or actual type of disadvantage within the mathematics domain, including performance, outcomes, and continued pursuit of mathematically related degrees (or lack thereof).

imbalance (Mura). Those who subscribe to this perspective believe that mathematics is the product of male development. This idea is rejected by numerous mathematicians that believe that there exists a feminism of equality (Mura). Theorists holding to this belief argue that such critiques only further discourage women from pursuing mathematics. Researchers such as Willis (1995) adhere to the discipline perspective; albeit, not for the discipline of mathematics as a whole. Willis (1995) and Burton (1987) believe school mathematics,[21] not the entire discipline, creates the gender imbalance. Burton (1987) argues that it is those features of school mathematics that set it apart from the overarching discipline that can be identified as being responsible for gender imbalances. The feminist perspective places responsibility for gender imbalances on the instruction of mathematics. In particular, proponents of the feminist perspective call for changes in pedagogy that will benefit all students (Becker, 1995; Boaler, 2008; Burton, 1995; Mura, 1995; Willis, 1995). They encourage the fair treatment of every student and believe that same does not equate to fair.

A pedagogy of fairness is thus based on the relationships that can be formed between teachers and their students: "Relationships between students' expectations and predispositions and the demands of new teaching practices are very important to consider" (Boaler, 2002b, p.241). This sort of pedagogy is based on teachers being sensitive to the not only the cognitive but also the emotional needs of students (Mura, 1995). By developing a pedagogy of fairness, those adhering to the feminist perspective, believe that teachers will minimize the hierarchal relations between teacher and student,

[21] School mathematics can be defined as the structures, curriculum, and methods used in the learning of mathematics within the formal school setting.

empower all (and in particularly female) students, and force male students to give up their dominance in the mathematics classroom (Mura, 1995). By making these philosophical perspectives explicit, Mura (1995) hopes that teachers and researchers become able to readily evaluate the advantages and dangers of each approach.

Jo Boaler (2002a) also explores issues of gender equity. As she sees it, research into the issue of girls' underachievement in mathematics in the 1970s and 1980s was presented as being concerned with the "characteristics of girls rather than as coproductions of people, society and environment" (Boaler, 2002a). This tendency to "blame" certain characteristics and attributes of girls for "lesser" performance is a reflection of society (Boaler). Traditional research has had a tendency to define women as having a "gender" that characterizes the entire group. Gender, however, being a response to ones context (Butler, 1993), whether sexual or other, defines individuals, not an entire genetic group. Thus, to argue that all women have some characteristic that makes them less able to perform mathematically (or otherwise cognitively) is a fallacy. Furthermore, such arguments accept that there is an essence to female mathematics students that makes them less capable. Such definitions lack the consideration of how culture and personal history play a part in one's opportunity to achieve. The history of equity research that draws on narrow minded conclusions about people is costly. In particularly, I believe, the perpetuated assumption that girls are mathematically inferior that has been developed from early equity research has been harmful to girls' opportunities in the mathematics classroom. Boaler emphasizes the importance for researchers to refocus the lens of equity research away from methods and questions that are essentializing for women.

Each of those theorists and researchers just reviewed has evolved past interpreting mathematics and mathematics education in traditional ways. Each has challenged mathematics and mathematics education on philosophical, pedagogical, and epistemological grounds. As Burton (1995) emphasizes, traditional curriculum reform has not taken feminist concerns into account. Mathematics has traditionally been seen as the "objective" science. This traditional view, however, ignores important cultural implications for the discipline. Sandra Harding (1986) points out that mathematics, in order to be objective in the traditional sense, relies on one's awareness of the relationships between mathematics research and the current society. In many ways, what I believe Harding is alluding to is that historically, societal needs drive mathematical development while at the same time mathematical discovery allows society to progress. When these social contexts are allowed to "invade" the discipline of school mathematics, we begin to move toward a feminist epistemology for mathematics. Burton proposes five categories that must be considered for a feminist epistemology. These categories include: (a) a personal and socially/cultural related curriculum, (b) the aesthetics of mathematical thinking, (c) acceptance of intuition and insight, (d) acceptance of divergent approaches to problem solving, and (e) global application. Mathematical knowledge, then, should be based on who the knower is, under what contexts the learner is working, and how the knowledge is to be applied (Burton, 1995). By adopting a feminist epistemology, teachers and researchers are enabled to question what is taught, why it is taught, how it is taught, and how it is learned for the benefit of all students. A feminist epistemology "transcends dichotomies, insists on the scientific validity of the subjective, on the need to unite

cognitive and affective domains; it emphasizes holism, harmony, and complexity rather than reductionism, domination and linearity" (H. Rose, as cited in Burton, 1995). Thus, in an effort to inform the research community about equity in mathematics education, feminist researchers have encouraged the development of an epistemological position from which not only female students but also all learners might benefit.

Girls and Mathematics: A Review of Literature

For many years educators and researchers have investigated female students in mathematics (Benbow & Stanley, 1980, 1983; Boaler, 2002a; Burton, 1995; Reyes & Stanic, 1988; Morrow & Morrow, 1995; Tartre & Fennema, 1995; Sherman, 1982; Lesko & Corpus, 2006; Ryckman & Peckham, 1987). Inequities for women in mathematics have compelled researchers to investigate possibilities to explain women's "lesser outcomes." These investigations range from examining the sociocultural to the genetic (Steele, 1997). Traditionally these researchers have looked at female mathematics students as "the underdogs" in the mathematical arena (Gallagher & Kaufman, 2005). Thus, much of the research that has been conducted with regard to gender and mathematics has been done under the assumption that women are put at a disadvantage when it comes to the learning of mathematics.

These beliefs, held by laypersons, education professionals, and researchers, have continued to stigmatize the mathematics domain as a male dominated arena. For this reason, the assumption that a "gap" exists between the academic performance of male and female students has been perpetuated. While in some areas, such as the numbers of majors in mathematics and mathematically related fields continue to be unbalanced,

many recent studies have found that the gap between male and female students' performance in the mathematics classroom has lessened (Cole, 1997). Researchers have found what many teachers have recognized for years: in many cases female students are outperforming male students (Kimball, 1989). In a recent study, Hyde, Lindberg, Linn, Ellis, and Williams (2008) found that girls are scoring as well as boys on standardized tests. Hyde et al. gathered test data from 10 states governed by No Child Left Behind (NCLB) legislation. These states provided the research team with statistical information regarding gender, grade level, and ethnicity. By completing a quantitative analysis of the data, Hyde et al. concluded that "the general population no longer shows a gender difference in math skills" (p.495). They further hypothesize that this finding can be explained as a result of the eradication of the gap between boys and girls taking [higher-level] mathematics courses, partially as a result of NCLB initiatives.

In my experience as a classroom teacher for the past 10 years, I have found that teachers, as well as others, continue to believe that the reasons for this perceived change in performance is based simply on work ethic among the female students who are believed to be inferior, mathematically, to their naturally talented male classmates. This stereotype has been perpetuated by students, teachers, and research (Boaler, 2002a). My experiences as a mathematics teacher and social scientist, however, have indicated that a gender gap does exist within the secondary mathematics classroom. The gender gap to which I refer differs from the traditional gap in achievement that the majority of early research in gender and mathematics refers. This gap is much more indicative of both intrinsic and extrinsic affective factors rather than those from the biological or cognitive

domains. The gap that I, as a classroom teacher and social scientist, have identified is that there is a perception of mathematics and gender that is maintained by young men and women regarding “who can” and “who should” do mathematics. These perceptions might or might not affect grades and test scores. In fact, as more recent data has indicated, the earlier gap between males and females students’ test scores has closed (Cole, 1997; Hyde et al., 2008). There continues to be a trend, however, that young women, even those that are identified as mathematically talented, choose not to pursue mathematically related degrees or careers (Gieger, 2002). Hyde et al.’s study further alludes to this discouraging trend as their results fail to explain the gap that remains in young women pursuing mathematically related careers. Their statistical model predicts that 67% of men and 33% of women should make up the population of a mathematically specific field. Statistics, however, show that the average is only about 15% women (Hyde et al). This evidence indicates that there does continue to be a gap between male and female mathematics students. It is important for researchers to begin to identify and characterize this “new gap” in mathematics education. Thus, I believe, as others (Boaler, 1996, 2002a; Fennema, 1994, 1996; Hyde, et al., 2008) it is important for the focus of research in the field of gendered mathematics change direction.

I believe that mathematics education researchers that have conducted investigations in the past have done so with the noble goal of “liberating” female students from the oppressive atmospheres created in mathematics classrooms. Whether the research dealt with “why boys are better at math than girls” (Benbow & Stanley, 1980, 1983; Sohn, 1982; Gallagher, 1989; Ai, 2002), or “what do girls believe about math”

(Sherman, 1982; Ryckman & Peckham, 1987; Fennema, Petersen, Carpenter & Lubinski, 1990; Tartre & Fennema, 1995; Greene, DeBacker, Ravindran & Krows, 1999), or "how are girls impacted by stereotyping" (Quinn & Spencer, 2001; Keller & Dauenheimer, 2003; Schmader, Johns & Barquissau, 2004; Lesko & Corpus, 2006; Steele & Aronson, 1995), each researcher was investigating ways to better understand the female problem(s) within the mathematics domain, I believe, in order to better the mathematics education for females.

While this goal seems worthwhile, researchers must be reminded that this sort of "liberation" must be acquired through the efforts of the individuals involved; therefore, liberation of any kind cannot simply be given as a gift (Freire, 1970/2005). Researchers interested in investigating the role of gender in mathematics, external from these young women's situations, have the unique responsibility to critically investigate the themes that allow young women to be successful in mathematics classrooms. Thus, I believe that it should be the goal of research in this area to assist young women to become reflective about their roles in the learning of mathematics and furthermore, mathematics itself. Therefore, it is important that these participants be included as co-investigators in order to gain a deeper and reflective understanding of how and why they were successful in the secondary mathematics classroom.

In order for classrooms to begin transforming into safe and fair places for all students to practice mathematics, I believe that researchers should explore how female students understand how they were affected by personal, social, and structural factors of the mathematics domain. As teachers assist young women to become aware of these

factors and how they are defined within this domain, they may begin to reflect on their own beliefs about the social and cultural structures in the mathematics classroom and their opportunities to become mathematics learners within these contexts. Through this reflection, female mathematics students, I believe, will have an opportunity to begin a personal journey that may lead them to a greater understanding of themselves and the sociocultural structures that are in play around them. The process of reflection, as Freire (1970/2005) states is "critical thinking by means of which people discover each other to be 'in a situation'" (p.109). This realization results in a *conscientization*,[22] within the situation (in this case, a research study), where Objects (students and teachers) may become aware of themselves as Subjects (students and teachers) within that situation. By participating in such social reflection, a dialogue between the participants of the reflection is created. This dialogue is an avenue by which a (newly discovered) Subject can pursue their *self*-liberation within the mathematics domain. It is within this belief that this study will be conducted. This research, by allowing young women to reflect upon and tell their personal histories and discuss what they believe allowed them to be successful within what is traditionally thought of as a male dominated domain, is meant to develop a discourse through which young women can continue to investigate and interpret their experiences with regard to their learning of mathematics.

[22] *Conscientization* refers to a type of learning that is focused on perceiving and exposing social and political contradictions; it also includes taking action against oppressive elements in one's life as part of that learning.

A Chronological Review

In an effort to better understand the research that has been reported relating to the investigation of the "gender gap" in mathematics, I have chosen to begin by compiling an historical overview and analysis of previous studies on gender and the learning of mathematics. In order to complete this analysis, I have proceeded chronologically so as to better understand the longitudinal development of this research and the path or paths along which the research has continued to develop. By organizing the research in this way, I have gained insight as to how the study of "gendered mathematics" has changed with regard to theme and method. The process of reading and then chronologically organizing the literature, surprisingly, allowed me to determine overlying themes that exist within the research of gender and mathematics.

As I narrowed the scope of my investigation, I found the research that seemed most relevant to begin with the seminal works of Fennema and Sherman published in 1977. Much of the research completed previous, I consider outdated and unreflective on modern mathematics education. Furthermore, research done in mathematics education previous to those conducted in the 1970s seems to discount the importance of minority and female students in the study of mathematics and how it should be instructed. This consideration may result from the vast sociocultural differences and societal expectations that existed in schools previous to the 1970s. No matter what explanation might be given, though, studies conducted earlier than those included in this historical review require little more than the reference given here, as they primarily considered only white male students' importance in the pursuit of mathematics. Thus, the overview, analysis and

critique presented here will begin with those studies that I deem as “modern” with regard to the inclusion of female students and their importance when investigating how best to teach and learn mathematics.

The following summary, while divided into common themes, is primarily chronological. The chronological analysis assisted me in developing the themes that I present here. For the purpose of understanding the research that was previously conducted, I present a sample of studies that are common in each era and within each theme. For each study, I give a summary of the study including the methods used in acquiring the data and its analysis. At times, I critique the findings or assumptions that were made within the studies. As I progressed through this research, however, I found that many of the studies were common in methodology as well as theme. Thus, I have chosen to critique the overall breadth of the research at the end of the summary, rather than provide a methodological analysis of each study.

Deficiency Theory. The earliest research done with regard to gendered mathematics was conducted in order to determine the extent to which the achievement gap between boys and girls in school mathematics was prevalent. Most of this research was conducted during the 1970s and 1980s and was greatly influenced by the seminal works of Elizabeth Fennema and Penelope Peterson (1985, 1987), and Juha Sherman (1982), as well as investigations conducted by Camilla Benbow and Julian Stanley (1980, 1983). In these studies, researchers found that the perceived gap between boys’ and girls’ achievement was, in fact, “real,” based on quantitative data such as standardized test scores and the numbers of female students taking higher-level mathematics courses. They

report that several characteristics, both genetic and social, lead to different levels of achievement in all levels of mathematics.

Fennema and Sherman (1977) determined that gender differences in achievement were caused by differences in spatial abilities. The long-held belief that the ability to learn mathematics was genetic was greatly influenced by this study and cited in much of the early (modern) literature. As more research was conducted, however, those investigating gendered mathematics began to conclude that affective traits, both intrinsic and extrinsic, greatly impact gender differences in mathematics. As a secondary conclusion to their study, Fennema and Sherman hypothesized that boys and girls were influenced, by their reasoning abilities, to take different types of mathematics courses upon reaching upper grades.

This hypothesis was the basis of Benbow and Stanley's (1980) initial study. During their investigation Benbow and Stanley used the data provided by six separate Studies of Mathematically Precocious Youth (SMPY) that had been conducted between 1972 and 1979. The SMPY administered the SAT to junior high school students that were identified to be in the top 3% in mathematical ability as judged by an unidentified standardized achievement test. Their study looked at the difference between boys and girls scores on both the verbal and mathematics sections of the SAT for each year. Their hypothesis was that mathematically talented boys and girls, having received the same basic mathematics instruction before high school, should score statistically similar on the mathematics portion of the SAT at this age. Their findings, however, indicated that there was a statistically significant difference between the perceived aptitude and reasoning

ability of boys and girls taking the test. The basis for their decision was the difference between mathematics scores for each year collected and the large difference in percentage of boys over girls scoring greater than 600 on the mathematics portion of the SAT coupled with the fact that the verbal scores were very similar.

Benbow and Stanley's (1980) research was lacking. Upon further analysis, I argue that the researchers made many assumptions in order to validate their conclusions. In an effort to "prove" the existence of the perceived ability differences between the "sexes," the authors go on to share (their opinion) that the later SMPY's that found a greater number of mathematically talented females as a result of a larger number of participants being included in the study, rather than as a (possible) result of there actually being more talented girls choosing to "come out of the closet" to participate. Benbow and Stanley continue to express their opinion later by arguing against researchers that concluded that higher scores by boys on the mathematics portion of the SAT found during the high school years may have resulted from a greater opportunity to practice as boys tended to take more and different types of mathematics courses. Benbow and Stanley share their assumption by stating that they find it "more likely that mathematical reasoning ability influences subsequent differential course-taking [in the first place]" (p. 1263).

Benbow and Stanley's (1980) study was flawed in that they discounted other possible attributes that may affect the perceived differences between boys' and girls' mathematical achievement. For example, Benbow and Stanley stated, "it is hard to dissect out the influences of societal expectations and attitudes on mathematical reasoning ability" (p. 1264). In their attempt to discount these other factors, Benbow and

Stanley use inflammatory statements such as “we favor the hypothesis that sex differences in achievement in attitude and aptitude toward mathematics result from superior male mathematical ability” (p. 1264) to strengthen their claims. I argue that such circular logic is a critical flaw in their results and an attempt to undermine the importance of emerging research that attempted to show that differences in mathematics achievement are based on numerous and multiple types of variables. One positive result of this type of study and the criticisms it received, however, is that they opened the door for research in the area of how affective traits influence the success of female mathematics students.

Affective Attribution Theory. Generally, affective attributes can be defined as the subjective attitudes and dispositions held by a person. Educational research has examined two areas of student attributes (Bloom, 1976). Cognitive attributes are those characteristics considered in most of the early educational research. These attributes pertain to students’ “abilities” to acquire knowledge and information, logic, and processing skills. Mathematical facts, figures, and use of formulas represent cognitive attributes.

Affective attributes, on the other hand, refer to those factors pertaining to students’ attitudes, values, and beliefs. These factors were often discounted in earlier educational research, as evidenced in Benbow and Stanley’s (1980) report. Factors such as motivation, patience, persistence, and the effects of expectations (internal, familial, or societal) are representative of affective attributes.

Affective attributes can be thought of as those factors that are caused or influenced by a person’s feelings or emotions. The study of how these attributes impact a

person relies greatly upon understanding the person's response to other factors. A person's response, then, relies greatly on their perception of those factors as well as their aptitude, previous experiences, personality, and ability to handle external and internal stresses. Research in mathematics education with regard to affective attributes includes the study of how attitudes, fear, expectations, confidence, and joy of mathematics (for both the participant and those around them) play a part in their opportunity to effectively learn mathematics. Thus, as the gap between the number of female and male students taking upper-level courses closes, there seems to be a natural progression towards research in the area of affective attributes.

Sherman (1982) investigated the attitudes of high school girls towards mathematics learning and achievement. Sherman's reasons for conducting the investigation resulted from her own recognition that in previous studies conducted with Fennema (e.g., Fennema & Sherman, 1977), they found that "differences in math achievement, when found, were accompanied by less favorable attitudes toward mathematics" (p. 132). Sherman was specifically interested in two questions: (a) Is attitude toward mathematics a causal factor in girls' enrollment in mathematics classes? (b) What changes in attitude occur in girls over the scope of their high school careers?

Sherman's (1982) study was developed as a quantitative analysis of a carefully selected group of high school girls. All of the girls had been previously tested several years earlier as part of Fennema and Sherman's (1977) earlier study. The participants were presented with a battery of tests including vocabulary, IQ, spatial visualization tests, space relations test, mathematics achievement tests, academic progress tests, and an

attitude scale developed by Fennema and Sherman. The goal of the testing was to evaluate the general intelligence and achievement of the participants. The attitude scale was used to analyze the beliefs of the girls with regard to usefulness of mathematics, confidence in learning mathematics, perceived teacher beliefs and motivation.

Sherman's (1982) study resulted in a statistical relationship between four attitudes (usefulness, confidence, teacher belief, and motivation) and the girls continuing in advanced mathematics courses. From this finding, Sherman questions whether the groups were equated sufficiently for her comparisons. Thus, she questioned whether attitude really plays a role as a causal factor or whether attitude results from a pre-existing disparity of mathematics achievement. She points out that even the high–achieving girls believed that mathematics was a domain where females traditionally perform poorly and do not belong.

Upon further analysis, Sherman's (1982) report shows the need for more research into affective traits and the roles they play in mathematical achievement. While Sherman does suggest that the affective attributes that she investigated may have an impact on the success female mathematics students have, it also appears that she hoped that the study would indicate that the differences lay within the realm of her initial study done with Fennema. She referenced that results "appeared to be maturational and attributable to more experience and facility in dealing with female role requirements… consistent with the results [from Fennema & Sherman, 1978]" (p.139). Her ability to look past her initial hypotheses, though, allowed Sherman to begin the discussion of the roles fear and stereotyping play in the academic lives of female students. She also suggested that

teacher beliefs play an important role in female students' success in mathematics, and should be further explored.

Follow-up research conducted by Fennema and Peterson (1985) and by Fennema, Peterson, Carpenter, and Lubinski (1990) seem to confirm that teachers' beliefs about gender and ability have a direct influence on the learning behavior of students. They found that several external factors were considered to have impact on the development of gender differences and in the motivation to learn mathematics as well as the ways in which different genders participated in mathematics learning activities. Factors such as teacher beliefs about gender, instructional decisions, and learning activities each influenced what learners did in classrooms, which in turn influenced their learning. Teachers' attributions of what causes students' success was also found to be of interest. While this research was done with early elementary school students, Fennema et al. (1985, 1990) consider the impact of such extrinsic factors to have a far reaching impact. They concluded that "the attributional style exhibited by these teachers would be more detrimental to girls' achievement behavior than to boys" (Fennema, et al., 1990, p. 66).

Ryckman and Peckham (1987) examined how attributions for success and failure were perceived by each gender. While this study was done across subject areas, the findings were reported both as a whole and as separated subject areas. The report began with a discussion of "learned helplessness." Learned helplessness is a well studied phenomenon that is believed to be an awareness that girls develop with regard to intellectual achievement: "A learned-helpless pattern of attributions is characterized by an ascription of success to unstable factors such as effort and/or luck and failure to stable

factors such as ability or task difficulty" (p. 120). These attributions were found to be related to both content areas and "feedback histories." According to Ryckman and Peckham, feedback history was an external attribution seen by students as objective, directly leading to students' beliefs about their own ability, success and failure. In order to study attributes of success and failure, Ryckman and Peckham focused on the attributes of effort, perceived ability and luck.

Ryckman and Peckham's (1987) study was conducted with 365 students in grades four through twelve. They used the Survey of Achievement Responsibility (SOAR) that is designed to test beliefs about success and failure from three school domains: mathematics/science, language arts, and physical education. For the purposes of their research, Ryckman and Peckham excluded the physical education portion.

In general, a quantitative analysis showed that boys and girls differed in what they attributed to their successes and failures. In mathematics, Ryckman and Peckham (1987) found that girls tended to attribute their success to effort and their failures to ability. They also attributed their success in mathematics to luck much more often than they did in language arts. The study also showed that boys attributed their success to ability while believing that failure in mathematics was caused by lack of effort.

Ryckman and Peckham's (1987) research, then, does seem to confirm previous notions about how girls *feel* about mathematics success. It also gives a vivid indication as to the fact that "learned helplessness" for females in the mathematics domain may be authentic. It does not, however, give us any indication as to how helplessness is learned nor, and more important, how the affective variables that contribute to its development

may be altered. Thus, by confirming the existence of gender differences in attributions Ryckman and Peckham's study indicates several directions for future research including the impact of teacher relationships and internal attributes such as confidence and perception of ability.

In response to Benbow and Stanley's (1980) study 9 years earlier, Gallagher (1989) reenlisted the use of the SMPY as well as three other indicators to test for variables that may predict success on the SAT mathematics section rather than as evidence for gender differences in ability. His participants were members of a residential school for which the students were believed to be of equal abilities as they were given the same battery of academic tests for acceptance.

After analyzing his data, Gallagher (1989) found that boys scored significantly better than girls, replicating the previous studies. Through his analysis of the other indicators Gallagher believed that he found possible answers as to why the gender gap in mathematics has continued. In his analysis, Gallagher determined that spatial visualization appeared to be a factor for boys' better performance. A deeper analysis showed that it was not simply the spatial ability, rather the "quick" version of spatial visualization that seemed to make a difference. Another factor from the Myers-Briggs Type Indicator[23] also suggested that the speed of performance was different between boys

[23] The Myers-Briggs Type Indicator (MBTI) uses the theory of psychological types described by C. G. Jung (1921/1976) to develop and analyze a personality inventory of the individual. The essence of the theory is that much seemingly random variation in the behavior is actually quite orderly and consistent, being due to basic differences in the ways individuals prefer to use their perception and judgment. In developing the MBTI, Isabel Briggs Myers, and her mother, Katharine Briggs, wanted to make the insights of type theory accessible to individuals and groups (Myers & Briggs Foundation, 2008).

and girls. This difference indicated that males, who were assumed to have a tendency to favor logic and analysis, were able to find more efficient ways of solving problems. Gallagher reported no evidence to support this assumption, or to support his assumption that boys have more practice at applying these problem-solving techniques (or their speed of use).

In 1995, Tartre and Fennema published the findings of a longitudinal study in which they examined the relationship between specified cognitive and affective attributes of 60 randomly chosen students as they progressed from sixth through twelfth grade. Their purpose was to investigate two questions: (a) Are there consistent patterns of gender differences for any cognitive or affective variables? (b) Is there a pattern for any variables that allow us to predict mathematics achievement for either gender?

To accomplish their goal, Tartre and Fennema (1995) conducted the study in two batteries of tests. First, they administered a series of cognitive assessments for mathematics achievement, spatial visualization, spatial orientation, and verbal skill. Second, they used the same Fennema-Sherman Mathematics Attitude Scales that was used by Sherman in 1982. Upon analyzing their data for gender differences Tartre and Fennema found that the there was no statistically significant difference in cognitive attributes between boys and girls. They also found that the only affective attribute to be statistically significant was the belief that mathematics is a male domain. This belief was determined by Tartre and Fennema to be held at a greater degree by the males than the females, thus indicating that females (over a decade since the previous study) may have begun to believe they could succeed in mathematics to a greater degree than did their

predecessors from Fennema and Sherman's (1977) previous study. As far as finding any consistent patterns within the data that may be used as predictors, Tartre and Fennema found only previous mathematical achievement to be a good predictor for future mathematical success for both genders. Surprisingly, they also found that when spatial visualization was removed as a variable for males the variables effect on the regression analyses was minimal. Thus, Tartre and Fennema concluded that Fennema and Sherman's previous hypothesis, that spatial skills are the main cognitive trait that allows boys to better achieve in mathematics, might need to be reevaluated.

Tartre and Fennema's (1995) study, although small, has greatly impacted the study of gender and mathematics achievement. Fennema, being one of the most recognizable researchers in the area of gendered mathematics, along with her co-researchers have been well-cited as believing that there are several factors leading to gender differences in mathematics. Having previously been quoted by many researchers for the fact that spatial visualization is the key domain that separates boys' achievement from girls', this finding, by the same researcher(s), leaves open the possibility that other factors greatly impact female students' success. Thus, the door has been opened to new areas for future research into the impact of affective traits, both internal and external.

In 1999, a study relating gender and motivation as it relates to students in high school mathematics was conducted by a team led by Barbara A. Greene. The study included 366 student volunteers from a large, middle-class high school. Roughly 60% of the participants were female. The goal of the study was to examine the issue of choice in terms of differences in the prediction of effort and performance for students that took

required courses and those that took elective mathematics courses. The quantitative study used a 92 item survey to measure five sets of variables dealing with goals, values, beliefs, effort, and a short set of mathematics questions to test ability. Greene, DeBacker, Ravindran and Krows (1999) concluded that the importance of goals, values, and beliefs that students bring with them to the learning experience impact the prediction of both achievement and effort. They found the impact of future goals especially important to the selection of coursework. They also concluded that all of the variables examined were influential on both male and female students. The belief variable was found to be much more important to female than to male students. To Greene, et al., this indicated that females were more vulnerable than boys to unsuccessful challenges in mathematics classes. It is interesting to note, after concluding that there was a negative influence when mathematics was presented as a male domain, Greene, et al. infer that the idea has been renewed by feminist critiques of traditional mathematics teaching. For example, Fennema's (1994) critique of traditional teaching methods and society's belief that mathematics competence is one of the most important schooling factors (Noddings,1998) are both alluded to as ways to "dress the old stereotype up for a post-modern audience" (p. 456). Greene et al. indicated that by taking up such arguments, feminist researchers are not only recalling the threat of such stereotyping, but reinforcing it. Their solution was that mathematics as a male domain "should be discouraged since these beliefs discourage the motivation to learn mathematics in both males and females" (p. 456).

While Greene et al.'s (1999) study does address several affective domains (including beliefs, goals, and values), it lacks the depth needed to thoroughly try to

understand the affective attributes that allow female students to be successful. This study began like most of the other studies presented: with a belief that there is some sort of deficit on behalf of the female mathematics population that contributes to the mathematics achievement gender gap. By assuming this position, Green et al., themselves, continue to reinforce the argument that girls achieve mathematics differently and at a lesser rate than boys, thus allowing the argument that "math is a male domain" to continue with strength.

Steele and Aronson (1995) further referred to the affects culture and social identity play on marginalized groups within the schooling domain. Their work, while focusing primarily on African American students, can be generalized to include other social groups such as women. Steele (1997) identifies social structure, culture and academic identity as major affective variables that impact student achievement. The threats that students perceive based on these characteristics, especially for students that are previously defined members of social groups, was their intended focus. Steele and Aronson (1995, 1997) defined the cumulative sum of these threats as *stereotype threat*.

Stereotype Threat Theory. Much of the recent research has focused on the effects of stereotype with regard to women's mathematical success. Stereotype threat is defined by Steele (1997) as "a situational threat that can affect the members of any group about whom a negative stereotype exists" (p. 614). Such threats affect students' academic abilities (Steele, 1997). The emotional results of stereotyping in any situation can be harmful. Educationally, as the threat is experienced in the midst of a specific domain (in this case, women in the mathematics classroom), it particularly interferes with

performance indicators and assessments such as participation, presentation, and test taking (Steele, 1997). While these studies continue to accept that a gap between males' and females' achievement in mathematics exists, they do provide a new perspective into the investigation.

A study published by Quinn and Spencer (2001) investigated how stereotype threat interferes with females' abilities to formulate problem-solving strategies. Quinn and Spencer ran two separate studies as part of the investigation. The first was designed to compare men and women working on practical application problems (commonly referred to as "word"). They found that women were, in general, less able to apply previously learned skills and concepts to solve more contextual problems. Further evaluation showed that these women were able to solve the numerical equivalents to those same problems. In doing so, they showed that the women, who did not score as well as the men on the contextual problems, possessed the appropriate skill set to be able to adequately solve upper-level mathematics problems. Quinn and Spencer, then, hypothesized that "on the word problems, stereotype threat interfered with women's ability to strategize successfully to solve the word problems" (p. 67).

In order to test the hypothesis developed from Quinn and Spencer's (2001) first study, a second investigation was conducted to compare the ability of men and women to work in settings that were both highly stereotyped situations and those that were not. The data from the second study showed that females were much less likely to formulate

appropriate problem-solving strategies in highly threatening stereotyped settings.[24] Quinn and Spencer used these results to conclude why female students may perform better in the classroom setting when material was presented in traditional or familiar ways while not being able to do so in other settings. They suggested that when female students encountered problems that required the use of higher-order mathematical skills, those students became uncomfortable and cautious as a result of a perceived stereotype threat. Thus, in time, they "come to distance themselves from situations and domains where they feel continually devalued" (p. 68).

Another study designed by Keller and Dauenheimer (2003) examined the effect of stereotype threat on students during mathematics tests in a secondary school. The study was performed with 74 students (35 girls and 39 boys) who were presented the same test, but given different introductions to the assessment. The first half of the students were presented the test (and following questionnaire) as being unbiased with regard to gender. The other half were told beforehand that the test questions had, at an earlier time, been determined to give an advantage to boys. The researchers examined grades, mathematics problems (attempted and correctly answered), anxiety, and emotions. Not surprisingly, their findings showed that females that believed that the test was designed to be fair did statistically better than those that were led to believe the opposite.

Lesko and Corpus (2006) performed a study similar to that conducted by Keller and Dauenheimer (2003). Their study consisted of 121 undergraduate students from a

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[24] A stereotyped setting might include any environment, physical surrounding, or other series of characteristics that might identify and impact a person as "othered": different based on attributes such as race, nationality, gender, sexuality, or religious orientation.

selective liberal arts college taking a (challenging) mathematics test. Again, small groups of students (both male and female) were given the same test under the same conditions except for the stereotype threat condition that was presented to random groups in the form of a statement regarding gender differences in mathematics. The study could not be conducted among mathematically similar sets of students. Therefore, the test scores were corrected for comparison using students SAT mathematics scores as the basis for correction. Comparisons were done between male and female scores within each condition. Again, the evidence supported the claim that female students score lower, compared to their male counterparts, when presented with stereotype threatening conditions. Lesko and Corpus' study also revealed that women identified as high-mathematics achievers tend to give less validity to assessments when presented to them within a setting that contains a stereotype threat. Lesko and Corpus reason that it is through this "discontinuing" that high-mathematics identified females allow themselves to remain within their domains.

Finally, an article published in 2004 by Schmader, Johns and Barquissau was among the first in a series of investigations that I identified as being conducted solely with female participants. The first of their two studies surveyed 86 female undergraduate students who were majoring in mathematically related fields. The survey was conducted in order to assess the women's self-perceptions, likelihood to continue graduate study in the field, and how they felt stereotype threat affects test performance. The analysis of the survey data revealed that women who tended to believe that the status differences between men and women were fair and legitimate tended to endorse the stereotype that

women are less able mathematically than men (p. 840). The survey also showed that women that endorse, or believe in, the stereotype also have less confidence in their own mathematical ability. Endorsement of stereotype was also found to be an indicator of likelihood to not continue further in their major area of study. All of the analyses were done while controlling for current success within the major field so as to rule out academic performance as an alternative explanation.

Schmader et al.'s (2004) second study was similar to the study done by Keller and Dauenheimer (2003). The study was performed by presenting small groups of women (and one man so as to not give an indication to the study being about women) a mathematics test for which they were told (a) it was a study that would compare their mathematics scores to each other or (b) the study was of interest because the researcher wanted to compare the scores of male students to those of female students to test for a difference in performance. The results of this study did indicate a marginal effect of stereotype threat on test performance. When coupled with personal beliefs regarding stereotyping, however, the results were found to have greater effect. That is, women who indicated that they held a belief in the stereotype that mathematics is a field in which women are less able, performed worse on the test than those who indicated otherwise.

Schmader et al. (2004) indicated that they were unable to draw any firm conclusions regarding causality. Their results did indicate some interesting directions for future research. While each of their two series of investigations indicated that there is a relationship that exists between stereotype endorsement and women's self-perceptions, they called for further research to help clarify those relationships. Noting an interesting

outcome of the second study, Schmader et al. also indicated that the relationship between women who do endorse the stereotype and their test performance should be further studied. These women seemed to more strongly resist the stereotype as this factor seemed to indicate higher test scores.

It is important to note, however, that this research was done to extend the understanding of stereotype endorsement and how beliefs held by female mathematics students regarding stereotype affect their achievement within mathematical domains. Thus, unlike the previous investigations on stereotyping, these studies examine the actual participants' affective beliefs about stereotype rather than those held by others.

Female Participation. Research like that conducted by Schmader, Johns and Barquissau (2004) furthered the exploration of the gender gap in mathematics. As researchers analyzed these studies, questions began to emerge as to why women, even when successful within the mathematics domain, choose not to pursue mathematically related degrees and careers.

One such study that examined the role gender plays in degree and career choice was conducted by Judith L. Gieger in 2002. Gieger's qualitative study sought to answer the question "What are the factors that influence mathematically talented college women's choice of major" (p. 8)? As she progressed through interviews and online focus groups, she began to have a greater understanding of the impact (or lack thereof) that familial support, relationships with instructors, and personal interest have on women's choices to stay or not stay in mathematics. Gieger's work, however, was done with post-secondary students and focused primarily on the experiences her participants felt

impacted their college mathematics choices. Thus, her conclusions, being focused on college-aged women, coupled with the fact that the purpose of her study was to determine ways that universities might attract mathematically talented women to pursue mathematics, is limited in scope so that it might not be directly related to my own study.

Gieger's (2002) results seem to be muddled when related to the previous research done in the area of female participation in mathematics. As she states, "the findings of this study both supported and refuted findings from previous research" (p. 150). For example, when Gieger speaks of the social value of these women's academic choices, she states that the major finding of Eccles[25] (as cited in Gieger, 2002) was supported as "value" had a greater influence than "expectancy" (p. 152). She further states the specific type of value described by Eccles, such as spending time with family, was not the sort of social value that her participants cited. Through the confusion, though, Gieger does conclude that a major problem with research in the area of degree/career choice has been, as with her own study, the fact that researchers have not been specific or consistent across the research in their definition of what they consider a loss of talented women in mathematics (p. 155). Without clearly defining mathematics, science, or mathematically related fields consistently, patterns cannot be determined with regard to research in this area.

Gieger's (2002) work should play an important role in the study of gendered mathematics. But research in this area has clearly skipped a seemingly untouched area of

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[25] Eccles, J. (1989). Bringing young women to math and science. In M. Crawford & M. Gentry (Eds.), *Gender and thought: Psychological perspectives* (pp. 36–58). NewYork: Springer-Verlag.

gender research in mathematics. As one begins to analyze the body of knowledge that has been created within the field of mathematics education for female students, one should quickly realize that there is one prevalent fault in the at-large body of research.

Critique of Methodology

A chief deficiency of the body of research, as a whole, is that it consists overwhelmingly of quantitative studies. Such studies, typically based within a positivist paradigm, are oriented toward establishing facts and predication (Firestone, 1987; deMarrais & Lapan, 2004; Bogdan & Biklen, 2007). Furthermore, the narrow focus on methods in traditional research and the continued socialization of the view that good science is defined as quantitative science leaves researchers lacking the preparation needed in order to obtain a critical understanding of even their own research (Paul & Marfo, 2001). This means, then, that the type of information that has been examined is limited to quantifiable or statistical data that can be objectively measured and generalized (Firestone, 1987; Bogdan & Biklen, 2007, Creswell, 2009). Quantitative studies also de-emphasize the importance of the individual while stressing whole groups of participants as satisfactory sources for recognizing unbiased social fact (Firestone, 1987). As a result, in the aforementioned studies, there is little hope that researchers have been able to accurately gain a critical or even adequate understanding of what affective variables have impacted female mathematics students. Strict quantitative methods that allow young women to share what they feel, believe, or think about their own learning do not exist. In order to acquire rich descriptive data, personal and meaningful, delivered in participants' own words, researchers should employ qualitative methods (Bogdan & Biklen, 2007). If

participants are not asked to discuss their stories past the point of quantification, the impact of often studied affective attributes may not be able to be determined. While such information has been successfully quantified through the use of questionnaires and Likert-Scale[26] surveys, the internalizations of how participants actualize their own experiences is essential to developing a critical understanding about the habits, thoughts, and feelings that influenced participants' histories.

While I do not dismiss the importance of quantitative methods for testing theory, determining certain relationships between variables, or even promoting theories that might be used for prediction, researchers might find that qualitative methods are more useful for studying the interactions with and among their participants in an attempt to make meaning from and describe their participants' experiences. Lather (2004) advises us that "there are many ways to do science" (p. 207). Such statements have led to a greater acceptance of qualitative research as legitimate research (Paul & Marfo, 2001). As more researchers have recognized the significance of issues such as the researcher–participant relationship, accurate representation of participants, and the moral force of participant voice, they have also come to recognize the importance of qualitative methods that can provide an opportunity to acquire the descriptive data that leads to a critical understanding of the participants' experiences.

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[26] A Likert-Scale style survey is made up of items whose typical responses are of the form: (1) Strongly disagree, (2) Disagree, (3) Neither agree nor disagree, (4) Agree, (5) Strongly agree. The Likert-Scale is the sum of the numbered responses to a series of these items (http://www.socialresearchmethods.net/kb/scallik.php).

Qualitative research methods, then, might be more appropriate in analyzing affective traits of participants. These methods allow researchers to observe, ask about, and discuss those variables their participants identify as being important. Qualitative methods also allow for in depth clarification about the meaning those variables have to each participant, whereas quantitative instruments rarely provide the opportunity for such understanding (Creswell, 2009). The majority of studies presented in the reviewed literature collected data using traditional quantitative "hands-off" survey instruments. Thus, while their information might have been easily quantified and analyzed, it rarely provided researchers with an adequate picture of what their participants actually experienced. Within the historical research regarding gender in the mathematics domain, then, the lack of studies that employed qualitative methods resulted in a lack of understanding about young women's experiences in mathematics. Without in-depth discussion, questioning and listening, researchers cannot, I argue, pursue meaningful understandings of how different factors impact the mathematics and school experiences of young women.

Also, the studies reviewed (with the exception of Schmader, et al., 2004 and Gieger, 2002) were conducted by performing a comparative analysis of female students to male students. With the exception of Gieger's work, none of the studies examined the traits of high-achieving female mathematics students. The previous research seems to be lacking in this regard. Rather than investigating what factors result in girls' lack of achievement (when compared to other groups), I argue that we, as mathematics

researchers, should focus on identifying and fostering the traits that high-achieving young women believe allow(ed) them to be successful within the mathematics domain.

Further discussion requires us to ask how the pursuit of higher-level mathematics courses has been affected by the requirements of higher institutions for admissions. Much of the previous research was done at a time when secondary schools required a limited number of mathematics courses for graduation. Thus, many of the studies investigate, or at least mention, how mathematics success affects the choice to take advanced mathematics courses (electives). Many colleges and universities now recommend (or even require) that students take four years of secondary mathematics in order to gain admission as an undergraduate.[27] Most require students to have taken at least one course past what is traditionally considered algebra two. As a result, in order to be admitted to college, girls are required to take more advanced mathematics courses. Enrollment in these courses, then, no longer requires girls to want to take advanced mathematics. Thus, we, as mathematics researchers, must reconsider the methods through which we investigate the role motivation plays in girls' achievement in mathematics.

Finally, research regarding gender differences in mathematics achievement seems to have developed as a result of a search for equity (Boaler, 2002a). This research began

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[27] This information can be found on the admissions page for most universities and colleges. A sample that includes admission requirements for mathematics at 10 universities may be found at http://collegeapps.about.com/od/theartofgettingaccepted/a/HighSchoolMath.htm. Furthermore, there are states where the governing body of the state's university system has developed admissions rules for the entire system that includes such requirements. The State of Georgia is an example of one of these state systems; their undergraduate admission requirements can be found at http://www.usg.edu/academic_affairs_handbook/section3/301-310/301-310.phtml#n3.01

by trying to determine the reasons girls were deficient mathematically as compared to boys. As research evolved the search for equity continued to develop. This history of equity research, having drawn and published conclusions about females has not always caused a move towards equity (Boaler, 2002a). It is important to realize as this research has been done, equity research itself has continued to foster a sense that girls are inferior mathematically. As a result, researchers must again amend their conceptions as to how we should examine equity for girls in the mathematics domain. As research conducted using traditional quantitative methods seems to have perpetuated the inferiority of female mathematics students, researchers should consider the use of qualitative methods as a way to begin to understand the experiences of young women in mathematics.

Justification for the Study

The importance of this study becomes apparent when considering the lack of focus on female students' successes in secondary education within the body of previous research. While the ideas for such a study resulted from a combination of my personal experiences, both with my sister and with my students, the analysis of the previous research shared here with regard to gender and mathematics (by its omission in the historical record) calls attention to the need for studies that focus on young women's achievement in the field of mathematics.

CHAPTER 4

METHODOLOGY

This chapter begins with a description of how the design for this study was established. By reflecting upon the aspects of three studies that had previously been conducted, I was able to develop an appropriate methodology for researching successful female mathematics students. Within this description, I detail two earlier studies that investigate gender's relation to mathematics. I also share how the design of a study on/with mathematically successful African American male students influenced the design for my own.

I then discuss the methodology through which this design was incorporated. First, a justification is provided for the use of qualitative methods. Second, a brief history of phenomenology as a philosophy is shared. Within this section the influence of Kant and Husserl are chronicled. The utilizations of essence and bracketing in phenomenology are also defined. Following these descriptions, an extensive account of my use of phenomenology as a methodology is provided. Throughout this discussion, I rely on the explanations of van Manen to describe the breakdown of phenomenological methodology, as I also trouble phenomenology from my combined postmodern and feminist (standpoint) theoretical frameworks.

Finally, I describe the qualitative methods employed for the implementation of the study. The use of questionnaires, autobiographies, and interviews are discussed. I end

with a description of my use of the final series of interviews as a method to re-analyze the accounts provided by my participants for accuracy in interpretation and reporting.

The Study

As previously discussed, much of the research done in regard to studying the gender gap in mathematics has been conducted with the mindset that female students must be compared in some way to their male counterparts. My research differs from the aforementioned studies in that I solely examined the affective variables that successful adolescent female mathematics students believed impacted their achievement. Rather than studying the differences between boys and girls in similar classes, I investigated the traits that these young women, looking back on their mathematics schooling, attributed to their high level of achievement. The previous research, with the exception of a minority of studies like that conducted by Gieger (2002), lack, I believe, the methods that are necessary to obtain the an understanding and knowledge concerning the experiences had by young women in the mathematics classroom. I believe how these women interpret and assimilate such experiences is crucial to their success. Much of the previous research neglects to address women's success in the mathematics classroom. Studies regarding women's outlooks or perceptions about their experiences while learning mathematics are even rarer. Furthermore, when researchers did choose to focus (in part) on success or the perceptions young women had about their mathematics learning, their conclusions relied greatly on generalizations about the experiences of large numbers of women.

This over generalization, I believe, is a major flaw in not only the data collected, but also the methods used to collect that data. Most important, then, when analyzing the

previous work reported by researchers in this area, we must understand that there is a lack of depth in the data collected as a result of the exclusion of those important personal narratives from which we are able to retrieve valuable information regarding the affective variables and experiences that young women believe impacted their success most.

As stated earlier, the studies reported in the literature review were most often limited by the type of data collected as a result of the methodology of the studies. While I understand that much of the previous research was conducted during a period when qualitative research may have been "frowned upon" (Piantanida & Garman, 1999, p. 165), the lack of close, personal involvement with individual participants is detrimental to these studies simply collecting easily "generalizable" data. These sets of data, and their analyses, do give indications as to what might be happening with regard to gender and the learning of mathematics. This information, like most quantitative data, is limited to operational and generalizable statistics (Bogdan & Biklen, 2007). Thus, when probing topics such as gender and mathematics education, it may be necessary to use methods that allow researchers to explore the personal histories of those who have lived in the relationship (Creswell, 2009).

While my study differed in both scope and direction from the following studies, I used three previous qualitative doctoral dissertations to aid in the design of my study. Stinson's (2004) study regarding African American male students and achievement in school mathematics provided a general framework for an appropriate methodology for studying the same domain with female mathematics students. Anderson's (2002) and Gieger's (2002) studies provided an opportunity to analyze qualitative studies that were

concerned with similar populations. Anderson's study was conducted with the intent to "learn from the voices of adolescent girls in a feminist mathematics classroom" (p. 172). Although the background of my research was a traditional secondary mathematics classroom, like Anderson, I was able to rely on my participants' perceptions, thoughts, and feelings to acquire data. Gieger's research, while done with college women in a university setting, also chose to use methods that allowed her participants to "speak" to and through her. By using focus groups, interviews, online discussions and email, Gieger gathered large amounts of data that allowed her to continually immerse herself in the thoughts, feelings, and opinions of her subjects. By analyzing each of these investigations, I was able to design a study that probed my participants for information relevant to my study while allowing them to participate by including information from their personal histories.

By using these studies to help in the development of my own, I was better able to take previous information, research, findings, and methodologies and adapt them to develop and implement a study that contributes to the existing body of research and that will inform mathematics teachers and researchers as to how adolescent girls might achieve in the mathematics domain.

Methodology

Qualitative research designs should be chosen when theories are not readily available that explain behaviors resulting from or responses to experiences had by the participants in the population of a study (Creswell, 1998). Furthermore, phenomenological methodologies are motivated by the desire to further understand the

impacts these experiences have had on these individuals. Processes within a phenomenological research design, then, require all participants (including the researcher) to be reflective both on their previous experiences so as to realize the impacts these experiences had on their lives, and the understandings that are developed through the process of investigating the phenomena in question (van Manen, 2002). Phenomenological approaches to research thus require those involved in the study to ask unspecific and open substantive theoretical questions as the study is developed (Bogdan & Biklen, 2007). In doing so, researchers are encouraged to follow a path, driven by the participants' stories, that emphasizes the subjective "reality" of the participants (Bogdan & Biklen).

As I continue to analyze my interest in the perceived gender gap in mathematics, and how young women have been able to be successful in the mathematics classroom, I knew that it was important for me to explore the background of these topics, including the types of experiences, settings, and attitudes successful young women have in regard to school, success, and specifically mathematics. To not presume that I know what it takes for these young women to successfully negotiate the domain of mathematics and education, I came to understand that I would be required to develop an exploratory study that would allow me to navigate the role of a researcher deeply investigating a phenomenon for the first time. For this reason, I chose to pursue this investigation, methodologically, through a phenomenological lens.

Phenomenology as philosophy

Modern phenomenology, like many philosophical schools of thought, is comprised of many overlapping doctrines. The study of phenomena was used by Immanuel Kant in the 18th century to denote the description of consciousness and experience (Smith, 2008). For Kant (1781/2004), a phenomenon was something revealed through experience; objects or events that are only understood as our experience allows. Kant insists these objects are shaped by our cognitive abilities. As a result, our experiences allow us to not only realize phenomena, but see how they are related (Kant).

Phenomenology, as attributed to Edmund Husserl, concerns itself with the study (description) of what is experienced (Smith, 2008). It involves a reflective analysis, called *bracketing*, of the acts of consciousness and a description of the phenomena (van Manen, 2002). For both Kant and Husserl a phenomenon was something that was realized through personal experience. Thus, phenomenology is a process of acquiring and interpreting the descriptions of experience from a primary source. In short, data acquired through phenomenological methods can only be subjective in nature (Kockelmans, 2006).

In the twentieth-century phenomenology continued to gain followers that adhered to certain principles while adding or amending others, thus developing secondary phenomenological traditions (Kockelmans, 2006). As a result, many philosophers believe there is no longer a strict "phenomenology." Rather, phenomenology has become an encompassing school of thought that is based on understanding experience (van Manen, 2002). To understand the lived experiences of others, then, one must first be conscious of how one's own consciousness allows her to understand the contexts and

interconnectedness of her own experiences. For this reason, phenomenology can be referred to as the study of consciousness (Blackburn, 2005).

Consciousness itself is the context of all explanations. Thus, it cannot strictly speaking be explained, only described and interpreted (Warmoth, 2006). Husserl's primary vision of phenomenology consisted of a process through which consciousness was broken down in order to obtain a description of one's experience. This process is often referred to as "bracketing" (Husserl used the word *epoche*) (Beyer, 2007). Bracketing requires that researchers suspend their preconceptions in favor of developing an awareness of how they cognitively understand experiences (Smith, 2008).

Warmoth (2006) defines three domains of phenomenological study. First, the *subjective* domain is that in which one develops a description of one's self. Second, the *intersubjective* domain is the study of the foundation of social consciousness. In this domain, researchers develop descriptions of how humans communicate, develop, and share knowledge. Finally, the third domain is the *objective*. This is the domain for which phenomenological methods have been primarily developed. Within this domain, researchers strive to develop rich description and understanding of the human intellectual consciousness of others. From the viewpoint of social science research, the objective is the most important (Warmoth, 2006).

While different fields (e.g., sociology and psychology) privilege the importance of one domain over the other, I believe that the domains, and in particular the subjective and intersubjective domains, should not be considered separately. In order to remain cognizant of the descriptions of others experiences, I believe the researcher must first

understand the development of their participants' personal understandings of those experiences. Thus, I had to try to understand my participants' roles in the development of their consciousness. Furthermore, in order to communicate effectively with my participants, I had to be conscious of the intersubjective domain. As phenomenological studies are social in context and design, I had to remain aware that the study evolved within all three domains even while I primarily focused on the objective. By doing so, I continually questioned my own beliefs, preconceptions, and motives throughout the progression of the study.

As the purpose of this study was to examine the experiences that young women felt impacted their success negotiating the secondary school mathematics domain (the phenomena), I found that a phenomenological frame of reference was most appropriate. Such a framework allowed the participants to reflect upon their experiences and a venue in which they could give first-person accounts of how these experiences impacted their opportunities to be successful. Furthermore, phenomenology as the lens for research required that I, as the interpreter and secondary story-teller, "adequately grounded" my own truth-claims when analyzing these accounts for evidence (Mohanty, 1996).

Regardless of which version of phenomenology one follows, a phenomenologist begins by working toward some sort of reduction (van Manen, 2002). Phenomenologists are said to reduce actual experiences to their *essence* (Kockelmans, 2006). The use of the word essence, however, troubles many social science researchers, especially those who work within a postmodern frame. Postmodernists define knowledge (and truth) to be personally and socially constructed. Thus, postmodernism rejects the acceptance of an

objective *T*rue *R*eality (Kvale, 1995). Likewise, postmodern researchers must reject the existence of an actual and true essence.[28] As I interpret phenomenology, however, the purpose of this reduction is to move researchers away from the study of participants' experiences as objects and toward the study of the meanings affixed to those objects. Furthermore, as a researcher that chooses to work within a postmodern frame, these meanings must be considered personal and specific to the subject. While a modern phenomenologist inquires about experiences so that a generalizable objective understanding can be made, the postmodern researcher understands experience as individual, historical, and socially defined (Kvale, 1996). This process of reduction, however, is the basic foundation of phenomenological research in social science. Thus, it is necessary for us, as researchers, to understand the role of our own values when trying to see what values and perceptions animate other groups and individuals (Smart, 1999).

Phenomenology as presented by both Kant and Husserl are modern in nature. Phenomenological thought, however, has greatly influenced the work of postmodern theorists (Ritzer, 1996). The process of the postmodern philosopher known as deconstruction that is used to break down, question, and reverse social norms is also highlighted in phenomenology (Dickens & Fontana, 1994). I believe the deconstructive aspect of Husserl's "bracketing," then, clearly provides phenomenology with a postmodern component. Reality, for a postmodern philosopher, does not exist apart from discourse. As such, I contend, that personal experience is rooted in phenomenological

[28] In the Aristotelian essentialist tradition, *essence* is the belief that there is a universally defined Truth of *what* an object is, as compared to *how* others might perceive the object (Loux, 2006).

claims. Postmodernism's emphasis on understanding that the representational world develops a personal (experiential) reality further links postmodern philosophy with the reflexive attitude of phenomenology (Orleans, n.d.).

As my study was conducted as an initial exploration into the experiences these young women had that they claim allowed them to be successful in secondary mathematics, and in so far as it is expected that I was their teacher, and in so far as I am a man asking young women to explain their experiences, I expected it to be necessary that I question and deconstruct the power relations[29] in play throughout the entire process of data collection. I had to be aware of how I thought about and interpreted their stories through my personal viewpoint and these relations. By working within the subjective domain, and by consistently reflecting upon my own thoughts as well as the information provided by my participants, I grew in my understanding of their experiences that enabled me to provide a more accurate interpretation of their stories (Warmoth, 2006).

I was also required to accept that as an exploration, the data collected from these young women did not provide any "clear cut" "objective" understanding of women's abilities to succeed in secondary mathematics. Rather, each of my participant's stories regarding their lived experiences, and how those experiences impacted their ability to succeed were personal and thus, not generalizable as an objective reality. Although, patterns were recognized between some or all of the participants, these experiences had to be understood from within the context of the life history of each young woman. Thus, it

[29] Michel Foucault's (1983) analysis of power relations defines power as a kind of *power-over*; whereas when we speak of the structures of power, it implies that certain persons exercise power over others (p. 217).

was inappropriate for me, as the researcher, to make essential,[30] the lives of all women in the mathematics domain based on these few personal histories.

Phenomenology as Methodology

As stated earlier, the *philosophy* referred to as phenomenology has continued to branch into multiple secondary versions. In fact, the term "phenomenology" is now used to describe not only philosophy but also an analytical perspective, a research tradition, an interpretive theory, and a research methodology (Schram, 2006). As a research methodology, phenomenology is rooted in the foundational aspects of the philosophy. That is, phenomenological studies investigate the meaning of the lived experiences of homogeneous groups from the perspective of specific phenomena. By pursuing a phenomenological methodology, researchers are able to examine human experience in close and personal ways. This form of inquiry allows researchers to focus on describing and reporting what experiences mean to those who participate in their studies. The results of such inquiries are contextual, holistic, and thematic descriptions of the meanings of lived experiences (deMarrais & Lapan, 2004).

Thompson, Locander and Pollio (1989) further explain:

> phenomenology seeks to describe experience as it emerges in some context(s) or, to use phenomenological terms, as it is "lived"… The world of lived experience does not always correspond with the world of objective description because objectivity often implies trying to explain an event as separate from its contextual setting…. Rather than separating and then objectifying aspects of [lived experiences], the purpose is to describe human experience as it is lived. (pp. 135–136)

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[30] The experiences of young women are vastly different. Thus, postmodern feminists believe that it is impossible to explain women's experiences in essentialized (or generalized) terms for the purpose of constructing theory (Benhabib, 1994).

The goal of phenomenologists, then, is to learn about particular, everyday experiences in people's lives. "Phenomenology," as van Manen (1990) states, "aims at gaining a deeper understanding of the nature or meaning of our everyday experiences… [It consists of] a systematic attempt to uncover and describe the structures, the internal meaning structures, of lived experience" (pp. 9–10). Thus, phenomenological researchers must assume that the information gathered through qualitative methods such as interviews and discussion can actually reveal and help them understand the underlying meaning of some experience.

The aspects of phenomenological research, however, described above lead to one of the major criticisms of the methodology (and furthermore, qualitative research in general). As a result, critics of phenomenological methods could argue that studies in the tradition are pointless. The approaches used depend on a set of assumptions that are different from those used when human behavior is approached with the purpose of finding "facts" and "causes" (Bogdan & Biklen, 2007). Nevertheless, phenomenological researchers do not deny that the purpose of their research is different from those who set out to discover or prove causality. The goal of phenomenology is to investigate phenomena without pre-existing ideas of "what is" and "why" (van Manen, 2002). Thus, I, as the researcher, have the opportunity to approach this study as an exploration that will help me to come to a personal understanding about the phenomena surrounding women in secondary school mathematics.

Schram (2006) explains further that the researcher's imperative is not to simply report the experience or give an opinion regarding what meaning the experience held for

a participant. Rather, the goal of the investigator is to convey the fundamental meaning of the experience no matter which individual has had the experience. Phenomenology as a methodology is marked by its use in understanding the lived experiences of a small number of participants (Creswell, 2009). To accomplish this task, Schram describes several basic fundamental assumptions that must be held by phenomenological researchers. First, human behavior is a natural occurrence that is only understandable in the context of relations with other objects. Second, humans perceive their world. That is, one's understanding of her world is based upon her perceptions and how she acts upon those perceptions. Third, reality is linked to one's consciousness of it; one cannot understand without first being conscious of experience. Fourth, language is the natural medium through which understandings are shared. That is, experiences can be revealed through linguistic interaction. Finally, it is possible, as a result of language, to acquire an understanding of and share phenomenon and related meaning when experienced by others.

Van Manen (2002) provides an extensive framework for phenomenological methodology. Within this framework, van Manen identifies two distinct, but inter-connected, methods of inquiry. The first is the traditional process of reflection upon one's lived experiences. This process takes place using the philosophical practice of bracketing in order to situate one's self apart from her "natural attitude" (van Manen, 2002). This method is termed the *reductio*.

In order to learn about and express the stories through which one understands her experiences, researchers must use linguistic forms. The emulation of a participant's story

telling, by the researcher, is done through writing. The *vocatio* is the method of putting participants' stories in context through writing and analysis (van Manen, 2002). The *vocatio* phase that I develop for this study center upon van Manen's *convacative* and *provocative* "turns." A more thorough description of the characteristics of these phases is provided in the following discussion.

Phenomenology as a methodology relies on a process of radical reflection (van Manen, 2002). This reflective action spurs researchers to investigate their own, or others', lived experiences. It is imperative for researchers, as they proceed through an investigation, to attempt to understand the world as it was experienced, rather than how the world was conceptualized. In order to accomplish such an understanding, researchers must first focus on an aspect of phenomenology that van Manen terms the "reductio."

Reductio

The "reductio" refers to the use of phenomenology as a means of deconstructing preconceived claims and assumptions, so that lived experience can be brought to the forefront as the phenomena is investigated (van Manen, 2002). By recognizing the world as a series of experiences that have particular meaning(s) in the lives of the participants, the researcher is better equipped to understand those experiences without the veil of preconceptions projected upon them by either the researcher or the participant. In order for the researcher to acquire the information, the participants must be given opportunities to reflect upon and share stories regarding their lived experiences. Thus, participants, by reducing an experience to its meaning and deconstructing those experiences through the sharing of their personal histories, and through the conversations that are developed from

this process, the researcher and participant may both develop a greater personal understanding of how these occurrences impacted participants' lives.

Bogdan and Biklen (2007), however, remind us, throughout this investigative process, researchers must keep in mind that some participants' recollections will be more accurate than others. This fact brings about another criticized aspect of phenomenological research. How can the data acquired from a person's telling of a recalled experience be trusted? A participant's story is only a partial telling of the occurrence (Bogdan & Biklen). There are other characteristics and aspects of the experience that may differ from the version given by a participant. For example, a teacher's understanding of what is meant by the statement "You could have done better on this test," will probably differ greatly from the way the said statement was internalized by the student. If one was to take a methodological approach that simply observed the "facts," one would never get at the meaning of the statement from either perspective. And, thus, we would never move toward being able to understand the impact the statement had for either person involved in the incident.

Furthermore, the fact that phenomenological researchers intend to gather data from "participant perspectives" presents a problem in itself. By asking participants to reflect on their experiences and share their perspectives with the researcher is naturally intrusive (Bogdan & Biklen, 2007). While there are no more appropriate methods that can be used to gain insight into how someone else has come to understand the ways in which their previous experiences have impacted their lives, researchers must be aware that the process of collecting information in this manner will naturally cause informants

to distort their own understandings in an attempt to explain their experiences (Bogdan & Biklen).

Although each of the previous criticisms of phenomenological research may be valid, it is important to remember the purpose of this type of research. Studies that are designed from within this methodology are not meant to be truth seeking investigations. Unlike quantitative research methodologies whose aims are to establish fact, the phenomenological researcher endeavors to help her or his participants interpret and further understand her or his personal realities (i.e. the "reductio") in an attempt to gather data and come to her or his own understanding of the phenomena (Bogdan & Biklen).

Vocatio

While the "reductio" allows researchers to place themselves in the proper mindset for the investigation, a second aspect of phenomenological methodology, which van Manen (2002) named the "vocatio," is the resulting creation of written expression from the findings of the investigation. This written expression allows researchers to present textual portrayals of the experiences described by participants (van Manen). Van Manen warns, however, that the difficulty with this type of expression is the decision as to how to relate implicit, "felt," experiences in an explicit and reflective text. The goal for the reporter (i.e. researcher), then, is to express ideas and experiences that could not otherwise be written. In doing so, the researcher can better attend to the experiences of the participant, and more important, begin to understand the impact those experiences had on those participants.

Revocative turn. The "vocational" phase is constructed within multiple viewpoints. A minimum of three of these points of view should be considered for this study. First, the *revocative* aspect of phenomenological vocation encourages investigators to reflect upon subjects' lived experiences by creating well-written or well-told anecdotes that create a sense of closeness for both the participant and the writer (van Manen, 2002). By creating vivid textual versions of experiences, readers are able to feel as if they understand these experiences almost as if they had experienced them for themselves.

Convocative turn. The *convocative* aspect of the methodology results from the fact that, while exploring a phenomena with such openness that the experiences also have personal meaning to the investigator, there exist opportunities for an awakening, an insight, that can neither be simply stated nor ignored (van Manen, 2002). The meanings held by subjects in the study are acquired by the researcher. This meaning leads to greater understanding, empathy and finally an appeal towards transformation. The textual aspect of phenomenology, then, also requires that lived experiences, now understood by both story-teller and listener-writer, be carefully presented to the audience so that all might share in feeling the need for the transformation demanded by the previous series of stories and reflections (van Manen).

Provocative turn. The convocative characteristic naturally leads to the third aspect that could become a critical issue for this study. The *provocative* phase of the "vocatio" deals with the realization that ethical questions that arise as a result of the study must be addressed (van Manen, 2002). In this phase, the researcher, subjects, and intended audience are all asked to consider what sorts of ethical challenges must be faced when

considering where the experiences presented have led. The provocative phase does not end with simple recognition of the ethical underpinnings that have been presented through those experiences. Rather, researchers must take the results further and begin to consider what sorts of responses, what actions, must be taken to remedy any ethical predicaments that have been realized by conducting the study. We, as researchers, are asked to begin to consider what the findings of the study direct us to do. We must ask ourselves if there is anything that needs to be or can be done about situations of which we have become aware. Initially the answer to this question is to report the findings by creating strong, vocative texts. In doing so, the researcher develops an atmosphere where the audience also understands the need for action. Thus, the researcher uses the experiences of the participants, and a rich and meaningful text, to open up an ethical domain for her or his readers.

Thus, by choosing to take a phenomenological approach for this research project, I designed a study through which I was able to learn more about my participants' and gain a deeper understanding of their experiences. As the scope of the study was limited in the number of participants, we, the researcher and participants, were better able to study, in-depth, those factors, or phenomena that influence(d) their lived and future experiences. By conducting a phenomenological study, I was better able to focus on the stated contexts, events, and conditions surrounding the specific subject, successful women in school mathematics, and describe (rather than simply explain) my interpretations of participants' experiences so as to discuss what motivations and actions she took with regard to the research question(s). Through this in-depth study, I was able to sharpen my

own understanding as to why these factors influenced the successful negotiation of mathematics curricula by each of the subjects. Another reason that I chose to conduct a phenomenological study was that, while I had certain beliefs about the possible results of the inquiry, I questioned whether my beliefs should be expected. Thus, I felt the need to explore the subject in order to gain a deeper understanding from the perspective of young women that have successfully negotiated the mathematics domain. As a result of employing an exploratory methodology, I would have expected the process to produce findings that re-focused the investigation on more specific or particular aspects of the indicated question. This was the case. At the outset, there was no way for a male graduate researcher to have an adequate understanding of the meaning(s) of women's experiences in secondary mathematics. Thus, I asked open phenomenological questions such as those suggested by Schram (2006). In doing so, I also observed several commonalities (not necessarily generalizable) among the stories that were shared by the participants. These commonalities also allowed me to narrow the focuses of the investigation as it progressed. In this way, I was able to identify an additional research question that needed to be included as part of the inquiry.

A Feminist Form of Phenomenology

Investigations done within a feminist frame provide for a range of perspectives on social and political phenomena. Such frameworks work within and across a multiplicity of philosophical and methodological traditions (Tuana, 2007). For feminist researchers, women are seen through their experiences with injustice or through their disadvantages. Furthermore, women's experiences are constituted by a complex system of social and

cultural structures. Phenomenology from a feminist perspective, as a result, conceives that women's understanding of themselves is based within their experiences (de Beauvior, 1949; Young, 2005). Young (2005) suggests that women must be interpreted from the perspective of their lived experiences. Phenomenologically this implies that we, as researchers, must understand the individual from her history which is situated within her cultural and societal contexts. The result of understanding women from within her situatedness and from the impacts of her experience is what Young (2005) defines as feminine consciousness.

Feminine consciousness in this respect can also be interpreted as a feminine (or feminist) standpoint. Research conducted from within the frame of feminist standpoint theory begins, by definition, with research questions that are rooted in women's lives. It is a collective process that focuses on the social practices and differences in (situatedness of) knowledge that are based on differences in gender (Hartsock, 2004). Regardless of the methodologies employed, research done within a feminist standpoint tradition considers the impacts of women's interests, beliefs, and self-identities (Brown, 2003).

Likewise, phenomenology aims at obtaining a greater understanding of the nature of participants' everyday experiences (van Manen, 1990). The goal of phenomenology, as a methodology, is to reveal the structures within, and the meanings of lived experiences (van Manen, 1990). Thus, phenomenological researchers also explore those experiences that impact their participants' lives. As a result, feminists utilizing a phenomenological approach to their research use the methods available to them to investigate the structures surrounding the phenomena of particular forms of oppression.

Methods

Defining Success

According to the American Heritage Dictionary (2000), *success* is "the achievement of something desired, planned, or attempted." I assert that society's definition of success draws largely on this categorization with respect to the domain in which success was attained. Within the realm of education, I also argue that society (i.e. policymakers, parents, administration and many educators) defines success to be measured by grades and scores on standardized tests. The present society existing within the United States, as it is capitalist and thus, competitive, demands measures of success so that one can judge the winners and leaders whom deserve the most expensive post-secondary educational opportunities in our nation's history.

For the purpose of this study, I defined success based on the conventions society had set. This definition is thoroughly stated within the *Participants* section that follows.

An interesting aspect that I examined as the study progressed was how these participants, deemed successful by society based solely on numbers such as grade point average (GPA) and SAT scores, defined success. I found it interesting to hear why and even if they thought of themselves as being successful, specifically within the mathematics domain. I was also interested to learn what role each of their personal definitions of success (their own and society's) played in their ability to achieve within the mathematics domain.

Participant Selection

For this study a purposeful sampling[31] (Patton, 2002) of four female undergraduate students was conducted. Participants were defined as mathematically achieving in secondary mathematics. By defining achieving as "successfully negotiating secondary mathematics curricula," evidence of such accomplishments such as having passed AP mathematics or joint-enrollment (college) mathematics courses or having scored well on standardized mathematics tests were among the indicators of success. A list of students that qualified was created from personal experiences that I had with former students and acquaintances[32] that met the following criteria.

For the purpose of this study, I followed definitions similar to those proposed by Stinson (2004, 2008) for successful mathematics students. As test scores and grades are social norms for defining success in schools, the same criteria was used for determining achievement. By defining participants in this way, I hoped to eliminate any possibility for those outside the study to question whether these young women were high achieving in the mathematics domain. Therefore, for an informant to be invited to participate in the study she must have demonstrated achievement in secondary school mathematics. Invitees were defined to have achieved if one or more of the following were realized while in high school:

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[31] Also *purposive* sampling or *judgment* sampling. "Purposeful sampling focuses on selecting information-rich cases whose study will illuminate the questions under study," [based on having specific characteristics or by meeting certain criteria] (Patton, 2002, p. 230).

[32] Acquaintances may be students that I have tutored or students that I have had personal mathematics educational experiences with outside that of the formal classroom setting.

1. completed an AP Calculus or Statistics course with a grade of B (80%) or better while scoring a minimum of 3 on the AP Exam (or AP Calculus AB sub score)
2. completed a joint-enrollment calculus or statistics course with a grade of B (80%) or better, or;
3. scored in the 4th quartile (top 25%) of the mathematics portion of the SAT.

A list of possible participants was generated from students with which I had personal experience. Undergraduate women from this initial list that met the criteria were sent letters of invitation to participate. The letter informed each of the potential informants of the purpose of the study and the requirements for participation. It asked each young woman to contact me by telephone, electronic mail, or U.S. postal mail if they were interested. The participants for the study were chosen from those who responded as interested in participating. Initially there were five respondents that volunteered to be included in the research process. As a result of the time constraints set forth by her university curriculum, however, one woman chose to eliminate her participation in the study upon my request for the initial data collection set.

As I had previous experiences with each of the participants, there was little difficulty in re-developing the interpersonal relationships needed to acquire the type of personal information required for the study. These former students were directed that if they were asked about experiences for which they were not willing to divulge information that they were not obligated to share that information. To initiate the research process, the first two data collection pieces (described below) were to be completed by

the participants in private and submitted as reference. These facts, coupled with the assurance of confidentiality, which was further emphasized in the initial questionnaire where participants were encouraged to choose their own pseudonym, helped me to ease any apprehensions the participants might have had about the research process.

Participatory Research

As an integral part of this phenomenological study, I chose to implement a participatory inquiry. As Garaway (2004) points out, participatory research "can be as limited as simply answering a questionnaire or being part of an interview, or as extensive as full, active involvement in all phases of the research process" (p. 251). While informants in this study were initially asked to provide information in the form of a questionnaire and written autobiography (described below), these tools were used to later help the participants and me to reflect upon deeper meanings of the information gathered from these research methods. Thus, participants become co-researchers in regard to the meanings made from their own experiences. In this way, then, participatory inquiry can be characterized as being a reflexive process that allowed my participants to be (somewhat) co-researchers as well as subjects within the investigation. I, as the lead-researcher directed the study and specified the modes of inquiry, while the co-researchers shared their experiences and knowledge within a framework of discussion and later in the context of reviewed literature. The co-researchers were allowed to review materials related to the research topic as the study progressed. This component of the research design provided an opportunity for the participants to view the process from an investigator's perspective. In comparison to "simple-participation" studies, then, the

participant was given an opportunity for self-reflection where she could see herself as "making action," not just as a studied object (Stinson, 2004).

According to Kemmis and Wilkinson (1998), this type of inquiry is a social process that requires a collaboration of participants and researchers that critically examine their sense of identity, the links between them, the discourses and power relations in which they live, and ultimately an investigation of their "reality" that will allow them to better understand, question and change that reality as they see fit to do so. By pursuing this type of research, I was able to acquire data that helped me to advance my personal awareness of the situational aspects of my participants' experiences and develop needed questions that were asked in order to clarify and move me toward an even greater understanding.

Data Collection

The format for data collection was adapted from a study conducted with African American students by Stinson (2004, 2008). Data was collected through an exploratory questionnaire, a narrative autobiography, and a series of three interviews. The questionnaire and request for the autobiography was given to the participant before any interviews were conducted (see Appendix A). The subsequent interviews were modified from a preexisting form based on responses given by participants in their written introductory materials.

The questionnaire was designed to be a comprehensive demographic survey. This survey allowed me to better understand the background of the informant (see Appendix B). It included questions about family and schooling histories, testing information, and

the participants' current educational information. The data collected in the survey was primarily what could be referred to as "traditional" data. That is, the information asked for in the survey deals with quantifiable information that cannot be misinterpreted such as number of siblings, ethnicity, SAT scores, and grade point average.

The autobiography section required each participant to further describe their background by asking them to provide a narrative that described her school life as it related to mathematics (see Appendix C). Within this narrative sketch, the participant was asked to reflect upon multiple aspects of school including social, family, and in-school influences. In this autobiographical reflection, participants were given freedom to explore and further explain who they believed themselves to be, experiences they believed were important to them, as well as how they wished to be understood. The combination of information from the survey and the autobiography was carefully considered so as to adapt and add to the questions designed for the first interview. In this way, the research process became individualized (to some degree) for each participant as, together, we explored her experiences and how they impacted her life.

The remaining portion of the data collection process consisted of the series of interviews. As stated earlier, a phenomenological approach enables researchers to examine everyday life in close and detailed ways (deMarrais & Lapan, 2004). Researchers should create contexts in which participants are encouraged to reflect on their experiences in detail within the interview process (van Manen, 1990). The goal of a phenomenological interview is to learn about those experiences that are described by informants. In order to achieve this goal, the researcher must take on the role of the

learner within the interview process. By conducting phenomenological interviews, I was aware that the informant had become the expert, as she was the one that had those experiences that were being considered (deMarrais & Lapan, 2004). These interviews, then, were conversations. At times, though, I, as the lead researcher, was required to direct and re-direct these conversations. The interviews began with open-ended questions that elicited recollections of experiences as they relate to the research question. Subsequent interview questions were asked in order to clarify or re-direct the conversation back to the study. By attaining first-person descriptions of my participants' experiences regarding the domain of the research question(s), I was able to gather critical and valuable information in our efforts to understand what experiences and variables impacted their successes in secondary mathematics.

The interviews were conducted in settings that I believed to be convenient and comfortable for the participants. The two initial interviews were conducted face-to-face near the participants' current campuses or homes. These interviews were typically conducted at quiet restaurants, over dinner or lunch, so that the settings made the participants feel at ease with the discussions rather than feeling like they were being investigated. The third set of interviews was conducted online as the participants had all returned to their universities, one of which was attending a university over 800 miles from my home.

The first interview considered specific aspects of the questionnaire and autobiography (see Appendix D). By focusing the interview questions on each participants' unique past, patterns "emerged" within each participant's story that signaled

to those people and incidents from their pasts that were the most important or most meaningful with regard to their mathematics education. Thus, we were able to explore more deeply those experiences and people that impacted her most. Each of these initial interviews lasted between 75 and 120 minutes.

Following the first interview, participants were given selections from the previous scholarly research that was used to frame this study. The selections include manuscripts that deal with deficiency theories (Benbow & Stanley, 1980) and affective attribution theories (Fennema, et al., 1990). As there are multiple topics for gender research that directly relate to secondary school mathematics, I also provided my own summary of previous research. For this process, however, I only included the summaries of historical research studies. I purposefully omitted summaries regarding feminist theories' role in mathematics education. The expectation for providing this summary was for the participants to acquire an historical overview of gender research in mathematics (my own) rather than the extremely limited perspective that would have resulted from reading only two pieces of literature. Furthermore, as each of these young women were undergraduate students with constraints on their time I felt obligated to offer them this extensive summary rather than asking them to read a large number of lengthy research articles. This sample of research literature, then, provided my participants with an overview of the research topics that have historically been developed with regard to gender and mathematics. The primary function of the literature was so that participants could read and reflect on their experiences within the context of the historical summary and research studies that were provided. In this way, they were at times able to situate

themselves within the historical context so as to learn more about their own mathematics and schooling experiences.

A secondary purpose for asking my participants to read the series of manuscripts was to provide them an opportunity to ingest the academic vocabulary used in discussing the specific research domain. This participation allowed me to be more accurate in analyzing the participants' responses rather than having to take an educated "guess" when attempting to interpret their stories. The articles were carefully considered so as to provide an introduction to the research that has been previously conducted with regard to gender and mathematics. In choosing which manuscripts participants read, I wanted my participants to appropriate an understanding of which aspects of gendered mathematics have been previously investigated. The goal of this "awakening" was not for me to be able to inquire about agreement or disagreement. Rather, I though it important that they had a personal understanding of the historical research so that they may come to see themselves as co-researchers within that context rather than participants being investigated. Thus, a third goal of reading the manuscripts was to bring the participants into the co-researcher domain as well as give them a language with which to discuss their experiences as women in secondary school mathematics.

A second interview was conducted for the purposes of discussing the literature. Participants were asked to discuss their views on the summary and articles provided following the initial interview. Participants were asked to consider the findings of the research, its validity, and how they perceived themselves within the research. In other words, participants were asked how they believed that the information presented

represented their *own* experiences. These interviews were driven by a set of questions that I created and the candid discussions that ensued. Each of these interviews lasted approximately 45 to 60 minutes.

Data Analysis

In order to analyze the stories shared by my participants I used a combination of postmodern and standpoint feminist theories. By incorporating aspects of postmodern feminism into the analytic framework, I was provided a lens through which I questioned the discourses surrounding power, position, subjectivity, and sexism within the learning of secondary mathematics. At the same time, standpoint theory provided a lens through which I was able to better understand my participants' stories and the personal meanings of their experiences. Thus, while postmodern feminism helped me to expose the discourses of oppressive structures within my participants' stories (St. Pierre, 2000), feminist standpoint theory enabled me to focus on the historical and gendered perspectives of the participants.

As a man exploring the impact of gender and questioning the discourses of power, education, and the cultural and societal structures that impact the mathematics learning of mathematics, I was determined to remain aware of the effects of structures surrounding me, as the researcher, being a man and my participants' former teacher. Thus, one aspect of postmodern feminism that was critical to the analyses conducted as part of this study was that it provided an analytic mirror in which I could reflect upon the patriarchal and social hierarchies that existed with regard to my relationships with my female participants.

While traditional forms of standpoint theory assert that the focus of inquiry should be centered on the standpoint of the group's oppression, by injecting my postmodern views, I approached the analysis in such a way that I allowed each of the participants' views to be understood as gendered, yet unique. Lather (1991) insists that it is at the intersection of postmodernism and emancipatory projects such as standpoint theory that new ways of knowing are generated. Thus, by utilizing a combination of these two feminist traditions I was not only able to focus on the impacts of gender but also the influences that were personally meaningful to my participants' learning of mathematics within their gendered cultural structures.

Standpoint theorists also focus on the objectivity of knowledge that results from studies regarding disadvantaged or oppressed groups (Harding, 2004). My postmodern stance within standpoint theory takes this definition of objectivity a step further by localizing it within the histories of the individual participants of the study. Thus, by incorporating postmodern feminism within standpoint theory my analyses focused on the context specific experiences of my participants (Pease, 2000). I attempted, through this analytic frame, to deconstruct the personal meanings of those experiences for each participant. Furthermore, as the aim of this study was to investigate the possibilities surrounding high-achieving female mathematics students with regard to their success, the emancipatory aim of revealing the standpoints within the study is solely to raise the consciousness of those whose interests include the success of girls in mathematics. In fact, because the participants views on the impact of their gender varied (as will be shown), any claim to the existence of a group standpoint would have been unjustified.

Thus, claims of scientific (positivist) objectivity, or to an essential (or generalizable) standpoint were unrealistic as each of these participants (as will be reported) was found to have unique and diverse personal experiences that impacted their success in mathematics.

Member Checking

The final interview was designed not only to provide me with an opportunity to verify my reporting and interpretations but also to assess what the participant learned from the process. Before this series of interviews, each participant was sent their sections of my interpretations of the data they provided as well as my initial analysis. This interview was conducted by questionnaire and online. Participants were able to carefully consider my interpretations of their experiences in private and respond thoughtfully in a manner of their choosing. They were welcome to contact me by phone, electronic mail, or by meeting. Participants were also given the option of sending me a detailed response (including any corrections to the data that was reported) to my interpretations. By conducting this interview, I was able to provide a more “truthful” summary of each participant’s story. The process also allowed me, as the researcher, to analyze my initial findings with the help of the participants. The participants were also asked to reflect upon their participation in the research process. By asking this question I was better able to begin to understand how each participant had "come to know" through their participation. As the participants also had the opportunity to begin exploring the history of gender related research within mathematics, I was also interested in what the participants believed would be important directions for future research with regard to female mathematics achievement. I was primarily interested, however, in ascertaining what

aspects of their stories and the research the participant felt were most important and meaningful while assuring that my interpretive reporting of their stories satisfactorily portrayed what the participants had shared.

CHAPTER 5

THE DATA AND ANALYSIS

This chapter begins with a summary and restatement of the research questions that directed the investigation. This summary includes a detailed account of the process through which I analyzed the data that was shared by my participants. Following this summary, I describe the quantitative data regarding the participants' mathematics success as it related to the criteria set forth in the methodology for inclusion in the study. Third, I share my interpretations of the four participants' stories and the information that was accumulated through the research process. Following each participant's account of their experiences, I share my analysis of the information that was provided. I conclude by summarizing my analyses within the context of the theoretical framework set forth in chapter 3.

Summary of the Research Study and Analysis Process

As the overarching question that guides this study, "how do these high-achieving young women interpret their success in high school mathematics?" required me to synthesize and analyze the details and descriptions that these young women provided throughout the course of data collection. In an attempt to examine possible answers to the question "to what factors do high-achieving female mathematics students attribute their success?" these young women were asked to reflect upon their experiences and situations that they believed directly impacted their success in secondary mathematics. This process

helped me to identify affective traits[33] that these young women directly attribute to their success.

The questions "do these students, defined as mathematically successful by common social standards,[34] identify themselves as 'high-achieving' or 'successful' with respect to their secondary mathematics histories?" and "what definition or personal significance does 'high-achieving' or 'success' hold for these participants?" prompted me to investigate how sociocultural factors,[35] elements of school and curriculum, teacher traits, and their relationships with teachers were attributed as having impacted these female students' mathematics achievements. Furthermore, the question as to how these participants perceived the relationships between their gender and their success in mathematics required that I investigate their personal understanding and development of gender roles, as well as how these roles impacted their mathematics education.

At the beginning of the research process the participants were given a demographic survey instrument to complete. This comprehensive survey asked them to

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[33] Reyes (1984) defines affective variables to be students' feelings, aspects of the classroom, or themselves that impact their learning. She limits her definition for her specific inquiry but indicates that affective variables may include perceptions of difficulty, usefulness, and appropriateness of subject matter.

[34] While "common social standards" can be seen as problematic, for the sake of this study the phrase is meant to identify a set of criteria that, when met, any student would be politically defined as successful. Political success in this case indicates that students achieved high test scores on standardized assessments such as the SAT, ACT, or PSAT and completed their required (and elective) schooling with a grade point average of higher than 3.5 on a 4.0 scale.

[35] Yoong, Taha, and Veloo (2001) define sociocultural factors as locally situated, including the historical backgrounds, cultural mores, major political events, national education structures and aims, and language policies that impact the education of a student.

provide information regarding their academic high school record, standardized test scores, family, and current educational status. They were also asked to identify themselves by ethnicity, nationality, and their family's socio-economic status.

In order to understand the importance of the participants' stories, I found it necessary to examine how each participant described herself. In order to do so, I began by analyzing their academic records, including their overall academic performance and their performance on standardized tests such as the SAT Reasoning Test. As I progressed, I narrowed the focus of this examination to their performance in mathematics, and more specifically, secondary mathematics.

Following the analysis of academic achievement, I examined the demographics of each participant. The demographics that I most considered included the make up of the participants' families as well as sociocultural information such as the ethnicity, nationality, and socio-economic status as identified by the participants. Factors such as the number of parents present, the make up of the parental units (i.e. were there two natural parents or were step-parents involved), the number of siblings in the family, and the participant's rank amongst those siblings were noted. Another inquiry that I considered might be important, and thus examined, was the educational history of the parents.

Following the analysis of the quantifiable data provided in the demographic survey, I began to analyze the autobiographical narratives that were provided by the participants. An initial analysis of these narratives was conducted so as to adapt the primary set of interview questions for each individual. By taking note of the major topics

discussed within each of the participants' narratives, I was able to better focus on the concepts that the participant thought important throughout the interview process.

At the conclusion of each of the first interviews, the participants were provided with three manuscripts that were to be read before the next interview. The literature included the report of Benbow and Stanley's (1980) study, which investigated the gender gap that existed in the reporting of mathematics scores at the time, Fennema and Tartre's (1995) study into affective traits of female mathematics students, and my summary of the historical research that had been conducted since the 1970s. After completing the first series of interviews, I began writing my interpretation of the stories that had been shared by each of the young women. The participants received a copy of the initial draft of their summary so that my interpretation that was to be reported could be verified and/or corrected before a formal analysis was written and conclusions were drawn.

Research Site

Each of the young women selected to participate in this study were former students. Thus, each of them attended the same high school which was located in a middle class suburban community situated within an affluent county 20 miles north of a large metropolitan city in the South. The school, which was less than ten years of age when the participants attended, had been built in a community that was 72% Caucasian and the median home value was $173,000. The managing school system was among the largest in the state, consisting of over 106,000 students, 15,000 employees, and 120 separate

facilities. The participants' school averaged a total of 1858 students over their years of attendance with the following (average) demographic break down:[36]

- 71.4% Caucasian/White;
- 15.5% African American/Black;
- 6.6% Hispanic/Latin American;
- 3.5% Asian;
- 50% female, 50% male;
- 16% of students eligible for free or reduced lunches;
- 5 ½ Administrators (4 women, 1 ½ men)
- 5 counselors, 1 graduation coach, 1 social worker (all women);
- 112 teachers (61% female, 39% male)
- 15 mathematics teachers (7 female, 8 male)

Since the school was opened, the faculty and staff have continued to help the school through their commitment to the students and the pursuit of excellence. The school is a model for the AVID program,[37] which is a program designed to help underachieving middle and high school students prepare for and succeed in colleges and universities. The school has also achieved designation as an AP Demonstration school, which is awarded based on the number of students that enroll in advanced placement courses and take the subsequent examinations. The school was also named as one of the top 1500 (top 6% of) public high schools in the United States.

Since teaching at this high school, I have developed a reputation as a caring and committed teacher. I have been chosen as the "Star Teacher" three times in the seven years it has been awarded. One of the participants was one of the Start Students that

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[36] The demographic breakdown presented was based on the reported totals for the academic years 2004-2007.

[37] AVID stands for "Advancement via Individual Determination." The AVID program is a nationally recognized educational program that requires teacher training and a high level of commitment from both students and teachers.

chose me for this honor. While these participants attending the school, I also lived in a neighborhood whose children are districted to attend this school. Therefore, I was also seen as a member of the community that had the school and its students' best interests in mind. This reputation, especially with my students, helped me with the study as I had previously developed a rapport and a sense of trust with my participants as their former teacher.

Description of Participants

As stated in the previous chapter, four female undergraduate students participated in the study. Each participant was identified as being mathematically achieving in secondary mathematics based on pre-set criteria that reflected the young women's success including grades, SAT scores, and Advanced Placement Examination scores. By defining achieving as successfully[38] negotiating secondary mathematics curricula, the following should be deemed as satisfactory evidence of these women's success in secondary mathematics. The following summary highlights the participants' mathematics accomplishments that are further detailed in Table 1 presented at the end of the review.

Each of these young women graduated with honors possessing grade point averages ranging from 4.339 to 4.620 (on a 4.0 scale). A grade point average (GPA)

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[38] For the purposes of this study success is defined has having shown evidence of such accomplishments as having passed AP mathematics or joint-enrollment (college) mathematics courses or having scored well on standardized mathematics tests were among the indicators of success. Participants were defined as having achieved if one or more of the following were realized while in high school:
a. completed an AP Calculus or Statistics course with a grade of B (80%) or better while scoring a minimum of 3 on the AP Exam (or AP Calculus AB sub score);
b. completed a joint-enrollment calculus or statistics course with a grade of B (80%) or better, or;
c. scored in the 4th quartile (top 25%) of the mathematics portion of the SAT.

higher than 4.0 is possible at their school as honors courses earn an extra one-half quality point and Advanced Placement (AP) courses are awarded an extra full quality point above the standard 4.0 scale. Furthermore, their GPA specific to mathematics courses is even more impressive. The span of their GPA's for mathematics is 4.30 to 4.78 (also on a 4.0 scale). Each participant also graduated in the top 10 in their respective graduating class. The smallest number of students in any of their graduating classes was 352. Thus, each young woman was in the top 3% of her class. One was the salutatorian.

Every participant also took at least one Advanced Placement mathematics course. The semester grades earned for these courses included 4 B's and 5 A's. Courses included AP Calculus AB, AP Calculus BC, and AP Statistics. Advanced Placement Examination grades earned include 3 threes, 1 four, and 1 five. None of the participants made below a B in any mathematics course and each of them earned a 3 or better on every AP Mathematics exam taken (a 3 being considered passing).

Upon analyzing the standardized test score records for this group of women, the scores on the SAT further accentuate their success in secondary mathematics. The overall scores on the SAT for this group range from 1430 to 1570 (for Mathematics and Verbal Comprehension, out of 1600). The lowest math score earned by a member of this group was 720 and the highest was an 800 (on a scale of 800). Two of the young women chose to take the SAT II subject test for mathematics. The respective scores for these tests were 720 and 800 (also on an 800 scale).

Having been successful (based on the definition provided for this study in chapter 4) on most every standard criterion that their high school had to offer, with regard to the

mathematics curriculum, each member of this group of young women should certainly be found worthy of inclusion in this study as it pertains to achieving in secondary mathematics.

Table 1

Grade and Test Score Data of Participants

Grade or Test	Farah	Clara	Sophia	Samantha
High School GPA	4.339	4.620	4.490	4.400
HS Math GPA	4.600	4.780	4.300	4.500
Class Rank	6	2	6	Top 3% (in top 10)
SAT Total[39]	1430	1570	1490	1460
SAT Math	720	780	730	800
SAT II Math	720	800	Not Taken	Not Taken
AP Math Courses	Calc BC	Calc BC, Statistics	Calc BC	Calc BC
AP Math Grades	B/A	A/A, A	B/B	B/A
AP Exam Scores	3	4, 5	3	3
College Math Courses	Calc I, II, III	Calc I, II	Calc I	Calc II, Statistics
College Math GPA	3.67	4.00	3.00	4.00

[39] SAT Total is for Mathematics and Reading Comprehension Sections only – Out of 1600 possible

Data Collection

As described in Chapter 4, data were collected from the participants through the use of a demographic questionnaire, autobiography, and series of three interviews. The interview experience with each participant during the data collection process was unique as a result of the opportunity to add and change the interview questions in light of the information provided in the questionnaire and autobiography. Furthermore, as I have personal histories with each of these former students, the process allowed the participants to update me regarding their post-secondary educational status. Having these previous interpersonal relationships with the participants seemed (to me) to result in their ability to quickly become at ease with the research process, in particularly, when they were asked to share details from their personal lives. As a result, I was able to acquire rich textural accounts of their academic and mathematics histories from which we, together, could explore the factors they attributed to their achievement in secondary mathematics.

While these young women were placed here within the same contexts of category and research scheme, it was important to remember that each is an individual with extremely different backgrounds and personalities. The experiences that were shared within the data collection process not only allowed me to develop an understanding of how they were able to negotiate cultural and societal structures within the mathematics domain but also reminded me as to the diversity that exists within even the smallest subgroup of mathematically talented female students.

Personal Histories

As indicated previously, I have a personal history with each of the four young women in this study. Each of the participants were at some point enrolled in mathematics courses that I taught and involved in extracurricular activities that I sponsored. I make this statement now as a prelude to the fact that while my effort is to share their stories from their perspective, I also have personal knowledge about these participants with regard to their interactions in my mathematics classroom, their successes, and their personalities. While it is my intention to suppress my own voice from the stories that are shared below, my intimate experiences with each of these former students might have limited my ability to accomplish this task. Throughout the sharing process, there were many instances when the participants alluded to experiences that were had while in my class or while participating in an activity with me. Furthermore, there were times that each of the participants referred to the ways that I, as their teacher, impacted their mathematics success. As a result, in order to be transparent in my reporting, I chose to refer to myself rather than as an "unidentified" teacher when appropriate.

Farah's Story

Farah is a young woman that at the time of data collection was in her senior year at a large technical university in the Southeastern part of the United States. At that time, when not on campus, she lived with her mother and father and her one older brother. Both of her parents have college degrees. She considers herself Black, although she is emphatic that she is to be called "African and not African American." Farah is originally

from Nigeria, and is now a naturalized U.S. citizen. She came to the United States when she was twelve years old. At that time, she had completed one semester of the 10th grade in her native country. Upon coming to the United States she was placed in the ninth grade of a local high school. Although she was considered a top student in her school in Nigeria, she was placed in traditional-level courses in the new high school. Her immediate successes, specifically in mathematics, encouraged her teacher to inquire as to whether she belonged in "on-level" courses or should be moved into the more rigorous and exploratory "honors" courses. Her initial high school guarded those classes carefully and the teacher's request was denied. Her second year in (U. S.) high school, Farah was offered an opportunity to move to a newly opening high school for which her neighborhood had been redistricted. She chose the new school, as did the teacher that made the request for Farah's change in level for mathematics. The teacher re-emphasized the request for Farah to be placed in advanced courses at the new school where it was not only accepted for mathematics, but for all of Farah's courses.

Farah contrasts her early schooling experiences in Nigeria with those in high schools in the United States. To begin, she recalls the following story that her mother told her about when she was 2 or 3 years old:

> My grandma used to take care of me when my parents were both working… my brother was at school… so no one was really at home, and one day I decided I wanted to go play with my next door neighbor while my grandma was asleep and so I just walked out the front door and went next door and um… my grandma, of course, flipped out and went outside and called all the neighbors and ordered a search party and of course I, I heard the ruckus outside, so I went outside to the balcony of my neighbors and I was like "there's, there's something going on at my house" and, and they looked and they saw my grandma with her hands in the air, like, just like "it's not my child! It's not my kid!" and they were like… "I think

> they're looking for you." And so my grandma just said… "I think it's time for you to start school." (Interview 1)

She shared this experience as an example of how she almost naturally was "forced to mature at an accelerated rate and adapt my actions to fit the level of maturity of my peers" (Interview 1).

Farah emphasized the fact that schooling in Africa was much more independent than in the United States. To her, the expectations seemed beholden to the fact that students that excelled were given greater opportunity than those that did not. There were three tracks of students in each grade level. One third of the students were placed in each track based on their previous performance. Although rare, students were able to compete for spots in each track level and move up or down each year. Farah's goal throughout this time was to maintain a position in the highest level track. This characteristic of the Nigerian schools greatly influenced Farah's deeply ingrained sense of competition. Farah also seems to have recognized how this method of schooling impacted her ability to be an independent learner and to develop her own sense of self-determination. These schools, however, with their strict business-like atmosphere and uniform dress codes, lacked in helping her develop a sense of self and to mature further on an inter-personal level. Progression in these areas was left for the out-of-school domain.

"Teachers in Nigeria are different than those in the United Sates" (Interview 1). Farah spoke of her African teachers as if they did little more than lecture, maintain discipline, and assign homework. She seemed to believe that their job was simply to transfer knowledge from themselves to their students. In her words, the teachers in

Nigeria “definitely were not accessible as compared to my teachers when I came [to the United States]” (Interview 1).

In both her autobiography and initial interview, Farah emphasized the impact that these teachers at her new (United States) high school had on her. She stated that her “teachers’ attitudes definitely had an impact on my success” (Autobiography). At this school, she had teachers that she called “mother figures,” that “looked out for her well-being, both academically and emotionally.” “These people,” she says, “helped me realize my potential which I did not initially see in myself” (Autobiography). For Farah, these teachers “took such a personal interest” in her, that she “considered them an extension of her natural family” (Interview 1).

Farah identified five teachers that had long-lasting impacts on her during her high school years. These teachers included a literature teacher, a chemistry teacher, and three mathematics teachers (including me). The greatest impact each of these teachers seems to have had on Farah is that each of them forced her to recognize her potential. Describing herself as “lazy,” Farah seems to have had little expectations of her abilities or what she could do. These teachers, acting like extended family in Farah’s eyes, implemented strategies that “not only encouraged my curiosity, but also compelled me to hold myself to the highest academic standards” (Autobiography). Farah states that these teachers’ “tough love and insatiable quest forced me to dig deeper and pushed me further than what I thought my limits were” (Autobiography). Farah goes on to describe her teachers:

> My teachers were amazing. My teachers here were definitely a big part of my success because I had the opportunity to be in a position where they expected a lot more than I thought I could give. And then when I achieved what they expected, they made me realize that what my perception of my

> potential was, it wasn't enough… so, having them around saying this is good, but I know you can do better, motivated me to think, well if they, if they say I can do better then they must see something I don't see in myself. And so I have to show them that I can (Interview 1).

For Farah, those teachers that made such a great impact on her were those

> who happened to care. Who happened to see me beyond the roll call… the register, beyond just the name on a homework or a test, to actually ask about my personal life, and actually want to know how I am succeeding… (Interview 1)

I also found it interesting how competitive Farah seemed to be when it came to grades and position among her peers while at the same time holding onto the sense that she not only is limited in her abilities but also limited in the types of opportunities that she deserved. Farah mentioned multiple times that she did not deserve the attention that these teachers gave her. She stated at one point that she has "never learned to take pride in what I've done" (Interview 1). Although, she describes herself as having achieved mathematically, she would not say that she is mathematically talented or gifted. I, however, would attest otherwise as I have seen not only her performance in class and on standardized tests but also in the competitive arena. She was consistently one of the highest scorers on the math team at her school and within her school system. Only talented mathematicians successfully undertake the challenge of competitive mathematics. I wonder if she did so without realizing how successful she was.

Farah went on to describe another aspect of this competition, however, that was intriguing:

> With my friends, I mean, I always had to hold myself accountable because they were, I, I always grouped myself with people I knew motivated themselves as much as I did. So, seeing them achieve stuff would make me want to achieve stuff as well, because, me being so proud of them, I

> wanted them to be proud to have me as a friend as well. I wanted to be able to go over to their houses and they'd be proud to call their parents and say this is my friend. And so, having them around, having them as my support whenever I thought I couldn't do it, having them say yes, we know you can, we know who you are, you can achieve this definitely helped as well. (Interview 1)

The discussion regarding Farah's influences naturally progressed into the topic of one of her greatest concerns throughout her secondary education. Her fear of "letting down those that invested so much time with her" (Interview 1) seems to have greatly impacted her personal efforts to remain a top performer in her class. Those that she was afraid to "let down" included her parents, teachers, and friends. This responsibility was compounded upon her realization that she was one of a limited number of Black and female students succeeding in school at this level. When she looked around her classes and at mathematics competitions, she rarely saw anyone that looked like her. "I didn't feel like people held me accountable for [what was possible] because I'm a Black girl" (Interview 1). Because she was not just Black, but female, she felt this stereotype was a "double whammy"; that she was forced to work twice as hard. She had been successful, however. For this reason, she felt obligated further to be a model of what can be to other women of color. It became a mission for Farah to succeed at the highest level—to show others that look like her what they could achieve. From her perspective, "Black and female students are not held accountable for what they can achieve… and I aim to show with how I live that they are capable of doing much better than they are now" (Interview 1).

Following high school, Farah has pursued a degree in biochemistry. Her plans include graduate school, where she hopes to earn a degree in either pharmacology or

pharmacokinetics. She has completed her mathematics requirements for her major and has no plan to pursue mathematics further. She added that college mathematics, like most "school mathematics" was boring and all about the grade. She no longer felt the thrill that she once received by doing "real" mathematics, especially in the atmosphere of competition that she so enjoyed.

Clara's Story

Clara is currently a freshman at a well-respected private university in the Southeastern part of the United States, where she has earned both a state-funded scholarship and a full academic scholarship from the university. When she is not away at school, Clara lives at home with both of her natural parents. She is White. Clara is the younger of two children; she has an older sister for whom she has great admiration. Her mother and father both hold bachelor's degrees. Her father works as a laboratory instructor at a local university while her mother works in human resources for a major corporation. Her family, as long as she has been a part, has always lived in the same area of the Southeastern part of the United States.

Clara's discussion of her schooling influences began with the first indication that she was exceptional. When she was in kindergarten she was tested for and placed in the gifted program. She credited this opportunity with her first exposure to critical thinking and logic. In the atmosphere of the gifted classroom, she "found joy in the logical process" that would later define her love of mathematics. Her mathematics experiences at this early age, however, "varied in both their level of thought and level of personal satisfaction" (Autobiography). In the third grade she was chosen, with two male

students, to be separated by their teacher for mathematics instruction. This opportunity opened Clara's eyes to the fact that she "had a gift for elementary mathematics" (Autobiography). The group received instruction that extended their opportunity to progress through the mathematics curriculum more quickly and at a deeper level. Clara indicated that this experience was the first time that she felt that she "was better at something than others." "The fact that the subject was math forever connected this feeling and mathematics" for her (Autobiography).

In the fourth grade, Clara was placed in an upper level mathematics course. This placement was the first time that students were separated for whole group instruction based on their perceived abilities. For Clara, this setting was a traditional mathematics class, though. She had no perception of what the other classes learned or how they were taught differently. This perception seems to have had little impact on her psyche with regard to learning mathematics. These years were the only two that mathematics was differentiated during her elementary school years. It is important to note, however, that it was during this time that Clara developed her immense sense of competitiveness. Through the accelerated reader program, she found herself in competition with a classmate. She calls both reading and the competition "obsessions." This characteristic has been long lasting; her competitive spirit is something that always stood out to me as one of Clara's teachers.

Clara's middle school years seem to have been instrumental in her continued development competitively. She, however, found herself "not particularly enthralled with math." At this point she realized her affection for her sister. As she wrote in her

autobiographical sketch, “I wanted to BE her.” As her sister’s degree and career choices centered on history and English, Clara found herself wanting to focus on the same subjects. “I didn’t hate math, but I didn’t love it either” (Autobiography). As far as mathematics was concerned, “what mattered most was the grade I earned in the course” (Autobiography).

At the middle school level Clara had been placed into an accelerated program for mathematics. This track resulted in Clara entering high school two full curricular years ahead of the traditional mathematics student. During her middle school years, however, she became a member of the math team. She joined the math team “because it was something that her sister had done” (Autobiography). She soon discovered, however, that “this was an outlet for my competitive spirit” (Autobiography). The math team also exposed her to people that would become her best and most influential friends. These two students, one male and one female, “became not only my confidantes but my strongest competitors” (Autobiography). “They drove me to improve my skills, mathematically and overall academically” (Autobiography). She stated that by the end of high school, “my urge to win, to beat my friends, had become an obsession” (Interview 1). While in middle school, her inability to do so on a regular basis coupled with the fact that she had just completed geometry (her least favorite course to that point) discouraged her from continuing with the math team when she entered high school.

Clara’s grades in middle school placed her in the accelerated honors track at the high school level. She thus took Honors Algebra II as a ninth grade student. As she describes it, Clara had a poor experience in this course. She felt that the standards for the

course, represented by the level of difficulty on tests and other assessments, was not met by the level of instruction or the difficulty of the daily assignments:

> I did not care for Algebra II. I thought the tests in that class were unfairly hard. I wasn't doing well. I actually brought my Dad and [my teacher] to the counselors to talk to her about my grade and how I thought she was a failing teacher. I felt the work she asked us to do for homework was too easy, and that she expected us to extend ourselves only on the tests (Autobiography).

This feeling resulted in Clara blaming the teacher for her difficulty in the course, her resentment of the teacher, and the development of malevolence toward the subject of mathematics: "I know I did hate her when I had her as a teacher, and by proxy also hated math" (Autobiography).

Her sophomore year, she states, was "the most important year to me." She emphasizes that much of this importance came from her development as a student and her rediscovery of her love for mathematics: "Sophomore year not only brought back my love of math, but also the most wonderful group of people I ever met… Sophomore year brought Analysis, Mr. Shildneck, and math team" (Autobiography). In the same way that she initially resented her best friends, she initially disliked me, the teacher she identified as being the most influential upon her high school experience. Clara was very comfortable being an exceptionally talented "traditional" student. She, like many standout students, had adapted her own way of ingesting information from her teachers and recounting, retelling, or reusing that information in ways that the teacher expected. She explains:

> I guess I have a trend of really hating things I eventually really love. It happened with [my friends] and Mr. Shildneck as well. I am fairly sure I told him to his face that I hated him at some point that year. This is

> probably directly related to the fact that the beginning of Analysis is an extension of Algebra II… and that Shildneck refused to teach it normally…. Over time though, I caught on to what Shildneck was actually trying to do, or so it seemed to me. Shildneck wasn't a lecturer–he was a real teacher. He taught us to teach ourselves, in the best possible way… To this day, I still remember the stuff from his class better than any other math I ever learned… It was the logic puzzles all over again–an answer found through a logical process (Interview 1).

As Clara indicates, upon entering her sophomore Analysis course with me, she found the class to be taught in a way that was different, not in her comfort zone. According to Clara, I "didn't really teach that much." The class was definitely not taught "in the traditional way." Over time, however, Clara "came to appreciate the time allotted for in-class problem solving and collaboration" (Autobiography). Clara "eventually saw this method leading me back towards the joy I felt in the gifted program when I developed my affection for logical and critical reasoning" (Autobiography). She also indicated that I influenced her to join the high school math team. Upon looking through her autobiography and notes from the interview, with regard to academics and specifically mathematics, joining the math team was "probably the most important choice" that Clara made while in high school. The math team allowed her to "fully realize [her] love and passion for mathematics and problem solving" (Interview 1). It also allowed her "to openly express [her] competitive spirit" (Autobiography). Her fellow teammates became her "school family; people that she could rely on both academically and emotionally" (Autobiography). A majority of Clara's most memorable moments from high school seems to have come from experiences with the math team. She openly credits math team with being "the main reason for loving mathematics the way I do" (Interview 1).

Clara's math team experiences seem to be the first time that she began to question whether there was a gender discrepancy in mathematics. She points out that "having grown up in a neighborhood with mostly boys and that a majority of my friends throughout school having also been male, I never realized that there were fewer girls pursuing mathematics in school at the same level as me" (Interview 1). When she began to go to mathematics competitions, however, she realized that "I was often one of only a handful, outside of my own team, which even brought girls to the competitions at all" (Interview 1). "The higher the level of competition," she noticed, "the fewer girls there were; until ultimately, at the state competition, I was one of only a handful of young women out of the several hundred in attendance" (Autobiography). Clara, however, having such a competitive streak, says "I took this as more of a challenge to keep excelling and earning my way back to those competitions, year after year" (Autobiography).

Clara continued to achieve in her mathematics curriculum after the Analysis course. Her junior year she earned an A in AP Calculus (also earning a score of 4 on the BC level exam). Although, she notes:

> [My teacher] was a very different teacher than Mr. Shildneck. She graded our homework and the class was completely lecture and note-taking… To go from one teaching style to the other was a bit of whiplash, especially in the homework department… But it worked too, in its own way. While Analysis was exploratory, Calculus was learned by rote. To me, it seemed similar to the way that math was taught in the past. I like Calculus, and I like [my teacher], but I feel that I was in the minority for that. Lots of people were struggling in the class—mostly girls from what I could tell… several others went to other teachers for help (Autobiography).

Her senior year she was credited with three mathematics units including AP Statistics (earning an A in the course and a 5 on the exam) and Multivariable Calculus and Linear Algebra, which she took from a major technical university. She earned an A in both of the college courses. Clara specifies, though, that "these courses were taught much more traditionally than was the Analysis course I took as a sophomore" (Autobiography). Teachers and professors again followed a specific routine "including lecture, question and answer, and homework" (Autobiography). "The expectations for these courses were the same as those in middle school; the content was simply more difficult" (Autobiography). She did, however, "have math team and the competitions to provide a place to simply enjoy math" (Interview 1).

Clara went on to further analyze how her teachers affected her academic achievement when she stated:

> As for the teacher affecting my academic career, I will be honest. My enjoyment of a class is directly related to how I feel about the teacher. When I had [my Algebra II teacher], who I did not like at the time, I hated math. When I had Mr. Shildneck and [my calculus and statistics teachers], I loved math. My dislike for [my physics teacher] influenced my dislike for physics. My dislike for my various French teachers was the cause of my dislike for the language…. I am a people person… It's no surprise to me that teachers change the way I view a subject. If they love it, if they want to share their love with me, I will have no problem connecting to them and loving it too. (Interview 1)

Clara also described a major difference between what she felt mathematics is and what mathematics is when taught in school. Mathematics, for Clara, "is a joyous undertaking." It is a subject "made up of problems and logical reasoning" (Interview 1). "In the real world," to Clara, "there are all types of problems to be solved. Each solution has a logical progression that is fun to work through. That is what math is" (Interview 1).

School mathematics on the other hand "is about developing skills within the context of what the teacher (or other decision makers) feels important to know. School mathematics is about playing the game and earning the grade" (Interview 1). Clara did indicate that her initial experiences in the mathematics curriculum at her university have been positive. These experiences include an opportunity to act as a student instructor for the introductory calculus course. This position has allowed her to interact with other mathematics students and develop relationships with the instructors that seem to have lead to a continued positive feeling towards the subject. Interestingly, as a result of her love of investigation, classic literature, history, and acquiring general knowledge, Clara is pursuing a degree in Library Sciences. She is, however, considering pursuit of a minor in mathematics.

Samantha's Story

Samantha is an actuarial science major in the honors program at a large state university in the Southeastern United States. She is originally from the area where she attended elementary, middle, and high school. She attends college within the same state. Samantha is White. Throughout her high school years she lived with her mother, step-father, and younger step-sister. She has an older brother as well. Both of her parents work. Her mother is a medical coder and her step father is the manager of a warehouse. Both of Samantha's parents went to college, but neither received a four-year degree.

Samantha's education, specifically in mathematics, began with her parents before she ever had any formal schooling. She recalled being taught how to add and subtract by playing games with her parents. "When I was four, my parents began teaching me to add

and subtract by giving and taking away M&Ms" (Autobiography). Upon entering first grade, her older brother continued to advance her arithmetic skills. "In first grade my brother taught me multiplication because he wanted me to be smarter than my classmates" (Autobiography). From this time on, she began to feel that mathematically, she "was always more advanced than most of her classmates" (Autobiography). In second grade she was tested for the gifted program and accepted. She believes that the methods used in the gifted courses forced her to start thinking "outside the box." This opportunity, she believes, was one of "the most important influences in becoming an adept problem solver" (Interview 1). The program "forced me to start thinking outside the box at an early age" (Autobiography). She "enjoyed the logic problems and critical thinking exercises that were used" to advance her problem solving skills.

Unlike Farah and Clara, Samantha spoke little about her formative years in elementary and middle school with the exception of mentioning that as she grew up, she took up dance because it was a creative and artsy outlet for her. She continued, "As I grew up, I developed a sense that girls were creative and artsy while boys were scientific and analytic" (Autobiography). She mentioned that "while in middle school, I thought that I shouldn't join the math team because only boys participated in it" (Interview 1). As she began high school, this trend seemed to be reinforced for Samantha. She found herself "assigned to and participating in committees, made up primarily of girls who organized bulletin boards and posters for clubs and organizations" (Autobiography). Although she felt that she was talented mathematically, she "continued to resist participating on math team, until some of my math teachers finally convinced me to try

it" (Autobiography). She stated that she noticed a majority of students who participated in the math competitions were male. But, by the time she had begun to participate she no longer felt out of place. Instead, "it made me want to prove myself" (Interview 1).

Samantha indicated that the math team gave "an opportunity to hone my analytic and mathematics skills further" (Autobiography). It also gave her "a place to enjoy the challenge of mathematics without the fear of it impacting grades" (Autobiography). Samantha's teachers (including me) that had recognized her potential and began to encourage her to take on this challenge "also boosted my confidence and made me want to achieve even more [academically]" (Autobiography). She also credits her involvement with math team with her "ability to develop advanced problem solving techniques and mathematical skill beyond that of the typical student" (Autobiography). Furthermore, she states that this participation directly resulted in her earning a perfect 800 on the mathematics portion of the SAT.

Having known Samantha for several years as both a teacher and coach, I was extremely surprised at one specific characteristic that she continued to speak about throughout the first interview. I had always thought of Samantha as a quiet, smiling, soft spoken, kind hearted, helpful young lady that sat in the back of the room and did everything that was asked of her. Her work ethic was always impeccable and her insights in the classroom enlightening. The one thing that I never noticed about her was how competitive she was. She hid this aspect of her personality underneath a kind and demure exterior. Throughout our conversations, she continually recalled how she was motivated to be one of the top members of math team. She was proud of the fact that she "took

positions away from other students that were perceived as having a mathematical gift (typically boys), while she quietly toiled away on her work to earn her grade" (Interview 1). She was not a bragger, like many of her classmates, although to me, she was obviously mathematically talented.

She indicates that she might have begun to develop this competitive streak by competing with her older brother when she was young; however, she cannot pinpoint any details other than sibling rivalry. She was able to disguise her competitiveness throughout the years when she was involved in the stereotypical female activities as described earlier. Samantha, however, was given opportunities to re-develop her competitive edge upon entering high school. She gave much of the credit for her success and advancement through upper-level mathematics to her competitive spirit. Mathematics was an area of study where she not only could compete with the subject matter but also with others. For Samantha, there was a measurable quality to the successes that she had in mathematics. She was able to take on a challenge and master it. She was able to participate in competitions. She was able to take the highest level classes and be successful (she earned an A and a B in AP Calculus and a 3 on the exam). And then, to prove the teacher who gave her the only B she ever earned in mathematics wrong, she went to college and earned 100s in each of her subsequent mathematics courses. Furthermore, Samantha is earning a mathematically oriented degree, in actuarial science. She plans to either double major or minor in mathematics or statistics.

Sophia's Story

Sophia is a freshman at a prestigious private university in the Southwestern part of the United States. She is majoring in History and Anthropology. She intends on pursuing a graduate degree and pursuing a career in the academy. As for her reason for choosing these areas, she answers "simply intellectual interest" (Interview 1). Sophia describes herself as White-Latin American. She is originally from Brazil and as a result speaks multiple languages. Her immediate family consists of her mother and step-father, a mixed "race" couple, and four younger sisters. Sophia's biological father, who still lives in Brazil, is the only parent of a participant with a graduate degree (a doctorate in medicine). Sophia has moved several times and thus has the most diverse schooling experiences, having attended school in both Brazil and multiple parts of the United States.

Sophia's early schooling experiences are by far the most intriguing. She was brought up in a country where the public school system was extremely limited. Most children, as she did, attended private schools. Schools in her area "were very open to instructional method and very influenced by the constructivist movement" (Autobiography). For Sophia, constructivism centers about learning through exploration and experience, and following ones curiosity: "Throughout my early education, my family contributed immensely to my success by exposing me to different places, activities and cultures, and encouraging my curiosity… In general, the environment I grew up in and the constructivist method that guided my elementary education complemented each other very well" (Autobiography). According to Sophia, these

constructivist methods “spurred curiosity and encouraged students to explore different subjects” (Autobiography). Sophia said that the most important aspect of the schools that she attended “was that the focus was on learning, not on earning grades as it is in the United States” (Autobiography).

This philosophy of education lends itself, according to Sophia, to a greater enjoyment of learning. She goes on to state:

> I think constructivism and its lack of emphasis in measurement imparted to me the “learning for knowledge’s sake” philosophy that I maintain to this day; otherwise, I might have decided to pursue a “useful” field of study like engineering. I believe that such a philosophy is advantageous in that it makes for a happier mind. (Interview 1)

Another difference that Sophia noted between the schools she attended in Brazil and in the United States was that the “relationships between students, teachers, parents, and administrators [in Brazil] were much less formal than in the United States” (Autobiography). Teachers and administrators at her schools in Brazil were seen as “human.” “Teachers were able to relate to students and parents on an interpersonal level in and out of the school setting” (Autobiography). According to Sophia, this characteristic further encouraged students to take chances in their learning, as they always felt supported by their instructors. Sophia and her mother had one special relationship that is worth mentioning. Sophia and her mother were close enough with Sophia’s principal that they spent a summer with the principal and her family at the beach. During this vacation, Sophia had the opportunity to not only swim and play but also to work on her reading skills with her principal’s father, Paulo Freire. Needless to say, Sophia had a unique and special schooling experience when she was young.

Sophia's move to the United States in the fifth grade required multiple adjustments to her expectations of schooling. First, she was required to use a new language, English. Luckily she had a 4-year head start on developing that skill. Her new school system tested her to determine whether she needed to be enrolled in English as a Second Language courses. They concluded that Sophia was "a fifth-grade aged girl who was reading and writing [English] at the eighth-grade level." Thus, she was placed in a traditional fifth grade classroom. Second, "the constructivist and experiential type of learning that I had grown accustomed to was replaced by a lecture-practice format that seems to be so prevalent in American schools" (Autobiography). For mathematics, this change included "an adjustment to using and relying on calculators on a regular basis" (Autobiography). She rapidly acquired these new skills, however, and excelled in the new style of American education. A year later, she was introduced to "another foreign concept"– advanced/honors courses. She had excelled to the point where she was recommended to take the more accelerated versions of her sixth-grade courses. She was surprised by the emphasis on separating students, as "tracking" was not done within the structure of her Brazilian constructivist schools.

After moving to another state, in the eighth grade she was tested to see if she would qualify for gifted services. She was accepted and placed into the program for gifted students:

> I was distraught at how standardized tests were the assessment required for being placed in this sort of program. In Brazil, all students [in her private schools] are required to take the same classes no matter what. In a way, that was instrumental in motivating me to learn independently and pursue my own interests and passions on my own and beyond the classroom. (Autobiography)

According to Sophia's mother, "Fatima Freire (her first principal) told my mother that she could either place me in a school for gifted children or let me have a normal childhood" (Autobiography). According to Sophia, "gifted education in Brazil is limited to schools so small and marginal that attending them is practically synonymous with being socially deprived" (Interview 1). Thus, Sophia doesn't seem to recall any specific impact the gifted program might have had on her learning of mathematics. She readily points to "my early constructivist opportunities and independent explorations" as they "opened her eyes to the same opportunities to develop analytic skills as the gifted program.

During this time, she became particularly close to two teachers–me, her mathematics teacher, and her Latin instructor. She points to our "humor and genuine interest in and enthusiasm for the subjects we taught" as the primary reasons why we appealed to her. Sophia indicated that our courses were "challenging and engaged my desire for inquiry" (Autobiography). The lessons that we presented "instilled a need to study further outside of the classroom." During high school, she says, these "same sorts of teachers impacted my education most" (Autobiography).

In high school she had been recommended to take honors-level mathematics. She began with honors geometry in the ninth grade. Sophia states "three of the four years I was in high school I had exceptional teachers. My geometry teacher and my Analysis teacher (me) both based much of how they instructed in constructivist methods" (Autobiography). These methods greatly appealed to Sophia's preferred method of learning. Her geometry teacher also convinced her to join the math team, which in time

> became as integral part of my education as any math class. Through my experiences with the math team I developed the ability to think creatively in a subject that is considered strictly objective. This ability greatly contributed to my success in my math classes. (Autobiography)

She also appreciated the "lack of focus on winning" that her school's math team had. "This attitude," she states, "was passed down by our coach [me]." Sophia indicates that our relationship was more than simply a teacher and coach but she also considered me "a mentor." My belief that the purpose of the math team at our school was to allow students to "try out different things" and "have fun with math," as Sophia put it, was integral in students connecting with mathematics in a different way (Interview 1). "The focus," as Sophia understood it, "was not on winning tournaments, but in giving students the opportunity to develop their mathematic and analytic mind" (Autobiography). The diverse group of students did have their competitive side, though. Some were competitive with other schools, some with each other, and others, like Sophia, were immensely competitive with themselves. Sophia was impacted by her experiences with the math team as they gave her "an opportunity to develop a social network," a collaborative, in which she could engage for the purpose of self-improvement. Through these relationships, the discussions, the problem solving, and the competitions, Sophia "developed new ways of thinking that not only helped me in my math courses, but will continue to help me throughout the remainder of my academic career [in anthropology and history]" (Interview 1).

Data Organization

My interpretations of the participants' personal histories display the individuality that characterizes this group of young women. Although each of these women were

highly successful (as defined earlier) in their secondary mathematics education, their revelations confirmed that they were each complex and unique. Although it is true that each of the participants had attended the same high school, only two were of the same graduating class. Thus, the only characteristics that were consistent among the group were that each had been a successful female mathematics student (within the same physical school location). Their backgrounds, familial and cultural, as well as their schooling and mathematics experiences varied from one participant to another (see Table 2 for a summary of the participants' self-descriptions). Furthermore, when the context of two or more participants' experiences were the same (in setting), the reported impact of that experience (if reported by both) were often dissimilar. As a result, the participants' data are not presented as independent from one another. Rather, they are presented here, together, as a composition of young women whose achievement outcomes were similar regardless of their means of success. By presenting the data in this way I intend to exhibit the ways in which the participants' histories regarding their education, experiences in mathematics, and their successes, are similar and how they are different. In cases where the participants' reporting of a factor (or set of factors) is found within the recollections of multiple participants (regardless of similarity), I have chosen to share each of their perspectives. My aim in doing so is to illustrate that each participant's experiences were unique in both context and personal meaning. It is through these situated understandings that each participant developed their knowledge of mathematics and ability to negotiate their struggles within the secondary mathematics curriculum successfully.

The data that follows has been categorized to relate to specific research questions. The data collected indicated that the factors that the participants attribute their success to

Table 2

Data from Participants' Self-Descriptions

Participant	Ethnicity/ Nationality	Family Background; Socioeconomic Status	High School Extracurricular Activities	Undergraduate (Intended) Major
Farah	Black/ Nigerian	Father, mother, one older brother; Middle class	Dance Team, Math Team, Academic Honor Societies	Biomedical Engineering, Pharmacology
Clara	White	Father, mother, one older sister; Middle class	Math Team, Model UN Color Guard Academic Honor Societies	Classics and Library Science
Samantha	White	Mother, step-father, one older brother, one younger step-sister; Middle class	Math Team, , Dance Church, Choir, Academic Honor Societies	Actuarial Sciences
Sophia	White-Latin American	Mother, step-father, four younger sisters; Lower-middle class	Junior Classical League, Math Team, Drama Club, Cultural Diversity Club, Chorus, Academic Honor Societies	History and Anthropology

directly related to their understanding of their personal successes. As such, the initial summary details not only the participants' definitions of success but also the factors that participants point to enabling their achievements. The second summary addresses the perceived impact gender had on the participants' mathematics education. Following each summary, an analysis of the data collected with regard to the specific research question is provided.

Contemplating Success

The discussion that follows shows that the participants' understandings of their success in secondary mathematics differed based on their personal beliefs as to what it meant to have succeeded. Their perspectives, as reported through the data, indicate that they defined success in terms that were both personally meaningful and meaningful for those who they perceived had the greatest influences on their lives. These definitions of success and achievement provided tools for creating goals, measuring accomplishments, and for motivation. The reflections regarding success that were shared by the participants provided an appropriate context for analyzing the balance of the data.

Defining Success

Farah, who identified herself as a very competitive student (and person in general), surprisingly defined success as "waking up in the morning, looking at yourself in the mirror and knowing that you've done what you wanted to do in your life" (Interview 1). For Farah, success is about "leaving a mark, something that makes the world better. If I did something for someone, or if I did something to better someone's life, then I will have been successful" (Interview 1). Questioning Farah about school and

mathematics, she also reassessed her outlook on success. She believes that success in mathematics "isn't just about the grade. It's about knowing; being able to use what you have been taught" (Interview 1). Toward the end of our discussion about success in school and mathematics, though, her competitive side came out. Referring back to her competitiveness in school she stated, "A lot of it had to do with being a Black female standing amongst a bunch of White and Asian males accepting awards [for mathematics and science]" (Interview 1). This aspect was extremely important to her. She stood out amongst her successful peers, most of which were male and few of which were Black. She felt, as a result, that she was special and believed that she represented what others that look like her could accomplish. For Farah, success seemed to have a lot to do with being a role model for other young Black women.

Clara was adamant that one's success could only be measured in comparison to others. For her, "it's all competitive. It matters that you outperform others, that you are the best at something" (Interview 1). In mathematics, Clara felt that competition meant you were able to show that you knew more and could solve problems better than others. Thus, within the school setting success was measured by grades and test scores. For Clara, having had the highest SAT score in her graduating class, as well as having (*only)* been the salutatorian, were extremely important to her measure of her success in high school. Interestingly, she added that earning the respect of her teachers was also important for her personal definition of success. This respect, she argued, was earned by having a genuine interest in the subject and by putting forth your best effort. By doing so, she believed, you earned the favor of the teacher or professor. In a sense, however, one

could argue that earning the favor of the teacher was also another competition that she created in comparison with her classmates.

Samantha believes, first of all, that success is different for everyone. For herself, success is measured by how happy you are with what you have accomplished and what you are doing. Samantha feels that "you must feel that you are doing something with your life" (Interview 1). When I asked her directly about success within mathematics, however, her answers changed. "For mathematics," she said, "it is more competitive" (Interview 1). Within mathematics classes Samantha finds it extremely important to get the best grades. She says that she works harder in those classes to ensure that she has the best possible grades and that she is among the top in her class. Within the school setting it is about earning As. Looking now at Samantha, pursuing a degree related to mathematics, I can see how her passion for the subject brings forth her sense of competition when it comes to defining success.

Drawing from her philosophy on competition, Sophia defined success as "being satisfied with one's own accomplishments—not in relation to other people" (Interview 1). For mathematics she translated this belief into the comprehension and appreciation of the subject. She stated that success in mathematics, for her, was being satisfied with her personal understanding of mathematics. For this reason, she held a personal belief that grades and test scores did not matter (other than being allowed to move on to the next level of tasks and accomplishments). During the first interview, Sophia argued, "test scores and grades serve their purpose, they did their job" (getting her into a respected university and being award scholarships) (Interview 1). As far as personal satisfaction

was concerned, however, Sophia believed that she only had to be personally satisfied with her ability to use what she has learned as she went forth and did not concern herself with how her scores or grades compared to those earned by her peers.

Sociocultural Factors Attributing to Success – Participant Reflections

As Farah discussed her achievement in secondary mathematics, she expressed the importance of several key factors that she believed led to her success. First, Farah identified the importance of her family's expectations and their influence on her attitude toward education. Farah's extended family is made up of a group of people that seem to be very influential on one another. As much of her family continues to live in Nigeria, it is not uncommon for family members still living in Nigeria to come to the United States to share in celebrations of accomplishment. It is this familial setting that Farah credits with her opportunities to develop both as a student and conscientious human being.

Farah's parents are also both successful professionals with college degrees. Her father has a Master of Public Administration (MPA) degree and a Bachelor's degree in chemical engineering. At the time of the study, he was a financial advisor. Her mother has a Master of Business Administration (MBA) and owns her own business. Their personal success and expectations have been observed by Farah throughout her life. Thus, her family, specifically her parents not only provided a safe and nurturing environment, but also leadership and mentoring from which she developed a self-awareness of what she should expect for and from herself.

Furthermore, Farah is the younger of two children. Her older brother progressed successfully through school, often taking the same courses that Farah would take a year

later. As such, she had the opportunity to observe a role model for how to successfully negotiate the curriculum throughout her schooling experiences. While she did not directly attribute this opportunity to her success, I believe that it must have accounted for, to some degree, her ability to negotiate difficult courses, including mathematics.

Second, Farah explained how her early learning experiences in Nigerian schools impacted her future efforts in her U.S. high schools. Farah's opportunity to experience schools outside of the United States seems to have had a significant impact on her as a student and a learner. As her family placed her into formal schools at a much earlier age than her peers, her early schooling experiences in Nigeria forced her to develop a sense of independence at a very early age. Furthermore, by maintaining extremely high expectations while remaining removed from students outside of the classroom, her teachers created an atmosphere in which students were forced to adapt their own methods of learning in ways that enabled them to become independent (and thus investigative) learners. Through these experiences, Farah learned to be self-motivated and how to ask herself what she really wanted to learn. As she progressed through school, both in Nigeria and in the United States, she also began to focus on what grades, scores, and measures of success were important and satisfactory for her. These developments might not have cultivated if her family had not chosen to place her in school at such an early age nor if her teachers had not required her to become independent in both thought and motivation. It is likely that these educational traits would not have been stimulated at this level, and in particularly at such an early age, if she had attended schools solely within a U. S. school system.

Third, Farah credits the influence of several of her high school teachers. Within each of the different methods of data collection, Farah identified a group of teachers that she believed had the greatest impact on her success in mathematics while in high school. The first group of three teachers that she identified she labeled as “mother figures”; women that had her “best interest at heart.” This group included the teacher that first encouraged and enabled her to pursue upper-level mathematics. Farah stated that this group of women made her want to work hard so that she would live up to the potential that those teachers saw in her, because she did not want to let those teachers down. Farah also spoke about me having impacted her mathematics achievement. My “tough love,” as she termed it, pushed her to “cross any boundary that she had set for herself.” By using the term “tough love,” Farah indicated that she knew that while I “always demanded excellence from her” as a student that I was also “supportive and “there to help” when she faltered. She went on to state that my belief in her “created a self-awareness … that she could achieve in mathematics at the highest level” (Interview 1).

A topic that naturally followed from the influences of Farah’s teachers is how she thought about mathematics. First, Farah’s opinions about the idea of mathematics and the mathematics she learned in school differed. In her opinion, the mathematics done in the classroom was typically boring and straight forward. This sort of mathematics was all about developing a required set of skills that one must prove they know in order to move on to the next course. In this way, the mathematics of the classroom was simply about making grades and moving on to the next level.

Alternatively, however, for Farah, “real mathematics” was a way of thinking, the ideas and thought processes that went into solving problems. These skills, she believed, were applicable to other subject areas as well as “real life.” She identified mathematics as something that she enjoyed doing. In this way, Farah saw mathematics as both a set of skills and as a game. “Real math is fun,” Farah shared. She went on to describe the mathematics that she enjoyed as being the mathematics that she did as part of her mathematics competitions with the math team. These problems, she indicated, were high level and thus required a different level of thought. She described the problems that were presented at these competitions as being very different than those presented in the classroom setting. Rather, these problems required her to logically apply previously learned skills and even develop innovative ways to implement those skills to solve them.

Upon leaving high school, Farah found that the college classroom setting continued the same pattern for learning mathematics as the secondary classroom. While her intended major required only a sampling of upper-level college mathematics courses, she had at one time thought about pursuing mathematics further, maybe as a minor. She chose not to, however, as a result of the lack of enjoyment she had within the classroom setting.

A fifth factor that Farah identified as having impacted her success was her sense of competitiveness. Farah, throughout the process, identified instances where she was competing with either herself or someone else. First, Farah indicated how her early schooling experiences while in Nigeria required her to develop into a competitive student. The three-track system of education employed by her elementary school in

Nigeria required students that wanted the best opportunities to compete for the top 30 spots in their grade level. Her understanding, even at such an early age, of the impact of this system led her to develop an awareness of her rank among her peers. In this way, she was in constant competition to remain in the "upper group" of students so that she had the better teachers and better learning experiences that were provided for students at the school.

Second, having an older brother that was also a successful student made her compete with him in a sort of natural sibling rivalry. While she indicated that she and her brother are very close emotionally, they have always tried to best each other in school. Thus, Farah had two experiences that began at an early age that helped to spawn her competitive spirit.

Upon entering her sophomore year in the United States, Farah was encouraged to join the math team at her school. As the sponsor of a new competitive academic team, my expectations were that my students, as a team, would perform as well as they naturally could. I did not expect them to excel and compete with other teams or individuals that had been participating and/or practicing with math teams for several years. Farah, however, developed rivalries with her teammates that spawned success for both herself and other members of the team. Ultimately, she, along with her teammates, became more competitive with schools local to their own. Farah was very open about wanting to beat her friends, almost all of which were male, as well as wanting to place high enough to win awards. Farah's goal-oriented academic personality, she believed, was spurred by her competitive edge.

Clara also described the important impact that her family had on her efforts to achieve academically. As Clara had an academically successful older sister who had won numerous accolades throughout her schooling career, Clara had an in-home role model from which she could learn what it meant to achieve at a high level. Furthermore, her admiration for her sister was so resolute that Clara said at one point, "I wanted to BE her." As a result, throughout her schooling career, Clara chose to follow in her sister's footsteps:

> I was like when I really did like hero worship my sister, was when she was good at math and so when I got up to middle or when I got into middle school I was like, "my sister's good at math, she was on math team, so I'm going to do math team too!" because I wanted to do everything she did. And so without her being good at math in the beginning and so me wanting to be good at math and without her being on math team and me wanting to be on math team, I don't feel like I would have even paid much attention to math when I was…when I was little. (Interview 1)

This decision included choosing to take the same upper-level courses and participating in the same extracurricular activities. Thus, having this role model, in a way, paved a path that Clara could follow towards a successful academic career if she so chose.

Clara coupled the influence that her sister had on her education with the fact that both of her parents were academically successful, and had helped mentor their elder daughter through a similar educational path. This mentoring, Clara believed, gave her ample familial support to achieve academically. Her mother, having majored in mathematics in college, understood the difficulties that young women could possibly face in their mathematics and science educations. Having negotiated this space successfully herself, Clara's mother also provided support from which Clara could call upon during difficult experiences. Furthermore, her mother might have been able to help guide Clara

in ways that enabled her to avoid many difficulties in mathematics that other young women may have encountered. Interestingly, Clara mentions, she never knew that her mother had majored in mathematics until she began to discuss her experiences for this process with her family. Thus, any such attempts by her mother to help Clara negotiate the mathematics domain throughout her school experiences would have been disguised, at least to the extent of mathematics knowledge.

While it remains undetermined whether Clara's mother helped her in these ways (intentionally or unintentionally), there is no doubt that Clara's family experiences impacted her in ways that lead her towards an academically successful career. Most of all, Clara drew upon her sister's previous experiences as a guide and as motivation for her own success:

> I wanted to be competitive with my sister so you know everything she did I wanted to do too, or better. Because I didn't want to be 'oh the little sister' who is inferior, you know, I wanted to be as good as my sister and surpass her. And so I did. I got better grades than her and I got a better scholarship than her. (Interview 1)

As her sister had also successfully negotiated the mathematics curriculum and extracurricular activities (such as math team), she was shown a method that could be employed, and maybe even improved upon, that might provide Clara the opportunity to achieve in much the same way.

Clara spoke extensively about the gifted program in her elementary school. The opportunities this program afforded her to experience education differently seems to have greatly impacted her attitude towards learning and mathematics. From within this setting, she began to understand how logic could be used to solve problems in all contexts. In

fact, much of the gifted curriculum she said dealt with using logic and solving puzzles. She alluded to the fact that being included in this pull-out program gave her the opportunity to investigate, analyze, and critically reason about problems. This experience, in turn, greatly influenced the way that she later approached problems, especially in mathematics, in her mathematics courses. In fact, she further indicated that her passion for this type of learning is what led to her initial affection for mathematics as a subject of study (although she admits that her passion at one point subsided as a result of boredom in the classroom and dislike of specific teachers).

Clara credited one specific teacher with her re-discovery of the joy of mathematics. Throughout middle school Clara had become bored with the mathematics that was taught in the classroom. Once outside of the gifted program in elementary school, she found the mathematics that was taught to be rote memorization. The logical puzzle solving that she had long connected with was gone. At that point, mathematics became a class that must be taken in order to move on to the next course. Furthermore, upon entering her freshman year in high school, Clara encountered a class and teacher experience that turned her off from mathematics entirely. Not only did she no longer enjoy the mathematics, but the teacher's methods did not meet Clara's expectations. At this point, she had not only become discontented with her mathematics teachers and their methods but also, as a result, had come to dislike the subject.

When she began her sophomore Analysis class she was enrolled in my class. Her poor attitude towards mathematics was in no way encouraged by my teaching style, at least not at the beginning of the year. I, she stated, "taught differently" than any other

mathematics teacher to whose class she was assigned. At first resistant to my methods, she soon recognized that the fact that I provided her with opportunities to develop her own sense of not only mathematics but also encouraged her to investigate mathematical topics outside of the typical classroom setting. By incorporating projects and encouraging her to participate on math team, she says, I helped her to once again find mathematics an enjoyable and intriguing subject.

As a result of her gifted experiences as well as the influence that her mathematics experiences with me provided, Clara had developed very different definitions for what she termed “real mathematics” and “school mathematics” (Interview 1). For Clara, school mathematics was a rote exercise in which information or skills were transferred from the teacher to the student. Within this process, the accuracy of this transference was judged, primarily by tests, and a grade was earned. The purpose of school mathematics was to achieve such a grade so as to complete a task towards graduation. Clara shared her disillusionment with this style of learning of mathematics. For her, school mathematics was important, but only in so far as what grade was earned and how that grade impacted her future in ways such as college acceptance and scholarship opportunities.

When speaking about the “real mathematics” that she enjoyed, she often used the term logic to describe the processes involved. Logic, for her, played in integral role in the development of mathematics as she understood. “Real mathematics” was “fun.” The fun resulted, for Clara, from participating in the logical processes and critical reasoning required to solve high-level, difficult problems. Mathematics was about problem solving, whether those problems were given in the classroom, come across outside of school,

presented in other curricular contexts, or as parts of mathematics competitions. For Clara, real mathematics was not simply about receiving information or developing skills; it was about using that information and those skills to do something, in particular solve problems using some sort of logic.

The sense that mathematics was something you do, not something you are given by a teacher, was enforced by her participation on math team. The math team, as it was discussed by Clara, seems to have provided an outlet in which she could enjoy the challenge of mathematics without the fear of having to be successful in terms of grades. This arena for mathematics, then, allowed her to experience the joy of doing mathematics for the sake of "fun" rather than the monotony of the typical classroom experience. These extracurricular experiences seem to continue to play an integral role in Clara's love for mathematics as she currently is working for the mathematics department of her university as a student instructor. Furthermore, these enjoyable mathematics experiences seem to have positively impacted Clara's attempts to achieve within mathematics during her high school campaign.

Finally, Clara described herself as extremely competitive. In fact, she indicated that she had an almost constant need to compete when it came to academics. By comparing herself against her classmates, she found ways in which she could motivate herself to achieve, both academically and extracurricularly. Her competitive personality seems to have begun to develop early in her life as she compared herself to her older sister. As a result of her great admiration, she continually compared her own accomplishments to those of her sister.

In an effort to further replicate her sister's achievements, she chose to join the math team while in middle school as her sister had done. Through this activity, Clara's inner competitiveness was further developed. She developed a rivalry with another female student that had been given an opportunity to progress further in the mathematics curriculum than Clara. Clara referred to this young woman, who was now a full year ahead of Clara in mathematics, as her "rival and enemy." For Clara, this meant that she was now "second place" in mathematics at her middle school, an experience that she had never felt. Over the course of the year, particularly in other classes, Clara and this other student became friends, especially after each was chosen as alternates for the state middle school math team while in sixth grade. Upon entering seventh grade, a young man joined their class who was also a full year ahead of Clara in the mathematics curriculum. She was now ranked her, in her mind, in third place. This young man, Clara states, "was made to be an antagonist for me" (Autobiography). As such, he was "a marker against which I could judge myself" (Autobiography). She goes on to explain that she spent "the remainder of my middle and high school careers" attempting to "beat [him]" (Autobiography). It became an obsession.

Needless to say, Clara's focus on competition was s focal point for motivation, especially in mathematics, a subject that she had developed a passion for. While she might have achieved otherwise, this motivation was a tool from which she could find ways to focus on her education and learning. At different points of the sharing process, she described instances in which she felt that she was not successful. Her pride, a direct result of her competitiveness, was damaged during these experiences. One such example,

when she was cut from the middle school state math team squad as an eighth grader, discouraged her from joining the math team her freshman year in high school. The experience, she explains, did motivate her to show those who had made that choice their mistake by outperforming the members of the team while in the classroom setting. Thus, even through her trials and failures, she drew upon her competitive streak, which she says was "a mile wide," to propel herself into future successes.

At the outset of the research process Samantha stated that "my family definitely pushed me academically" (Interview 1). As she further explained in her story, her parents began teaching her basic mathematics by giving and taking away M&M candies when she was 4 years old. Later, when she was in fourth grade, her older brother began teaching her multiplication because he wanted here "to be smarter" than her classmates. She also began to develop her competitive edge as a result of her relationship with her brother:

> I had an older brother so everything was really a competition growing up… whoever could eat breakfast the fastest, brush their teeth the fastest, and such… I was raised in a very competitive environment and it just kind of stuck. (Interview 1)

Samantha's parents also encouraged academic advancement as a source of in-home activities. They continually gave her workbooks to work through. Upon completing tasks from these workbooks, she was always rewarded with treats. In this way, learning became a game that ultimately she continued to enjoy without the treats. As a result, Samantha states, "I was ahead of my grade in math from the beginning."

Besides the opportunities that were provided by her parents and her brother, Samantha was also afforded an important learning opportunity by her elementary school.

By being placed in the gifted program of her school, she was forced to think differently about all types of problems. Samantha said that the focus of this program centered on logic and problem solving. By doing so, the program promoted "outside-the-box" thinking. Furthermore, the type of problems and projects that were encouraged compelled students to begin developing the analytic and critical reasoning skills that she would later use in her upper-level mathematics courses. She identified this opportunity as integral to not only her development of these skills but also to her ability to recognize her mathematical talent. The impact of this recognition was long standing as she had an established a sense that girls were "creative and artsy." This early experience, for Samantha, was her first personal awareness that she might be different than what she had learned would be expected of girls in school. While she did not apply this understanding outwardly until high school, she, at this early stage, had begun to develop her "sense of self" as a mathematics student.

Once in high school, Samantha's mathematics experiences were greatly impacted by those who had the opportunity to teach her. This set of teachers, she believed, motivated her to better herself in both the mathematics classroom and in mathematics competitions. Samantha believed that when these teachers shared their belief in her potential it "gave [her] the confidence and the boost she needed to try harder in school [mathematics]" (Interview 1). In particular, Samantha singled out two teachers who took the time to "encourage and push" her "further than any others before or since" (Interview 1). The first of these teachers was the woman who first encouraged her to join the math team. This teacher had taught her both Honors Geometry and Honors Algebra II.

Through these classroom experiences, Samantha further recognized her mathematical ability and came to recognize her opportunity to achieve within the field. By joining the math team, Samantha began to see the joy of mathematics outside the classroom. The focus on problem solving and critical thinking allowed her to develop a different sense of mathematics, one in which grades were not the measure of accomplishment. In this setting, mathematics was done for enjoyment, with no danger of academic failure.

Samantha also identified me as the second of these teachers. She said that I provided her with a classroom opportunity within which she could continue to grow, not only in mathematics skills but also as a problem solver. This opportunity, along with my sponsorship of the math team, provided her a setting in which she could flourish and continue to develop her analytic skills.

The teachers she identified (including me) she stated, at the time "thought highly, possibly too highly of me, but that made me try harder and harder in my classes and outside of class at math team" (Autobiography). Thus, in these ways, this pair of teachers, "opened my eyes to mathematics outside of the classroom"; she believed these teachers to be a primary reason that she was so successful within mathematics at the secondary level. Furthermore, chose to pursue a mathematically related degree and career.

When discussing the subject of mathematics, Samantha typically spoke in terms of the mathematics that is taught within the context of the classroom. This classroom mathematics, as she described it, was the stereotypical subject that people disliked. As she put it, even in her college courses, "when you bring up math, people cringe" (Interview 1). She went on to say, "People either like it or they don't. And, most people

don't" (Interview 1). She further explained that she believed it had a great deal to do with the fact that the subject of mathematics (which I call school mathematics) deals with definite answers. From this viewpoint, people have no room for error. There is a right answer and if you do not get it, you are wrong. It is these aspects of school mathematics that Samantha believes turns people away from the school subject; therefore, they never learn the enjoyment of the field.

Samantha goes on to contrast this typical version of mathematics with mathematics, both the academic subject and the field, she enjoyed. She described the difference, for her, by comparing how one solves problems in mathematics, as a whole, and in mathematics, the school subject. As opposed to the academic subject where you are typically restricted to a specific set of skills that must be used as proof of your knowledge, she explained, "you have the freedom to use whatever you want to solve the problem" (Interview 1). She later described how the two fit together for her. By understanding the purpose of the academic subject, classroom mathematics provided her an opportunity to learn and develop mathematics skills that she could use to do mathematics. This classroom mathematics and the addition of the logic and analytical mathematical processes that she developed in her elementary gifted program combined to provide her a basis for future problem–solving endeavors in the field of mathematics. The opportunities provided by the math team helped her to further realize her potential to succeed in doing mathematics.

Samantha, like Farah and Clara, described herself as extremely competitive. She stated that upon joining the math team, where competition was expected, she found

herself to be conscious of the fact that she wanted to outperform her teammates (and others), especially the boys. While other members of her team were openly competitive with each other and their classmates, Samantha disguised her competitive attitude. Instead, she chose to simply "do what was expected of a good mathematics student" while in the classroom and to focus on her advanced preparation privately. Thus, while outwardly presenting herself as having a strictly personal focus on success, improving throughout, and providing herself with the best opportunities for her future endeavors, inwardly, she was toiling in an effort to be ranked ahead of others both in the classroom and on the math team. This sense of competitiveness, particular to mathematics, for Samantha, provided another instrument that she could use as a motivational aid.

Sophia's family, unlike the other participants, has changed in numerous ways over the course of her life. She was born in Brazil to parents who both had college degrees. Her father is a doctor of medicine. Throughout her early life in Brazil, Sophia explains that her parents "contributed immensely" to her success. By exposing her to different places, activities, and cultures, and by providing opportunities that spurred her curiosity, they created a setting in which she wanted to learn.

When Sophia was 5 years old, her parents went through a bitter divorce. According to Sophia, the divorce did not directly impact her education. Both of her parents continued to treat her schooling as they always had. It appears as if Sophia's well being and, thus, her education was the one thing that her parents agreed on. Her mother, though, remarried. Her marriage to a man from the United States resulted in the family moving to Southeastern region of the United States when she was 10 years old. At that

time, she had been learning English for 4 years. Therefore, at the time she came to the United States she was writing on an eighth-grade level and placed in her age-appropriate fifth grade class. She states that it was at this point that her formal schooling drastically changed, although her mother's influence and expectations continued to propel Sophia towards excellence.

Sophia had by far the most intriguing description of her early schooling experiences. She attended schools that used what she identified as "constructivist" practices as their primary method of instruction. When asked what she meant by constructivism she said, "I think constructivism and its lack of emphasis in measurement imparted to me the 'learning for knowledge's sake' philosophy that I maintain to this day" (Interview 1). At times she also described constructivist methods as relying on "the curiosity of the child" and allowing students "to investigate their interests" in ways that made sense to them. Sophia believed that these methods of instruction gave her the opportunity to develop a natural curiosity about different subjects as well as a love for experiential learning.

Sophia was also entered into a form of schooling of some sort at the age 2 ½. She said that within the next year she had learned to read on her own, and upon entering formalized school, she was able to help others in her class learn to do the same. Furthermore, she felt that her family's efforts to expose her to educational settings complemented her school's constructivist philosophy extremely well. Upon summing up her early education in Brazil, she said that this "atmosphere helped make learning enjoyable, rather than an obligation" (Interview 1).

Sophia also had the unique opportunity to learn under one of Brazil's most respected educators. Fatima Freire, Paulo Freire's daughter, was the principal of her school as well as a friend of her mother. As Sophia explains it, "relations among students, teachers, and parents in Brazil are far less formal than in the United States" (Autobiography). Teachers were often called by their first names and parents, teachers, and administrators were commonly friends outside of school. Such was the case with Sophia's mother and Fatima Freire. This friendship led to two important experiences for Sophia. First of all, Sophia's opportunity to meet and read with Paulo Freire turned out to be a once in a lifetime opportunity. While Sophia's mother and Fatima Freire continue to be friends, Paulo Freire passed away soon after the meeting. At the time, the elementary aged Sophia did not realize the significance of this interaction. Now, however, she says, she recognizes what a privilege this experience was. Second, the relationship between Sophia's mother and principal provided guidance for decisions regarding Sophia's education. At one point, when Sophia's mother considered placing Sophia in a school for gifted children (in Brazil), her principal advised against it as there were so few students that attended the school she felt that Sophia would end up growing up without developing the social skills needed to be successful in real life. While this advice led to Sophia continuing to learn within the same courses as "everyone else," ultimately, she feels that this decision helped her to develop in much the way that her principal had claimed.

Sophia, unlike other participants in the study, pointed to teachers outside of mathematics having impacted her success. While she included mathematics teachers on the list of those that had influenced her achievement, she listed specific qualities such as

enthusiasm for the subject, dedication to students, and academic and personal support as characteristics that her most influential teachers possessed, none of which are specific to mathematics teachers. Sophia did identify one math teacher in particular as having impacted her mathematics education while in high school. Sophia said that when she reflected upon those who impacted her mathematics learning most, I was who she thought of. She described me as not only a teacher but also as a mentor that helped her develop a new understanding of mathematics—outside of the classroom setting and set apart from grades.

For Sophia, our student–teacher relationship helped her to see mathematics as a "real world analytic tool" rather than simply a rote school subject that had to be mastered. In this context, then, mathematics was a device that could be used for and within any subject matter. She also related this relationship to those learning experiences that she remembered from her childhood in Brazil. I, she said, provided a setting in which she "developed the valuable ability to think creatively in a subject that is typically thought of as strictly objective" (Interview 1). She further explained the impact that my attitude towards mathematics competitions had on her. "I appreciated math team for its non-competitive spirit, which matched my own—we were there because we liked mathematics and wanted to try out different things and have fun" (Autobiography). She explained that while "we did have our share of accomplishments," that the expectations for the math team lead to "a diverse group of 'mathletes' ranging from football players to theater enthusiasts" (Autobiography). This diversity, in turn, lead to the opportunity "to forge close bonds with people," which in itself is an invaluable skill for real life.

In light of her lack of focus on mathematics when discussing her influential instructors, her views on the subject of mathematics were intriguing. When asked what aspects of mathematics she believed to be important, Sophia answered, “It would be easier to ask what’s NOT important” (Interview 1)! For Sophia, mathematics is a tool that “is used to understand everything in the world” (Interview 1). To emphasize the point, she shared the fact that in her ballroom dance practice on the previous day that her partner had used mathematics to figure out what had gone wrong with their choreography. She concluded by saying that “math is everything” (Interview 1).

Sophia also differentiated what she termed “pure math” and “math in schools.” She explained that she had always loved pure mathematics. Sophia, however, had chosen to no longer pursue school mathematics as she had completed the last of the required mathematics courses for her majors (history and anthropology). She went on to speak about how pure mathematics was applicable to other fields. It was not as concrete as school mathematics where the applications involved were specific to the contexts of the courses.

When asked what about mathematics appealed to her, she answered that “the logic of it is immensely appealing” (Interview 1). She also found it fascinating how it could be used to explain and explore so many things. Furthermore, it was the logic and the game she had enjoyed pursuing while on the math team in high school. And while she had at one time considered pursuing mathematics in college, the realization of what was required to earn a degree in (school) mathematics quickly changed her mind.

As a result of the other participants' emphasis on competitiveness, I thought that it might be important to discuss the topic with Sophia. Sophia's description regarding her attitude towards competition, however, differs greatly from those of the other participants. Throughout the interview process, Sophia indicated that she was in a constant state of self-improvement. Her immediate future goals were always developed in relation to her previous measures of success. She described this process as though she was in competition with herself at all times. She stated that she "never felt the need to compete with anyone else" (Interview 1). In order for her to achieve, she only had to compare what she had done most recently with what she had accomplished in the past. This attribute seems to have been developed early on, when she had the opportunity to learn for "learning's own sake" as an elementary age student in Brazil.

As a result, Sophia felt the need to constantly keep track of how she had achieved on prior tests, in prior courses, or competitions. This comparison was her personal measure as to how much or little she had developed over time. In this way, she was involved in a constant competition with the person that most mattered—herself.

A Summary of Sociocultural Factors

While I found it difficult to synthesize the stories of such unique and diverse young women, after reading their autobiographies and having met with them to further discuss details regarding their stories, there were several pronounced factors (as described by the participants) that seemed similar to be described by all of the participants. When conducting the individual analyses, I discovered that the traits listed seemed to form possible themes for discussion. As each of the traits described is but a single attribute

within the contexts of much more complex lived experiences, one should not deduce that having shared in one, or even the entire set of these experiences should indicate that a female secondary mathematics student would achieve at levels similar to those accomplished by these young women.

That being stated, however, the fact that all four participants alluded to each of these characteristics, in whole or in part, throughout our discussions might indicate that the characteristic or experience was integral to the success enjoyed by each of these students. A summary of these traits is described here as a reference for the theoretical analysis that follows regarding the participants' views on success and gender.

Family. First, each of the participants described ways in which their families impacted their mathematics learning opportunities (directly or indirectly) from an early age. These family experiences ranged from parents who directly taught mathematics through the use of games to the impact sibling admiration had on one of the participant's efforts. All of the participants had parents who were successful in their respective fields, regardless of the levels of degrees earned by their parents. Thus, each of the participants had parental models for success that influenced their attitudes regarding achievement. Also, all of the participants were influenced by older siblings that had achieved in secondary mathematics and their future schooling. Their siblings provided examples of not only what might be achieved but also modeled the attitudes and methods through which this success might be attained. As Clara suggests, sibling rivalries also played a role in the development of a competitive psyche:

> I wanted to be competitive with my sister so you know everything she did I wanted to do too, or better. Because I didn't want to be 'oh the little

> sister' who is inferior, you know, wanted to be as good as my sister and surpass her. And so I did. I got better grades than her and I got a better scholarship than her. (Interview 1)

By observing these family members that had benefitted from their secondary education, these participants learned to value their own educational opportunities. Furthermore, these family members held firm to their expectations of academic success:

> I would actually probably say my dad [had the greatest influence on me] because I mean, in math, and in everything else as well like…'cause he really…he really stressed the fact that you should do your best in whatever you did. Like, like I said, he didn't care necessarily if I got a B, as long as I did what I was supposed to do. ….in math and everything else like… I felt like I couldn't do anything less than my best…I will put every ounce of effort that I can into it, ya know, because this idea of half doing something or, ya know, just writing like ya know crap answers for something is like a completely foreign thing to me… And my dad was really the one who instilled that in me. (Clara, Interview 1)

Having been around family members who had been successful in school, these participants developed their own similar expectations. Thus, having been surrounded by others who had shared in their own success, my participants were constantly reminded of the expectations for success.

Early learning experiences. Second, each of the young women discussed early schooling experiences in which they had opportunities to develop formalized thought processes different than many of their classmates. The forms of these experiences took place both in the home and in schools. These opportunities often were created as some form of experiential learning. Having both parents and teachers that developed learning experiences from which the participants learned through observation and experience was critical for their development as students. Each of the participants alluded to the

importance of these opportunities to investigate, analyze, and critically reason about problems:

> I know I had to do a lot of like logic kind of stuff in elementary school in my target class. So that got my brain working kind of in that way… Well it's important like in the early stages in your life to get you thinking differently, like logically and in the real world it helps solve everything pretty much. It can be applied to any career or area of the world. (Samantha, Interview 1)

These early learning experiences greatly influenced the way they approached problems, especially in mathematics, later in their schooling careers. Furthermore, all of the participants indicated that they had developed affections for this type of learning. They also shared that these experiences helped them to develop a love for mathematics, and in particular the application of logic in problem solving.

Teacher influence. Third, every participant described the impact of a teacher or series of teachers that influenced them with regard to their mathematics achievement. These teachers, mostly at the middle and high school levels, saw potential in one or more of the participants and shared these beliefs with them. This support was manifested in multiple ways. First, the caring relationships that these teachers shared with the participants provided encouragement and engagement in their respective curricular areas. In mathematics, this engagement was critical for the participants' continued development. In some instances, the participants re-discovered their fondness for mathematics. In other cases, they were encouraged to challenge themselves further within mathematics by competing as members of the math team:

> The teachers were really supportive and then when I got involved in math team it just kind of let me know that it was okay to do well in math, that I wasn't a nerd just because I liked it. It got me just thinking a lot more

> about tons of types of problems in a totally different way than any classes have. So I could do a much bigger range of problems than I had just from in the classroom. Stuff like that helped. (Samantha, Interview 1)

Needless to say, these relationships encouraged the participants to develop mathematically.

Furthermore, these teachers established expectations for success beyond the borders of the participants' homes. The participants discussed the importance of having teachers that held them to high standards of performance. Also, the trusting relationships that these teachers formed with the participants were critical:

> I felt that those teachers thought I was better than I was. But that made me try harder, so I guess that was good. I don't see myself as amazing at math. I see myself as pretty good compared to most…but…so I wanted to do better for you and [my Geometry teacher] because I know how you thought I was at math. (Samantha, Interview 1)

The participants also found it valuable to have someone that was perceived as an expert in the curricular field sharing their belief in the participants' abilities to succeed. Teachers who developed these trusting relationships compelled the participants to enjoy learning and motivated them to pursue mathematics further.

Defining mathematics. A fourth topic is how each of these young women defined mathematics. All of the participants differentiated between "mathematics" and "school mathematics." For each of them, school mathematics was a rote exercise in which information or skills were transferred from the teacher to the student. Within this process, the accuracy of this transference was judged, primarily by tests, and a grade was earned. The purpose of school mathematics was to achieve such a grade so as to complete a task towards graduation. Each of the participants shared some sort of disillusionment with this

style of learning of mathematics. For them, school mathematics was important, but only in so far as what grade was earned and how that grade impacted their futures in such ways as college acceptance and scholarship opportunities.

All four participants, when speaking about the mathematics that they enjoyed, all used the same word: *logic*. Logic, for each, played an integral role in the development of mathematics as they knew it. “Real mathematics” was labeled by each participant as “fun.” The game of mathematics was in the logical and critical reasoning required to solve high-level, difficult problems. Mathematics for each of these women was about problem solving, whether those problems were given in the classroom, come across outside of school, presented in other curricular contexts, or as parts of mathematics competitions. For these participants, mathematics was not simply about receiving information or developing skills; it was about using that information and those skills to do something, in particular solve problems using some sort of logic.

The sense that mathematics was something alive, something you do, was enforced for each of these young women by their participation in their schools’ math teams. The math team, as discussed in highlighting each of these participants’ individual stories, seems to have provided an outlet in which each of these young women could enjoy the challenge of mathematics without the fear of having to be successful in terms of grades. This arena for mathematics, then, allowed each of the participants to experience the joy of doing mathematics for the sake of “fun” rather than the monotony of the typical classroom experience. These sort of outside-of-the-classroom experiences seem to have

played in integral role in how these women experienced mathematics while in high school and, thus, directly impacted their level of achievement within that domain.

Competitiveness. Finally, a characteristic that each participant seems to have possessed is that each of them had a highly acute awareness of their own competitive spirit. While each of them differed from the other, all four participants discussed the fact that they were in competition in one sense or another when it came to mathematics:

> I like being better than other people. It's a…it's a very fulfilling feeling. And so I see these people who are better than me and I'm just like oh, I want to beat them 'cause it's… it'll almost give me like…I don't know like so much of my self-worth is wrapped up in this idea of like being better than other people, which is just a horrible thing to think, ya know. It's very elitist, but I like having a goal to strive for and being able to do so and ya know, having people like…like [the valedictorian from her graduating class] around who are like this…this thing that is always above me. It's kind of frustrating that you can't reach it and pull it down to your level or rise up to get there as well. And so it's...it's sort of a…it's sort of a goal but like you can reach, and you'll achieve…(Clara, Interview 1)

Samantha goes on to describe her efforts in upper level mathematics classes:

> It all comes back to being competitive and I want to do better than everyone and (laughs) that was an area where I was already good at it so I felt like I could pursue that more and maybe have more success at it that if I had tried all of the AP English and history classes where I probably could have pushed myself really hard….but I wouldn't have enjoyed it and math is something that I really enjoy, so I could work hard at it and have a good time doing it. (Interview 1)

I find it intriguing that competition, in some form, played such a vital part in each one of these young women's achievement in mathematics. I find myself asking whether they sought out areas for competition as a result of some personality trait, or if this competitive streak was developed as a result of the competitive atmosphere our schools create in the United States. If the latter is the case, would this competitive edge not be

more prevalent in the mathematics classroom, and students more apt to perform on a consistent basis? I also find it very interesting that Sophia, having been educated in a low-competition setting for the first several years of her education, never felt the drive to compete with anyone but herself:

> Success to me is being satisfied with one's own accomplishments in themselves, not in relation to other people… I hate being competitive against anyone besides myself! In that sense, the definition of success is totally personal. (Interview 1)

Again, I must question whether Sophia's beliefs about competition result from her singular personality or is this difference based on her upbringing and early schooling?

Summary of Success

The perspectives of the participants were easily observed when they shared their personal understandings of what success meant to them. For Farah, success meant that she had left a mark by bettering the world or someone else's life. For Clara, success was defined as outperforming one's peers (whether in the workplace or the school setting). Samantha and Sophia defined success as being happy or satisfied with what you have been able to accomplish. As I reflect upon these definitions, I can see how the differences in how the participants defined success directly related to their experiences. Regardless of their definitions, however, all of the participants' commentaries about success included an emphasis on the importance of education and schooling for their advancement towards their future personal and professional goals.

While there were numerous sociocultural factors that these young women perceived lead (in at least part) to their success (and in particular mathematics success), each could be classified within one of three themes: (a) having external influences such

as family members and teachers that encourage and guide expectations toward success; (b) having developed a personal understanding of how one learns; (c) having developed a personal instrument for motivation such as one's sense of competitiveness.

Each of these women indicated from the beginning of data collection that their family had provided a setting within which they were encouraged to follow a path toward success. These family members not only provided encouragement, but reinforced the importance of education by developing educational experiences for them in their homes. Furthermore, as they moved into formal school settings, the families of the participants provided guidance, either explicitly or by their examples, from which they could learn the actions and ethics of successful professionals. Through this informal instruction, the participants developed the attitudes toward education and school from which they established their personal sense of success (both in general and academic).

Encouragement and direction was not only provided by members of the family but also by teachers. As indicated by the data, teachers (and in particular secondary teachers) had great influence when it came to the perceptions of academics for the participants. This influence ranged from motherly advice to forceful guidance. Many of the teachers identified by the participants provided a nurturing school environment where the participants could come to seek both personal and academic advice. Others demanded academic excellence from the participants in ways that had not been expected of them before. In either case, the participants reported having formed strong relationships with these teachers. Within these relationships the participant came to see these teachers as people that they could trust. They also reported that these teachers remained strong

positive influences and mentors once the participants had left those teachers' courses. Academically, these women reported the impact of teachers that had established high academic expectations and learning goals for their students. The participants described how those teachers that had developed classroom settings in which they were forced to go above and beyond their normal expectations advanced not only their knowledge of the subject but also their understanding of what it meant to be successful. Regardless of the context of the relationship, however, within the school setting, the impact these teachers had through their caring relationships and their high academic expectations was the most similar factor described by all of the participants.

Within the context of schooling and learning, each of the participants reported having begun, at an early age, to develop an understanding of how they most enjoyed learn. Being provided alternative learning experiences, both at home and within the formal school setting, all of the participants were provided an opportunity to experience education differently than many of their classroom peers. These differences ranged in experience from being included in a gifted classroom to being allowed to learn on one's own within the context of her interests. As these opportunities were either continued or ended, the participants' feelings toward formal schooling evolved. As school became (for some) monotonous in the opportunities provided within classroom settings, they were forced to seek other alternative learning environments apart of the classroom. In these cases, the classroom became a means to an end. In each case, however, the premise for participant's definition of success had been (for the most part) formalized based on the influences of their family. This definition continued to evolve through their schooling

experiences and adapted to include social indicators of success for the contexts accomplishing the next formal school requirement.

Furthermore, with regard to mathematics education, the participants also described having developed (at one time or another) an affinity for mathematics. This positive outlook toward the subject seems to have been developed (whether continued or not) early in their schooling careers. For Clara and Samantha the gifted program in which they were enrolled allowed them to experience mathematics from the encompassing perspective of problem solving. These experiences, while not readily recognized as mathematics at that age, proved to be a catalyst from which the participants readily learned mathematics and its applications. While Farah and Sophia did not explicitly report similar experiences, they too provided evidence that supports the importance of the perception of mathematics. All four of the participants described the joy of mathematics in its "logical" and puzzle-solving qualities. Thus, at some point during their mathematics (academic) careers, all of the participants came to define mathematics in similar ways. Furthermore, the participants differentiated between the mathematics that they enjoyed and saw use for, and what I term "school mathematics." The participants spoke about the mathematics they were taught in the classroom as typically rote and an exercise in memorization. The problem sets they described were skills based and again, a means to an end; this time a grade in a course. As a result, the participants all described having to find a venue separate from the mathematics classroom in which they could continue to enjoy the problem solving aspect of the field of mathematics.

The participants also described one final important characteristic for their success. They described finding ways in which they were able to motivate themselves. For Farah, Clara, and Samantha this motivational instrument was the development of their competitiveness with others. For Sophia it was the development of an awareness of herself as successful and attempting to outperform her previous accomplishments. Thus, she learned to compete, in a way, against herself. The development of these motivational tools was essential to the participants' abilities to succeed. Their accomplishments, as time went on, required that they, independent of external sources, find ways that they might be motivated to accomplish their personal goals as well as those set forth by school and society. As a result, their success in high school, and in particularly mathematics, to a great extent, depended on the participants being able to establish routines and habits in their personal motivations. These routines, in turn, reaffirmed their attitudes about success and the efforts required to achieve.

Perceptions of Gender

The following discussion describes the participants' perceptions of gender and its impact on their mathematics education. As the data that is shared here was provided through the reflections of the participants while in high school, it is likely that the information that was collected might have been influenced by an educated past student as opposed to the students who actively participated in the experiences that were discussed. As there was no better way to acquire this data, however, the descriptions shared by the participants are the most accurate accounts of their perspectives (both during and after) these events. Also, as all of information shared was provided after the participants'

investment in the research process, they were aware of the topic of the research study. Furthermore, some of the data was accumulated after the women had been provided with previous literature regarding gender and mathematics. Thus, as a result, the opinions shared at that point in the research process would come from a source that had been versed in the types and scope of research that had been previously conducted.

Much like the participants' perspectives on success, their views on gender were diverse and far ranging. The reported impact of gender ranged from one participant who shared that she had always understood the influence of gender to one who stated that she had never felt that gender impacted her mathematics education at all. The following is my interpretation of the participants' reflections on the impact gender had on their mathematics education. Immediately following, I provide a summary and analysis of these reflections.

Participants' reflections

Farah believed that her gender and race were both issues that motivated her to be a role model for others like her. Upon arriving in her new high schools, after having attended school in Nigeria, Farah realized immediately that her achievements put her among groups of students that did not look like her. She felt that Black females were an underrepresented demographic when it came to upper-level mathematics and science courses. Having noticed this absence, being Black and female (she never separated the two demographics) has motivated her to go beyond what she ever thought she was capable of achieving. She believed that being both Black and female made her have to work doubly as hard to prove herself to others. She stated:

> Because I feel like… being perceived as a Black female, even though I don't see myself as that, it,… on first impression, people don't expect as much from me as they should… as I expect from myself… I don't feel like people hold me accountable for that because, "Oh, she's just a black girl"… I'm not just Black, I'm female, so, I feel like I have to work twice as hard to prove myself in everything. (Interview 1)

A major fault that Farah observed about the American school system was that school leaders tended to not hold students to the same standards. In her instance, she believes that she was initially not held accountable for what she could achieve because she was a Black girl. Because she was given no expectations for achieving in upper-level mathematics, she had to find ways to create those expectations for herself. She felt that people, and specifically those who found themselves being held to minimal expectations, "do not rise up and achieve to the levels of their ability, because they reach that plateau, that acceptable level, where they (or someone of importance) is minimally satisfied with their accomplishments" (Interview 1). The difficulty for Farah was to not hold herself to the same minimal expectations that seemed prevalent for Black girls in her community. Her ability to do effectively negotiate these minimal expectations, within the high school setting, made her feel as though she was a role model for other young women of color. This belief was evident during the first interview, she stated:

> I think that's part of the reason I like being a Black female… because it motivates me doubly to do better, to show that, you know, even though I feel like from what I've seen Black people and females are not held accountable for what they can achieve… and I aim to show with how I live that they're capable of doing so much better than they are now. So, I hope by showing this that other females would be inspired to be better, to reach above and beyond what they think they're capable of now and I hope that black people will be better off saying, "I can do that, and I can do that so much better… I don't want to take the easy way out. I actually want to work hard for what I want to achieve. (Interview 1)

In this statement Farah evidences her wish to inspire others that look like her. Furthermore, her acceptance of this responsibility, she feels, propelled her towards achieving at even higher levels and ensuring that she did everything possible to be successful.

Farah, thus, saw her success in the mathematics classroom as a "responsibility." This responsibility, however, was not just for her, but to other Black girls, and even more so, all Black and all female students. As a role model, Farah believed that she should and could show, by example, what was able to be done in the mathematics classroom.

Clara indicated that she never noticed her gender as an issue until at least her sophomore year in high school, when she noticed that females were less often represented in the competitive environment surrounding high-level mathematics. I, however, would have to mention that her early "rival and enemy" in middle school, having also been a female student, impacted her significantly. As this young woman had been provided opportunities that Clara had not, and thus was placed ahead of Clara academically, Clara recalls the fact that only she and this other young woman were the only female students that were chosen to participate on the math team. Thus, Clara did notice, at least to some degree, the fact that, mathematically, she was different than most of the girls in her middle school.

Clara's early recollections about mathematics and gender, as she recalls, was that gender had little impact on her mathematics success. She believed that she never really noticed any impact on her education from her being female as a result of growing up in a neighborhood where she was surrounded by male friends and classmates. This lack of

perceived impact is not to say that she meant that gender did not influence her education, but that she did not ever have a reason to discern any effects resulting from her being female. At one point, she did recall that someone pointed out to her that she was "different" for a girl because of her talent for and love of mathematics, but not much more than that. She really first noticed a discrepancy between male and female students at mathematics tournaments:

> There are very few specific events I attribute to being female. I recognized that my perception of them might be altered by my gender, such as noticing the gender and race make-ups of other math teams, but all around, I never felt that I was receiving a certain treatment (either negative or positive) solely because of my gender. (Autobiography)

Clara went on to describe the mathematics tournaments: "I remember looking around and seeing very few girls there. In fact, a majority of the girls at the tournament were there with my school" (Interview 1). At first, she says, this absence was "simply a curiosity" (Interview 1). In time, though, she began to pay more attention to this fact. She says "the discrepancy that I noticed did not define any specific concern for me, but I drew motivation to outperform my male classmates" in the area of mathematics (Interview 1).

When asked if and why this discrepancy exists, she simply answered "yes, statistically I believe it does; especially in competitions and at the university level" (Interview 1). She went on to question whether the choice to pursue competitive mathematics or mathematically related degrees is something that is "driven by the female psyche" (Interview 1). She goes on to further question that "if that were the case, could we ever know if that part of ones' psyche was developed genetically or by the environment, which then includes the stereotype in the first place" (Interview 1).

Other than the previously indicated mentioning of being different at an early age, Clara does not remember any female students ever "being singled out or stereotyped in her high school mathematics classes, at least not explicitly" (Interview 1). The differences that she was able to pick up on were based on the "expectations of my teachers and what sorts of behaviors and pursuits were acceptable" (Interview 1). Again, these expectations revolved about the work ethic girls tended to have and boys did not.

Upon further reflection, Clara made some poignant observations regarding gender's influence in mathematics. She summarized these opinions:

> I don't think my math experiences were necessarily influenced by my gender, but I can comment on a few things. One is the gradual decrease in females in my classes as the level of the math grew greater. Just take a look at my Multivariable [calculus] class—all boys [with the exception of Clara, of course]. Even the state math tournament. In elementary and middle school, it was fairly even. The girls gradually dropped in favor of other things though.
>
> Girls are no longer being discouraged from pursuing a career in mathematics like they were in my mom's time. But at the same time, we aren't being encouraged to do math, either. Science is taking steps forward to be seen as good for both genders, but not math so much. Boys nowadays are being herded into business, and business requires math. Girls aren't accepted as readily into the business world. Sure, they'll be good workers, but as far as pure business goes, how many girls do you really see? Not to mention, there is still a certain oddity regarding girls in math. The reaction [by female students] to my saying math is my favorite subject: EW, why math? I hate math. The reaction to boys [by female students] saying math is their favorite subject: Oh. Well, I like English. There seems to be something wrong about girls liking math. Also, a lot of people are under the impression that girls are more creative and emotional than boys—nicer and less competitive. Boys are supposed to be the competitive and logical ones. By these definitions, I should have been a boy. (Interview 1)

I believe that Clara is extremely accurate in her observations with regard to how many female students feel about or perceive mathematics and its related fields. It is

obvious from her statements, that as she matured, she did begin to understand the different influences felt by female students in the mathematics classroom. However, her competitive edge, her passion for the subject, and the opportunities created for her by her family and teachers all seem to have helped her to, maybe unknowingly, overcome the obstacles of which she spoke.

Furthermore, upon being asked to reflect upon the previous research that had been provided for the participants to read, of all of the participants, Clara was, by far, the most outspoken. Regarding the Benbow and Stanley (1980) report, Clara immediately shared her disdain for the study. Having achieved mathematically at such a high level, in comparison to her peers (including boys), Clara found it "offensive that girls were believed to be inferior to boys" in mathematical ability (Interview 2).

"There is a certain inequality built into everyone," said Clara, "but that is the case with every discipline, not just math. It's not gendered, and it's not predictable" (Interview 2). Clara best summarized her beliefs that the research at the time Benbow and Stanley (1980) conducted their study "simply upheld the prejudice of the time—male superiority in mathematics" (Interview 2). As a result, Clara said, "female students may have been further discouraged from pursuing mathematics and teachers may have felt no reason to encourage them to do so" (Interview 2).

Clara found the Fennema and Tatre (1995) study much more tolerable. Although she believed that the study continued to lack the focus on understanding why women were successful in mathematics, she shared her belief that the focus of research, from 1980 to 1995, had progressed towards such a focus. As Clara stated, "The research has

become progressively more female-friendly and less a proof of male superiority" (Interview 2).

For Clara, her attitude about mathematics was vital in its importance to her secondary experiences and who she has become, as well as her personal interests. This attitude also played a key role in her mathematics success. Clara indicated her favor for the Tartre and Fennema (1995) study as she felt "attitude about math is a rather important factor to focus on. I have an interest in math and I think that it attributes a lot to my success" (Interview 2).

Samantha believed that she was able to use her understanding of how others perceived gender in the mathematics arena as motivation to propel her to achieve within the field of mathematics. Samantha had learned from an early age that "being creative and artsy was just kind of assumed" for girls while boys were "supposed to be good at math and science" (Interview 2). Although she felt connected to the logic and critical reasoning aspects of learning that went hand-in-hand with mathematics, she felt pushed to pursue "girly activities like dance" and only focus on mathematics as it pertained to her basic schooling requirements. Upon entering high school, these feelings were reinforced as she found that there were certain expectations for girls when it came to the tasks that were carried out for clubs and organizations within the school. Specifically, she was not initially encouraged to join the math team as her prior experiences from middle school emphasized this activity for boys. Ultimately, when Samantha finally did "break through" and join the math team, she found that she was able to compete with her male counterparts. And while she was quietly competitive, the fact that she had waited so long

to participate in this "male" activity drove her towards working harder to ensure that she was successful.

Samantha also spoke about her perception of this stereotype having been maintained in light of the fairly recent phenomenon that girls are performing as well and often outscoring boys in school mathematics.[40] She believed that "the myth [that girls are not as good at math as boys] has been perpetuated mainly by the media and entertainment industries" (Interview 2). She felt "the media rarely emphasizes the progress female students have made" in this regard (Interview 2). When speaking about education and mathematics in particular, "the popular media tends to focus primarily on negative aspects of the educational system" (Interview 2). Furthermore, she believed that entertainment outlets continue to portray scientifically successful people as men. "Have you ever noticed," she asked, "that the nerds [in movies and television shows] are almost always guys" (Interview 2)?

Samantha also claimed that her high school experiences after joining the math team greatly contributed to her overcoming her perceived gender differences when it came to mathematics. "In math team," she stated, "girls could have been the minority. But our math teachers pushed everyone to join" (Interview 1). This difference was reinforced by another participant and Samantha's teammate, Clara, when she said, "Our math team wasn't like others. When we went to competitions, most of the other teams

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[40] Kimball, M. M. (1989). A new perspective on women's math achievement. *Psychological Bulletin, 105*(2), 198-214.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*(5888), 494-495.

had very few girls or none at all. Our math team always had as many girls as we did boys" (Interview 1). Thus, the school, and in particular those teachers that influenced students' participation with math team, seems to have given Samantha an opportunity to achieve mathematically against those obstacles that (at least) she perceived would be against her as a result of being female.

Upon being asked about the studies that she had been given to read, Samantha reflected upon the purpose of the study. She said that she tried to understand the context and understandings about female mathematics students at the times that the research had been conducted. First, she drew upon her belief that people, both female and male, have natural mathematical abilities. Samantha, however, equated this aptitude to natural musical, or natural physical abilities that are possessed by members of both genders. Every person "is born with certain, unique abilities," Samantha stated (Interview 2).

As a result, Samantha saw the Benbow and Stanley (1980) study as focusing on "how mathematics should be taught" (Interview 2). While she feels teaching methods are probably still the focus of research in mathematics education, she thinks, "teachers and researchers have a more progressive attitude [now]" (Interview 2). Rather than "trying to fix the gap" the current research seems to be more "gender equal." Although Samantha is majoring in a statistics related field, she felt that the study lacked the search for understanding why female students had not (to that point) performed as well as their male classmates in mathematics. Furthermore, she said, "This research did not uncover any major discoveries" (Interview 2). Rather it gave credence to the myth that girls can't do math as well as boys.

Samantha did, however, look more favorably upon the Tartre and Fennema (1995) study. She felt that this study had been conducted without the flaw of having preconceived notions as to how gender (negatively) impacts the learning of mathematics. Samantha stated that she did not feel that "the study was done under the assumption that girls could not do mathematics" (Interview 2). She also thought that as successful as she had been within the contexts of mathematics, she continued to sometimes struggle with her confidence and her sense of belonging. "Generally, I am confident in my mathematical ability, but the field still scares me a bit" (Interview 1). For Samantha, confidence has always played a large part in her achievement. This need for confidence in ability was a key finding of the Tartre and Fennema (1995) study. Samantha continued,

> This research does not really change the way I feel. It does change the way I understand the performance of others [female students] in this subject… The conclusions lead me to believe that confidence must play a large part in achievement. (Interview 2)

Interestingly, as Samantha began to conclude her discussion regarding the historical research, she started referring to the sexism in the mathematics field rather than the perceived gender gap. As a successful female mathematics student that is pursuing a related degree, she could not determine (or believe in) the existence of any genetic or biological factors that might result in a lack of mathematical performance for female students. She did, however, perceive from experiences and her interpretation of the previous research a sexism that existed within the field.

When asked about the impact being female had on her mathematics education, Sophia stated that she felt that her being female had no major impact on her success.

Sophia states, “I do not feel that being female has ever impacted my mathematics schooling” (Interview 1). She went on to say, “Despite the fact that males’ minds are more suited to math, there were always a great enough number of girls excelling in my classes to eliminate any possibility of gender differentiation” (Interview 1). Contradicting both her views on competition and success, there were times, however, that Sophia did feel pressure to earn the highest grades in her high school mathematics courses. She felt, “if anything …being female might have put me in a position of being expected to be above average” (Interview 1). In other words, Sophia noticed that for girls in her classes, there may have been a supposition that the girls should outperform the boys when it came to grades in the classroom. While she says that she never perceived a difference in intellectual ability, nor did the teachers ever indicate that they believed so either, Sophia noticed that the teachers had different expectations for the boys than they did for the girls. These expectations, though, Sophia believed came more from the belief that “female students typically had a stronger work ethic” than did their male counterparts (Interview 1). Boys were allowed to “goof off,” which impacted their grades in multiple ways. Girls, however, were “the ones that always did everything right… keeping up with all of their homework and such” (Interview 1). Sophia further indicated her belief that gender is not a factor that impacts the learning of mathematics when she stated that the underpinning factors that lead to success “result from personal characteristics rather than gender” (Interview 1).

Characteristics of the impact of Gender

Gender was presented in numerous ways within the characterizations provided by the participants. As Clara and Sophia perceived that gender had no impact on their mathematics education, their descriptions indicated ways in which (they thought) that gender (for themselves) had been eliminated as a source of influence. Farah and Samantha, however, perceived gender as having a direct influence on their success. As such, their descriptions detail those means by which they incorporated gender into their schooling and their learning of mathematics.

Becoming a role model. Farah understood her gender and race as modes through which she could become a role model for other young women as well as Black women and men. As she felt that she had worked extremely hard to achieve within the school settings and mathematics classrooms, she was determined that her example was one that other students might have been able to follow to create their own successes:

> I hope by showing this that other females would be inspired to be better to reach above and beyond what they think they're capable of now and I hope that black people will be better off saying "I can do that, and I can do that so much better… I don't want to take the easy way out. I actually want to work hard for what I want to achieve." (Farah, Interview 1)

Furthermore, as many students within her school that had failed to achieve were also Black, she felt that the combination of her success and race might encourage other Black students to develop educational habits and attitudes similar to her own. Furthermore, as a female mathematics student, Farah stood out above many of her peers. She was one young woman among a large group of young men who had pursued mathematics and achieved at the highest of level. While many girls within her classes struggled, her grades

in class and her standing as a math team competitor placed her among the elite student mathematicians in not only her school but also her entire school system. As such, her female classmates often looked to her for help and guidance with their mathematics education. As a result, she felt the obligation to model her study habits and attitudes toward mathematics, success, and academics in general. By doing so, Farah was able to not only maintain her standards of learning, but to pass them on to other young women who were also inclined to participate in similar ways.

The impact of "The Myth." Each of the participants, at the time of reporting, had at one time or another heard of "the myth" that boys were better at mathematics than girls. To some, this myth indicated the belief that girls were not supposed to be able to learn mathematics as easily as boys. For others, it indicated the belief that if girls could learn the mathematics, they could not use it with the same abilities as could their male classmates. No matter what it was perceived to tell us, however, the participants managed their own beliefs regarding the myth in different ways.

For two of the participants, Clara and Sophia, the myth was believed to fundamentally be untrue. These women stated that they chose to not simply disbelieve what the myth signified, but to disregard it entirely. The first, Clara, shared how she had, to an extent, been sheltered from these beliefs. Having been surrounded by male friends for the greater part of her elementary and middle school careers, she felt that she was simply developing in the same ways as her classmates. Thus, she was not exposed to the attitudes that are typically generated by the myth. The second participant, Sophia, had been schooled in another country and within a unique educational setting that provided

the equitable opportunities for all children. For her, the students that she went to school with all learned the same things within the same classes. The beliefs of teachers and parents alike at that time, she said, were that all students could learn. Thus, beginning school in this setting set her in a path within which she understood herself as educationally talented, the same as any other student. The impact then, of this attitude, was that she never had reason to doubt that she could learn mathematics.

The other two participants, Farah and Samantha, stated that this myth had impacted their learning of mathematics at some time or another during their mathematics education. First, Farah saw the myth as a challenge to not only herself but also to all girls. As a result, as discussed earlier, she developed the attitude that her success in mathematics was an example of what could be attained. As a result, she saw herself as a role model for other female mathematics students.

Samantha, however, is the only young woman that reported having felt a personal struggle with the myth in regard to her own mathematical abilities. She reported the impact societal expectations had on her as a young girl as she came to believe that as a result of her gender she should take up "artsy" pursuits:

> I feel if you asked pretty much anybody who's better at math, girls or guys, people would say that guys are better at it. I mean, it's in movies all the time…the nerds are mostly guys and when you say "nerd" it's mostly like math and science and I don't really know why that's associated [with] it. But, that's kind of how it seems still in the media and so that kind of leaves the stereotypes. On TV and the movies, math nerds were always boys with glasses and graphing calculators in their pockets and girls were always the ones dancing and drawing and English teachers were…I guess just pop culture showed me that side of it. And then in [elementary] school girls always were like playing house or would draw when we had free time. (Interview 1)

As a result, she developed the belief that her responsibility as a student was to make good grades and participate in activities such as dance and drama. As Samantha continued to easily achieve in the mathematics classroom, however, she began to develop a belief in her own mathematics ability. Furthermore, as she reached high school, her teachers began to encourage her to participate competitively in mathematics. This strengthened Samantha's desire for success within upper-level mathematics to the point where she was the only female student in her school (at the time of reporting) to earn a perfect score on the mathematics section of the SAT. That being an indication of her successes, however, Samantha reported that she, at times, continues to struggle with her mathematics identity. As a college student she is pursuing a degree in a mathematics related area. Within these courses, however, she is one of only a handful of young women pursuing that major. As a result, she stated, "even though I often have the highest grades in my classes, I still find myself questioning my ability" (Interview 1).

Pollyanna. Clara and Sophia, the two participants that reported having not noticed an impact of gender on their learning of mathematics, specifically recalled never having received "any special treatments" as a result of their gender. Additionally, these participants shared their observations that there were always enough girls both enrolled and performing well within their mathematics courses to ever notice that gender might have had an impact on the learning of mathematics in their classes. Moving out of the classroom setting, one participant also reported that the math team (at her school) also had a large number of girls that participated. As a result, these women felt that mathematics as a curricular subject, as they had experienced it, had been gender free.

The Pollyanna hypothesis, as proposed by Roslyn Arlin Mickelson (1989), contends that women believe that gender inequality is a thing of the past. As a result, these women, and those who influence them, understood gender strictly from the viewpoint of one's sex and as not being accompanied by social norms and (sub)standards set for women in school. These participants, then, did not see themselves as being acted on by some social structure that minimizes girls' accomplishments in mathematics nor limits their potential.

While each of these participants reported no external influence as a result of their gender, they did indicate that there were ways in which gender (both their own and their peers) influenced their decision making processes as they continued into and through high school. These differences are the topic of discussion in the section that follows.

Convoluted beliefs. The two participants who reported having not felt an impact from their gender on their learning of mathematics and their opportunities to succeed both later reported instances in which their choices were influenced by their opinions regarding gender. In this way, these two participants' reflections regarding how gender affected their schooling were lacking in both retrospection and consistency.

First, when Sophia stated, "there were always enough girls that were successful in my classes that I never noticed any gender differences" she followed the statement with the comment "I always felt that as a girl, I was held to the expectation that I would succeed" (Interview 1). When directly asked about the remark, she indicated that the boys and girls seemed to be expected to have a different work ethic. Thus, when female students were enrolled in advanced mathematics courses, she believed, they were

expected to do well as a result. Later, Sophia made a comment that began with the statement, “Although males’ minds are more suited for math…” While the remainder of her comment (which was presented as part of her story earlier in the chapter) was very much in line with her belief that gender had little or no impact on her successes, the lead in to this part of the discussion indicates that she might of accepted, at least in part, the conclusions made in early gender studies that had been maintained by “the myth.” It is likely, however, that Sophia, in the search for the “right answers” during the interview, also alluded to those previous studies in this way. At this time, having not further pursued that line of questioning, I cannot accurately make a conclusion regarding the addition of the comment.

Similarly, Clara, who reported the lack of an impact of gender consistently throughout the process, admitted later in the interview processes that she wanted to be known as the girl at her school that was best at mathematics. As a result of her success on the math team, she held great pride in her accomplishments. Thus, as a competitor, Clara was well known as the best female mathematics student at her school. While her goals might have included that she be known as the best mathematics student overall, she seems to have relegated herself to the fact that there were consistently at least two male math team members who outperformed her on a regular basis. Thus, Clara seems to have knowingly accepted that she was the best female math team member. Furthermore, upon being asked to compete with the team at the highest levels, she again recognized the fact that she noticed that she was one of only a few girls that were in attendance at this level. For example, she shared how she was not only the only girl that was included on her

school's team for the state mathematics tournament but also that there were very few other schools that had included a girl on their roster. As a result of these experiences, Clara indicated that she was further motivated to continue to perform at this level and had a greater need for recognition for her accomplishments. Being a girl that was able to achieve mathematically at such high levels became one of her greatest personal indicators for success. As such, her recognition of gender, even if it was only as a secondary student, had great personal influence on her motivation and efforts to succeed.

Summary of Perceptions of Gender

The overarching purpose of this study was to explore the experiences faced by these four young women that they identified as having impacted their opportunities to succeed with the secondary mathematics classroom. Additionally, I was interested as to which variables among the participants' histories were identified as having impacted their success in mathematics as well as whether and how these young women felt their gender played a role in their mathematics development. In an effort to examine the information that was provided, I began by seeking to determine if the participants held common views on what it meant to be successful. This examination, however, determined that not only did these women define success differently but also that their views, based on their experiences and historical contexts, were varied and unique. As a result, I continually found myself migrated back and forth across their data in search of homogeneous and generalizable information that was non-existent. Thus, after attempting to take this more traditional and positivist approach in an effort to categorize the data, I returned to my

theoretical stance for this project: a synthesis of postmodern feminism and standpoint theory.

By conjoining these theoretical traditions I was better prepared to approach the analysis from the standpoints of the individual, rather than the (gendered) social group. I was not only able to focus on the impact of gender (in general) but also the impact of gender, race, culture, family, and schooling experiences for each participant. Furthermore, these traditions offer me, as a man, opportunities to examine the lived experiences of my female participants (even though it is impossible for me to experience them in the same ways). "Standpoint epistemologies," explains Harding (2004), "offer opportunities for men to develop distinctive subject positions as socially situated men who have learned to think through feminist theories, descriptions, and practices that themselves started from women's lives" (p. 189). These opportunities offered me, as a researcher "the same resources for producing knowledge" as women who investigate similar topics (Harding, 2004, p. 188). Thus, by incorporating postmodern feminism within standpoint theory, I was able to focus on the experiences of and deconstruct the meanings of those experiences for each individual participant within the overarching context of the study.

The critical analysis of the data that was performed using this combination of postmodern and standpoint feminist theory indicated that each participant was aware of her gender as well as the perceived "male dominance" of mathematics. As a group, the participants, however, felt that the stereotype of mathematics as a male domain had little or no bearing on their aptitude to learn mathematics. In this way, each of these women

identified themselves as being mathematically skilled regardless of their gender. Each of the participants also identified numerous factors and experiences that might have attributed to their ability to succeed mathematically. None of the participants, however, described any of these factors as having been explicitly influenced by their gender. Thus, I find that it is highly unlikely that there exists an essential singular standpoint from which successful female mathematics students understand their situation within the mathematics domain. I find it more likely that these female mathematics students, as individuals, created individual and personal viewpoints, based on their lived experiences, from which they developed their own sets of beliefs and opinions. Some feminist social scientists might perceive that by not being able to determine a singular feminine standpoint from my participants that standpoint theory is a defective analytic lens. By focusing on postmodern tenets of standpoint theory, however, we acknowledge women's standpoints not as singular, but as multiple and unique (Pease, 2000). It is from this multiplicity of viewpoints and as a result of the contextually specific opportunities that were experienced by my participants, both in and out of school settings, that these young women were provided a foundation for success within the mathematics classroom.

Incorporating a postmodern form of standpoint theory, the analysis revealed that the participants' perspectives regarding success and gender varied greatly. A comparison of statements such as "I felt like a minority" (Samantha, Interview 1), "Being Black and female, on a first impression basis, people don't expect as much from me as they should" (Farah, Interview 1), and "I found [it] more of a curiosity than anything else" (Clara, Interview 1), and "Being female might have put me in the position of being expected to

be above average" (Sophia, Autobiography) highlights the distinct and almost opposite viewpoints on gender for these participants. These differences surprised me as I would have been apt to believe that young women having achieved in mathematics at such similar levels would have held similar views on both what it means to be successful and the impact being female had on their personal success.

In particular, the perceived impact gender had on the participants' education, and particularly their mathematics education, was unexpected. I, as the research began, expected that gender would have had a similar influence in the academic lives of these young women. My narrow viewpoint, both as a teacher and a man, led me to believe that young women that had achieved similarly in secondary mathematics would have developed similar standpoints when it came to their gender. However, the affect gender had on their mathematics education was perceived quite differently by each participant.

Furthermore, the analysis of the data did not suggest any perceived consistency as to how gender impacted these participants' mathematical achievements. Thus, it is inappropriate for me to attempt to identify any common gendered standpoint from which this group of young women identify themselves as female mathematics learners. Each of the participants reported differing ways in which gender influenced their mathematics education. Sophia reported gender as not having impacted her mathematics education in any way:

> I do not feel that being a female has ever impacted my mathematics schooling. Despite the stereotype that males' minds are more suited to math, there was always a great enough number of girls excelling in my classes to eliminate any possibility of gender differentiation… My gender has only affected my relations with my peers, but that is a natural consequence of human nature. As for teachers, I think the only good

> relations I had with most of them throughout my entire life resulted from personal characteristics rather than gender. (Autobiography)

Clara felt that having grown up in a peer community generally made up of male counterparts might have impacted her to believe that she was simply "one of the boys." This belief then impacted her early education as she simply was successful in the same ways as her male classmates. She reported only ever noticing a gender difference in her mathematics education upon entering high school. By this time, however, she had developed into a highly successful mathematics student, regardless of her gender:

> [The make up of the math teams was] more of a curiosity than anything else. I didn't mind hanging out with boys. Like I said, I'd hung out with boys my whole life and so that wasn't an issue with me, to not have girls around all the time. But, I look at …why aren't any girls here? Like, I don't know…it was something I could never really completely fathom from that point of view, maybe because I never really did have enough girlfriends growing up or whatever. But I found it more of an oddity than anything else. A…a curious feature to just sort of keep track of more than anything that was going to impact my decision to…to keep moving with math. (Interview 1)

Samantha indicated that she understood her gender role from an early age. Having participated in traditionally female associated activities, she believed that in order to be a girl, she must be artsy and creative. This perception went against, what she termed, her "aptitude for mathematics." As a result, she felt that she had to overcome the obstacle of "being a girl" in the mathematics classroom:

> I don't think [teachers] treated girls differently as much as the students who would like answer questions in class made it seem different. The boys, when it came to math, were always the first ones to like jump up and want to answer and be more outspoken. The teachers…I don't want to say they don't care enough about [the girls in] math [class], but it wasn't a huge deal to them [for the girls to be left out]. (Interview 1)

Eventually, however, when she reached high school, Samantha was exposed to a setting within which she was able to foster her mathematical talents:

> In high school math became a bigger part of my life because of math team and so I saw that girls could do it too. And there weren't as many girls by any means at math team events, but I could still go… There were enough girls on our team that I didn't feel so out of place and I wanted to try. Especially how competitive I can get, I wanted to do better than the boys to kinda disprove that. (Interview 1)

Farah, similarly to Samantha, saw her gender as a social obstacle in the mathematics classroom. She indicated that at the same time she was forced to consider the impact that her Blackness had on her overall educational opportunities:

> Being a black female, even though I don't see myself as that, on first impression basis, people don't expect as much from me as they should. As I expect from myself. I mean, if I didn't live up to what I felt was my full potential… I don't feel like people would hold me accountable for that because… "Oh, she's a black girl." I mean that's like a double whammy because I'm also female. I'm not just black, I'm female, so I feel like I have to work twice as hard and I have to prove myself in everything so I'm not just any black female. (Interview 1)

As a result of competitiveness, and through her support structures (family and teachers), Farah was able to use the stereotypes that she identified as motivation to achieve among the highest (societal) levels in secondary mathematics and in high school in general. Furthermore, as a result of her gender and ethnicity Farah saw her success in the mathematics classroom as a "responsibility." This responsibility was not just for her, but to other Black girls, and even more so, all Black and all female students:

> I definitely think that being black and being female has definitely motivated me some more to be more successful. And to, go beyond, above and beyond everything I see. If I see somebody else, you could be black, you could be male, you could be female, it doesn't matter to me, but if I see you doing something, I want to see that and go, you know, I can do that, but I can do it better. I want to always be able to do that, and I like, I

> think that's part of the reason I like being black female… because it motivates me doubly to be better, to show that, you know, even though I feel like from, from what I've seen black people and females are not held accountable for what they can achieve… and I aim to show with how I live that they're capable of doing so much better than they are now. (Interview 1)

Thus, as a role model, Farah believed that she could show by example what could and should be done in the mathematics classroom.

One might assume the teachers identified by the participants, including me, might have chosen to pursue assisting these students because of their (disadvantaged) gendered status. When asked about this possibility, the participants, however, insisted that the assistance and encouragement offered by these teachers was given to many students, female and male students alike. Another factor identified by these women was the impact that their early schooling offered. Again, these opportunities were open to students of both genders. The remaining two variables that were similar in comparison, definition of mathematics and competitiveness, could have possibly been viewed differently by boys than girls within the mathematics domain. It is more likely, however, that outside the realm of this study and away from the influences of the specific teachers mentioned throughout this study, these might vary as well among and within the gender groups.

Thus, there seemed to be no common impact of gender for this subgroup of young women. Gender, then, should not be assumed to have impacted these high-achieving female mathematics students in the same ways. If I were to attempt to essentialize the affect of gender on girls in the secondary mathematics classroom, and in particular, these participants, I would fail to address "the multiplicity of experiences and the issues of import" of girls in similar settings (Hesse-Biber, Leavy, and Yaiser, 2004). The fact that

the participants' views on gender were diverse implies that I must apply a "multidimensional" standpoint in which these women's lives are viewed as individual, communal, and contextual (Hesse-Biber, et al., 2004). As the primary variable from which this study was conducted, however, gender must continue to be critically analyzed.

The analysis, in this case, indicated that each of these women possessed their own unique standpoint from which they understood and pursued mathematics. While aspects of their standpoint might be shared with other women, the standpoint that was developed by and for each participant was based within each of their personal histories and personal understandings of not only gender but also success, race, and other structures surrounding the learning of mathematics. As a result, I chose to apply postmodern tenets of standpoint theory, such as situated knowledge, as I attempted to deconstruct the stories of each participant. Moving past more traditional forms of standpoint analysis that tend to generalize women's perspectives into singular essential frameworks, postmodern versions of standpoint theory interpret women's experiences as concrete, historical, discursive contexts (Pease, 2000). By applying these principles, I was able to focus on the characteristics and composition of each participant's unique standpoint. Conducting the analysis in this way, I discovered that each of the participants had experienced unique sets of opportunities that helped them construct their own contextual understanding of who they were (in relation to learning mathematics). Their individual constructions of success, mathematics, learning, and motivation further aided in the participants being able to negotiate the mathematics domain that had (for some) long been defined as masculine. Each of the women had drawn upon their familial influences, early learning

experiences, and teachers in their efforts to develop their personal understandings of what mathematics was. Furthermore, through their schooling experiences each developed a personal definition as to what it meant to be successful. Through this definition each participant created a series of academic (and mathematics) goals that were personally important to them. It was through these goals that they defined themselves as having achieved within the secondary mathematics domain.

CHAPTER 6

SUMMARY AND DISCUSSION

This chapter begins with a review of the study including the rationale and the guiding research questions. I follow with a summary and discussion of my conclusions. Subsequently, I address questions that might be interpreted as limitations to the study. The chapter is completed with suggestions for additional research and courses of action.

The Study

Rationale

Having a younger sister that had very personal and negative experiences within the mathematics classroom influenced the way that I viewed my role as a secondary mathematics teacher when I began my career. Her poor mathematics experiences in calculus made me aware of how teachers and classroom settings can adversely affect the opportunities and success of mathematics students. In particular, I was enlightened as to the role one's gender might play in those opportunities. As a result, as I began my teaching career, one of my primary focuses was that all students, including girls, would have equitable opportunities to learn mathematics in my classroom. As a classroom teacher for the past 11 years, I have seen too many instances where students have struggled in mathematics classrooms while the teachers held little or no expectations of success for these students. While not all of these students were girls, many were. Because of my sister's previous experiences, I took a personal interest in the students that were

impacted by these instances. This study was created in part as an effort to "open the eyes," so to speak, of educators and educational researchers that still hold the belief that boys have a natural aptitude to be successful in mathematics while girls do not.

The purpose of the study was to explore how successful female mathematics students were able to succeed within mathematics courses that were offered at the highest levels within the context of high school mathematics. At the outset of the study, I was primarily interested in examine the possible answers to two specific questions:

1. To what factors do high-achieving female mathematics students attribute their success?
2. Do these students, defined as mathematically successful by common social standards (as indicated in the methodology) identify themselves as "high achieving"? What definition or personal significance does "high achieving" hold for these participants?

These questions guided the development of the study as well as which young women were invited to participate. As a result, only female students that could be commonly accepted[41] as having superlative mathematical achievements both in class and on standardized tests were asked to participate. Ultimately, four young women completed the obligations for the study. These women had exceeded almost every minimum criterion that was set forth for being considered for participation.

[41] By "commonly accepted," I mean the same social standards detailed in the Methods section in Chapter 4.

Theoretical Development

The study was developed through the lens of postmodern philosophy. Postmodernism provided a framework for research from which I could investigate the discourses surrounding the traditional quantitative and generalizable conclusions of previous research (Edwards & Usher, 2001). By adopting a postmodern framework, I attempted to incorporate methods that required the questions that were asked to be open-ended and non-leading so that the participants might explore those experiences that they believed, through their personal reflections, impacted their success within high school mathematics. The aim of research conducted upon a postmodern foundation is not to seek out the structures that define human phenomena. Rather, as these structures are dynamic, continually changing and adapting, by investigating the intersections and movements of these structures, and how they contradict in both idea and action, postmodern tenets of research design can reveal new sources of knowledge as well as new meanings as a result of inquiry (Lather, 1991). This adoption of postmodernism for the development of the study allowed me to anticipate and accept the participants at both the time data was collected and from within the historical and social contexts of their stories.

Furthermore, by relying on my personal postmodern ideas, I believe that I created a setting within which the participants felt the importance of their honesty and openness. In this way, the participants felt that their opinions were valued and became the experts and leaders of the discussion. Thus, by framing my study within postmodern theory, I was better able to provide a new and different space for my participants to investigate their personal histories with regard to their success and their learning of mathematics. In

this way, I was also able to allow for alternative viewpoints, methods, and questions to be added to the exploration. Research conducted from within the postmodern are concerned with the historical evolution of social structure and the assumptions and power relations that allow such discourses to exist (St. Pierre, 2000). My research, having been developed from within a postmodern frame, then, provided my participants with an opportunity to re-examine the discourses that were in place as they had matured into successful mathematics learners.

Methods

These four participants were first asked to complete a demographic and school history questionnaire as well as write a brief autobiography that was not limited to, but addressed several specific questions that were included with the request for information.[42] These items were the initial step in providing an avenue for the participants to detail recollections of their experiences that had impacted their learning of mathematics. The data collected through this process included autobiographies that ranged in length from 1 to 12 pages. Needless to say, the amount and detail of the information provided at the outset differed between the participants. Upon analyzing the data provided by the participants during these initial collection opportunities, it became clear that a third research question needed to be addressed. As a result, the following question was added to focus the research as the study progressed:

[42] See Appendix A and B

3. How do these participants define gender as it functions in their lives? What relationships do they perceive between their gender and their success in secondary mathematics?

After an analysis of the information collected from the demographic survey and autobiography, the original protocol for the first interview was adapted to clarify questions specific to each participant and to address the updated set of research questions. As each participant was currently in session at their respective college or university, each interview was conducted in a way, and at a locale that was convenient for the student. The interviews helped to shed light on the views of what each participant felt impacted their success and mathematics learning.

Analytic Frame

Being that I am a male researcher, conducting a study in the area of gendered mathematics, I also decided that feminist philosophy must be incorporated into the analysis of the data collected. I believe that it would have been impossible for me to begin to understand the lives of female mathematics students without being versed in the theories that have been used to describe my participants' circumstances. To say that a study is "feminist" is to acknowledge that gender is the central lens through which the inquiry is conducted and analyzed (Anderson, 2007). Patti Lather (1991) stated, "Feminist researchers see gender as a basic organizing principle which profoundly shapes/mediates the concrete conditions of our lives" (p. 71). Furthermore, traditional (patriarchal) philosophies often fail to recognize women's knowledge and their philosophical beliefs regarding knowledge production. This lack of recognition,

according to Brown (2003), results in the devaluation of women's perspectives. Thus, by not recognizing women's ways of knowing, these traditional philosophies place greater value on the men's perspectives (Belenky, Clinchy, Tarule, & Goldberger, 1997). As a result, I chose to utilize feminist theory as the lens(es) through which I attempted to organize and understand the data that were collected.

In my attempt to analyze and understand the lives of these four female participants, I chose to incorporate an overlay of two distinct, but related, feminist theories. I found myself "theoretically migrating" (Hartsock, 1998, p. 237) between aspects of postmodern feminism and feminist standpoint theory as a result of both the methods used to collect data and the foci of the analyses. This blurring between postmodernism and standpoint theory was often difficult to traverse. As I conducted the analyses throughout and after the data collection process, however, I found it helpful to be able to pull from tenets of both theories so that I could reflect upon not only the impact of their previous experiences but also my influences and biases as well.

While some philosophers believe postmodernism and feminist theories are inconsistent, I contend that they are, by way of their differing strengths, mutually correcting (Giroux, 1991). Additionally, for the analysis of complex situations such as the underpinnings of the achievements of female secondary mathematics students, their frameworks are individually inadequate. By utilizing tenets of postmodern feminist theory to guide aspects of my analysis the weaknesses of each separate tradition were conjointly supported by the other's strengths.

One of these strengths lied in the fact that postmodern feminism allowed me to reflect upon and examine any possible presuppositions that I might have possessed, as a person whose perspective was one of privilege, while conducting the study. As a male researcher, and as one of the participants' former mathematics teachers, I had to consider the impact of my privilege during the study. My prior relationships with my participants, as well as the fact that I am a man, were possible sources of power that might have affected both the topics and details that the participants chose to discuss. A postmodern feminist analysis focused on the effects of this power. As a result, examining the information using aspects of both postmodernism and feminist theory resulted in raising my own awareness, through continual reflection, of the powers that were at play within the dialogue between me and my participants. As a result, I was better able to discern the complexities in their belief structures as they related to both their experiences and their comments regarding their beliefs. Rather than focusing on questions of gender difference, I was also better equipped to ascertain an understanding of the multiple factors that impacted my participants. "Even within theories that maintain a highly qualified or situated subject, the subject still encounters its discursively constituted environment" (Butler, 1990, p.182). Thus, the participants in this study, while being highly successful in mathematics and in school (in general), were and continue to be constructed within their social contexts. Gender, in this way, could be seen as an identity that had been socially imposed. Postmodern feminist theory also aided in beginning to critique and challenge the discourses surrounding these gender-impositions (if any) on the participants' opportunities to succeed within the mathematics classroom.

Second, I employed the use of feminist epistemology, and in particular theories regarding situated knowledges within standpoint feminism. The central claim of feminist epistemology is that a knower is situated within her own social and cultural context (Haraway, 1988). The knowledge that is developed is thus situated. That is to say, the knowledge produced reflects the particular perspectives of the knower. By focusing on women's experience researchers focus on issues of difference, questioning social power, and the development of knowledge from within a gendered context. Feminist epistemology, then, is concerned with how gender impacts the knower within the learning process. In this case, I was concerned with how gender influenced the learning of mathematics within the secondary school climate. Specifically, as society has traditionally defined roles and traits as either "masculine" or "feminine," and as mathematics has traditionally been labeled as a "masculine" pursuit, it was important to examine if and how these labels were negotiated by my participants. The impact gender roles and expectations have on learning is what feminist epistemologists find important to question (Haslanger, 2000). Because "knowledge is always situated by the standpoint of the knower; from a feminist standpoint, knowledge begins with women's lives" (Damarin, 1995, p. 247). Thus, as the analysis was conducted, I began by comparing the lived histories of each of the participants. As the analysis progressed it became apparent that traditional forms of feminist standpoint theory would not be adequate for analysis. As a result, I focused my analysis on the structures within and beliefs resulting from individual participants' backgrounds. Given that traditional forms of standpoint theory are based on the standpoint of the whole group, by injecting my postmodern elements, I

was able to perform the analysis with respect to each of the participants' standpoints. Utilizing aspects of postmodern theory "more recent interpretations [of standpoint theory] have located women's experience in concrete, historical, and discursive contexts" (Pease, 2000, p. 140). As a result, postmodern turns in some forms of standpoint theory have led to the acceptance of analyzing multiple female perspectives.

My postmodern stance within standpoint theory also utilized Harding's (2004) definition of strong objectivity by applying it to the knowledge that each participant (from their own unique standpoint) provided. From within this analytic frame, I deconstructed the personal meanings of each participant's experiences that she regarded as important to their mathematics success. Strong (feminist) "objectivity means quite simply *situated knowled*ge" (Haraway, 1988, p. 580). By equating objective knowledge with situated knowledges, Haraway indicates that women have unique positions and perspectives through which they understand their experiences (and they and others might learn from them). My participants' recollections of their experiences, therefore, provided my participants and me with the most accurate (objective) knowledge(s).

Finally, as this study was conducted primarily as an exploration into what structures were in place for and what beliefs were held by high-achieving female mathematics students with regard to their success, and in so much as the aim of standpoint theory is emancipatory action in light of situated knowledge, the only emancipatory claim that I might have made was that I hoped to raise the consciousness of those whose interests include the success of girls in mathematics.

Analysis

By incorporating multiple philosophical frameworks, I was able to reflect upon the data that was collected by understanding my maleness with regard to my interpretation of the participants' stories. In this way, I was able to utilize the data for analysis through a lens that allows my participants' stories to be documented, and the importance of those stories understood. Furthermore, by examining the problem, methodologically, through a phenomenological approach, I was able to focus on the contexts, events, and conditions identified by the participants, as successful female students in secondary mathematics, and better describe my interpretations of their experiences. This methodological approach also allowed the participants to discuss the topics they felt should be addressed with regard to the research questions. The openness of a phenomenological study further permitted me to analyze the information that was gathered and organize it in multiple ways so as to not limit the scope of the study. By doing so, I was able to determine two primary categories on which to focus.

The first category was how participants defined success and those factors that helped to bring about that success. Within the category centered on success, I identified three characteristics that the participants appeared to have in common. These characteristics, however, upon further analysis, are complex and multifaceted. Thus, to classify them as common factors of success across the participants would reduce down these characteristics to the point of limiting the understanding of both the participants' success and the complex nature of the development of their achievements.

Secondly, I focused on the participants' views of how gender impacted their success in mathematics. I earmarked four means in which gender played a role for particular participants or subsets of participants. The nature of these four approaches to gender attempted to capture how the participants understood their gender and how, at times, they were able to utilize gender as an instrument through which they could achieve. The combination of these characteristics and perceptions, however, highlight the complexity through which these participants situated themselves and the development of their unique methods for success. Without investigating the elaborate means through which these young women were able to achieve, I would be unable to understand the rich and complex nature of their success.

Summary and Discussion

Each of the participants in the study defined success in ways that were personally meaningful. By doing so, they were able to utilize the successes and beliefs of those around them for guidance through the academic and mathematics domains. For Farah success was defined as "knowing that you've done what you wanted to do in your life" and "leaving a mark, something that makes the world better." She went on to say, "It isn't just about the grade. It's about knowing; being able to use what you have been taught." For Clara, success "is all competitive. It matters that you outperform others, that you are the best at something." Samantha believed success to be defined by that "you must feel that you are doing something with your life." Meanwhile, Sophia defined success as "being satisfied with one's own accomplishments—not in relation to other people."

Each of their definitions was unique and personal. Upon discussing success further, each shared detailed accounts as to how they came to their conclusions regarding success. Within this discussion, it became apparent that there were five distinct sociocultural factors that helped them to define their goals. These factors included the beliefs held by their family members, their experiences learning both before and during elementary school, the influence of and their relationships with their teachers, how they defined mathematics, and their competitiveness. While each of these factors played an important role in their understanding of success (and in particular success in mathematics), how each participant experienced and perceived these factors was diverse and unique. Thus, in order to discuss these concepts, in general, I attempted to categorize these five factors by defining them (as I interpret them) based on how they impacted the participants.

The first category that I defined is that each of the participants had come to understand the means through which she best learned. She knew the methods through which she enjoyed being taught and comprehended which learning situations helped her to best acquire and learn to use information. Those portions of our discussions that centered on how the participants learned generally focused on some sort of alternative learning experience that each of the participants had early in their schooling careers. These opportunities varied from participating in the gifted program to experiences in other countries. They all, however, reported that these experiences altered not only the way they learned later on but also how they viewed mathematics as problem-solving rather than rote set of skills to be acquired.

In many ways, these early learning experiences lead directly to how these young women defined mathematics for themselves. As they all had opportunities to experience problem solving within alternative school settings, they developed a different sense of what it means to solve problems in general. Upon entering the mathematics classroom, where solving problems is the definitive task, these young women looked at mathematics as the solving of problems itself rather than seeing mathematics as the skills acquired in their courses. The opportunities that these women had to participate academically, including the math team at their school, helped them to further develop a broader view of mathematics.

A second category is that these participants had developed tools for self-motivation. For three of the participants, in mathematics, this tool was constituted by direct competition and the comparison of their achievements with others. The fourth participant, Sophia, was competitive as well, but only with her self, in comparison to her prior achievements. The math team was also an opportunity from which each of them could openly be competitive with others. While competitiveness was reported by all four participants as integral to their development mathematically, only three of the women reported competitiveness with others. As mentioned earlier, Sophia claimed that math team gave her a chance to test herself and continually see how and in what areas she had improved her mathematical skill sets. Each of the others, however, reported that the math team gave them an outlet where they could openly be competitive with their teammates and others. Clara identified math team as a place where she could challenge herself,

gender-wise, as she was only one of a few female competitors that participated at regional and state tournaments.

All four participants reported having chosen to participate with the math team at their school at the bequest of one of their teachers. In fact, the most similar characteristic between the participants' stories is that of teacher and family influences. Thus, the final category that I define is that there were external influences from which the participants learned about success. These influences included the beliefs and expectations held by their parents, siblings, and teachers.

For each of the participants the relationships they developed with one or more of their mathematics teachers were integral in the development of their passion for and their success within secondary mathematics. Samantha, the only participant that has continued to pursue mathematics at the post-secondary level, reported that without the encouragement of her teachers she would not have participated on the math team which led directly to her love for the subject. Her future degree and career choices, then, were directly impacted by the influences of these teachers. Clara had developed a disdain for mathematics by the time she reached high school. This disdain was reinforced by her mathematics teacher during her freshman year. Clara reported, however, that the relationship she developed with me during her sophomore mathematics class influenced her to not only join the math team but also rediscover her love for problem solving and, thus, mathematics.

The participants also diverge in their understanding of how their gender had impacted their achievement. With such varying accounts of gender within their stories, I

found it impossible to determine a singular or common stance from which these women viewed gender to have influenced their mathematics learning.

Samantha details the view of gender that I believe to be the most traditional and expected when examining gender in mathematics. Through her early experiences, she developed an understanding that girls were to be artsy and creative. While she believed that she had a "natural" aptitude for mathematical and analytical thought, she avoided these fields outside of traditional student expectations. Clara never understood herself as different from her peers because she grew up within a community made up primarily of boys. She only ever saw herself as doing what her friends did. Upon entering high school, she began to notice that there were few girls that pursued courses at the level of mathematics that she was able to achieve. At this point, she finally began to question if gender plays a role in mathematics pursuits, but used this question to further fuel her competitive drive towards success in mathematics. Unlike the others, Sophia understood her role as a female, but had no recollection as to sensing gender as having an impact on her opportunities in the mathematics classroom. She stated that at no point did she question the number of girls in her classes nor her opportunity to achieve at the highest levels. Farah, on the other hand, saw her role as a successful female mathematics student differently. She believed her success to be a responsibility to others. Being a Black female student, she understood herself to be a role model for other students that resembled her.

Upon entering high school, each of these women understood themselves as a female student. Their unique perceptions as to what that meant, however, differed in both

formation and impact on their achievements. Further analysis of their stories regarding gender helped me to identify four key concepts on which to focus. First, the combination of Farah's success and gender roused in her the need to be a role model for others. Thus, the development of one's success as a responsibility in light of one's gender might be a topic for further investigation. Second, all of the participants reported having heard "the myth" regarding female under-achievement in mathematics. How this myth influenced the beliefs and decisions made by the participants varied. While some, like Samantha, used it as motivational tool towards their personal goals, others such as Sophia (and at times, Clara) felt that the myth was false and could be ignored. This disregard for the influence of the oft perceived gender gap brought about a fourth concept. The Pollyanna hypothesis (Mickelson, 1989) is based on the fact that women achieve in part as a result of their belief that gender no longer plays a role in one's opportunities to be successful. This belief was apparent in the statements made by Sophia and Clara at times throughout the research process. These two participants, however, did at times relate their accomplishments to those achieved by their male classmates. Sophia, at times, would compare her female peers' levels of success to those of her male peers. In some instances, she would bring in "the myth" as a basis for the statements she was making. Thus, in some ways, she seemed to buy into the gender-gap perceptions that have been researched over the past 3 decades. Clara's entrance into high school seemed to awaken her to the fact that there were few girls that had accomplished what she had been able to achieve in mathematics. As a result, she saw her gender as a motivational factor for her continued

success. Therefore, my final topic for analysis became the observation of these statements and actions that seemed to be confused with the beliefs held by the participants.

Throughout the research process, the participants seemed to be able to understand their individual circumstances as they related to their current and past contexts. As such, they seemed to have developed a personal standpoint through which they understood their achievements. In many instances, these young women also seemed to have related thoughts and feelings as to how their gender had impacted their progress. Upon further investigation, however, these beliefs were uniquely defined based on the participants' experiences and personal histories. In this way, I believe that a search for a singular gendered standpoint with regard to the learning of mathematics is unjustified. As one might deduce from the recollections of these women's stories, the factors that impacted their mathematical and academic achievements were numerous and complex. Thus, to attempt to reduce their unique situated positions down to one over-generalized standpoint would show disregard for the importance of their extraordinary histories and achievements.

Limitations and Issues of Power

Throughout the development of and implementation of the study, I remained acutely aware of four possible limitations that could complicate the data analysis and conclusions. These limitations can be expressed in the form of the following questions whose answers are addressed in the following discussion.

First, as I have previously indicated, I realized that I had come to in this study with certain beliefs about young women's abilities and their achievement in school

mathematics. In an effort to limit the effects of these beliefs on the study, I approached the study from the viewpoint of an explorer. By addressing the research questions phenomenologically, I was able (or made concerted attempts) to limit the impact of my beliefs on the design of the study and the data that were collected. As my goal in developing this study was not to uncover any undisputable truths, I accepted that my preconceived notions, as a teacher, a man, and a brother, might not be substantiated. Instead, I was encouraged by the fact that the study might provide insight into the success of young women in secondary mathematics and help address concerns that would refocus a discussion that might motivate different conversations among educators and educational researchers, including me, about the possible reasons as to why some female high school students have achieved at such extraordinary levels.

Second, is it possible that the data collected was influenced by simply asking these young women to take part in the study? In other words, it is important to note that these women may have never considered the impact, if any, gender might have had on their learning opportunities. By broaching the topic of gender, any of the participants could have begun to understand their previous experiences through a different lens than they had before. While the development of such an awareness is not in itself harmful, the fact that their personal analysis of their experiences might change through this reflection could alter which influences they reported as having impacted their achievement. For example, at times Sophia answered questions that asked for her opinion with comments that related to the belief that boys are more apt to be successful in mathematics than girls. At the same time, however, she addressed the fact that she believed that gender had no

impact on her classroom opportunities. Thus, it is possible that her awareness of the topic under investigation impacted not only the way she answered the question but also the phrasing of her answer in such a way that it might have implied that she expected something that was not necessarily characteristic of her personal beliefs.

These young women, however, as are all people that participate in the reflection of their lives, are always evolving. This process, then, can be understood as a step in that evolutionary process. As the participants were asked to reflect upon their personal sets of circumstances through which they were able to achieve within secondary school mathematics, these post-secondary female students had already begun to incorporate their newly adapted opinions into their reflections. Only at times after they had occurred could the participants have understood the importance of those experiences that they chose to share and discuss with me. Thus, their understandings of those experiences had been changed and re-changed over time as they matured. Furthermore, these understandings, being uniquely acquired through both prior and future experiences, will continue to develop. Thus, there is nowhere that I, as a researcher, can or ever could have drawn a line as to the evolution of these young women's opinions regarding the impact of gender. Therefore, their inclusion in this research process can be seen as a decidedly positive process through which they continued to evolve as both women and learners, and as such contributed in ways that were unforeseen at the outset of the study.

Third and fourth, how does the fact that I am a male researcher and each of the participants' former teacher impact the study? Some might find my being a male teacher and researcher exploring the impact of gender in mathematics troubling. As I entertained

the notion of developing a research project about gendered mathematics, I had to ask how I, as a man, could ever understand the role gender plays in society, much less a field that has continued to be labeled as male. I understand that I can never claim to understand the relationship gender plays for women in society. By using a postmodern lens to frame the study, however, I can question the relations of power that are at play in our society and especially in our schools. I used this frame to remain keenly aware of the power relations that being male and that having been these women's teacher provided me. Postmodern philosophy requires that I continually reflect on my role as both man and researcher. Thus, as the study progressed, I was required to reflect upon the impact that my relationship with my participants was having on both the data that was being collected and my interpretations of that data. Furthermore, by incorporating a philosophical framework based in both postmodern and feminist philosophies, I was forced to continually step back and critically examine myself and my views in an effort to maintain the phenomenological direction intended for the study. I also provided my participants with copies of the report of my initial interpretations. By doing so, the participants were able to read, explain further, clarify, and correct inaccuracies (such as which parent held which degree) that had been included in my interpretive descriptions. I believe that in this way, I was able to provide an account that adequately described my participants' recollections of their personal histories. Through the completion and reporting of this study, I hope that we (me and my participants) have provided a springboard from which the broader discussion of successful female mathematics students might be inspired.

Recommendations for Future Research

The initial findings of the study indicated several recommendations for future research. First, how does gender influence the outcomes for achievement in secondary mathematics? Or even, how does gender impact the learning attitudes of successful female mathematics students? As the participants in this study suggest, one's personal conception of gender might have a singular impact on the individual. The findings in this study indicated that there was no common gender experience or view of how gender influenced the participants' success as a group. They did, however, share personal feelings as to how feelings about their gender motivated them towards or away from success. Thus, one direction for future research might focus on if and how a female student's personal understanding of her gendered situation within the mathematics domain motivates her towards or away from achieving within that domain.

A second focus for future research might be that researchers examine the role one's definition of success plays in their achievement. As each of these participants had, through their cumulative experiences, developed their own definition of what it means to succeed, researchers might find it important to understand the importance of this definition as compared to the levels of success that are achieved. Such an investigation would require that researchers focus on not only the definition itself but also those factors that lead to the development of the characterization. Furthermore, the complex structures surrounding the participants' beliefs about success would require that researchers work to understand the backgrounds of women as well as how these beliefs influenced their efforts to be successful throughout their academic careers.

Third, the influence of teachers and the relationships made between students and those teachers seems undeniable. Among the factors discussed throughout the research process, no other aspect had a greater and more consistent impact on these participants. The development of such teacher–student relationships seems to be “instrumental in the effective teaching and learning of all students, and critically important for secondary mathematics teachers—given that most students have an aversion toward the discipline” (Stinson, 2004). It is through these relationships that students develop not only a comfort in but also a fondness for the subject. Each of these participants reported that at some point a mathematics teacher forced them to recognize their potential and encouraged them to participate in mathematics at a new level. This “belief” in them, as students, often pushed them past the before-stated aversion for mathematics and towards a love for the subject. It is my contention that research surrounding the impact classroom teachers have on their students is critical in developing an understanding of how these students were able to achieve. If the development of relationships between students and teachers, at any level of schooling, can impact the attitudes of students, then the role these relationships play in students’ successes is critically in need of examination. Furthermore, if the teacher–student relationship allows teachers to re-direct students toward constructive learning opportunities, the lack of these personal relationships could have the opposite impact on student outcomes. These interrelation structures, as a result, should be further studied as they might directly impact the success (or lack of success) that female mathematics students achieve while in high school.

By sharing the detailed accounts of the lives of my participants, this study allowed me to better understand the successes of high achieving young women within the secondary mathematics classroom. Reflecting upon my sister's educational experiences, and understanding her as a brother, I know that she was competitive and had early learning experiences similar to some of my participants. Her definitions of success and mathematics at the time, I do not know. As my participants explained, however, these personal definitions resulted from a combination of their early schooling experiences, their parents' expectations, and their relationships with their mathematics teachers, the latter of which my sister lacked. Thus, I maintain that the teacher–student relationship must be considered among the most important factors in students, both female and male, learning mathematics.

Finally, the purpose of this study was not to discover an answer as to how young women are able to achieve mathematically in high school. Instead, I hope that my research might re-focus research regarding gender and mathematics toward female students' success in mathematics. As much of the previous literature has focused on the lack of success achieved by girls in high school mathematics, I urge educators and researchers alike to re-focus the directions of their research from studies about deficiency and stereotype to those that center on the complex nature of girls' success. Thus, we might begin to connect all of the research that has been done within the context of its purpose: to provide opportunities through which all students might be successful in their learning of mathematics.

Furthermore, by refusing to limit our focus on the study of gender to only those methods that reduce women into the singular variable “girls,” mathematics education researchers allow for investigation into the complexities that define female mathematics students. Including traits such as perceived ability, personal experiences in mathematics and schooling, and how success and mathematics are personally defined, researchers incorporate the diversity of young women as learners and open up possibilities for teachers and researchers to begin to understand the role these complexities play in women’s successes. As all of these factors contribute, at times, to female students’ mathematics achievement, researchers must be open minded and implement studies that allow for the inclusion of these characteristics (and more).

Each young woman in this study successfully constructed a bridge or network of bridges that enabled them to achieve within the mathematics domain. Each of their bridges was different while accomplishing similar outcomes. The foundations and designs of these bridges were based on unique and personal experiences and belief systems. My charge for researchers, then, is to begin to examine how young women are able to create structures through which they might traverse waterways of failure toward the success that they desire. What are their tools for motivation? What are their experiences that encourage them to be successful? What are their definitions of success and mathematics? As mathematics education researchers explore these answers, we might begin to understand the complex natures of achievement within gendered mathematics. Furthermore, we researchers might also begin to connect these success stories with the work of others, such as Gieger (2002), that examine why many of these

successful women continue to choose not to pursue mathematically related post-secondary degrees. By focusing on the uniqueness of the individual, maybe we, as education researchers, can begin to correct the disconnected science of investigating the relationships between mathematics and gender.

Significance for Mathematics Education

The impact of legislation such as No Child Left Behind has further directed the focus of education researchers toward investigating the essential nature of failure. As evidenced by the survey of previous research presented in chapter 3, failure in secondary mathematics is easily studied and generalizable through quantitative measures. Success, however, is a much more difficult and complex issue to investigate. As a result, both researchers and policymakers have historically shied away from conducting studies that focus on student achievement (rather than lack of achievement). Furthermore, educational policy, either governmental or that set by school systems, tends to be politically motivated and concentrate on the lack of success attained by students. Proposed solutions to well politicized problems tend to be described in terms of the perceived problems within the educational system. Rather than looking to successful students for guidance as to which methods aided in their achievements, policymakers default to the generalizable stance of failure and blame. In doing so, educational leaders have implemented new requirements for teachers and additional testing in an attempt to further measure acquired student knowledge. Policymakers have even gone so far as to design new curricula as wholesale replacements for identified “problem” curricula. The result these approaches,

however, in the real-world classroom has been a lack of focus on success and achievement and a re-focusing and acceptance of mediocrity and averageness.

Leaders in mathematics education have often spoken about “closing the gap” between those who learn and do not learn. In mathematics, particularly in the state of Georgia, one attempt to close this gap has been to require teachers to dismiss their well-developed instructional methods in favor of a “one-for-all” guide through which all students, regardless of their mathematics background, are taught the same set of newly designed college preparatory mathematics courses. This “catch all” philosophy does not incorporate methods that previously served successful teachers, nor, more important, students who had been successful prior to the implementation of the new curriculum. According to many teachers, the result of this policy decision, with its lack of focus on success, has been that students have come to understand that mediocrity is satisfactory. For the teachers, “average” has become the new standard by which success is judged. This is not to say that teachers, in general, lack a personal belief that every student can learn mathematics. Instead, this example illustrates how the political reference to “closing the gap” might be understood on some level as “lowering the bar” in terms of what is to be expected as achievement in secondary mathematics.

Robert Moses, in contrast, has emphasized the use of the term “raising the floor” when speaking about changing the expectations for achievement in mathematics. In doing so, Moses believes that the tone of the conversation focuses on student success rather than the lack of achievement. Moses (1989) structured the Algebra Project around defining success for low-achieving African American mathematics students. Rather than

focusing on the past failures of similar students, Moses and his colleagues based their efforts on the goals and motivations maintained by successful mathematics students in an effort to help guide those students who had previously struggled in mathematics. The goal for those instructing students within the Algebra Project became that students' future goals not be limited by their mathematics experiences. If one is considered successful mathematically, doors might be opened to both post-secondary academic endeavors as well as future career aspirations. By focusing on student achievement, the Algebra Project encouraged students to focus on their opportunities to succeed rather than "trying not to fail."

Like Moses, I believe that the focus of mathematics education needs to be based on the success of students. Women have made great strides in their levels of achievement in secondary mathematics (Hyde et al., 2008). However, as stated earlier, the majority of research with regard to gender has been limited to the essential nature of failure. As policy is directly influenced by educational research, the essentialism of these studies is dangerous. The impact of investigations such as that conducted by Benbow and Stanley (1980, 1983) was far reaching and greatly impacted the decisions of policymakers in the 1980s. The negative implications of this research resulted in lower expectations held for women studying mathematics, and can still be felt almost 30 years later. Furthermore, the negative focus of gender-related research in mathematics education has continued. Only a few theorists and researchers (e.g., Boaler, 1996, 2002, 2008) have even attempted to change the direction of the conversation regarding women in mathematics. Until researchers begin to focus on the successes young women have attained within their

mathematics education, policy will continue to center on the negative, essential, and easily generalizable nature of failure. In an effort to counteract the influence failure-oriented research has had on mathematics education, I encourage researchers who have interest in exploring success for mathematics students to join in the re-direction of the type of research that might be conducted and as a result, the re-focusing of the policy decisions that might follow.

Personal Reflections

It is my hope that this study begins a discussion regarding gendered mathematics that might be different from traditional gendered studies. As this project focuses on the success of young women from their perspective rather than the lack of success from an outside (social) perspective, I hope that researchers begin to gain insight as to how successful female mathematics students negotiate the social and expected contexts within which they reside. I agree that research has come a long way since the early deficiency theory studies that were conducted in the 1970s and 1980s. More recent research, however, has either focused on proving that girls are doing as well as boys (Hyde, et al., 2008), or on understanding why those women that are successful in mathematics continue to pursue other areas in their post-secondary education (Anderson, 2002). The question remains, then, how were these women able to negotiate their success in the first place? If there is an answer, it lies in the complex and unique nature of women's backgrounds and beliefs. If educators and researchers can come to some understanding as to how young women such as these were able to achieve at such extraordinary levels in mathematics, it

is possible that educators might be informed by their stories so that other young women might also be successful.

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APPENDIXES

APPENDIX A

DEMOGRAPHIC QUESTIONNAIRE[43]

Part I: Demographics

1. Name: _____

2. Preferred Address _____ (school or permanent)

_____

_____

3. Phone numbers (_____)_____ _____

(_____)_____ _____
Indicate Home/Work/Cell

4. E-mail address(es):_____

5. Pseudonym for reference during the research process: _____

6. Current Age: _____ 7. Birthdate: _____

8. Ethnicity (optional): _____

[43] Adapted from Stinson, D. W. (2004). African American male students and achievement in school mathematics: A critical postmodern analysis of agency. *Dissertation Abstracts International*, *66*(12). (UMI No. 3194548).

9. Are you currently employed? YES NO

10. If so, describe your profession. _____

11. Which living arrangement best describes your current status?

_____ Single, never married _____ Single, previously married

_____ Married _____ Living with a Partner Other _____

12. Do you have children? If so, please list their ages. _____

13. How many people lived in your home during a majority of your high school years (include yourself)?

14. Do you have siblings? _____ Number of Sisters: _____ Number of Brothers: _____

Were you the eldest, middle, youngest?_____

15. Please describe your relationship with your family while you were in high school.

Part II: Schooling

1. Elementary School(s): _____ County, State_____

2. Middle School(s): _____ County, State_____

3. High School(s): _____ County, State_____

4. Were you in a mathematics and/or science magnet program? _____

5. Were you identified by the school system as "gifted"? _____

   If yes, please tell what grade you were identified. _____

6. What mathematics courses did you take in middle school and high school? (Please list course, grade year, grade in course and teacher/school)

7. Were any of these courses taught by the researcher? If so, which?

8. What academic awards and recognitions were you awarded (elementary through high School; e.g. student of the month, top math student, STAR student, etc.)?

9. What honors organizations were you involved in (e.g. Beta, NHS, MAT, GHP, etc)?

10. What extracurricular activities were you involved in (Band, athletics, student government, etc.)?

11. What after-school, summer, and/or mentoring programs did you attend (Boys Club, Girl Scouts, etc.)?

12. What was your class standing when you graduated from high school (Valedictorian, top 10%, etc.)?

13. Overall GPA: _____ Math GPA: _____

14. Test Scores from High School:

AP TESTS: Subject(s): Score(s):

SAT Verbal: _____ Math: _____

ACT Verbal: _____ Math: _____

GHSGT Verbal: _____ Math: _____

Writing: _____

Social Studies: _____ Science: _____

Others (please list):

15. Is there any other information that you feel is important to include about your kindergarten through twelfth grade schooling experiences?

Part III: College Information

1. What college/university do/did you attend? _____

2. What class are you currently in? Freshman Sophomore Junior Senior

3. Are you in an Honors Program? Yes No

4. What mathematics courses have you taken/are you currently taking?
   (Please give course, year, and grade earned.)

5. Have you received any awards/citations while attending? If so, please list them.

6. What honors organizations are you a member of?

7. What extracurricular activities are you involved in?

8. What is your GPA? _____ Math GPA _____

9. Do/did you receive any type of financial support (grants, loans, scholarships)? Please list? If you have received scholarships please indicate the nature of the scholarship.

10. Is there any other information that you feel may be pertinent to the study?

APPENDIX B

REQUEST FOR AUTOBIOGRAPHY

Please write a brief narrative of your life during your kindergarten through twelfth grade years. Please be sure to include the following points, although you are not limited to these topics.

1. What events/experiences do you attribute to being female?

2. Identify activities and organizations that you feel contributed to your academic success.

3. Are there significant individuals that you feel contributed to your academic success?

4. Discuss your teachers. How many male and female teachers did you have? At what grade levels and courses did you have them? Did your teachers' attitudes, expectations, actions, and techniques have an impact on your success? If so, explain how.

5. How do you perceive your mathematics experiences were impacted by the fact that you are female? What was it like being a female during your mathematics schooling? Was it different at differing ages?

6. What factors do you feel contributed (or impeded) your success in school mathematics?

7. What is your current status with mathematics? Does your major/future occupation require the study of mathematics? How do you feel your mathematics achievement has impacted your life?

APPENDIX C

INTERVIEW PROTOCOL FOR FIRST INTERVIEW[44]

Pre-Question: Introduce myself and the purpose of the study. Describe their role in the research. Go over consent forms. Ask the participant for a preferred pseudonym.

1. What is your name, age, and current educational status?

2. How would you describe yourself (your ethnicity)?

2. What is your current status with your mathematics education?

3. When you think of mathematics, what is the first thing that comes to mind?

4. What do you think is important about mathematics?

5. What about mathematics appeals to you?

6. What does it mean to be mathematically talented?

7. Do you perceive yourself as mathematically talented?

8. When did you first believe that you were (or were not) mathematically talented?

9. What mathematics or school experiences have influenced these beliefs?

10. Are there other experiences that influence your beliefs?

11. How do you define "success"?

12. How about success in school mathematics?

13. Given that you have been identified as mathematically successful in secondary mathematics, how do you believe that this success impacts your ability to be successful in (any) future endeavors?

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[44] Adapted from Stinson, D. W. (2004). African American male students and achievement in school mathematics: A critical postmodern analysis of agency. *Dissertation Abstracts International, 66*(12). (UMI No. 3194548).

14. Do you have any commentary that you would like to make about your mathematics experiences, high school and the significance of mathematics within society in general?

15. Discussion about autobiographical information. Questions specific to the information acquired from previous questionnaire and written autobiography.

APPENDIX D

INTERVIEW PROTOCOL FOR SECOND INTERVIEW

This interview was based on readings regarding previous research and reflections upon the research process thus far. The readings that participants were asked to read included:

Benbow, C. P., & Stanley, J. C. (1980). Sex differences in mathematical ability: Fact or artifact? *Science, 210*(4475), 1262-1264.

Tartre, L. A., & Fennema, E. (1995). Mathematics achievement and gender: A longitudinal study of selected cognitive and affective variables [grades 6-12]. *Educational Studies in Mathematics, 28*, 199-217.

1. Is there anything about the previous research that stood out to you that you would like to discuss?

2. Do you believe that people have god-given mathematical talent? Boys and Girls?

3. What do you think the purpose of conducting the study was?

4. What do you think that says about the focus of mathematics in 1980? Do you think that we have progressed in those regards?

5. What kind of message do you think this gave students, teachers, and other researchers?

6. What about how the study was conducted. This is a quantitative research study. Do you think it is possible to understand the whole story "through the numbers?"

7. Do the results from this study, the conclusions that were drawn, have an impact on you? How? Why not?

8. What factors do Tartre and Fennema choose to focus on? Are these the most important? Did they leave anything out? What? Why?

9. What do you think the purpose of conducting this study was?

10. Do you think that this kind of research shows progress with regard to the way researchers (and others) feel about gender and mathematics?

11. What kind of message do you think this gave students, teachers and other researchers?

12. What stands out to you with regard to this historical research? Are there any major contributions that you feel have impacted your opportunities?

13. Are there any glaring items that have not been accounted for in this brief glimpse? What else do you think needs to be considered?

APPENDIX E

INTERVIEW PROTOCOL FOR THIRD INTERVIEW

1. What do you consider to be your most rewarding secondary school experience?

2. If this is not in mathematics – What is your most rewarding mathematics experience?

2. What factors, individuals, circumstances, etc. led to this experience?

3. What do you consider to be your most disappointing secondary school experience?

4. If this is not in mathematics – What is your most disappointing mathematics experience?

5. What factors, individuals, circumstances, etc. led to this experience?

6. Who was your most influential teacher? Why do you consider this person to have had such an influence? Under what circumstances did this person have influence on your success?

7. Thinking back about our previous interviews, what do you think it means to be successful? Under what circumstances is a person considered successful? Do you consider yourself successful? In what areas? What factors do you believe to have directly affected your success(es)?

8. Do you believe that you were successful because of your gender or in spite of your gender?

9. What about in the area of mathematics?

10. What do you believe that you have learned about yourself through this process?

11. What do you believe that you have learned about achievement/success by participating in this research?

12. In what ways do you imagine this research impacting future successes of female mathematics students?

13. What areas of research do you think that we have not discussed with regard to the success of female mathematics students that should be addressed in future research?

APPENDIX F

GRADE AND TEST SCORE DATA OF PARTICIPANTS

Category	Farah	Clara	Sophia	Samantha
High School GPA	4.339	4.620	4.490	4.400
HS Math GPA	4.600	4.780	4.300	4.500
Class Rank	6	2	6	Top 3% (in top 10)
SAT Total[45]	1430	1570	1490	1460
SAT Math	720	780	730	800
SAT II Math	720	800	Not Taken	Not Taken
AP Math Courses	Calc BC	Calc BC, Statistics	Calc BC	Calc BC
AP Math Grades	B/A	A/A, A	B/B	B/A
AP Exam Scores	3	4, 5	3	3
College Math Courses	Calc I, II, III	Calc I, II	Calc I	Calc II, Statistics
College Math GPA	3.67	4.00	3.00	4.00

[45] SAT Total is for Mathematics and Reading Comprehension Sections only – Out of 1600 possible