

A FEMINIST TALE IN THREE MOMENTS: PERCEPTIONS AND EXPERIENCES OF
ADOLESCENT FEMALES IN A FEMINIST MATHEMATICS CLASSROOM

by

DAWN LEIGH ANDERSON

(Under the direction of Patricia S. Wilson)

ABSTRACT

Informed by feminist standpoint theory, this research study portrays the experiences of seven adolescent girls in a feminist mathematics classroom in an all-girls' summer mathematics program. I examined adolescent girls' perceptions of themselves as learners of mathematics, their perceptions of mathematics, and their perceptions of their experiences in a feminist mathematics classroom. The literature on feminist pedagogy and how it can be applied to a mathematics education context provided the conceptual framework for the study. Using a case study design, I collected data over a five-week period using participant observation, focus group and individual interviews, documents, and an instrument. I analyzed data using a thematic analysis.

The central themes that emerged from the data were power relations, agency, authorship, and collaboration. The interrelationships between these themes formed the basis for envisioning a feminist mathematics classroom as a site for empowerment. The participants gained agency and authorship in a feminist mathematics classroom. They perceived that they controlled their own learning and that their role was to author mathematical knowledge. As the participants gained agency and authorship, their

confidence level improved and they became more independent and persistent as learners of mathematics. The participants encountered numerous frustrations and struggles and eventually valued the journey. The shift in power relations prompted the participants to rethink the role of a mathematics teacher, which was to guide learning and to foster exploration of ideas. Yet the participants never identified the teachers as teaching, because their view of teaching meant teacher-directed instruction. The participants saw the benefits and limitations of collaborations. Their epistemological stance on mathematics began to change as a result of their experiences in a feminist mathematics classroom. Data also show that the participants who entered with disparaging views of mathematics left with an optimistic perception of mathematics.

Findings hold promise for understanding the complexities of teaching and learning in a feminist mathematics classroom. The participants' voices shed light on the complex nature of agency, authorship, and collaboration. The findings describe a reconfiguration of power relations for students and teachers.

INDEX WORDS: Gender and Mathematics Education, Feminism and Mathematics Education

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For Olga Johanna Konell and Johan Helge Andersson

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The perpetual migration

Marge Piercy (1999)

How do we know where we are going?
How do we know where we are headed
till we in fact or hope or hunch
arrive? You can only criticize,
the comfortable say, you don't know
what you want. Ah, but we do.

We have swung in the green verandas
of the jungle trees. We have squatted
on cloud-grey granite hillsides where
every leaf drips. We have crossed
badlands where the sun is sharp as flint.
We have paddled into the tall dark sea
in canoes. We always knew.

Peace, plenty, the gentle wallow
of intimacy, a bit of Saturday night
and not too much Monday morning,
a chance to choose, a chance to grow,
the power to say no and yes, pretties
and dignity, an occasional jolt of truth.

The human brain, wrinkled slug, knows
like a computer, like a violinist, like
a bloodhound, like a frog. We remember
backwards a little and sometimes forwards,
but mostly we think in the ebbing circles
a rock makes on the water.

The salmon hurtling upstream seeks
the taste of the waters of its birth
but the seabird on its four-thousand-mile
trek follows charts mapped on its genes.
The brightness, the angle, the sighting
of the stars shines in the brain luring
till inner constellation matches outer.

The stark black rocks, the island beaches
of waveworn pebbles where it will winter
look right into it. Months after it set
forth it says, home at last, and settles.
Even the pigeon beating its short whistling
wings knows the magnetic tug of arrival.

In my spine a tidal clock tilts and drips
and the moon pulls blood from my womb.
Driven as a migrating falcon, I can be blown
off course yet if I turn back it feels
wrong. Navigating by chart and chance
and passion I will know the shape
of the mountains of freedom, I will know.

From my earliest memories of schooling, I have always known that I wanted and needed a doctorate degree; thus began my perpetual migration toward a Ph.D. I followed a not-so-direct path toward graduate school at the University of Georgia (UGA). I wound my way through an undergraduate program, middle, secondary, and college mathematics classrooms, and a master's program, arriving on the steps of Aderhold Hall. Over the past five years, I have felt like turning back many times, giving up on a dream that seemed distant and far off. Yet numerous people helped me to navigate my way through the challenges of graduate school and dissertation research. I would like to acknowledge and thank these people individually and collectively.

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CHAPTER 1

A FOUNDATION FOR INQUIRY: LAYING THE CORNERSTONE

Purpose of Study

Mathematics, as it is currently and widely taught, is not equally accessible to girls and boys and this appears to relate to preferences of pedagogy. (Boaler, 1997, p. 123)

Boaler (1997) indicates that “gendered styles of learning” exist in mathematics and that these differential learning styles are influenced by particular mathematical pedagogical practices, namely “traditional” and “progressive” (pp. 110-124). As defined by Boaler (1997), a traditional approach to teaching mathematics places “emphasis upon order and control, the learning of specified, mathematical methods, ‘chalk and talk’ transmission teaching, with children divided into... narrow bands of ‘homogeneous’ ability” (p. 145). At the other end of the continuum, a progressive approach to teaching mathematics is “based upon principles of independence and self-motivation” (Boaler, 1997, p. 145), and students work in a cooperative, noncompetitive learning environment. Conceptual understanding is the norm.

Boaler contended that the traditional way that mathematics is taught enhances boys’ learning experiences in mathematics and hinders that of girls. Her research shed light on how girls and boys learn and experience mathematics differently in traditional and progressive mathematics classrooms. Boaler found that girls preferred progressive mathematics classrooms, which stressed understanding, collaboration, and open-ended problems. Responding to a progressive approach, girls were on a “quest for understanding”

(Boaler, 2000a, p. 33) mathematics. Boys, on the other hand, tended to prefer closed, traditional classrooms, which emphasized competition, speed, and procedural learning. Boys also seemed to have greater adaptability to traditional classrooms even when they preferred a progressive approach to learning mathematics.

Boaler (1997) contended that a progressive pedagogy in mathematics teaching might enhance the learning experiences for girls and thereby increase their participation rates, achievement, and enjoyment in mathematics. In keeping with this notion of progressive pedagogy, feminist pedagogy applied to the teaching and learning of mathematics is a relatively new idea with little supporting research. I provide a detailed discussion of feminist pedagogy in Chapter 3. For purposes of this dissertation, I classify feminist pedagogy as a type of progressive and liberatory pedagogy. Very briefly, feminist pedagogy considers the gendered, hierarchical, and oppressive nature of classrooms, pays attention to power relations in the classroom, connects learning with students' experiences, and fosters agency, empowerment, and collaboration.

In light of this void in the research and Boaler's (1997) findings, this study attempted to add to the literature on progressive pedagogies, namely feminist pedagogy, within mathematics education by exploring the experiences of seven adolescent girls in a feminist mathematics classroom.

The primary research question for this study was, What are the experiences of adolescent girls' in a feminist mathematics class? To address this question, I proposed three secondary questions that guided the study:

1. What are adolescent girls' perceptions of their experiences in a feminist mathematics classroom?

2. What are adolescent girls' perceptions of themselves as learners of mathematics in a feminist mathematics classroom?
3. What are adolescent girls' perceptions of mathematics in a feminist mathematics classroom?

Rationale

There is a need to research adolescent girls' experiences in learning mathematics because their voices have been and still are eclipsed in mathematics classrooms. This research provided an opportunity to hear and study the voices of adolescent girls in a feminist mathematics classroom. In the mid 1990s, Fennema and Hart (1994) advocated feminist research in mathematics education. They argued that "feminist perspectives can contribute to mathematics education research in the kinds of research questions that are explored, whose questions are asked, whose voices are heard, and the research methods employed" (Fennema & Hart, 1994, p. 653). Leder, Forgasz, and Solar (1996) also maintained that "research incorporating feminist theory and using feminist research paradigms has the potential to extend understandings of gender issues in mathematics learning" (p. 959). This study was partly in response to these leading researchers' calls for research in mathematics education informed by a feminist perspective, and partly in response to my desire to study females' experiences in mathematics from a feminist standpoint perspective.

Most of the past research (Leder, 1992; Leder et al., 1996) on female students and mathematics has been posed as a comparison to male students. Researchers have queried how female students compare with male students in mathematics, but rarely have they studied female students on their own accord, making no comparison to male students.

Campbell and Greenberg (1993) called attention to the potential problems in difference-based research. “When research looks only at differences, the focus is on that which divides.” What happens when female students are compared to male students is the strengthening of the male/female dichotomy where male students are seen as the norm and female students are seen as somehow deficient. In an effort to confront the limitations of difference-based research studies, Fennema and Hart (1994) called for research in mathematics education that investigates females’ experiences in mathematics. In this study, adolescent girls were the central “focus of inquiry” (Fennema & Hart, 1994, p. 653). I wanted to speak and write about their experiences in a mathematics classroom that was grounded in feminist pedagogy.

Over the span of two decades, a number of feminist researchers (Becker, 1995, 1996; Buerk, 1982, 1985, 1990, 1996; Erchick, 1996, 2001; Koch, 1996; Morrow, 1996; Pasztor & Slater, 2000) have attempted to answer Damarin’s (1995) question, “How do women experience mathematics?” (p. 250), which is critical to feminist research in mathematics education. This literature contains research about females’ experiences in mathematics but lacks research that focuses on how female students experience mathematics in a classroom taught from a feminist perspective. There are, however, a few feminist scholars (Rogers, 1995; Solar, 1995) who are interested in exploring feminist pedagogy in mathematics education. Rogers (1995) provided a personal account of her experiences of incorporating feminist pedagogy in her undergraduate mathematics classrooms. Taking a more theoretical approach, Solar (1995) described a model of inclusive pedagogy in mathematics education that was built on principles of feminist pedagogy and on tenets of nondiscriminatory classroom practices. In regard to this research, Rogers’s and Solar’s

scholarship provided a springboard for exploring adolescent girls' experiences in mathematics classes taught from a feminist perspective.

A multi-year study by Boaler (1997, 2000a, 2000b) offered support for conducting research on feminist pedagogy in mathematics education. Boaler compared the mathematical experiences of students in two high schools in England. Teachers in the first high school taught mathematics from a traditional, procedural approach that stressed rules, drill, and practice. The second school faculty's stance toward teaching mathematics relied on an open-ended, project-based, progressive approach that emphasized conceptual learning. Boaler found that the high school girls preferred the latter approach, which emphasized a relational, connected way of knowing, doing, and understanding mathematics.

Many of the girls in both schools were driven by a *quest for understanding* that was not evident amongst the boys.... Many of the girls wanted more. They wanted to locate the rules and methods they were introduced to within a wider sphere of understanding. They wanted to know *why* the methods worked, *where* they came from and *how* they fitted into the broader mathematical domain. (Boaler, 2000a, p. 33, italics in original)

This quest for understanding on the part of the girls supported Morrow's (1996) model for connected teaching in mathematics, which was built on Belenky, Clinchy, Goldberger, and Tarule's (1986) research on women's epistemological development. Belenky et al. maintained that women prefer a connected way of knowing rather than a separate, disjointed way of knowing. Boaler's research offered further evidence in support of this claim. It is important to note that Boaler's study was in sharp contrast to other research (Walden & Walkerdine, 1985; Walkerdine, 1998) in England that contended that girls prefer to learn mathematics in a mechanistic fashion, where rote memorization and procedural learning are hallmarks.

Boaler (2000a) noted that research on progressive pedagogy is lacking. She emphasized that “an important limitation of many previous research studies investigating gender relations in mathematics is that they have not researched the teaching environments in which students were working” (p. 36). In support of a progressive pedagogy of mathematics, Boaler (2000a) explained:

The equitable achievement of the students at the project-based school I researched for three years seems important, as although feminist researchers have claimed that problem solving approaches would enhance the attainment of girls, there has been little data available to support that idea. (p. 39)

Boaler’s research underscores the need for understanding girls’ experiences in progressive mathematics classrooms. She suggested that researchers have a great deal to learn about the possibilities that progressive pedagogy holds for girls in the mathematics classroom. There is the belief that “traditional pedagogical practices will maintain inequality in the attainment and representation of mathematics students, particularly at the highest levels, even as stereotypical societal expectations diminish” (Boaler & Greeno, 2000, p. 197). The present study afforded an opportunity to examine adolescent girls’ experiences in a feminist mathematics classroom in order to identify possibilities for increased participation, achievement, and satisfaction. Boaler’s research as well as the work by Rogers (1995) and Solar (1995) led me to explore uncharted territory. I investigated this territory because, I contend, feminist mathematics classrooms may hold promise for girls’ attainment and participation in mathematics.

Disparities in mathematics achievement still exist between girls and boys (Leder, 1992; Leder et al., 1996; Tate, 1997). To understand how gender disparities in mathematics achievement arise and are maintained, Ernest (1995) examined the relationship between

philosophies of mathematics, values, and teaching. Figure 1 illustrates the reproductive cycle of gender inequality in mathematics education that perpetuates the status quo.

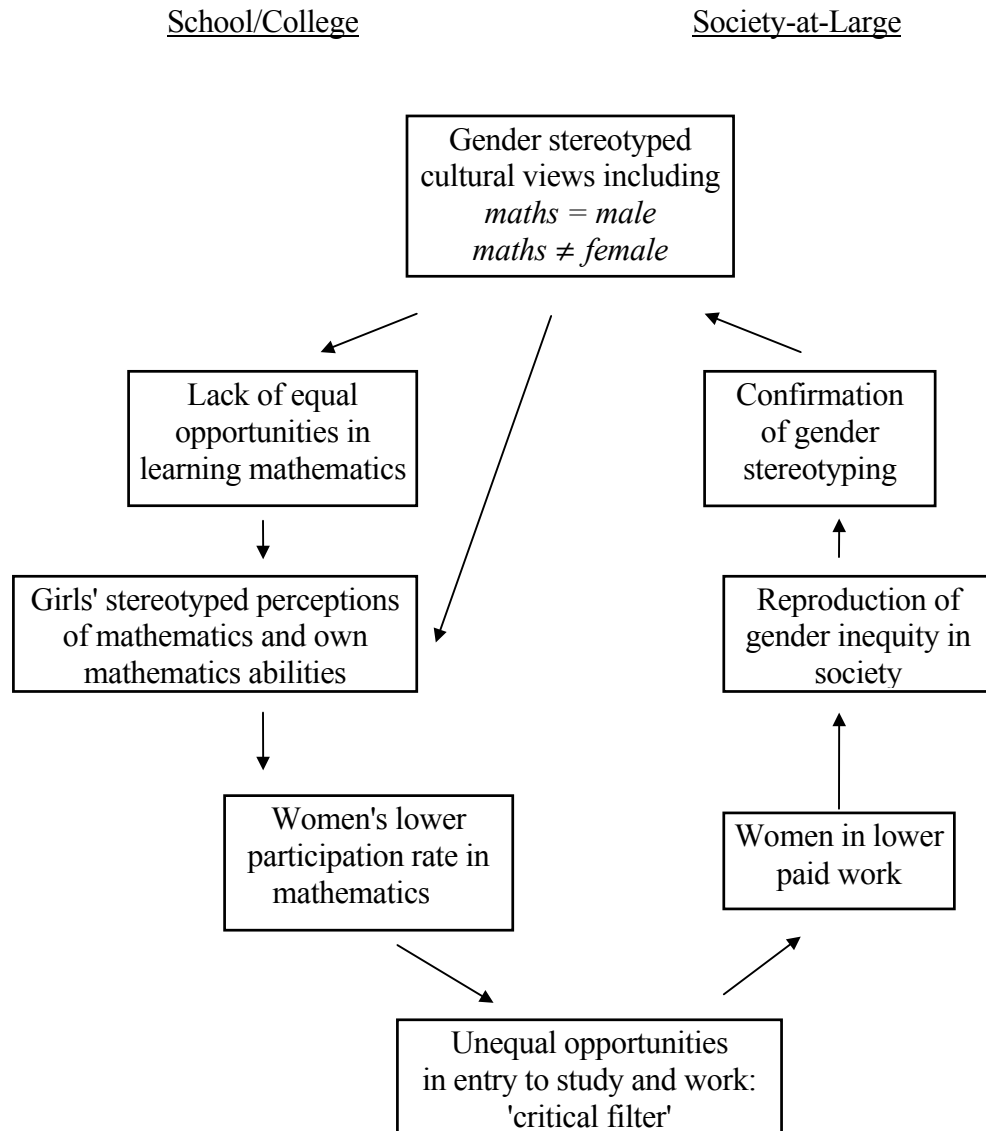


Figure 1. The reproductive cycle of gender inequality in mathematics education (Ernest, 1995, p. 457).

If one enters the cycle where women's participation rate in mathematics is lower than that of men's, one notices that these lower participation rates lead to fewer opportunities to gain entry in areas of advanced study, which in turn lead to fewer opportunities for women to pursue work in mathematics related fields, which ultimately contribute to women working in lower paid jobs. This cycle reproduces gender inequality in society and perpetuates gender stereotyping, which in turn reinforces dominant discourses about mathematics. For example, mathematics is associated with masculinity whereas femininity is stereotyped as nonmathematical, thus sending the message that female students are unsuited for mathematics. In other words, female students' underachievement in mathematics and underrepresentation in mathematics-related careers is partly due to the dominant discourse that associates mathematics with masculinity and power.

Ultimately, as Ernest (1991) noted, "the cultural domination of rational and scientific knowledge by masculine values, serves to legitimate and sustain men's domination of the power, status, and wealth, and hence political hierarchies in society" (p. 278). These dominant values lead to a lack of equal opportunities in learning mathematics, which negatively affect girls' perceptions of mathematics and their beliefs about their abilities in mathematics. These negative beliefs adversely influence girls' decisions to participate in mathematics, thus completing the vicious circle. Ernest (1995) contended that "only if every link in the circle is attacked can the reproductive cycle of gender inequality be broken" (p. 456). By investigating the experiences of girls in a mathematics classroom that uses feminist pedagogy, I had an opportunity to examine how feminist pedagogy may affect girls' achievement in and perception of mathematics, thereby studying a link in this cycle: the link

between how girls perceive of themselves as learners of mathematics and how these perceptions influence their participation in the field.

I chose to study how feminist pedagogy might inform the mathematics classroom because there is a silence in the literature on this point. To shatter this silence, I have studied and written about girls' experiences and perceptions in a feminist mathematics classroom. By listening to girls' voices in a feminist mathematics classroom, I had an opportunity to understand their perceptions about themselves as learners of mathematics and their perceptions of mathematics. I also had a window on their perceptions of their experiences.

Code (1991) summarized what I envision as one reason that it is necessary to examine the influences of feminist pedagogy on the mathematics education of girls:

Posing the question Whose knowledge are we talking about? is a revolutionary step in this refusal [women's refusals to remain Other]. The next steps cannot merely be the addition of some notes about women's subjugated knowledge to the existing corpus of received knowledge, or the integration of women on equal terms into received epistemological theories. They must transform the terms of the discourse, challenge the structures of the epistemological project. Such transformations will reveal that the discourses feminists are developing are themselves empowering, informing innovative practices, and producing a resistance against domination that signals profound inner metamorphoses. (p. 324)

This study attempted to understand the possibilities that feminist classrooms hold for providing a learning environment that nurtures such a metamorphosis in adolescent girls with respect to mathematics as well as the problems that make this metamorphosis a challenge.

Posture and Positionality

We need to avoid the “objectivist” stance that attempts to make the researcher’s cultural beliefs and practices invisible while simultaneously skewering the research objects beliefs and practices to the display board. (Harding, 1987, p. 9)

For the question of whether or not a position is right, coherent, or interesting, is, in this case, less informative than why it is we come to occupy and defend the territory that we do, what it promises us, from what it promises to protect us. (Butler, 1995, p. 127)

Wolcott (1992) defined *posturing* in qualitative inquiry as “behaviors ranging from assuming an affected pose to taking a strategic position” (p. 4). He explained that qualitative researchers take a particular posture, stance, or position in their inquiry. This posture affects the kinds of research questions that are asked and how data will be collected, analyzed, and interpreted. Wolcott acknowledged that he strategically positions his research in cultural contexts. He wrote that “it [a cultural orientation] has become the position, or strategy, from which I ordinarily pursue research” (p. 42).

With regard to this study, Wolcott’s notion of posturing raises the question, From which posture and position do I pursue my research? This question boiled down to examining the theoretical lens through which I view the world and understanding how this lens directly influences my research agenda. It was clear that my posture as a researcher was intricately connected to my position as a feminist. I also realized the significance that this political and personal position had on my research.

One core component of doing feminist research concerns itself with identifying the multiple positionalities in which researchers locate themselves. Harding (1987) argued:

The best feminist analysis . . . insists that the inquirer her/himself be placed in the same critical plane as the overt subject matter, thereby recovering the entire research process for scrutiny in the results of the research. That is, the class, race, culture, and

gender assumptions, beliefs, and behaviors of the researcher her/himself must be placed within the frame of the picture that she/he attempts to paint. (p. 9)

This quote by Harding implied that I must consider my multiple positionalities and how they shaped this research. The way that Harding (1987) recommended that we deal with our multiple positionalities and biases is to embrace our subjectivity. She contended:

Only in this way can we hope to produce understandings and explanations which are free (or, at least, more free) of distortion from the unexamined beliefs and behaviors of social scientists themselves. Another way to put this point is that the beliefs and behaviors of the researcher are part of the empirical evidence for (or against) the claims advanced in the results of the research. . . . Introducing this “subjective” element into the analysis in fact increases the objectivity of the research and decreases the “objectivism” which hides this kind of evidence from the public. (Harding, 1987, p. 9)

In essence, I cannot eliminate my subjectivities, I can only trouble them (i.e., interrogate and deconstruct their meaning) and use them to make this study more “objective.” The goal was to intentionally include my subjectivities in order to see more “with the mind’s eye” (Belenky et al., 1986, p. 19).

The kinds of research questions that I ask, the methodologies that I employ, and the manners in which I analyze and interpret data are a direct result of my feminist identity. Because I identify as a feminist mathematics educator and researcher, I choose to research issues that pertain to female students’ experiences in mathematics. To that end, in this study, I am concerned with exploring adolescent girls’ experiences in a feminist mathematics classroom.

The following quote by Reinharz (1992) specified the seed from which this research grew, that is, my personal experience:

There is a common notion in feminist research that inquiry is rooted in experience.

Feminist researchers frequently start with an issue that bothers them personally and then use everything they can get hold of to study it. In feminist research, then, the

“problem” is frequently a blend of an intellectual question and a personal trouble.
(pp. 259-260)

In my case, the “problem” originated with the disconcerting feelings that I had regarding mathematics teaching and learning in traditional contexts. There seemed to be few alternatives in learning and teaching mathematics. The primary way that I learned and experienced mathematics centered on an absolutist, Eurocentric, male view of mathematics, which made little room for females in mathematics. The dominant model served those who prospered from competition and abstract, decontextualized forms of mathematical knowledge.

These concerns were magnified when I enrolled in a Social Foundations of Education course, Gender and Education, which was taught by Jerome Morris and Judith Preissle. It was in this course that I awoke to the inequities in education, particularly in mathematics, science, and technology, that females face and must overcome. At this point, I was angry and realized that I needed to take further action. Upon the recommendation of Jude Preissle, I enrolled in a feminist theory course. I thought I was angry before, but that anger was dwarfed by the rage that I felt after learning about women’s oppression both locally and globally. These feelings affected how I viewed mathematics education. As a result, I became distressed by what I had seen, learned, and experienced in mathematics courses all of my life. By engaging in feminist thought, questioning how mathematics is taught, and acknowledging that female students might be socialized to learn differently than male students in mathematics, I began treading a path that has led me to where I am today in my thinking about the intersection of mathematics education and feminist theory.

I have come to believe that feminist theory can inform the mathematics classroom based on my experiences, readings, and interactions in women’s studies courses and

readings about feminism and mathematics education. Through my involvement with multiple teaching and learning experiences in women's studies courses, I have been empowered and transformed by classrooms grounded in feminist pedagogy. These past learning experiences in women's studies have provided fodder for change and have reshaped my ideas about teaching and learning mathematics. I have come to believe that feminist pedagogy holds promise in mathematics education.

Inherent in understanding the ways that female students construct, learn, and experience mathematics from a feminist perspective is the notion that the structure of the mathematics classroom itself is problematic for female students (Damarin, 1995). By structure, I mean the classroom dynamics and the classroom environment, which continue to be constructed in ways that foster the needs and demands of male students (Belenky et al., 1986). Furthermore, mathematics itself and the ways in which mathematical content is presented often tend to favor male students more than female students (Boaler, 1997; Burton, 1995; Damarin, 1995). In essence, female students experience a kind of *epistemic oppression* (Code, 1991) in the traditional mathematics classroom. If this epistemic oppression continues, then "university mathematics will continue to be a white, male preserve and large numbers of girls and students from minority groups will be excluded from a subject at which they could excel" (Boaler & Greeno, 2000, p. 197).

As part of this research, I questioned how mathematics is taught and challenged the notions of what mathematics means and what it means to do and know mathematics in order to make mathematics more accessible to female students. In a similar vein, Fennema (1995) stated, "I am coming to believe that females have recognized that mathematics, as currently taught and learned, restricts their lives rather than enriches them" (p. 34). It is my hope that

feminist research in mathematics education can aid in availing female students new ways of thinking about, doing, and learning mathematics.

My research hinges on the belief that mathematics education framed within a feminist perspective will look different from the traditional view of mathematics education. I also maintain that approaching mathematics education from a feminist perspective holds promise for creating gender-equitable classrooms that empower all students, in particular, subordinated groups. Ultimately, though, I hope that by viewing mathematics education through a feminist lens, this research will open one more avenue for understanding adolescent girls' experiences in mathematics.

A primary issue that I reflected upon in terms of my positionality as a researcher in this study revolved around my stance towards the impact that feminist thought can have on mathematics education. I acknowledge that feminist pedagogy is not the only way to transform the mathematics classroom for female students. I also recognize that there are limitations and trade-offs in the application of feminist theory and pedagogy to the mathematics classroom. For example, mathematics classrooms grounded in feminist pedagogy emphasize collaboration and deemphasize competition. There are students who may prefer competitive learning environments over collaborative inquiry. Hence, I not only searched for possibilities, but I was open to identifying problems and discussing inevitable concessions. This search for possibilities and problems prompted me to examine adolescent girls' perceptions of the possibilities of learning in a feminist mathematics classroom and their perceptions of the problems of learning in a feminist mathematics classroom. Examining and understanding adolescent girls' experiences in a feminist mathematics class

will, ultimately, help me to discern how feminist pedagogy can inform mathematics education.

In summary, an important part of doing feminist research is to understand and acknowledge researcher subjectivity and to become aware of how a researcher's beliefs undermine or enhance her or his research. By revealing my posture as a feminist researcher in mathematics education, I provided a portrait of who I am and what theoretical lens I use to view the world and this research. At the same time, I attempted to situate myself in regards to the research at hand and to inform the reader as to what I believe and think about this research.

CHAPTER 2

A THEORETICAL FRAMEWORK FOR INQUIRY: PROVIDING A PLATFORM

The task of feminist epistemology is to uncover how patriarchy has permeated both our concept of knowledge and the concrete content of bodies of knowledge, even that claiming to be emancipatory. Without adequate knowledge of the world and our history within it (and this includes knowing how to know), we cannot develop a more adequate social practice. A feminist epistemology is thus both an aspect of feminist theory and a preparation for and a central element of a more adequate theory of human nature and politics. (Flax, 1983, p. 269)

Before I launch a discussion about a feminist epistemological framework, I must mention that there is no one feminist epistemology. Feminist epistemological frameworks are numerous and diverse, both in nature and scope. Nowhere will you find one true feminism or feminist epistemology. The feminist theoretical framework that I most subscribe to and feel most comfortable with is feminist standpoint theory. At times as I conducted the study, however, I found myself “theoretically migrating” (Hartsock, 1998, p. 237) to feminist poststructural theory. In fall 2001, I was fortunate to take a class from Elizabeth St. Pierre. During her course, I began exploring feminist poststructural theory in education (St. Pierre, 2000). In particular, I found its reinscription of power, freedom, resistance, and subjectivity useful in my analysis and interpretation in this study. For example, I moved toward thinking about power as power relations. Walshaw (2001) explained that power framed within poststructuralism moves “from a contemporary negative idea to a positive conception—an enabling, constitutive, and productive force” (p. 481). She posited that “a Foucauldian analysis is focused on the effects of power rather than on offering explanations” (p. 482). In the present study, I examined the effects of power on the

participants' experiences in a feminist mathematics classroom. That is, I explored how the participants changed their perceptions as learners of mathematics that were based on a reconfiguration of power relations within a feminist mathematics classroom. A feminist poststructural view also encouraged me to highlight the partiality and locality of this study.

Nevertheless, feminist standpoint theory most aptly describes the lens through which I approached the study and served as a foundational epistemology for it. In this chapter, my purposes are twofold. First, I provide an overview of feminist standpoint theory in order to familiarize readers with its main tenets. Second, I discuss the application of feminist standpoint theory to mathematics education.

A Sketch of Feminist Standpoint Theory

Hartsock (1983) is credited with having introduced the notion of a "feminist standpoint." The origins of a standpoint in feminism can be traced back to Marxist thought, which introduced the idea that the proletariat maintains a standpoint that is unique to the working class. Other feminist scholars such as Rose (1983) and Smith (1988) formulated notions of a feminist standpoint based on a Marxist perspective. (For an overview, see Tanesini, 1999.)

Tenets of Feminist Standpoint Theory

Women as Constructors of Knowledge

A major principle of feminist standpoint epistemology is its reliance on knowledge that is created by and situated within the viewpoint of women. Women construct their own knowledge and do so differently than men (Tanesini, 1999). As Damarin (1995) stated, "Knowledge is always situated by the standpoint of the knower; from a feminist standpoint, knowledge begins with women's lives" (p. 247). It is important to note that a feminist

standpoint, which is “not simply an interested position (interpreted as bias) but interested in the sense of being engaged” (Hartsock, 1983, p. 285), hinges on the lives, knowledge, experiences, and voices of women. Hartsock (1998) noted:

A standpoint is not generated unproblematically by simple existence in a particular social location. It is a product of systematic theoretical and practical work, and its achievement can never be predicted with any certainty. The adoption of a standpoint may require a theoretical migration. (p. 237)

In other words, one does not merely fall into a standpoint because of her or his allegiance with a particular group but must *actively* work to *achieve* a feminist standpoint. Proponents of feminist standpoint theory rally around the notion that “a standpoint is not the same as a viewpoint or perspective, for it requires both science and political struggle” (Hartsock, 1998, p. 150). Furthermore, “a standpoint is an objective position in social relations as articulated through one or another theory or discourse” (Hartsock, 1998, p. 150).

Privileged Epistemic Viewpoint

Feminist standpoint has an advantage that, at first sight, appears to be a disadvantage. This epistemology assumes that women perceive their worlds from a subjugated position that arises from the patriarchal world in which we live. As a result of living in a male-dominated world, women are better situated than men to examine the inequities of their position and to evaluate those occupying the positions of power and dominance. Tanesini (1999) referred to this position as a *privileged epistemic viewpoint* (p. 142). Women hold dual social positions that are antithetical in nature. That is, women play a central role in sustaining the current system but maintain a marginal position in terms of power within the system. Because women are in a less advantageous position, they gain a perspective that is not possible for men. Thus, they are in a preferred position, which allows

them to view the world with a more finely focused lens. This distinct lens allows women, by virtue of their less powerful position,

to perceive a rupture between what the world is like for them and what dominant views say about it. It is this “line of fault” which alerts women that something is amiss. Starting from their experiences it is possible for them to expose those aspects of social reality that are invisible from other positions. (Tanesini, 1999, p. 142)

Herein lies the privilege that women possess. Damarin (1995), in agreement with Harding (1991), argued that “women can know the world in valid ways that are not available to their oppressors; because they have less to lose in changing their status quo, they are less bound to it and better able to examine it” (p. 247).

Agency

In an overview of its main components, Damarin (1995) noted two important features that are central to feminist standpoint theory. First, the notion that we are only products of our environment is rejected. In other words, feminist standpoint theorists (often referred to as essentialists) oppose constructionism, which maintains that the “natural is *produced* by the social” (Fuss, 1989, p. 3, italics in original). Fuss clarified the constructionists’ stance: “Constructionists are concerned above all with the *production* and *organization* of differences, and they therefore reject the idea that any essential or natural givens precede the processes of social determination” (pp. 2-3, italics in original). Feminist standpoint theorists, who side with essentialism in the essentialism versus constructionism debate, maintain that the “natural is *repressed* by the social” (p. 3, italics in original) and stand in opposition to constructionism for fear of loss of agency. Damarin (1995) noted:

The view that everything is socially constructed implies that our bodies are simply blank slates on which society writes its messages. This view is rejected by standpoint theorists because it leaves women (and men) without agency. Unless women have agency, they cannot construct and act upon a standpoint. (pp. 247-248)

This feminist cry for agency is critical when we speak about feminist standpoint theory. That is, women move from being object to subject and agent. Without agency, women lose power within themselves to make choices. No longer can they be their own advocates. With agency, however, women feel a sense of empowerment and control over their own lives. They recognize that they can use their marginal status as women as a “site of resistance” (hooks, 1996), which offers a “location of radical openness and possibility” (p. 55). When women have agency, they feel empowered to act and speak on their own behalf.

Objectivity

Damarin (1995) highlighted another important feature of feminist standpoint theory, which is the notion of the interplay between objectivity and knowledge. One interpretation of this relationship is Harding’s (1991) *strong objectivity*, which hinges on the notion that objectivity, as it is traditionally defined, is no longer valid when considering a feminist standpoint epistemology. Harding noted the importance of strong objectivity:

A feminist standpoint epistemology requires strengthened standards of objectivity. The standpoint epistemologies call for recognition of a historical or sociological or cultural relativism—but not for a judgmental or epistemological relativism. They call for the acknowledgment that all human beliefs—including our best scientific beliefs—are socially situated, but they also require a critical evaluation to determine which social situations tend to generate the most objective knowledge claims. They require, as judgmental relativism does not, a scientific account of the relationships between historically located belief and maximally objective belief. So they demand what I call *strong objectivity* in contrast to the weak objectivity of objectivism and its mirror-linked twin, judgmental relativism. (p. 142, italics in original)

Harding makes a clear distinction between strong and weak objectivity in order to reconceptualize traditional patriarchal views of objectivity. Harding commented that “the notion of ‘strong objectivity’ conceptualizes the value of putting the subject or agent of knowledge in the same critical, causal plane as the object of her or his inquiry” (p. 161). An

ultimate goal in the process of knowledge acquisition is that there is a “reciprocal relationship between the agent and the object of knowledge” (p. 161).

Using newly defined notions of objectivity, like that of Harding’s notion of strong objectivity, as a springboard, Damarin (1995) noted that “the objects of knowledge are not static and passive, but are actors; knowledge is constructed dialectically through interactions between object and knower” (p. 248). In summary, knowledge acquisition begins with individual women who, through their experiences and privileged epistemic vantage points, construct their knowledge through a process that is interactional, dynamic, and transformative. Harding (1991) summarized this main point:

In a society structured by gender hierarchy, “starting thought from women’s lives” increases the objectivity of the results of research by bringing scientific observation and the perception of the need for explanation to bear on assumptions and practices that appear natural or unremarkable from the perspective of the lives of men in the dominant groups. Thinking from the perspective of women’s lives makes strange what had appeared familiar, which is the beginning of any scientific inquiry. (p. 150)

Harding’s words reiterate the importance of grounding research in women’s and girls’ experiences, which is where feminist research originated. Frye (1996) added to this conversation by stating:

It is an unforgettable, irreversible and definitive fact of feminist experience that respect for women’s experience/voice/perception/knowledge, our own and others’, is the ground and foundation of our emancipation—of both the necessity and the possibility of rewriting, recreating, the world. (p. 37)

Starting from women’s lived experiences is the place to begin when attempting to recast traditional paradigms, alter dominant discourses, and transform research practices.

Multiplicity

Implicit in feminist standpoint theory is the concept of multiplicity (Harding, 1991; Tanesini, 1999). Though not a feminist standpoint theorist, Flax (1983), who emerges from

a psychoanalytical feminist perspective, argued for a feminist epistemology that honors multiplicity. “All concepts must be relational and contextual. Ways of thinking and thinking about thinking must be developed which do justice to the multiplicity of experience, the many layers of any instant in time and space” (pp. 270-271). Within this epistemological framework, therefore, multiple feminist standpoints exist; there is no single feminist standpoint. Standpoints arise out of different positions or locations that women hold, which may vary according to race, class, sexual orientation, age, abilities, to name a few. For example, women from diverse ethnic backgrounds, such as African American (e.g., Collins, 1991), Latina, and Third World women, maintain different standpoints. Proponents of this ideology contend that “a feminist standpoint must be actively pursued and constructed as a way of knowing, which begins with the lives of (particular) women in the world” (Damarin, 1995, p. 247).

It is also important to note that women from diverse backgrounds who hold *different* standpoints may also *share* standpoints. For example, two women in academia, one black and one white, may hold different standpoints based on their race, yet, may also share standpoints based on their position as women within a patriarchal university system. In summary, the notion of standpoint is highly complex and multidimensional, having many layers due to the numerous positionalities that women may hold. Standpoint theory holds promise for women because it calls for unity based on shared positions that women hold within patriarchy. Yet, this very call for unity should not be misconstrued as a call for homogeneity. Frye (1996) called attention to this point:

What we want to do is to speak of and to and from the circumstances, experience and perception of those who are historically, materially, culturally constructed by or through the concept *woman*. But the differences among women across cultures, locales and generations make it clear that although all female humans may live lives

shaped by concepts of Woman, they are not all shaped by the same concept of Woman. (p. 36)

What Frye proposes is moving away from the essentializing notion that there is “*a* or *the* woman’s story” (p. 37); rather she imagines branching out “along various associative axes” (p. 39) based on “discovering, recognizing, and creating patterns” (p. 39).

Feminist Standpoint Theory and Mathematics Education

Women and Girls as the Focus of Inquiry

A feminist standpoint in mathematics education values women’s and girls’ voices in the classroom, considers their mathematical and nonmathematical experiences in the learning and teaching process, and acknowledges the unique perspectives that they bring to the learning environment. Key to creating a feminist standpoint in mathematics education, though, is understanding the ways that women and girls construct their mathematical knowledge and experience mathematics (Fennema, 1996). In this context, the mathematics content itself is peripheral; the ways in which women and girls build their mathematical knowledge takes center stage. At the heart of feminist standpoint in mathematics education is the ideal that “feminist research about girls and women would seek to help them understand and transform their place in mathematics education rather than working to identify differences between female and male students” (Fennema & Hart, 1994, p. 655). In other words, women and girls are not simply compared with males. Instead, research about women and girls in mathematics stands on its own merit. No longer is there an urgency to compare women and girls with men and boys, who, in most accounts, are perceived as the norm.

Damarin (1995) insisted that “to arrive at a feminist standpoint with respect to mathematics and mathematics education, the primary question to be addressed is ‘How do

women experience mathematics?’” (p. 250). This is a radical shift away from research in mathematics education that seeks to investigate females’ mathematical experiences and understandings by using the prototypical white male as the norm of comparison. In this theoretical framework, adolescent girls’ mathematical experiences are at the core of inquiry; their *mathematical experiential realities*, a term coined by Les Steffe, take center stage. A core component of this epistemology is the need to “honor the individual gendered student, believing that some of the answers to ‘the problem of women and mathematics’ will be found at the level of the global structure of curriculum” (Damarin, 1995, p. 249). Damarin called attention to the idea that we need “to begin a radical reorganization of the familiar ways of thinking about and interpreting issues and studies of gender and mathematics, and, by so doing, to shed a different light on this area” (p. 242).

Mathematics as a Gendered Process

One way to begin a radical reorganization of the ways in which mathematics educators think about gender and mathematics is to frame related and appropriate discourse within a feminist standpoint epistemology. That is, students’ mathematical experiences must be queried as a *gendered* process, a process that enables those with power and voice to control what and whose mathematical knowledge is valued. Two prominent mathematics education researchers, Confrey (1994, 1995a, 1995b, 1999) and Burton (1995, 1999), writing about similar issues, offered insights into what a feminist standpoint entails in mathematics education. Their ideas provided a foundation on which to build a feminist standpoint model of mathematics education. I explain their ideas in the following discussion.

Diversity

Confrey (1995b) posited a theory of intellectual development that integrated ideas from constructivist and socioculturalist perspectives but that is couched in a feminist perspective. Confrey centered her discussion of this epistemology on seven issues, which she maintained “have been accorded less than adequate examination within the Piagetian and Vygotskian perspectives” (p. 36). Because the purpose of this chapter is not to discuss Confrey’s revised theory of intellectual development in its entirety but only key ideas of her framework that aid in articulating what feminist standpoint theory looks like in mathematics education, I will simply list the seven issues that Confrey articulated, if only to pique the reader’s interest:

1. Human development depends on the environment.
2. The self is both autonomous and communal.
3. Diversity and dissent are anticipated.
4. Emotional intelligence is acknowledged.
5. Abstraction is reconceptualized and placed in a dialectic.
6. Learning is viewed as a reciprocal activity.
7. Classrooms are studied as interactions among interactions. (p. 36)

All seven add to a discussion of feminism and mathematics education. For the immediate purpose at hand, I want to focus attention on the third and sixth issues, both of which offer insight into connecting feminist standpoint theory with mathematics education.

Confrey (1994; 1995b) argued that diversity is an issue that receives little attention within a radical constructivist perspective. For instance, Confrey (1995b) criticized “radical constructivist views for their failure to recognize a person’s placement in many

classifications, not only as members of a developmental age-group” (p. 38). In order to acknowledge students as members of diverse groups and honor the multiplicity of their identities, Confrey argued for a revised notion of autonomy and self as postulated in radical constructivism:

The self is constructed as a viable actor in accomplishing its purposes. It is, physically, the most immediate actor, in that we can control our physical actions. However, there is nothing in such a concept of autonomy that denies the possibility of creating a sense of identity within a dyad, a group, or a community. (p. 38)

This (re)presentation of autonomy allows the knower to be part of multiple groups and communities. The concept of self is no longer “limited to solitary individuals” (p. 38); rather the self is viewed as “communal *and* autonomous” (p. 38, italics in original). This revamped view of autonomy opens the doorway for dissent, whereby “some form of negotiation and resolution of conflict needs to be established as a part of knowledge development” (p. 38). If I apply this view of self to a feminist standpoint perspective in mathematics education, I argue for the acknowledgment of the multiple identities of our students and the multiple communities to which they belong. I accept that these multiple memberships aid in the ways the students come to know and learn mathematics. In allegiance with Confrey (1995b), I argue for a theory of learning mathematics that values the learner as an individual capable of creating her or his own knowledge, yet views the learner as a human being living in particular social and cultural contexts where knowledge and meaning are in constant flux.

Learning as a Reciprocal Activity

The sixth issue presented for debate by Confrey (1995b) is “learning viewed as a reciprocal activity” (p. 41). This notion rests on the idea that

a reproductive view of human development in which cycles of interaction are expected, in which the student voice is solicited and valued, and in which authority

does not come from the dispersal of knowledge but from the creation of a knower, is a key quality of empowerment. (pp. 41-42)

Both Confrey (1995b) and Burton (1999) recognized the importance of a mode of knowledge acquisition that values both teacher and student as learners. Building a mathematics classroom on principles that affirm students' experiences, in conjunction with fostering an environment where each person is valued as having knowledge, creates a space where mathematical learning can be empowering. Empowerment is a fundamental component of a feminist standpoint perspective in mathematics education. When mathematics learning is viewed as a context in which both actors, the student and teacher, have mathematical knowledge to offer and gain, the classroom is transformed into an empowering place. Both students and teacher feel that their knowledge and experiences are valued. Confrey's (1995) revisionist ideas about autonomy and learning as reciprocity are helpful in articulating a feminist standpoint in mathematics education.

Agency and Authorship

Agency is another term woven throughout feminist theory. Burton (1999) examined agency as well as *authorship* in the learning of mathematics. "Agency and authorship [are] the 'who' and the 'what' of mathematical learning" (p. 22). That is, agency is the process through which a learner acts on her or his behalf. Authorship refers to what mathematical knowledge is valued and the process through which this valuing takes place. Burton argued for a narrative approach to mathematics learning and teaching, which hinges on learners' agency and authorship in the learning process. She noted:

Accumulating evidence points to the likelihood that viewing the learning of mathematics as a narrative process where the learners have agentic control over the authoring makes a substantial difference, not only to how they view mathematics and their relationship to it, but even to the results that they obtain on the extremely

restrictive public tests through which societies tend to make judgments about “success.” (p. 31)

Burton also highlighted the importance of voice within a narrative approach to learning mathematics:

To be “agentive *and* transformative” shifts the agenda into the socio-cultural so that, as learners develop insight into the quality and demands of their learning, and compare its similarities and differences in the learning community, they find their voices as mathematical authors and come, critically, to evaluate these voices. (p. 30, italics in original)

Essentially, Burton is proposing a narrative approach that places the learner at the center of her or his mathematical learning. The learner controls what is learned, how it is learned, and what gets authored. As a consequence of agency and authorship, “the purpose of schooling in mathematics, then, shifts from the acquisition of knowledge ‘objects’ to the acquisition and usage of a reflective process of coming to know within a learning community where discourse is paramount” (Burton, 1999, p. 31). To a reflective knower, agency and authorship become the cornerstones of mathematical knowledge.

Burton (1999) contended that students and teachers must assume new responsibilities for the development of agency and authorship in a narrative-based mathematics classroom. For the learner, she asserted that “this set, largely discourse-based, includes a willingness to:

- make learning claims in a dialogic setting;
- be prepared to provide some evidential, convincing basis for these claims;
- expect multiplicities of voices and heterogeneity of approaches and be ready to address resultant similarities and differences;
- critique the claims of others in a connected way, providing counter-examples to their justifications;

- accept and work with the critiques made by others of their claims and incorporate these into new positions;
- operate on a “what if” and a “what if not” basis;
- act, to others, as a supportive and caring member of the learning community” (p. 32).

The teacher has a responsibility to:

- “establish a connected, caring and personally accountable classroom environment;
- nurture the learners’ enquiry processes, maintaining positive self-images and commitment;
- imbue the learning process with the excitement and challenge of seeking comprehension;
- raise alternatives in order to stimulate the process of evidence gathering and critique;
- clarify different intellectual roles (such as that of the predictor, the explainer, the maker of inferences or the creator), identify their appropriateness to certain settings or activities and provide opportunities to engage in them;
- legitimate the students’ participation in this kind of learning community” (p. 32).

Voice

A concept that is closely related, perhaps indistinguishable, from authorship is voice, which is a critical element of Confrey’s revised theory of intellectual development. Secada (1995) referred to voice as the “discourse that is created when people define their own issues in their own ways, from their own perspectives, using their own term—in a word they speak for themselves” (p. 156). Belenky et al. (1986) noted that voice is the “hallmark of women’s emergent sense of self and sense of agency and control” (p. 68). To fully engage in the lives

of particular women, women's voices are paramount, not only in understanding their experiences but also in achieving a feminist perspective. Secada (1995) elaborated on the significance of voice:

The struggle for voice should be seen as an effort to increase the likelihood that we really listen to how diverse groups perceive their educational status in general and their mathematics education in particular. How students of diverse backgrounds recount the experiences, beliefs, and values embedded in their stories should be regarded as an important, and hitherto ignored, source of information. (p. 157)

Voice is critical to breaking the silence of females and subordinated groups in mathematics.

Secada stressed:

Voice also stands in opposition to silencing. By silencing, I am referring to social settings and processes that do more than simply make it difficult for someone to fully articulate a position; everyone confronts such settings. Rather, silencing refers to the processes that make it seem as if it is simply not worth the effort of speaking. (pp. 156-157)

Belenky et al. (1986) highlighted the importance of listening to women's voices. They contended that the development of voice is intricately interwoven with the development of mind and self. This notion was evidenced in Morrow's (1996) work, which revealed that girls developed a "mathematical voice" (Erchick, 2001) in an environment that promoted multiple approaches to learning mathematics.

The notion of mathematical voice is pertinent to a feminist perspective on learning mathematics. Erchick (2001) defined *mathematical voice* as the following:

That way in which one expresses and seeks knowledge and understanding of mathematics while in the presence of mathematics. It includes perspectives on what and where mathematics is in the world. It is comprised of, contributing to, and revealing of one's construction of mathematics, its situatedness and values. (p. 156)

From a feminist standpoint theoretical perspective, mathematical voice is the notion that girls perceive that they have the "ability and confidence to ask questions, discuss and explore ideas, pose problems, and feel that they have something to say and have the right to

say it” (Char Morrow, personal communication, April 12, 2001). This notion of voice also leaves room for silence in the classroom. They can choose if and when they want to speak. Furthermore, mathematical voice does not refer only to spoken voice. It pertains to the ways that students develop their own authority and construct their own knowledge, which are representations of their voices. The similarities between the notions of authorship and mathematical voice are obvious. Therefore, I elected to use the term authorship throughout the report.

Joining Confrey’s (1995b) notion of learning as a reciprocal activity, Burton’s (1999) notions of agency and authorship, and Erchick’s (2001) description of mathematical voice provides one with the theoretical foundation for a feminist standpoint perspective in mathematics education. These three notions, learning as a reciprocal activity, agency, and authorship/mathematical voice help articulate what a feminist standpoint theory might look like in mathematics education. Because of the nature of the research questions, the notion of learning as a reciprocal activity was not pursued in the present study. I envisioned this study as a starting point for considering how agency and authorship can inform mathematics teaching. I used these notions to bridge theory and practice. In this study, I was concerned with how agency and authorship helped to understand adolescent girls’ experiences in a feminist mathematics classroom.

In summary, the key to understanding how adolescent girls experience mathematics in a feminist classroom is to understand how agency and authorship are evidenced in their mathematical experiences. This study examined adolescent girls’ experiences in a feminist mathematics classroom in light of these notions of standpoint theory. Feminist standpoint theory applied to mathematics education suggests that if we provide a safe caring

community of learners where girls feel mathematically empowered, then they may voice their mathematical ideas and realize that these voices are respected. In turn, girls will have agency and authorship over their mathematical knowledge. One of the aims of this study was to investigate how these theoretical constructs were evidenced in adolescent girls' experiences in a feminist mathematics classroom. In essence, the goal was to attach "flesh and bones" to theory (Belenky et al., 1986, p. 19).

Epistemological Perspective of Mathematics Within Feminist Standpoint Theory

Agency, authorship, and voice are not, however, the only features of a feminist standpoint perspective in mathematics education. I also want to borrow Burton's (1995) proposed feminist epistemological framework for coming to know mathematics. Burton posited that knowing in mathematics must be viewed in light of the following categories:

1. its person- and cultural/social-relatedness;
2. the aesthetics of mathematical thinking it invokes;
3. its nurturing of intuition and insight;
4. its recognition and celebration of different approaches particularly in styles of thinking; and
5. the globality of its applications. (pp. 220-221)

Each of these areas informed the present study's integration of feminist standpoint and mathematics education. Burton asserted:

Knowing mathematics would, under this definition, be a function of who is claiming to know, related to which community, how that knowing is presented, what explanations are given for how that learning was achieved, and the connections demonstrated between it and other knowings (applications). (p. 221)

Burton's view of knowing in mathematics strengthens the connection between feminist standpoint and mathematics education. Her epistemological view of mathematics moves us

toward recognizing that the traditional ways of doing and knowing mathematics are faulty and are in need of revision.

Running the Risk of Essence

A potential possibility or problem with feminist standpoint theory, depending on how you view the notion of essentialism, is that the theory runs the risk of essentialism (Fuss, 1989). Postmodern feminists question the theoretical underpinnings held by cultural feminists by alleging that standpoint theory is essentialistic and reductionistic (Fuss, 1989). That is, critics claimed that this perspective “smacks of essentialism—that is, with anything that attributes gender differences to biological, genetic, psychosocial, or other immutable factors” (Burton, Damarin, Koblitz, Ruskai, & Kilpatrick, 1995, p. 383). My own fear as a feminist researcher was that by attempting to understand adolescent girls’ experiences in a feminist mathematics class, I would draw conclusions about *all* adolescent girls.

On the essentialistic side of the essentialism versus constructionism debate, feminist standpoint theorists assert that women think differently from men because of their socio-historical-cultural position. Frye (1996) pointed out: “Schematically and experientially, The Problem of Difference in Feminist Theory is simple: a good deal of feminist thinking has issued statements and descriptions that pertain to ‘women,’ and are not modified to mark distinctions among women” (p. 37).

Another issue that cropped up when I thought about the essentialism versus constructionism debate was that of relativism. One of the main tenets of feminist standpoint epistemology is its allegiance to multiplicity; that is, the belief that females vary across race, class, sexual orientation, to name a few of the possibilities, whereby these differences lead to multiple standpoints. This allegiance has its own problems. If there is no single standpoint,

then we run into the problem of paralyzing relativism. Frye (1996) reiterated how an unrelenting allegiance to multiplicity can lead to this sort of paralysis:

Thus has the feminist faith in and respect for the experience and voice of every woman seemed to lead us into a valley of the shadow of Humanism—wishy-washy, laissez-faire, I’m OK-You’re OK, relativistic humanism (or seemed most recently to lead us into the bottomless bog of relativistic apolitical postmodernism) where there are no Women and there is no Truth. Which is not where we want to be. (p. 37)

If I identify with the anti-essentialists, then I run the risk of relativism. If I identify with the essentialists, then I run the risk of essentialism. What’s a feminist researcher to do? I vote for “deploying” essentialism (Fuss, 1989, p. 20).

Fuss (1989) argued that there are times when one must deploy essentialism. Those times depend “on *who* is utilizing it [essentialism], *how* it is deployed, and *where* its effects are concentrated” (p. 20). Fuss noted that the difference between “falling into” or “lapsing into” and “deploying” or “activating” essentialism, when she wrote, “‘Falling into’ or ‘lapsing into’ implies that essentialism is inherently reactionary—inevitably and inescapably a problem or a mistake. ‘Deploying’ or ‘activating,’ on the other hand, implies that essentialism may have some strategic or interventionary value” (p. 20).

With regard to this research, I strategically deployed essentialism to form a collective frame around which to view the experiences of seven adolescent girls in a feminist mathematics class. Within this essentialistic framework, I was cautious about reducing how girls know and do mathematics within a feminist classroom to a certain set of necessary characteristics that all girls have simply because of their membership in the female sex. I also recognized that there are many layers of essentialism because of the multiple positionalities that girls hold within any mathematics classroom. That is, girls may

know and do mathematics differently because of their race and class, to name two of the possibilities.

Deploying essentialism was and still is a complicated act. I was aware that certain girls may rebel against the expectations of their cultures. For example, some girls may refuse to be “feminine” learners, or they may choose mathematics as a way of resisting, as well as reaffirming, a given class identity. In other words, choosing mathematics may serve as a form of resistance or reaffirmation, adding to the complexity of multiple identities, none of which may be essential. I was aware of these issues as I began this study. Thus, I questioned how the essentialism vs. constructionism debate played out in this study.

To confront the possibilities for essentialism and relativism in this research, I played the “game” of “pattern perception” (Frye, 1996, p. 40), which “opens fields of meaning and generates new interpretive possibilities; instead of drawing conclusions from observations, it generates observation” (p. 39). I played this game by perceiving patterns as generative rather than reductive. I pursued the notion of sense making, which required that I focus on “epistemological issues” that “have to do with the strategies of discovering patterns and articulating them effectively, judging the strength and scope of patterns, understanding the variance of experience from what we take to be a pattern” (p. 40). In essence, I paid close attention to how I perceived patterns and was wary of drawing grand conclusions at the cost of essentializing girls’ experiences in mathematics.

Let me reiterate my position: I remained committed to the idea that there is no single feminist perspective of doing, knowing, and learning mathematics. I sought to understand the diverse experiences of adolescent girls in a feminist mathematics classroom. Yet I explored patterns and examined how they affirmed girls’ experiences in a feminist

mathematics classroom. To that end, I examined the notions of agency and authorship, among others, in relation to adolescent girls' experiences in a feminist mathematics classroom.

CHAPTER 3

A CONTEXT FOR INQUIRY: ESTABLISHING A CONCEPTUAL FRAMEWORK

Eisenhart (1991) discussed and compared three kinds of frameworks: theoretical, practical, and conceptual. She argued for the special merits that conceptual frameworks have and discussed their relevance to mathematics education research. Eisenhart summarized her views on conceptual frameworks:

Crucially, a conceptual framework is an argument that the concepts chosen for investigation or interpretation, and any anticipated relationships among them, will be appropriate and useful, given the research problem under investigation Conceptual frameworks then . . . intentionally are not constructed of steel girders made of theoretical propositions or practical experiences; instead they are like scaffoldings of wooden planks that take the form of arguments about what is relevant to study and why. (pp. 209-210)

A conceptual framework thus comprises the models, theories, and practical ideas that are necessary to conduct a particular research inquiry.

This chapter is devoted to examining the models, theories, and practical ideas that are relevant to understanding the experiences of adolescent girls in a mathematics classroom grounded in feminist pedagogy. The literature on feminist pedagogy formed the conceptual framework for this study. I paint a portrait of feminist pedagogy by providing three lines of discussion. First, I introduce feminist pedagogy by describing some of my experiences with it. Second, I examine the literature on feminist pedagogy in general. In this review, I discuss a model of feminist pedagogy called connected teaching (Belenky et al., 1986), provide several definitions of feminist pedagogy, and discuss its main principles. Third, I examine feminist pedagogy within the mathematics education literature, including several models.

A Portrait of Feminist Pedagogy

Teachers who implement alternative pedagogies in the university classroom work against the grain of centuries old structures for the authorization of knowledge, built into architectures that support frontal teaching and established discourse genres that oblige the teacher to act as the primary knower (Ekeblad, 2001, p. 202)

Feminist Pedagogy and Me

My first experience with feminist pedagogy was in a Feminist Ethnography course led by a feminist pedagogue, Carla Roncoli. I was intrigued by Carla's approach to teaching. Carla fostered an environment of trust and community where each student contributed to her own knowledge construction. She guided encouraged students to take intellectual risks and guided their intellectual growth. As a result of my participation in a classroom built on feminist pedagogy, I questioned how I had been taught over the course of two decades of schooling. Carla's pedagogical approach challenged my notions of traditional teaching practices. I soon began to wonder how I could apply what I had experienced in a women's studies course to a mathematics classroom. Three years later and with seven women's studies courses on my transcript, I am still pondering how feminist pedagogy can inform mathematics education and am striving to articulate what is meant by feminist pedagogy.

As I reflect on my experiences in women's studies, I have only participated in courses that practiced feminist pedagogy. Yet, I have never had opportunities to study feminist pedagogy as a practice. I have come to understand what feminist pedagogy is through my experiences and through readings that I have done on my own. I am able to write about feminist pedagogy because of the efforts of feminists who have articulated their notions of it. In this review, I draw heavily on feminist scholars in the humanities and social sciences who have reflected on feminist pedagogy. Their ideas have been enormously beneficial in how I think about feminist pedagogy in general and as it relates to mathematics

teaching. What follows is an interpretation of feminist pedagogy based on my experiences and readings and a discussion of how it can be applied to mathematics education.

Feminist Pedagogy in Practice: Connected Teaching and Learning

In an effort to confront the alienation that women feel while learning, Belenky et al. (1986) described meaningful educational experiences that weave together multiple aspects of women's lives and knowledge. They identified such experiences as *connected* learning. That is, students are encouraged to build on their entire knowledge base rather than leave their personal experiences at the classroom door. A teacher who facilitates this kind of education is engaged in connected teaching. Connected teaching is feminist pedagogy in practice.

Belenky et al. (1986) described the connected classroom as one in which the teacher acts as a *midwife* who nurtures the personal development of each individual and helps students “give birth to their own ideas” (p. 217) and knowledge. The midwife metaphor illuminates the nurturing and supportive roles that teachers take on in classrooms built on connected teaching. “Midwife-teachers help students deliver their words to the world, and they use their own knowledge to put students into conversations with other voices—past and present—in culture” (Belenky et al., 1986, p. 219).

Belenky et al. (1986) described primary components of a connected classroom. That is, members of connected classrooms value the experiences of each knower, honor all voices, confirm students as knowers, build a community of learners, stress problem posing, encourage questioning, encourage risk taking, place the responsibility of learning on the student, focus on engaging students, value cooperation and collaboration, maintain communication, attend to process, minimize power differentials between teacher and

student, encourage students to construct their own knowledge, and emphasize the synthesis of mind, body, and spirit. The primary goal of connected teaching is to empower all involved in the learning process. Empowerment is central to feminist pedagogy.

Principles of Feminist Pedagogy

Multiple definitions

Current feminist thought demands that there is no one true feminism or feminist pedagogy (Coffey & Delamont, 2000; Fisher, 2001; Maher & Tetreault, 1994). Feminism and feminist pedagogy honor multiplicity and difference. Solar (1995) noted that “feminist pedagogy is a grounded response to feminist theoretical analysis of education, and since feminist theories are numerous, feminist pedagogies are plural” (p. 313). To highlight the plurality of feminist pedagogy, I present several definitions of feminist pedagogy.

First and foremost, a feminist approach to teaching mathematics rests heavily on the “existence of a feminist consciousness” (Weiner, 1994, p. 140). That is, a feminist pedagogy begins with an understanding that schooling practices are gendered, hierarchical, and oppressive. Solar (1995) maintained that feminist pedagogy takes “into account the learners’ sex and gender, and how it is built up through education” (p. 315). Feminist pedagogy acknowledges that gender plays a role in educational practices and “speaks to the gendered character of the classroom, of interactions between students and teachers, of the curriculum itself” (Briskin, 1994, p. 1). Shrewsbury (1987) stated that “feminist pedagogy is concerned with gender justice and overcoming oppressions. It recognizes the genderness of all social relations and consequently of all societal institutions and structures” (p. 7). Feminist pedagogy is not, however, a method of teaching nor is it a tool kit of teaching strategies for liberatory education. Shrewsbury maintained that:

Feminist pedagogy is a theory about the teaching/learning process that guides our choice of classroom practices by providing criteria to evaluate specific educational strategies and techniques in terms of the desired course goals or outcomes. These evaluative criteria include the extent to which a community of learners is empowered to act responsibly toward one another and the subject matter and to apply that learning to social action. (p. 6)

Feminist pedagogues struggle to create classrooms that empower students to act in ways that consider others and that enable students to create knowledge that they can use to produce social change. Shrewsbury also described feminist pedagogy as “engaged teaching/learning” (p. 6). Students and teachers are engaged in multiple ways:

Engaged with self in a continuing reflective process; engaged actively with the material being studied; engaged with others in a struggle to get beyond our sexism and racism and classism and homophobia and other destructive hatreds and to work together to enhance our knowledge; engaged with the community, with traditional organizations, and with movements for social change. (p. 6)

Both students and teachers are expected to take an active role in teaching and learning. As might be expected, the roles of the teacher and student are altered because of the new expectations placed on each.

Fisher’s (2001) definition of feminist pedagogy rests on “teaching through feminist discourse” (p. 3), which centers on “understanding and resisting women’s oppression” (p. 3). She defined feminist pedagogy as “teaching that engages students in political discussion of gender injustice” (p. 44). Fisher’s definition hinges on a discussion that brings a collective set of voices together to examine and critique gender relations and oppressive power relations. Exploring the relationship between personal experiences and political issues via consciousness-raising as well as advocating social change through critical analysis is critical to her definition of feminist pedagogy

Though there are multiple definitions and interpretations of feminist pedagogy, most discussions contain some element of empowerment. A cornerstone of feminist pedagogy is

the notion of empowerment for each member of a community of learners. Students and teachers are empowered to act, connect, feel, lead, reflect, question, and critique in a feminist classroom. I highlight this recurring theme because my definition of feminist pedagogy hinges on empowerment for all members of a community of learners. Feminist pedagogy, I believe, is a theoretical and practical approach to teaching and learning that attempts to address inequities in the classroom, local community, and world by interrogating power relations in the classroom, fostering a community of learners, empowering learners to be agents of their own learning, and encouraging learners to critique ideas and discourses, their own as well as others. The goal is empowerment for all learners.

In light of the plurality of feminist pedagogy, various themes emerge from readings about feminist pedagogy (Belenky et al., 1986; Coffey & Delamont, 2000; Fisher, 2001; Kimmel, 1999; Maher & Tetreault, 1994; Shrewsbury, 1987; Solar, 1995; Weiler, 1994; Weiner, 1994), which include power relations, community of learners, leadership and agency, and difference and diversity. I discuss each of these themes in turn.

Power Relations

If we compare Shrewsbury's (1987) perspective on feminist pedagogy with Kimmel's (1999) and Solar's (1995) models of feminist pedagogy, all three are saying the same thing with regard to power relations. Shrewsbury uses *empowerment* in the same way that Kimmel uses *power*. At that same time, Solar uses *powerlessness* and *empowerment* to speak about power relations. Shrewsbury (1987) contended that "Feminist pedagogy embodies a concept of power as energy, capacity, and potential rather than as domination" (p. 8). In other words, power is redefined to mean shared power versus power defined in the traditional sense of domination. In feminist pedagogy,

power is redistributed to members of the classroom in an effort to counteract hierarchical and oppressive educational and institutional structures. Teachers problematize their authority and find ways to counteract the authority they hold in the educational system. The intent is for teacher and students to share power by working collaboratively to create a nonhierarchical community of learners. On a cautionary note, Shrewsbury (1987) stated that “our classrooms need not always reflect an equality of power, but they must reflect movements in that direction” (p. 8). Feminist pedagogues realize that there are constraints that might impede an equality of power. Yet the goal remains that the power in the classroom is shared, thereby giving learners some sense of empowerment.

Weiler (1994) recognized obstacles to a feminist teaching practice. She asserted that “the question of authority in institutional settings makes problematic the possibility of achieving the collective and non-hierarchical vision of early consciousness-raising groups within university classrooms” (p. 23). Weiler’s comment points out the Scylla and Charybdis of teaching from a feminist perspective. That is, teaching from a feminist perspective is difficult because while one is attempting to devolve authority and power, one is simultaneously responsible for evaluating students’ performance. What remains problematic is who has authority and how that authority is defined.

Authority of teacher. Because power is a central concern in feminist pedagogy, the role and authority of the teacher become sites for resistance and change. Weiler (1994) is concerned with women’s claim for authority in a patriarchal society that silences women. She wrote that “the question of asserting authority and power is a central concern to feminists precisely because as women they have been taught that taking power is inappropriate” (p. 25). For Weiler, feminist teachers have a responsibility to help

women claim authority and knowledge. She maintained that

the authority of the feminist teacher as intellectual and theorist finds expression in the goal of making students themselves theorists of their own lives, by interrogating and analyzing their own experience.... This strategy moves beyond the naming or sharing of experience to the creation of a critical understanding of the forces which have shaped that experience. This process of theorizing is itself antithetical to traditional views of women. (p. 27)

Weiler suggests that feminist pedagogues value students' voices and personal experiences. Personal experiences become a context for teaching. Contextual teaching is a hallmark of feminist pedagogy in that students' experiences outside of school are connected with the curriculum. There is a dialectical relationship between community, context, and content in which students construct knowledge based on the interplay between their experiences and their exposure to the content. Integral to the interplay between personal experiences and content is the goal of helping students become critical thinkers. Shrewsbury (1987) maintained that "critical thinking...is not an abstracted analysis but a reflective process firmly grounded in the experiences of the everyday" (p. 7). Critical thinking is a synthesis of personal experiences and content.

Shifting roles of student and teacher. The roles of teacher and student shift dramatically in feminist classrooms (Kimmel, 1999; Shrewsbury, 1987). The teacher is not viewed as the authority of knowledge; rather, students have authority for their own knowledge construction. In a sense, there is a collective bargaining that occurs in feminist classrooms. Students and teachers work together so that each person benefits. Each are colearners in a setting in which teachers also learn and students also teach.

Feminist teachers acknowledge that they have a certain amount of power because they have to meet societal and educational mandates. They are part of an educational system that stresses grades, test scores, and promotion. Yet, feminist pedagogues create

ways for students to work within system boundaries by allowing them to make decisions about courses, content, and grading systems. Kimmel (1999) noted that one of the main issues for feminist teachers is finding ways “to share power, empower students, and still claim our expertise and accomplishments” (p. 66).

Community of Learners

Feminist pedagogy seeks to establish a community of learners so that the classroom is a place where both students and teachers perceive themselves as colearners. Shrewsbury (1987) offered her support of this goal:

At the core of feminist pedagogy is a re-imaging of the classroom as a community of learners where there is both autonomy of self and mutuality of others that is congruent with the developmental needs of both women and men. (p. 10)

Hooks (1994) also speaks to the centrality of community in feminist pedagogy. She stated that “the power of the liberatory classroom is in fact the power of the learning process, the work we do to establish a community” (p. 153). Teachers and students create classroom environments that emphasize connection, collaboration, and community.

The concept of a liberatory environment suggests a new way to be with one another in the classroom. A classroom characterized as persons connected in a net of relationships with people who care about each other’s learning as well as their own is very different from a classroom that is [composed] of teacher and students. (Shrewsbury, 1987, p. 6)

The goal is for learners to perceive of themselves as part of a “community of mutuality rather than a community of isolated individuals” (p. 10).

In the block quote above, Shrewsbury introduced the notion of caring into the picture of a feminist classroom. An ethic of care (Fisher, 2001) is necessary to create a learning environment in which learners perceive that their voices are acknowledged and respected. To insure that that all students collaborate and feel emotionally connected with

the community, time and special care must be taken to build trust and respect so that each learner understands that her or his thoughts and emotions are appreciated. I include emotions because feminist pedagogy emphasizes the connection between knowledge construction, emotions, and intuition. Feminist pedagogy takes a holistic approach to learning. Rationality is deemphasized, and objectivity is redefined. Emotions and intuition are perceived as valuable sources of knowledge. A sense of trust and respect must permeate a feminist classroom if learners are to perceive that they can speak freely and honestly about their thoughts and emotions.

Briskin (1998b) shed light on an issue that deserves attention when thinking about the development of a community of learners, that is, the power relations within groups. Arguably, issues of power are always present in groups. Briskin cautioned, “Other dimensions of power—around race or ethnicity, for example, in a single-sex group—can emerge as significant” (p. 26). She argued for interrogating power relations within collaborative work as “collaboration and group work are not in themselves solutions; if the organization of group work does not take account of power dynamics, group work itself can reinscribe power relations rather than create openings for more inclusive learning” (p. 24). Otherwise, Briskin warned that feminist pedagogy may be implicated in maintaining the very same elitist, racist, and sexist hegemony that it attempts to dismantle.

Leadership and Agency

Leadership plays a strong role in feminist pedagogy. It is also linked with social responsibility and action. Shrewsbury (1987) noted that “leadership is the embodiment of our ability and our willingness to act on our beliefs.... Feminist pedagogy focuses on the

development of leadership” (p. 11). Learning leadership is synonymous with learning agency. In a feminist classroom, teachers create ways for students to direct their own learning by having them be part of the syllabus construction, evaluation process, and learning process. Students take an active role in leading their learning; that is, they have control over the learning process. By giving students opportunities to facilitate discussions, evaluate peers, and pick assigned readings, teachers help students become agents in their own learning. They are learning to lead themselves and others.

Shrewsbury (1987) envisioned the feminist classroom as one that empowers students and teachers. Her vision of feminist pedagogy is one in which the classroom is a “liberatory environment in which we, teacher-student and student-teacher, act as subjects, not objects” (p. 6). Both students and teachers are afforded agency. Shrewsbury’s vision of feminist pedagogy rests on the notion of a feminist teacher as one who is “above all a role model of a leader” (p. 12). The role of a feminist teacher as leader is to help “members of the class develop a community, a sense of shared purpose, a set of skills for accomplishing that purpose, and the leadership skills so that teacher and students may jointly proceed on those tasks” (p. 12).

Shrewsbury (1987) maintained that leadership is intrinsic to empowerment:

Leadership then is logically and intuitively connected to community and empowerment by providing the active mechanism for achieving the empowered community and for that community to continue to be effective within the broader world. It suggests that change does not take place magically but by the active exercise of agency, whether directed at ourselves or at structures. (p. 12)

When students have agency, they are prompted to take action and to find ways to create social change. Feminist pedagogy is built on the principle that social change is more likely to occur when learners feel a sense of agency, responsibility, and empowerment. Kimmel

(1999) views “social action as a cornerstone of a feminist classroom” (p. 67). Its significance lies in the fact that “social action fosters a sense of agency and connects ideas to action, keeping feminism alive and evolving to meet the changing conditions of women’s lives” (Kimmel, 1999, p. 67). Feminist pedagogy relies on the development of leadership in students in order to promote social change.

Difference and Diversity

At the heart of feminist pedagogy is attention to difference and diversity. Weiler (1994) noted that “in the actual practice of feminist pedagogy, the issues of difference, positionality, and the need to recognize the implications of subjectivity or identity for teachers and students have become central” (p. 23). Feminism has been criticized as playing into the hands of essentialism, claiming that *Woman* can be defined, which usually excludes women of color. Black women, Hispanic women, Third-world women, lesbians, differently abled women have questioned where they fit into feminist pedagogy. Weiler remarked that “the challenges of women of color and of postmodern feminist theory have led to a shattering of the unproblematic and unitary category of ‘woman’ as well as the assumption of the inevitable unity of ‘women’” (p. 23). In an effort to confront the possibility of essentialism, feminist pedagogy values the multiple positionalities of students and recognize the need to understand and uphold difference. Furthermore, teachers must not underestimate their subjectivities but be aware of their remarkable influence. Weiler (1988) argued that “feminist teachers, if they are to work to create a counter-hegemonic teaching, must be conscious of their own gendered, classed, and raced subjectivities as they conform or challenge the lived experiences of their students” (p. 145). She goes on to underscore the importance of voice in counteracting the hegemonic forces in the classroom. Weiler clarified

that “this does not mean avoiding or denying conflict, but legitimating this polyphony of voices and making both our oppression and our power conscious in the discourse of the classroom” (p. 145). In this passage, Weiler noted that voice is central to feminist pedagogy, critical to breaking the silence of women, and necessary for a climate that appreciates difference and diversity.

I have offered an overview of feminist pedagogy. I have also highlighted critical areas for discussion and elaboration. In summary, there are multiple perspectives of feminist pedagogy, each of which embraces a multiplicity of teaching practices and theoretical frameworks. The beauty of feminist pedagogy is its reliance on the voices and experiences of students, which make learning more contextual and transformative. In the next section, I provide a discussion of feminist pedagogy in the context of mathematics education.

Feminist Pedagogy Applied to Mathematics Education

For the past decade, there has been a small conversation brewing about feminism and mathematics. Damarin (1990) began the conversation by focusing on how mathematics might be taught from a feminist perspective. She pointed out the gendered nature of mathematics and how teachers might challenge their beliefs about the nature of mathematics and their notions of girls and mathematics. Damarin argued:

To recognize that mathematics has masculine roots is not to suggest that women cannot or should not learn it today, nor that mathematics as we teach it is irrelevant to the lives of modern women. Rather, this recognition can help us to see the depth of the “gendering” of the subject and to identify ways in which we might look for gender issues in instruction. (p. 145)

On the one hand, Damarin noted that mathematics has a significant role to play in the lives of women. On the other hand, she called for a concerted effort on the part of mathematics teachers to evaluate how they play a role in maintaining the “masculine” view of

mathematics, which sees mathematics as absolutist, culture-free, and hierarchical. What was missing from Damarin's discussion of feminism and mathematics was a clear explanation of how to incorporate feminism into mathematics education. She briefly touched on a few teaching techniques but avoided any discussion of feminist pedagogy and its possibilities in mathematics classrooms.

Since 1990, several scholars (Burton, 1995; Burton et al., 1995; Damarin, 1995; Mura, 1995; Rogers & Kaiser, 1995) have continued the conversation about feminism and mathematics education. Their efforts have essentially focused on articulating a feminist epistemology in mathematics and elaborated on a feminist perspective in teaching mathematics. Interspersed among these scholars are a group of mathematics educators (Becker, 1995, 1996; Brew, 2001; Buerk, 1982, 1985, 1990, 1996; Erchick, 1996; Koch, 1996; Morrow, 1996) who have investigated and documented women's experiences in mathematics. Barnes (1994) moved close to articulating what feminist pedagogy might look like in a mathematics classroom. She discussed an example of a feminist approach to teaching calculus, though she did not label the pedagogy as feminist. It serves as a model of a feminist approach to teaching mathematics.

Only a few scholars (Morrow, 1996; Rogers, 1995; Solar, 1995) have commented directly on feminist pedagogy and its application to mathematics education. Rogers (1995) and Solar (1995) centered their discussion on how feminist pedagogy might inform the mathematics classroom and provided ideas about what feminist pedagogy might look like when enacted there. Morrow (1996) presented a model of feminist pedagogy based on the connected teaching and learning model proposed by Belenky et al. (1986). Morrow's model paints a picture of what feminist pedagogy might look like in the mathematics classroom.

What follows is a discussion of these scholars' ideas and contributions to the literature on feminism pedagogy and mathematics education.

A Mathematics Pedagogy of Possibility

Rogers (1995) reflected upon her feminist teaching practice in mathematics classrooms. She characterized feminist pedagogy in mathematics as a “mathematics pedagogy of possibility” (p. 178), which is

an alternative approach to the teaching of mathematics, one which is rooted not in the authoritative and imposed style which distances and silences, but in a style which encourages direct access and engagement, free creative expression, and ownership of the subject. (p. 178)

This description echoes those of feminist pedagogy in general. Roger's vision of a feminist classroom values agency and voice. She described teaching strategies that are in concert with the theory behind the practice, which included “think-write-pair-discuss,” whole-group dialogue, board work, brainstorming, problem posing, investigation, cooperative learning, reading exercises, and proof generation (pp. 180-181). Evident in these strategies is an emphasis on collaboration and diversity of mathematical experience. Rogers relied on the notion of a community of learners (mathematicians) as a means of transforming the mathematical experiences of her students. She believed in the power of a feminist praxis:

A consequence of teaching in this way, a consequence I have found more rewarding and compelling than any other, is the strong sense of community and caring that develops among students. Students are more concerned about each other's welfare and progress than anxious to compete with each other for grades. Students develop close bonds of loyalty to one another which will carry well beyond the course itself and are often long-lasting. (p. 184)

Strong and lasting connections are a critical element of feminist pedagogy as evidenced in Roger's remarks. Through her personal teaching experiences of feminist pedagogy, Rogers envisioned a classroom that provides “a more meaningful and equal mathematics education

for *all* students” (p. 184). Her model helped me to understand what a feminist mathematics classroom might look like in a university classroom.

A Model of Inclusive Pedagogy

Solar (1995), a Canadian mathematics educator, adds to the ongoing discussion of feminist pedagogy in mathematics by explicitly providing a framework for an “inclusive pedagogy” in mathematics education. The twin pillars of Solar’s framework are feminist pedagogy and nondiscriminatory classroom practices, which, I contend, are feminist teaching practices. In an attempt to spark a new conversation in mathematics education, I present Solar’s model of inclusive mathematics education in Table 1. Solar’s model is by no means exhaustive or complete. In fact, she encourages adaptation, revision, and development of her model via future research. Solar’s model for mathematics education bridges feminist pedagogy and mathematics. It is a starting point for thinking about how feminist pedagogy principles can be applied to the teaching and learning of mathematics. Her model begins a conversation about the influence that feminist pedagogy can have on mathematics teaching. I used Solar’s model as a scaffold of ideas on which to build in this study. Though I did not depend on her model entirely (i.e., I also used Morrow’s (1996) model), I used it to illuminate areas of focus in a feminist mathematics classroom that otherwise I might have missed.

Table 1

Solar's (1995) Model of Inclusive Mathematics Education

Passivity/Active Participation	Omission/Inclusion
Teaching	Teaching
• Having high expectations for all women • Using pedagogical approaches that encourage participation • Introducing cooperation • Asking women high cognitive-level questions	• Paying attention to all students regardless of sex, race, age, etc. • Monitoring speech in order to include women • Using examples which relate to women • Describing mathematicians and scientists as both males and females • Valuing intuition and emotions
Learning	Learning
• Sharing the thinking processes • Sharing the understanding of mathematics • Learning cooperatively	• Solving problems that deal with women's situations • Receiving feedback and learning from mistakes
Curriculum	Curriculum
• Having women participate in defining the content	• Referring to the contributions of women • Using situations related to women's lives • Using non-stereotypical material • Including ethnomathematics • Revealing the omission of women
Educational environment	Educational environment
• Allowing women to participate in defining their learning process • Having women participate in defining the goals of the school • Addressing the issue of gender differences	• Including and valuing women • Making women visible

Table 1 continued

Solar's (1995) Model of Inclusive Mathematics Education

Silence/Speech	Powerlessness/Empowerment
Teaching	Teaching
• Using inclusive language • Forbidding sexist and racist humour • Using pedagogical settings that make it easier for students to speak • Limiting extended conversations with male students	• Avoiding stereotypes • Naming differences and explaining them • Giving women the time and means to learn • Letting women solve problems by themselves • Praising women's achievement • Sharing power
Learning	Learning
• Speaking about the learning of mathematics • Giving time for women to respond	• Demystifying mathematics: more than one solution and more than one process • Receiving appropriate feedback and instructions • Learning about women's participation in mathematics and science
Curriculum	Curriculum
• Explaining the construction of mathematics and its use in society	• Demystifying mathematical constructs • Mathematics as a process, not a set of rules • Including the lives of women scientists • Including women's perspectives
Educational environment	Educational environment
• Valuing women's contributions and concerns • Setting school goals which include women • Using inclusive language	• Creating a warm and supportive climate • Working out beliefs about men and women • Denouncing stereotypes

Connected Teaching in Mathematics

In an attempt to apply Belenky et al.'s model of connected teaching to mathematics teaching, Morrow (1996) presented a model that links the key components of connected teaching with mathematics (see Table 2). Her model articulates a feminist pedagogy of mathematics. The first concern of any mathematics teacher who uses connected teaching is

finding ways to honor students' voices and experiences. Teachers build their curriculum and lessons around the mathematical knowledge that each student brings to the classroom. Students are expected to construct their own mathematical knowledge and to be responsible for their own learning. Contextual learning is a hallmark of connected teaching in mathematics.

Feminist mathematics teachers hold intuition in high regard. Students are pushed to play with their mathematical ideas and take risks. Communication, collaboration, and community are highly valued. Students spend time in cooperative learning groups, write reflective papers, and value one another as doers of mathematics. Confirmation and affirmation play significant roles in building students' confidence in mathematics. Teachers do no doubt students but instead find ways to validate their mathematical knowledge.

The nature of mathematics as objective, value and culture-free is also challenged. An absolutist view of mathematics is rejected. Mathematics is a human endeavor where mathematical knowledge is constructed and developed by humans in a particular social and historical context. Mathematics is culture-bound and value-laden. The absolutist belief that there is only one right answer to every mathematical problem is discarded in connected mathematics teaching. Multiple perspectives on mathematics are accepted. Because connected teaching maintains that there is no *one* dominant epistemological view of mathematics, this perspective holds promise for acknowledging and valuing all students' mathematical experiences.

Morrow's (1996) model highlights seven concepts (i.e., voice, first-hand experience, confirmation of self as knower in the learning community, problem posing and questioning, believing versus doubting, challenge with support, and structure and freedom) that are

central to articulating a feminist pedagogy of mathematics. Her model hinges on principles of feminist pedagogy (e.g., power relations, community of learners, leadership and agency, and difference and diversity) as well as theoretical notions of feminist standpoint theory (e.g., agency, authorship, learning as a reciprocal activity). For purposes of this study, in addition to Solar's (1995) model, I used Morrow's model as a framework for understanding and analyzing what I saw in a feminist mathematics classroom.

The articulation of a feminist pedagogy by Morrow (1996), Rogers (1995), and Solar (1995) challenges traditional teaching practices and provides ideas for transformative and liberatory education in mathematics education. Belenky et al. (1986) saw a feminist approach to teaching as a way to empower women:

If we replace the separate with the connected model, we can spare women the "alienation, repression, and division" their schooling currently confers upon them. Education conducted on the connected model would help women toward community, power, and integrity. Such an education could facilitate the development of women's minds and spirits rather than... retarding, arresting, or reversing their growth. (p. 228)

Their words emphasize the importance of females' voices in the educational system and the teachers' role in challenging practices that hinder females' full participation.

Table 2

Connected Teaching Model for Mathematics Education (Morrow, 1996, pp. 15-16)

Implications of <i>Women's Ways of Knowing</i> For Mathematics Education		
Issue	Importance for Connected Teaching	Structures for Connected Teaching in Mathematics
Voice	• Education occurs in the context of conversation; hearing/listening/talking are primary modalities • Gaining a sense of self within an activity • Developing one's own authority	• Pair problem solving • Detailed explanations of solutions • Writing exercises, both for self-insight and for learning mathematical concepts • Class discussions to compare and contrast various solutions • Answers not given by teachers
First-Hand Experience	• Builds on intuitive understanding • Validates students' knowledge base; provides a basis for moving on • Provides insight into reasons for engaging in a particular area of study • Encourages activity as opposed to passivity; provides opportunities to be the "doer"	• Using visual representations in developing solutions to problems • Applications-oriented workshops • Computer programming projects designed by students
Confirmation of Self as Knower in the Learning Community	• Invites the student to remain within an area of study • Basis for moving beyond rule following and become one of the rule makers • Develops constructors of knowledge rather than just technicians	• Discovering and affirming that which is already known by the student; use as a basis for moving into new areas • Respect the students' existing ideas • Move into the students' world by engaging the class in activities outside of the classroom
Problem Posing and Questioning	• Focuses on process/means instead of outcomes/goals • Allows a student to become a flexible problem solver • Encourages initiative and independence	• Allow student to struggle for solutions • Have high expectations for student success • Focus on explanation/justification
Believing versus Doubting	• Gives the student alternative modes for academic (and other) discourse • Invites the student in rather than focusing on proving self as a rite of passage into a community • Increases confidence	• Ask the student for explanation even when she is right so that question asking does not become synonymous with doubting • Assume that the student has reasons for her opinion and listen to them • Ask for further details
Challenge with Support	• Allows the student to become a more independent learner without becoming an isolated learner	• Validate present level of understanding while providing challenging new material • Provide staff development and support • Plan community-building activities • Offer confidence-building workshops
Structure and Freedom	• Gives guidance/mentoring without imposing tyrannical expectations • Allows student to find path of personal connection	• Allows explorations that stray off the main path, but not as a way to avoid struggling with difficult material • Make multiple strategies and solutions visible • Ensure ways for all students to participate actively

CHAPTER 4

A METHODOLOGICAL APPROACH FOR INQUIRY: CASE STUDY

Research Design

Reinharz (1992) noted the value that case studies hold for feminist researchers when she wrote, “The power of the case study to convey vividly the dimensions of a social phenomenon or individual life is power that feminist researchers want to utilize” (p. 174). As a feminist researcher who was intent on employing this power, I used a case study design to understand the experiences that adolescent girls had in a feminist mathematics classroom. I focused on three dimensions of adolescent girls’ experiences within a mathematics classroom grounded in feminist pedagogy: adolescent girls’ perceptions of themselves as learners of mathematics, their perceptions of mathematics, and their perceptions of their experiences.

A case study is an “exploration of a ‘bounded system’ or a case (or multiple cases) over time through detailed, in-depth data collection involving multiple sources of information rich in context” (Creswell, 1998, p. 61). The “bounded system” consists of the case, phenomenon, or unit of analysis being studied, which might include a program, an event, an individual, a process, an institution, or a social group (Merriam, 1988). In the present study, the bounded system or case was an adolescent girl’s experiences, which were bound by time and place. That is, each girl’s experiences took place in a feminist mathematics class that was part of an all-girl summer mathematics program located on the

campus of a women's college during July 2001. I explored the experiences of seven adolescent girls; thus, there were seven cases.

Merriam (1988) posited four features that are necessary for a qualitative case study. First, a case study must be *particularistic*. That is, it must focus on one of something—one program, event, situation, person, or phenomenon. Second, a case study is *descriptive*, which means that a holistic, integrative, and complete account is provided about the case. The third feature is *heuristic*, which means that “case studies illuminate the reader’s understanding of the phenomenon under study. They can bring about the discovery of new meaning, extend the reader’s experience, or confirm what is known” (p. 13). In short, a case study provides insight into a particular phenomenon. The final feature, *inductive*, relies on inductive reasoning, which hinges on the notion that insights, meanings, and generalizations emerge from the data. The primary goal of a case study is to postulate “new relationships” rather than verify hypotheses (p. 13). Each case study in the present study contains these four features because I attempted to explore, describe, understand, and illuminate adolescent girls’ experiences in a feminist mathematics classroom. Furthermore, I attempted to generate theoretical concepts and new relationships from the data.

These case studies are both descriptive and interpretive. Each study provides a detailed description of an adolescent girl’s experiences. At the same time an inductive analysis of each adolescent girl’s experiences provides an interpretation of those experiences. The goal of an interpretive case study is to “develop conceptual categories or to illustrate, support, or challenge theoretical assumptions held prior to the data gathering” (Merriam, 1988, pp. 27-28). With regard to this study, I embraced the possibilities that an interpretive case study provided by questioning theory. I sought to describe adolescent girls’

experiences in a feminist mathematics classroom while simultaneously attempting to make meaning of adolescent girls' perceptions of themselves as learners of mathematics, their perceptions of mathematics, and their perceptions of their experiences.

Research Milieu

The intent of this section is to paint a portrait of the research setting, highlighting its important features. First, I provide an overview of the research context. Second, I describe the research context in detail by focusing on key features. I developed a detailed description of SummerMath based on several sources. I obtained information from the SummerMath Web site (<http://www.mtholyoke.edu/proj/summermath/>), a SummerMath Curriculum Guide for 1999, a research report (Morrow, 1996); participation in the GenderWise Working Conference in the summer of 1999; extensive collaboration with the codirectors, Charlene (Char) and Jim Morrow; and observations from the five weeks that I spent at SummerMath. I also include a discussion of the rationale for choosing this site.

SummerMath: Reform in a Feminist Framework

SummerMath is a world in which creativity and problem solving replace lectures and formulas. (SummerMath Website, March 22, 2001)

Overview

I conducted this study from June 24 through July 28, 2001, at SummerMath, an intensive, four-week, summer mathematics program for high school girls. SummerMath took place on the campus of Mount Holyoke College, a prestigious New England women's college located in South Hadley, Massachusetts. Since 1982, SummerMath has provided an alternative learning community for adolescent girls to experience and learn mathematics and computing in an environment that promotes collaboration, connection, problem posing, and problem solving.

A hallmark of SummerMath is its attention to diversity. In 2001, 58 eighth-through eleventh-grade girls from various mathematical, geographic, racial, and socioeconomic backgrounds engaged in a constructivist and feminist way of knowing and doing mathematics. An additional hallmark of SummerMath is that it is a “test free zone.” That is, there are no entrance tests, achievement tests, grades, or prerequisites.

The twin pillars of SummerMath are constructivism and feminist pedagogy. These two ideologies guide the structure and program. Girls learn mathematics in a classroom in which personal experiences are valued as mathematical knowledge, voices are acknowledged in the learning process, and challenging problems are presented in a supportive environment. Intuition and firsthand knowledge are primary means for creating mathematical knowledge. Instead of an emphasis on giving or getting one right answer, the problem-solving process is the primary means of learning mathematics. Hence girls are expected to struggle as they create meaning in mathematics. A goal of SummerMath is to move toward a problem-centered approach that stresses conceptual understanding.

SummerMath recognizes that adolescent girls are at important crossroads in their mathematical journeys. Adolescent girls are making decisions either to continue in or leave the mathematics pipeline. If they leave the pipeline, girls risk having fewer opportunities for advancement in careers that require high levels of mathematics, which may lead to lower paid careers that require little or no mathematics (Ernest, 1995). The SummerMath directors and teacher realize that a disproportionate number of high school girls are beginning to lose or have lost confidence in their ability to do mathematics. Many of the girls who participate in SummerMath also display a lack of persistence in doing mathematics. Hence, two goals of SummerMath are to help adolescent girls increase their confidence and acquire

persistence in mathematics. Helping adolescent girls feel empowered is a critical part of the SummerMath program.

Data that Char and Jim have collected through application essays and program evaluations indicate that an overwhelming number of girls who attend SummerMath dislike mathematics and see few possibilities for its use in their lives. Thus, an overarching aim of SummerMath is for girls to improve their relationship with mathematics. Once the girls have developed a more positive relationship, Char and Jim Morrow hope that it will lead to the following set of outcomes for adolescent girls. They will:

- feel, without great anxiety, that they can choose to study more mathematics if and when they need to;
- experience a sense of excitement and adventure in solving mathematics problems;
- have a sense of ownership, and even authority, when participating in mathematics classes or activities;
- understand how to collaborate in learning mathematics without giving up a sense of independence and ownership;
- understand that to be a good problem solver they will have to go beyond an algorithmic approach for an answer;
- develop a mathematical voice;
- focus more on exploration and understanding;
- internalize techniques for persistence in mathematics problem solving;
- experience an overall improved attitude toward mathematics;
- learn some mathematics by applying a concept or procedure to a problem in an appropriate way;

- feel a sense of accomplishment;
- experience a test-free zone, where they have the freedom to learn and explore without the ever present specter of outside evaluation; and
- have opportunities to learn to be self-evaluative. (Char Morrow, personal communication, April 12, 2001)

Research Site Selection

In the initial stages of this research, I wanted to explore both adolescent girls' and boys' perceptions of their experiences in a coeducational, feminist mathematics classroom. Unfortunately, I could not locate such a classroom. Thus, I refocused my research on a single-sex (all girls) educational environment.

I chose this research site for several reasons. First, the research questions that guided this study demanded that I investigate adolescent girls in a feminist mathematics classroom. Thus, to continue with this inquiry, it was necessary that I identify a mathematics teaching context built on feminist teaching practices and principles. I identified SummerMath as a potential site for this research because I was familiar with the program. My first exposure to SummerMath was in summer 1999. From July 16 through 20, I participated in GenderWise, which was a summer workshop for inservice teachers who wanted to become knowledgeable about gender equity issues in teaching mathematics. GenderWise was held on the campus of Mount Holyoke in conjunction with SummerMath. During four days, I attended lectures and discussion groups designed to raise my consciousness about gender equity in mathematics education. I also participated in activities that challenged my notions of gender equitable instruction and persuaded me to consider how these notions were compatible with principles of feminist pedagogy. As a GenderWise participant, I observed

several mathematics and computer classes in the SummerMath program, which deepened my interest in mathematics teaching from a feminist perspective. I became intrigued with the program and remained in contact with the codirectors, Char and Jim Morrow, via professional meetings and email contact.

Once I clarified my research focus, developed my theoretical and conceptual frameworks, and identified my research questions, the choice for the research setting became clear. I identified SummerMath as a potential research site because it offered three types of classes (Fundamental Mathematics Concepts (FMC), SuperLogo, Workshops) that were taught using feminist pedagogy. Based on my initial observations during the GenderWise conference and discussions with Char and Jim, I determined that FMC, SuperLogo, and the workshops were feminist classrooms because the pedagogy of these classes matched the theoretical notions of feminist standpoint theory (e.g., agency, authorship, learning as a reciprocal activity) and the principles of feminist pedagogy (e.g., power relations, community of learners, leadership and agency, difference and diversity). Even though two years had passed since my observations during GenderWise, I felt comfortable with choosing SummerMath as the research site. Numerous communications with Char and Jim assured me that the FMC, SuperLogo, and Workshops were taught using feminist pedagogy.

Once I determined that SummerMath was a potential research site, I discussed my research proposal with Char and Jim in the hope that they would consider my request to study a SummerMath class. Char and Jim agreed to my request subject to two provisions. First, they stipulated that when I observed classes I was not to disrupt the girls' learning experiences. This provision translated into not interrupting or asking the girls questions

during classes. The second stipulation was that the research should not subtract from but, instead, should add to the girls' experiences in SummerMath. Char and Jim wanted to be certain that I would not require an excessive amount of work from the participants. What was most important to Char and Jim was that this research would enhance and extend the participants' experiences. Girls who chose to be participants in this study would learn and grow from their involvement in it. There would be a reciprocal relationship between researcher and participant, which is a hallmark of feminist research. I accepted these two stipulations. In summary, I chose SummerMath because it provided an appropriate context for investigating mathematics teaching couched in a feminist perspective. Via personal contact, I developed a rapport with Char and Jim, who provided me access to the program.

Staff Preparation

For the past 16 summers, Char and Jim have integrated their respective disciplines—Char, a clinical psychologist, and Jim, a mathematician—to create a program that focuses on both psychological aspects and mathematical dimensions of learning and doing mathematics. Combining their professional expertise and talents, they developed a program that capitalizes on psychosocial aspects of learning and doing mathematics framed within a feminist perspective. In 2001, SummerMath entailed the collaboration of 29 staff members, including two codirectors, one administrative assistant, two mathematics teachers, two computer teachers, one head resident, one assistant head resident, six undergraduate teaching and resident assistants, eight workshop teachers, two seminar teachers, and an athletic coordinator. Through a grant from the National Science Foundation, SummerMath also enjoyed the participation of three full-time interpreters for eight deaf students.

Prior to the girls' arrival, staff members participated in a week-long series of activities designed to prepare them for their responsibilities. There were four foci during this week. First, the staff members spent a large portion of their time exploring and examining issues related to the teaching and learning of deaf students. Because this was the first summer that such students had participated in SummerMath, Char and Jim emphasized the importance of learning how to work with deaf students. Second, the staff members did mathematics and engaged in computer activities. There was a focus on understanding and reflecting on constructivist and feminist principles of teaching and learning mathematics. Third, all staff underwent extensive training suited to their particular responsibilities. Fourth, an element of consciousness raising was evident in the staff preparation. Char and Jim provided a safe environment for staff members to discuss equity issues relevant to teaching and to examine their own beliefs about these critical issues. Reflection, personal and professional growth, and community building were goals of staff preparation.

Courses

The curriculum was problem based with a focus on problem posing, solving, and questioning. No part of the curriculum was free from problem solving; it permeated each class and each activity. Girls had opportunities to develop their mathematical and nonmathematical voices in three courses: Fundamental Mathematical Concepts (FMC), Computer Programming (SuperLogo), and Workshops.

Fundamental Mathematics Concepts. FMC was the “heart” of SummerMath. For 90 minutes a day, the girls worked in pairs or trios on mathematical problems that were specifically developed for the program. They had the support of one teacher and two undergraduate teaching assistants in a classroom of 12-16 girls. In the midst of students

solving mathematical problems on the board, at their desks, or on the floor, the teacher and two teaching assistants circulated around the room offering encouragement and guidance.

Each girl chose one of four FMC classes, which centered on one of four mathematical topics: algebra, geometry, trigonometry, or precalculus to calculus. Her FMC choice depended on her goals for herself as a learner of mathematics and her interests in mathematics.

For the first three days, the girls took turns solving mathematics problems (see Appendix A for examples of the problems) using the *pair problem-solving method* developed by Whimbey and Lochhead (1980). This method of problem solving involved two learners, who were assigned one of two roles, that of *problem solver* or *listener-questioner*. The problem solver's responsibilities included reading the problem aloud, talking about how she solved the problem, drawing diagrams to illustrate her thinking, justifying her thinking, and actively working on the problem. The responsibilities of the listener-questioner were to listen carefully and actively, encourage vocalization and drawing of pictures, and ask questions to clarify the thought processes of the problem solver. After a problem was solved, the problem solver and listener-questioner switched roles. By the fourth day of class, the FMC teacher encouraged the girls to solve problems together and to move away from following the pair problem-solving method. This veering away from the prescribed method was permissible as long as the learners used the methods of questioning that they had gleaned from the pair problem-solving method.

The goal when solving mathematical problems in FMC was less to get the right answer than to explore mathematical ideas with a focus on conceptual understanding and the problem solving process. The teachers and teaching assistants avoided as much as possible

telling or even suggesting an answer to a student. Rather they created a supportive environment where the girls were expected to struggle with the mathematics. A belief that girls have the knowledge within themselves to create mathematics permeated the SummerMath learning environment. Thus, the teachers allowed the girls to experience frustration and encouraged them to work through these feelings of struggle. The goal was for the girls to confirm themselves as learners of mathematics. The teacher's roles were to provide a challenging mathematical experience for each learner, to offer support and encouragement to persist through frustration, to believe that each learner was capable of doing mathematics, and to continuously assess the students' learning.

For the first 15 minutes of FMC, the girls solved *Openers*, which were problems that the girls solved with someone other than their regular partner(s). This gave the girls opportunities to work with other students. When the girls felt comfortable with their solution(s), the primary FMC teacher, Lourdes, asked one member from each partnership to write the solution(s) on the board. Then each girl explained how to solve the problem. Lourdes guided the discussion, asking students to explain in more detail and justify their solutions.

Technology was used throughout FMC. Graphing calculators were readily available for each student to use when solving problems. The teachers encouraged the learners to use this technology to enhance their learning of mathematics rather than use it as a crutch. On most days, the girls engaged in mathematics activities in which technology was part of their learning experience.

The SuperLogo Class. The SuperLogo class provided the girls opportunities to explore mathematics in an environment that challenged stereotypes about girls and

computers. The girls explored mathematical concepts using the computer in order to confront and alleviate any anxiety or fear attached to computer use. For 90 minutes a day, the girls worked in pairs at a computer solving mathematical problems. They began by exploring basic geometrical ideas and worked toward understanding recursive functions using Logo, a computer language developed by Seymour Papert at the Massachusetts Institute of Technology. One assignment in the SuperLogo class was for the learners to use their mathematical and computing knowledge to design, develop, and complete a final computer project. While the students used Logo, two teachers and two teaching assistants circulated around the classroom and assisted the students with the computers. The teacher's roles that applied in FMC also held true in the SuperLogo class. That is, teachers guided students' learning; they refused to supply any student with an answer.

Workshops. Along with FMC and SuperLogo, the girls participated in two 2-week workshops. When they completed their SummerMath applications, they selected from a menu of eight workshop options. Seven of these workshops were applied mathematics workshops, and one was a confidence-building workshop.

The applied mathematics workshops provided the girls with a chance to connect with and apply mathematics. The goal was to bridge the gap between mathematics and the "real world." The workshops attempted to captivate learners' interest by making mathematics come alive. Hands-on learning was common. In previous summers, workshop topics had included architecture and mathematics, origami, medical ethics, economics, kitemaking and aerodynamics, optimization, and the biology of genetics and growth. A different teacher led each of the following workshops during July 2001: Introduction to

Economics, Biology, Origami, Art of Making Anatomical Comparisons, Architecture and Mathematics, Statistics, and Robotics.

An additional workshop centered on confidence building was available for those girls who perceived themselves as having little confidence in mathematics. This workshop focused on helping them explore ways to become more confident in mathematics. For example, the girls examined their mathematical histories and how those histories were shaped. They also explored their feelings and beliefs about mathematics. The workshop participants learned strategies for confidence building in mathematics, which included positive self talk, and explored anxiety issues in learning mathematics, including test anxiety. They also learned strategies for maximizing their learning in mathematics. The workshop functioned as a support group for “mathematically abused” students who perceived their experiences in mathematics as emotionally and physically disabling.¹ The workshop was composed of students who identified mathematics as a source of extreme anxiety, which caused them psychological distress. This distress sometimes manifested itself in physical illness and emotional pain. A goal for each workshop participant was to make the decision to become confident in mathematics by taking control over her emotions and mind and by taking responsibility for her learning in mathematics.

Residential Program

The goal of the residential program was to build a community of learners, where connection and collaboration were primary to the development of each participant. To help build a close-knit community, SummerMath participants lived in dormitories on the campus of Mount Holyoke. They had opportunities to experience independence from family

members, perhaps for the first time. The girls engaged in various activities outside of the mathematics and computer classes. They had opportunities to explore issues ranging from sexuality and health to music, dance, and crafts. There were social activities, workshops, and speaker presentations, all with a focus on empowering adolescent girls.

The residential program depended on the resident assistants, who were also teaching assistants. The main goals of the residential staff were to provide support, friendship, and encouragement to the girls who might be struggling with the feminist approach to learning mathematics or finding it difficult to be away from home. The resident assistants lived in the dormitories with the girls. They ate their meals together and shared in daily responsibilities. The purpose of the residential program to build a safe and trusting community where each girl felt accepted, nurtured, and empowered.

A Typical Day at SummerMath

From July 1 through July 28, the girls followed a schedule. On weekdays, they engaged in FMC and SuperLogo along with numerous activities, workshops, and seminars designed to boost their confidence and improve their mathematical communication and reasoning skills. The weekends were set aside for the girls to take Saturday field trips (i.e., two one-day trips to Boston and one visit to local college campuses), to explore the local area and campus, and to participate in leisure activities of their own choosing. In Table 3, I present a timeline that depicts a typical weekday for each girl who attended SummerMath. From Monday through Friday, the girls followed this schedule with one exception. The recreational activity was cut from the schedule on Friday in order that they might have additional leisure time. This extra time provided the girls a chance to visit the shopping

¹ I was privy to students' perceptions of themselves as mathematically abused because I taught the Confidence Building Workshop. Later in this Chapter, I discuss how I became the teacher of this workshop. I also comment

village across the campus or attend a summer theatre or musical performance. On July 4, the afternoon classes were replaced with holiday activities.

Table 3

SummerMath Weekday Timeline

Time	Activity
7:30 - 8:30 a.m.	Breakfast
8:30 - 10:00 a.m.	Fundamental Mathematical Concepts
10:00 - 10:15 a.m.	Break
10:15 - 11:45 a.m.	SuperLogo
11:45 - 12:45 p.m.	Lunch
12:45 - 2:15 p.m.	Workshop
2:15 - 3:00 p.m.	Break
3:00 - 4:30 p.m.	Recreational Activity
4:30 - 7:00 p.m.	Dinner and Leisure Time
7:00 - 8:00 p.m.	Evening Event
8:00 - 11:00 p.m.	Leisure Time

Participants

Feminist research demands that women and girls are central to the research process (Reinharz, 1992). Their value to the researcher lies in the active role they play. In an attempt to acknowledge the critical role that the participants played in the present study, I referred to the participants as *coresearchers* during the program. This research would have been impossible without their participation. I also referred to them as coresearchers to build rapport with them. The girls in the study delighted in the fact that they were called coresearchers. They rightfully perceived that they were a significant part of the research because they were part of the data collection.

The use of coresearchers did not imply equal participation in terms of the research process. I developed the research questions, designed the study, collected and analyzed the data, and wrote up the results. The participants contributed by giving their time, sharing their

on my role as the teacher in this workshop and the implications that this role had on my role as researcher.

experiences, and participating in member checks, which I discuss later in this chapter. Using *coresearcher* in place of *participant* during data collection was an attempt on my part to honor the critical role that the participants played. It was not meant to suggest that the researcher and participant roles were equal. In this report, I refer to the students as participants.

Even if I had wanted to, I would not have been able to interview every SummerMath student, observe every FMC and SuperLogo class and workshop, or participate in every activity. Time constraints and scheduling conflicts limited my access to the SummerMath students. To achieve the purpose of this study, I used a nonprobability sampling approach to select participants.

I chose the participants from among the 59 adolescent girls in grades 8 through 11 who participated in SummerMath in 2001. I chose participants who were in the same cohort, which was defined as a group of 12-16 girls who were enrolled in the same FMC and SuperLogo classes. That is, they followed the same schedule in the morning. There were four cohorts, which are shown in Table 4.

Table 4

SummerMath Schedule of the FMC and SuperLogo Classes

Time	FMC and SuperLogo Classes		
8:30-10:00 a.m.	Cohort 1 FMC [Geometry] (16 girls)	Cohort 2 FMC [Trigonometry] (13 girls)	SuperLogo (Cohorts 3 and 4 combined) (30 girls)
10:15-11:45 a.m.	SuperLogo (Cohorts 1 and 2 combined) (29 girls)		Cohort 3 FMC [Algebra & Precalculus to Calculus] (16 girls)
			Cohort 4 FMC [Algebra] (14 girls)

I selected the participants using a criterion-based sampling approach (Goetz & LeCompte, 1984). Diversity was the main criterion I used. A week prior to the girls' arrival, during the SummerMath staff training, I read the applications of each SummerMath student to gain background knowledge about her experiences in mathematics and obtain pertinent demographic and biographical data. I selected potential participants based on three factors: race and ethnicity, geographic location of home, and status as a scholarship recipient or not. The scholarship recipients received funds based on financial need and mathematical achievement. Therefore, I inferred that students who attended SummerMath on full or partial scholarships were possibly from disadvantaged socioeconomic backgrounds. I avoided choosing who were middle-class and white.

Once I was informed about the personal background and class schedule for each SummerMath student, I selected Cohort 3 for two reasons. First, it offered the widest range of diversity in terms of the three selection factors. Second, Cohort 3 was unique in that it was a class that combined both Algebra and Precalculus to Calculus. It contained nine girls taking Algebra and seven girls taking Precalculus to Calculus. Because there were two levels of mathematics in one classroom, I had the opportunity to include girls with the widest range of ages and mathematical backgrounds. The girls also varied in their confidence in mathematics.

After I selected the cohort, I reread the applications of the 16 girls to capture a sense of their reasons for coming to SummerMath, their initial confidence level in mathematics, and their past experiences with mathematics. On orientation day, July 1, I attempted to meet each of the 16 potential participants to gain a sense of her level of sociability and to gauge her level of interest in participating in this study. I also observed the first day of the FMC

and SuperLogo classes and the origami workshop to see the social interaction among the potential participants. I decided that day that I could manage data collection and analysis for seven participants given my time schedule as well as the participants' schedules. I selected seven girls who varied in race and ethnicity, geographic location of home, scholarship status, age, confidence in mathematics, and FMC class. The seven participants also varied in their level of sociability. That is, I intentionally selected some participants who seemed to be introverted and others who appeared to be extroverted. These judgments were based on preliminary observations and interaction with the participants on the orientation day and the first day of the FMC and SuperLogo classes and origami workshop.

There was one deaf student in Cohort 3, but I did not choose her because of the difficulty in scheduling interpreters, which were necessary to conduct the interviews. In Table 5, I present relevant background information about the participants.

Table 5

Background Information on the Participants

Name ²	Age	Grade in 2000-2001	Self-Identified Race and Ethnicity	Geographic Location of Home	Scholarship Recipient	Choice of FMC Class	Confidence Level in Mathematics ³
Angela	15	10	African American	Massachusetts	Full	Precalculus to Calculus	8
Hannah	16	10	White	New York	No	Algebra	3
Julie	17	11	Chilean American	New York	Partial	Precalculus to Calculus	6
Rachel	15	9	African American	Maryland	Partial	Algebra	6
Samantha	16	10	Korean American	Maryland	No	Algebra	7
Sarah	15	9	White American	Virginia	Partial	Algebra	4
Virginia	14	8	Hispanic American	New Mexico	Full	Algebra	7

² The participants' names are pseudonyms, which they chose.

³ As reported in her SummerMath application. In the application, students were asked to rate their confidence level in mathematics on a 10-point scale, where 1 represented the lowest level of confidence and 10 represented the highest level of confidence.

Below I present a brief character sketch of each participant to highlight her individuality. I first met Angela as I was leaving the student orientation. She struck me as someone who liked to be the center of attention. As I came to know Angela, I saw that she commanded a great deal of attention from those around her. She had a strong personality and could easily lead her peers. Angela was highly opinionated but respectful of others' thoughts and opinions. I admired her leadership abilities most of all her abilities.

Hannah exhibited a level of maturity that seemed beyond her years. She was politically aware and defended her liberal political position. She was highly articulate and reflective about her thoughts and behavior. In every conversation that I had with Hannah, it was apparent that she thought a lot about her actions and their consequences. Even though she was rather quiet, she spoke her mind. She possessed a strong sense of self and was grateful to her liberal-minded parents for the role they had played in her character development.

Julie appeared at ease with herself and those around her. She was optimistic and hopeful about the world. These may have been reasons why she was well liked by her peers. Even though she was soft-spoken, Julie felt comfortable with speaking her mind when the situation arose. What struck me most about Julie was her determination and passion to fulfill her life-long dream of becoming an architect. She loved talking about her future because she could see herself as an architect. She saw her future as full of possibilities and thought that no obstacles could stand in her way.

Rachel was difficult to know and understand. I had a challenging time determining what Rachel was feeling because she rarely expressed emotions. She seemed to have built a

wall around her for protection, from what I am not sure. I enjoyed the few occasions that I saw Rachel laugh or smile because it made her appear years younger. In a way, she seemed to recapture her childhood when she was expressing joy or happiness. Rachel tended to be introverted and revealed little about herself or her family. What stood out most was Rachel's need for independence. She preferred to take responsibility for herself and her actions.

Samantha seemed to carry sadness with her wherever she went. It is difficult to explain, but even when she was laughing, she seemed sad. When I first met Samantha, I also met her parents, who were from Korea. It struck me that she seemed embarrassed to be with them. Samantha was often reserved when she spoke with me. She seemed to be guarded in her responses and was cautious in how much she revealed about herself. At times, I perceived that she held back responses. I perceived that Samantha was introverted.

What struck me about Sarah was her love of life. She seemed grateful for every moment in the day. This gratitude came across in her cheerful smile and her positive attitude. Sarah had a wonderful sense of humor. She made her peers laugh, and I felt energized being around her. Sarah's fun-loving spirit revealed itself in the way that she joked with other students. I admired her honesty and her willingness to share her life story with me. Sarah gave much credit to her mother, a single mom, for raising her and her siblings as a single mom.

Perhaps because Virginia was younger than most SummerMath students, she appeared the most impressionable. She seemed both eager to meet new people and apprehensive about it at the same time. Virginia was proud of her Hispanic heritage. She speaking highly of her family, friends, and home in New Mexico. At first, she was soft-

spoken and shy. Once I knew her better, her shyness dissipated. She revealed herself as a caring and kind person who thought highly about the people around her.

Data Collection

Wolcott (1992) asserted that “qualitative researchers rely on the same three general categories of techniques for gathering information: experiencing, enquiring, and examining” (p. 22). To understand these adolescent girls’ experiences and to explore their perceptions of themselves, mathematics, and the learning environment, I gathered data by *observing*, *asking*, and *looking*. In more familiar terms, I collected data using participant observation, interviews, and documents, often referred to as ethnographic methods (Wolcott, 1992). I also used an instrument to collect data. These four data sources formed the methodological fabric of this study. What follows is a discussion of the data sources and the methods for data collection. In Appendix B, I summarize the data collection process by presenting a daily calendar.

Methodological Fabric: Data Sources

Experiencing: Participant Observation

To gain firsthand knowledge of these girls’ experiences in a feminist mathematics classroom, I used participant observation to inform my inquiry. That is, the observations that I made guided the individual and focus group interviews. For almost four weeks, Monday through Friday, I observed the participants in their FMC and SuperLogo classes. Except for the final Friday (July 27) of the program, I collected participant observation data for 19 days of FMC and SuperLogo classes, which totaled to thirty-eight 90-minute classroom observations.

During these observations, my role was that of an *observer as participant* (Merriam, 1988), which means gathering field notes by strictly observing. In other words, my role as researcher was to observe the participants. The participants were aware of my presence in the FMC and SuperLogo classes, but I did not interact with the participants during those classes. Char, Jim, and I agreed that any questions and interruptions would hinder the participants' learning experiences. In this realm, Merriam offered guidance: "The researcher's participation in the group is definitely secondary to his or her role of information gatherer" (p. 93).

To enable the participants and staff to feel comfortable with my presence, I participated in most of the SummerMath activities outside of the FMC and SuperLogo classes, which included workshops, weekly staff meetings, evening and weekend events, and meals. I also lived in an apartment on campus, which kept me close to all of the program activities. My participation in the program gave me access to casual, informal conversations, which served as additional data sources. I gained an emic perspective; that is, an insider's view. My daily presence also established rapport between the participants and me. Through my field work, I attempted to gain an understanding of the participants' experiences within and across various mathematical learning contexts.

In the activities outside of FMC and SuperLogo, my role as a researcher was that of *participant as observer* (Merriam, 1988). In this role, I gathered "fieldnotes by conducting an observation as a participant" (Creswell, 1988, p. 121). During the first two weeks of SummerMath, I participated as a student in the origami workshop. For 10 days, I learned how to fold and create origami along with a dozen adolescent girls, two of whom were case study participants, Hannah and Virginia.

As a participant in the origami workshop, I observed all 12 students without a field notebook or laptop. My role during the workshop was to participate. Of course, I observed what was going on. But notetaking and observation took a secondary role. Making the switch from observer to participant translated to a higher degree of researcher participation and allowed for more interaction with Hannah and Virginia. Because they were enrolled in the workshop, I often worked side-by-side with them, asking for their insight on a particular origami project. This interaction helped forge a more positive relationship with each girl.

My role as participant as observer also extended to conversations at meal time and weekend and evening activities. During these activities, I spent most of my time as a participant rather than an observer. The time that I spent with the participants outside of FMC and SuperLogo helped build rapport with them. Mealtime and weekend activities (e.g., Whalewatch in Boston) were valuable in strengthening that rapport.

As mentioned above, I attended the staff training seminar. I had several reasons for participating in it. First, it gave me multiple opportunities to meet all of the staff members. It made my presence known and helped to build my rapport with the staff members, who, I believed, perceived me as part of the program. Second, the week of staff preparation afforded me a unique opportunity to achieve more of an emic perspective. I saw firsthand the amount of preparation that the staff performed that week. Third, I gained a deeper understanding of the teaching philosophies and principles that guided SummerMath. Throughout the staff preparation, my role as researcher alternated between observer and participant. I took extensive field notes on the events and experiences during that week.

Halfway through SummerMath, my role as researcher took an unexpected turn when Char asked me to teach the Confidence Building Workshop. The original teacher had

unexpectedly become ill. Char, though mindful of possible ethical dilemmas, thought that I was an ideal substitute because of my middle and secondary teaching experience and the positive rapport that I had developed with the participants and other SummerMath students. An excerpt from my journal on July 23 illustrates my thoughts on the ethical and political dilemmas that this teaching experience posed:

One thing that I have not written about, which I should, is how my role as researcher has shifted since Char asked me to teach the Confidence Building class. Where I felt my role alter was in the staff meeting last Wednesday. Now I was perceived as staff and researcher, insider and outsider. From my observations in class, my role as researcher has not been a concern to those participants in the class, Virginia and Sarah. I felt slightly uncomfortable in the staff meeting because I continued to ask myself, When should I speak up? When is it appropriate to speak up? I am fortunate to have this teaching experience because it affords me another perspective in the SummerMath program. Now I can capitalize on the fact that I have three lenses with which to view my experiences at SummerMath. I have my role as observer, my role as student, my role as teacher. Does this mean that I have achieved an emic perspective? Having the opportunity to teach and observe has allowed me to view the research process through several lenses. I am happy in my decision to teach the confidence building class. Even though time in the confidence building class robbed me of time to devote to reading, writing, and analyzing, I gained a new lens through which to view the research. I also gained an opportunity to have first hand experience in teaching from a feminist perspective. In summary, what I lost in writing time, I gained in coming closer to achieving an emic perspective, which is what any researcher hopes to acquire when doing field research.

This teaching experience forced me to examine my role as researcher. I had to be mindful of my relationship with Hannah and Virginia, who participated in the workshop, and I had to consider the power dynamics that were operating in the workshop. I also considered how this teaching experience might enhance or undermine my relationship with Hannah and Virginia as well as with other students in SummerMath. After examining the ethical and political issues associated with my role as researcher, I decided to teach the workshop because it added an additional dimension to my research. I viewed this as an

opportunity to connect further with participants, immerse myself deeper in the SummerMath culture, and gain valuable insight as a teacher in the program.

My role as researcher also shifted in the weekly staff meetings. Because I was a *teacher* now, not the *researcher from the University of Georgia*, I participated in the meetings by providing input and sharing ideas. No longer was my role strictly to observe, but it shifted to one of participation. I moved closer to achieving an emic perspective because I was no longer sitting on the periphery of these meetings; rather, I was involved in decision making. Reflecting upon teaching the Confidence Building Workshop, I think the study is stronger and better informed because I had to move between observer and teacher. This teaching experience forced me to examine my role as researcher in ways that I might not have had to otherwise.

Inquiring: Interviews

There are many forms of interviews, which vary by purpose, structure, and content (Merriam, 1998). The two most common forms in educational research are individual and focus group. To achieve the purposes of this study, I conducted both types of interviews. All interviews were audiotaped and transcribed. In this section, I explain the different types of interviews along with their purposes.

Individual interviews. On Days 3, 4, and 5 of SummerMath, I interviewed the seven participants individually. The purpose of this first interview (see Appendix C for prompts) was to explore the participants' initial perceptions of mathematics and their initial perceptions of themselves as learners of mathematics on entering SummerMath as well as their initial perceptions of their experiences in the FMC and SuperLogo classes. The data from this initial interview served as benchmarks for future comparison. I was also interested

in drawing on the participants' perceptions as SummerMath began. What they first thought of their experiences in FMC and SuperLogo was important if I was to trace their perceptions of their experiences over the 4 weeks.

The next round of interviews occurred halfway through the program on Days 13, 16, and 17. The purpose of the second interview was to explore the participants' thoughts at the midpoint of SummerMath. Char and Jim had encouraged a mid-program interview because often students' thoughts and emotions seemed to vary throughout their SummerMath experiences, which turned out to be the case. The second interview (see Appendix D for prompts) explored the participants' perceptions of their experiences, their perceptions of mathematics, and their perceptions of themselves as learners of mathematics over the first 2 weeks in FMC and SuperLogo.

The third phase of interviews occurred during the final week of SummerMath on Days 26 and 27. The main purpose of this third interview (see Appendix E for prompts) was to explore how the participants' experiences over the 4 weeks in FMC and SuperLogo had shaped their views of themselves as learners of mathematics, their perceptions of mathematics, and their perceptions of their experiences in these two classrooms. This interview also afforded a final opportunity to ask questions that had surfaced earlier.

Focus group interviews. Kitzinger and Barbour (1999) defined focus groups as “group discussions exploring a specific set of issues. The group is ‘focused’ in that it involves some kind of collective activity” (p. 4). The purpose of the two focus group interviews was to paint a broader picture of the participants' experiences by gathering them together to make sense of their experiences as a group. Wilkinson (1999) contended that focus groups are ideal for feminist researchers “who see the self as relational, or as socially

constructed, and who argue, therefore, that feminist methods should be contextual” (p. 70). I wanted to observe the participants’ interaction within a group, to observe how they made meaning within a group, and to explore their perceptions of their experiences within the “social context” (p. 67) of a focus group.

Power differentials between researcher and participants often shift in focus groups (Wilkinson, 1999). No longer is the researcher controlling the interview; rather, the participants are leading the discussion, which centers on their experiences and agenda. Focus groups lend themselves to an open dialogue between participants. Feminist researchers view focus groups as a nonhierarchical data collection method that places participants at the forefront of the research process (Wilkinson, 1999). I used focus group interviews as a way to invite the participants to have more power in the interview process. The discussions centered on their thoughts and experiences. By participants taking more control of the interview, I had less control over the line of discussion, thereby reducing my power as researcher. My primary role was to facilitate the group discussion. Therefore, I spoke less; they spoke more.

To ensure that the individual and focus group interviews did not overlap, I conducted the focus group interviews one quarter (see Appendix F for prompts) and three quarters (see Appendix G for prompts) of the way through the program. The first focus group interview took place on Day 9, and the second focus group interview on Day 23. In both interviews, the seven participants worked on a collective activity. The discussion revolved around that activity. Throughout both focus group interviews, the participants were reflective and spoke at length about pertinent questions and topics. The focus groups zeroed

in on four topics. Hence, this format provided an exploration into topics and questions that might have otherwise received only cursory attention in the individual interviews.

Examining: Documents

Documents have various forms, including “public records, personal papers, physical traces, and artifacts” (Merriam, 1988, p. 117). For the purposes of this study, I examined two forms of documents, which served as additional data sources. First, as I mentioned earlier under participant selection, I read through the participants’ SummerMath applications for relevant biographical and demographic information. I considered the applications a valuable source of data because the students wrote an essay about a significant (positive or negative) experience in mathematics. The essays also provided information on the participants’ confidence level in mathematics. When students completed the applications, they were asked to rate their confidence level in mathematics on a 10-point scale. The applications provided an initial introduction to the students.

The second form of document that I analyzed was the participants’ daily journals for FMC and SuperLogo. Journal writing was part of the daily routine in both classes. The teachers encouraged all students to write about their emotions and thoughts surrounding their experiences in SummerMath, with a particular focus on the FMC and SuperLogo classes. The participants wrote in their journals at the close of each class. On some days the teachers provided journal prompts; on other days they did not. Every day, the teachers read and commented on the students’ journal entries. For privacy’s sake, the students were permitted to fold over a page if they preferred that a particular entry not be read by the teacher. This option afforded them the opportunity to vent about negative experiences

without fear of reprimand. On Day 27, I made copies of these journals. I did not copy the turned-down pages out of respect for the participants' wishes.

An Instrument: Mathematics Metaphor Activity

On Day 23, I administered the Mathematics Metaphor Activity (Appendix H), which I borrowed from Gibson (1994). Directly after the second focus group interview, I asked the participants to complete the Mathematics Metaphor Activity. This activity provided data about the participants' perceptions of mathematics in the FMC and SuperLogo classes.

In summary, these multiple sources of data helped me to “uncover meaning, develop understanding, and discover insights relevant to the research problem” (Merriam, 1988, p. 118).

Data Analysis

I analyzed the data using a thematic analysis (Bogdan & Biklen, 1992; Coffey & Atkinson, 1996), which is a general approach to making sense of data obtained through qualitative research. Several scholars (Bogdan & Biklen, 1992; Coffey & Atkinson, 1996) have contributed to the qualitative research literature with clear, insightful, and noteworthy discussions of data analysis methods using a thematic approach. Working within ethnographic traditions of data analysis are Wolcott (1999; 1994) and LeCompte and Preissle (1993). Even though these scholars might differ on the specifics of their data analysis approaches, a general pattern emerges within each approach. For the present study, I followed the approach discussed by Coffey and Atkinson.

When analyzing data using a thematic analysis, the first step is to read the data records from beginning to end, keeping in mind the research questions. I first had the complete set of 23 interviews transcribed by a professional transcriptionist. As I did an

initial reading of each transcript, I listened to the audiotape of the interview and compared it to the transcript to make sure that the transcript accurately reflected the interview. This listening process helped me to revisit the data after having been removed from then during the transcription process, which took 6 weeks. Listening to the tapes helped me glean possible themes and patterns. I caught a glimpse of the “big picture” through this process. Next, I performed a careful reading of each transcript, which served as an orientation to the data. I read the interview transcripts in chronological order for each participant and then the two focus group interviews.

The second step of a thematic analysis is to reread (and reread and reread) the data records, making notes and queries in the margin. During these multiple readings, initial patterns, themes, concepts, and categories began to emerge, and the process of data reduction began. In this step, I read the interviews chronologically four times, searching for themes and patterns as well as noting dissenting voices along the way. I also created preliminary codes during these readings.

The next phase involved coding. As I took the first steps to code, I was concerned about losing my participants’ voices. I feared distortion of their voices. A journal entry dated September 6, 2001, illuminates my concern and reveals my resolve:

All this time I worried that once I began coding data, I would venture into a world of analysis where coding is only defined as “data simplification or reduction” (Coffey & Atkinson, 1996, p. 28). I feared the minimization and reduction of data. Yet, at the close of today’s coding efforts, I was reminded me that “coding can be conceptualized as data complication. Coding need not be viewed simply as reducing data to some general, common denominators. Rather, it can be used to expand, transform, and reconceptualize data, opening up more diverse analytical possibilities” (Coffey & Atkinson, 1996, p. 29). Throughout the process of coding, I never felt doors closing. Instead, windows opened, allowing me to see the data in a new light. During the coding process, I will attempt to view coding from a perspective of possibility rather than impossibility.

Coffey and Atkinson (1996) described the coding process as two diametrically opposed concepts:

Coding is usually a mixture of data reduction and data complication. Coding generally is used to break up and segment the data into simpler, general categories *and* is used to expand and tease out the data, in order to formulate new questions and levels of interpretation. (p. 30)

In rather simplistic terms, coding is a systematic procedure used to assign categories to data. In an interpretive sense, coding provides a way to move beyond categories toward theory building and interpretation. Coffey and Atkinson cautioned against taking an oversimplified view of the coding process. They depicted coding in more complex terms when they stated that coding is “also about conceptualizing the data, raising questions, providing provisional answers about the relationships among and within the data, and discovering the data” (p. 31).

There are numerous sources for creating codes. I created codes that were informed by my theoretical framework, conceptual framework, and research questions. I also created codes based on intuition and hunches. Once I had identified codes, I used NUD*IST (2000), a qualitative research computer software package, as a tool to sort and manage the codes.

Once I had identified codes on the paper transcripts and then entered the initial codes in NUD*IST, I was ready for “category construction” (Merriam, 1998). I used these initial codes to form general categories, which I saw reflected in the data and “reflect[ed] the purpose of the research” (p. 183). During the category construction process, I attended to the connections and relationships between particular categories, which eventually helped me to identify themes. I saw how particular codes fit with other codes. I made meaning as I constructed categories. I saw relationships between other codes, which helped me build a network of codes that formed a category.

The next stage of thematic analysis is to identify “patterned regularities” (Wolcott, 1994) or themes that emerge from the coding process. During this process I transformed the data from codes and categories into meaningful data. The primary goal was to “sketch a schema within which certain meanings are sustained” (Frye, 1996, p. 39). Wolcott (1994) perceived this phase of research as the time “where we look for and discuss the relationships, the what-goes-with-what that realizes in the study of a single case the potential for understanding something beyond it” (p. 33). This phase is built on the premise that pattern making opens a wide range of possibilities. Pattern perception urges us to be “engaged with the greatest possible range of perceivers, of theorizers. What we are about is re-metaphoring the world” (Frye, 1996, p. 43).

An important part of this phase was to note patterned irregularities. At this stage, I relied on advice from Frye (1996): “Discovering patterns requires novel acts of attention” (p. 40). Not only did I identify patterns and make connections across categories, but I dutifully searched for irregularities in the data (e.g., dissenting voices, disconfirming evidence). That is, I asked the following questions of my data: Are there some data that do not fit? Do all of the data make sense? What stands out in the data as being different or strange? I attended to data that did not make sense and incorporated them into the data representation. By noting both pattern regularities and irregularities in the data, I attempted to create a picture of what was going on with the data, remembering that this picture is always partial, limited, and situated. Thematic analysis is a recursive process that is grounded in data simplification and complication, theme identification, and pattern making.

Validity

In this section, I address issues that pertain to validity. I explore notions of validity and describe procedures for establishing data trustworthiness.

A Notion of Validity

Wolcott (1994) challenged traditional notions of validity and questioned whether validity is an appropriate construct in qualitative research. He asserted:

I do not accept validity as a valid criterion for guiding or judging my work. I think we have labored too long under the burden of this concept (are there others as well?) that might have been better left where it began, a not-quite-so-singular-or-precise criterion as I once believed it to be for matters related essentially to tests and measurements. I suggest we look elsewhere in our continuing search for and dialogue about criteria appropriate to qualitative researchers' approaches and purposes. (p. 369)

In his need to move beyond positivistic notions of validity, Wolcott reconceptualized validity as a search for “understanding,” rather than thinking that there is one correct version of a particular reality that can be measured or discovered. He maintained, “I do not go about trying to discover a ready-made world; rather, I seek to understand a social world we are continuously in the process of constructing” (p. 368). Wolcott’s notion of validity as understanding guided this study. My goal in this research was not to convince, impose, or discover a certain reality. Rather, the overarching purpose rested on understanding and explaining the experiences of adolescent girls in a feminist mathematics classroom. Meaning making was the ultimate aim and underpinned the research process.

Strategies for Satisfying the Implicit Challenge of Validity

Wolcott (1994) offered nine strategies that “satisfy the implicit challenge of validity” (p. 347). Adhering to Wolcott’s advice, I spoke little and listened most of the time in the interviews. I took fieldnotes immediately, making sure that I recorded what the participants

said and how they said it, and documented classroom events and situations. In addition to Wolcott's recommendations, Merriam (1998) offered several strategies to ensure internal validity. I incorporated several of these strategies into this study: triangulation, peer feedback, and member checks. In this section, I discuss these strategies and how they added validity to this study.

Triangulation

Lather (1991) noted the importance of triangulation as a means to strengthen validity. She advised, "The researcher must consciously utilize designs which seek counter patterns as well as convergence if data are to be credible" (p. 67). Following Lather's (1991) advice, I used multiple sources of data, which included numerous participant observations, two types of interviews, and several documents. Furthermore, observing classes and activities outside of FMC and SuperLogo painted a holistic picture of the participants' experiences, thereby strengthening the validity of this study.

Peer Feedback

Wolcott (1994) stressed the importance of peer feedback for increasing validity. To this end, I relied on continuous feedback on the research process from Char and Jim Morrow, who I met with on a weekly basis during data collection to discuss issues related to data collection. They also read and reviewed drafts of the dissertation. During fall 2001, I met weekly with members of my writing/research group, who provided feedback on data analysis and critiqued drafts of this dissertation. Throughout the entire research process, I received feedback and critique from my major professor, Patricia S. Wilson, on all aspects of this dissertation study. My committee members provided feedback and offered critiques of my dissertation research at a prospectus meeting, a predefense meeting, and a final

defense meeting. Their comments also related to all aspects of the research process. The feedback that I received from these people doubled as *response data* (St. Pierre, 1997, p. 184), which provided alternative perspectives and assessed the quality of my writing and research.

Response data are any data that one receives from (and responds to) the interaction with “the Other, many different others, at every stage of the research process” (St. Pierre, 1997, p. 184), which may include peers, colleagues, research participants, mentors, journal editors, friends, relatives, to name a few of the possibilities. St. Pierre (1997) noted the importance of response data:

Peers do provide us with data that are often critical and that may even prompt us to significantly reconstruct our interpretation as we proceed. These data surely influence the production of knowledge, yet we hardly ever acknowledge them. (p. 184)

My inclusion of response data from those cited above is one way to acknowledge the significant role that they played in the research process. St. Pierre described the promise that using response data held in her research:

All these others move me out of the self evidence of my work and into its absences and give me the gift of different language and practice which to trouble my commonsense understanding of the world. They help me to move toward the unthought. (p. 185)

Without the response data that I collected from my peers, colleagues, and committee members, I would have produced knowledge in isolation and limited both myself and this research. Their guidance enabled me to make new interpretations, think differently about my data, and “moved me toward the unthought.”

Member Checks

Member checks also served as additional sources of response data (St. Pierre, 1997). I used member checks, which means “taking data and tentative interpretations back to the people from whom they were derived and asking them if the results are plausible” (Merriam, 1998, p. 204). After I wrote the initial “data story” (Chapter 5), on December 7, 2001, I sent a copy of this story to the participants for their review. I asked them to read and comment on my initial interpretations and perceptions and to add their own interpretations if my representation of their experiences differed from theirs. The participants had 5 months to complete this process. On May 20, 2002, I contacted the participants by email. In this message, I conveyed how important their comments were to the research process and requested their comments. Because the participants did not respond to this email, I contacted them by telephone on June 18 and 19. During these brief telephone conversations, I asked the participants if they wished to add to or react to Chapter 5. They all stated that they had no comments to add because my representation of the data was plausible.

Reflexivity

An additional construct held in high esteem for establishing validity is reflexivity. Feminist research demands reflexivity, which mandates that researchers understand how their socio-historical-cultural perspectives shape their orientations toward research. Both researchers’ and participants’ beliefs and experiences are molded by the particular socio-historical setting within which they live. The following quote encapsulates Harding’s (1991) particular brand of reflexivity:

A notion of strong reflexivity would require that the objects of inquiry be conceptualized as gazing back in all their cultural particularity and that the researcher, through theory and methods, stand behind them, gazing back at his [or

her] own socially situated research project in all its cultural particularity and its relationships to other projects of his [or her] culture. (p. 163)

Harding's *strong reflexivity* required that I continuously interrogate my positionality throughout the course of this study. Earlier in my researcher posture and positionality statement, I expressed my assumptions and scrutinized how these shaped this research. Stating my posture as a researcher was a step toward reflexivity.

A second step toward incorporating reflexivity was to maintain a journal throughout the research process. The purpose of this journal was to provide a space for me to record my thoughts and emotions about issues, concerns, and dilemmas that arose during the study. There were several important reasons for keeping a journal. First, I could trace the development of my thinking about methodological concerns. Second, I could use the journal to help me understand how I was shaping the study, and conversely, how it was shaping me. Furthermore, the journal enabled me to confront my assumptions and interrogate my positionality at every turn. In addition, the journal provided a place to make data collection memos and to document data analysis procedures. Lastly, it provided an outlet for writing throughout the research process. As Richardson (2000) suggested, I used writing as a "method of inquiry." As I wrote on a regular basis, I tried to understand the data, formulated conjectures, and explored ways to represent the data. To summarize, my journal stimulated an ongoing conversation between me and the research process. On a final note, the journal was a powerful tool for "navel gazing," which qualitative researchers must engage in if they are to acknowledge their positionalities and understand how those positionalities may undermine or enhance research.

Limitations of Study

The participants were diverse in race, ethnicity, and age, but there was little variation in where they lived. Only one participant, Virginia, lived outside of the northeastern region of the United States. All but Virginia resided in urban and suburban settings. Second, I did not know the socioeconomic status of each participant, but I did know whether or not each participant was receiving a scholarship for the program. Hence, this study offers no understanding of the experiences of adolescent girls in a feminist mathematics classroom based on differences across class.

A third limitation is the partiality, specificity, and locality of this research. The FMC class was part of a summer program that lasted four weeks. As a result, the classes were 90 minutes, there were no school curriculum mandates, tests, homework, or standardized tests. Hence, this study provides a view of one special feminist mathematics classroom.

A fourth limitation relates to the use of feminist standpoint theory as my theoretical perspective. Feminist standpoint theory was useful in this research in that it encouraged me to listen to the voices of adolescent girls and use their standpoints as a basis for understanding their experiences in a specific feminist mathematics classroom. However, I found that this theoretical perspective was insufficient at times in the interpretation process. When I interpreted the voices and standpoints of the participants, I also incorporated my voice and standpoint into the interpretation. I used my voice and perspective as a researcher to communicate their voices and perspectives as participants.

CHAPTER 5

DATA REPRESENTATION:

MOMENTS IN A FEMINIST MATHEMATICS CLASSROOM

Van Maanen (1988) spoke to the seriousness of data representation: “The crucial problem of what we so cavalierly call ‘writing it up’ is to balance, harmonize, mediate, or otherwise negotiate a tale of two cultures (the fieldworkers’ and the others’)” (p. 138). He offered several ways to represent data, which include a “realist tale,” “confessional tale,” and an “impressionist tale.” After considering the multiplicity of ways that I could “write it up,” I decided to represent the data as a feminist tale. I chose to write a feminist tale because of my allegiance to the participants’ voices and the feminist nature of the research. Furthermore, the themes that I noted in the data (e.g., power relations, agency, authorship, and voice) demanded a feminist tale.

This feminist tale weaves together the experiences of seven adolescent girls, Angela, Hannah, Julie, Rachel, Samantha, Sarah, and Virginia, in a feminist mathematics classroom. Like a Peruvian Quipu, this tale has multiple threads, each with its own color, position, structure, and meaning. Each thread is a part of the tale. The tale begins with a *prologue* that provides background information on why the participants came to SummerMath and what they expected from it. After this brief orientation, the tale proceeds with a revelation of three *benchmarks*, which serve as points of reference. These benchmarks provide room for comparison. The first of the three benchmarks is a *collective portrait*⁴ of the participants’

⁴ The four collective portraits in Chapter 5 are composed entirely of quotes from the participants. Each of the participants’ voices is incorporated into each collective portrait at least once. The first collective portrait reflects

perceptions of their experiences in their regular mathematics classrooms. This part of the tale also presents the participants' perceptions of themselves as learners of mathematics and their perceptions of mathematics that they carried with them into SummerMath, the second and third benchmarks, respectively.

The tale continues to unfold in three moments. The First Moment, "You Have to Figure It Out by Yourself," is a collective portrait of FMC⁵ as expressed through the voices of the participants. In this first moment, we are privy to the participants' preliminary perceptions of their experiences in FMC. The Second Moment, "The Teachers Don't Teach Here," reveals a collective portrait of the participants' perceptions of their experiences up through the midpoint of SummerMath. It paints an intermediate picture of what the participants thought of their experiences after two weeks in FMC. The Third Moment, "FMC is Even More Nonconformist Now!" paints a collective portrait of the participants' perceptions of their experiences after a month.

Prologue

Why Am I Here?

Each participant expressed a different reason for attending SummerMath. The participants' reasons varied from academic interest to parental pressure. Angela was attracted to SummerMath because she had plans to "do something academic anyway" and "it seemed interesting." She commented, "I am looking for a solution." Angela needed "an

the common themes of the participants' perceptions of their experiences in their regular mathematics classrooms. The other three collective portraits reflect the common themes of the participants' perceptions of their experiences in a feminist mathematics classroom. I created the collective portraits by choosing quotes that reflected the common themes. I discuss dissenting voices after each collective portrait.

⁵ I focused my attention only on FMC because the participants perceived FMC as the "math class" and SuperLogo as the "computer class." When they made comparisons between their regular mathematics classrooms and the classrooms at SummerMath, that is, FMC, SuperLogo, and the workshops, they spoke primarily about FMC. Not until the end of SummerMath did the participants begin to see SuperLogo and the

outlet” that would stimulate and challenge her mathematically. She believed that she was wasting her time “doing busy work” in her regular high school mathematics class, which based its curriculum on the Interactive Mathematics Project (IMP), a collaborative, problem-based approach to learning mathematics. Angela perceived SummerMath as a site for mathematical challenges.

Sarah attended an elite New England boarding school where many of her friends spent their summers on “extravagant trips” and in “enrichment camps.” Sarah was motivated to attend SummerMath because she wanted to enroll in an “enrichment camp” that would “look good on her resume” and allowed her to receive help in mathematics. Improving her mathematical ability was a high priority.

In a similar vein, Julie entered SummerMath to prepare herself for Advanced Placement (AP) Calculus. She offered two reasons for attending SummerMath:

I first saw it as a way where I could get more credit to go to college, because college would count it. But then I saw it as a way to prepare for next year. In New York, we take sequential [mathematics courses] 1, 2, and 3, and then comes Precalculus. But I am skipping Precalculus, and I am going to take AP Calculus, which is advanced placement, because I did good this year. So in coming in here, I am taking right now Precalculus-to-Calculus. So it is preparing me for next year since I am skipping Precalculus. (Individual Interview 1, July 4)

Julie never doubted that she could handle AP Calculus without having the customary prerequisite of Precalculus. In her application essay, she noted an additional reason for coming. “I want to attend this SummerMath program because I think it will help me in building up my confidence in math.”

Hannah learned about SummerMath in connection with her interest in attending Mount Holyoke College after graduation. She found out about the SummerMath Web site

workshops as possibly resembling a mathematics class. Even then, only a few participants made this connection.

through an e-mail message from her mother. After scanning the Web site, Hannah knew that SummerMath was a place for her to learn more about herself and mathematics. She stated:

I thought it just looked really interesting. That it was kind of a nonconformist math class, where you have more freedom, in a sense, for learning. They also help build your confidence. A big key to me wanting to come here was the fact that I would be able to feel better about myself and that it wasn't *really* a math camp. It is all-girls, so there are not really any distractions. There are other classes like Origami, which teaches you geometric shapes. (Individual Interview 1, July 3)

Hannah believed that she would have ample opportunity to have a “fun experience with math.” The college-like atmosphere also provided a sense of freedom that she welcomed.

A majority of the students who attended SummerMath were granted partial or full scholarships. Virginia was one of those students. She was selected by the Mathematics, Engineering, Science Achievement Program to receive a full scholarship because she was Hispanic and high achieving in her mathematics class. She viewed this scholarship as an honor. She often spoke of making the most out of her experience at SummerMath. In the first interview, she commented, “Out of this, I hope that I learn a lot more math because that is why I am here.” Virginia also viewed SummerMath as an opportunity to prepare for her first year of algebra.

Not all students who attended SummerMath entered willingly. Two of the participants, Rachel and Samantha, had come to SummerMath because of parental pressure. Rachel was not shy about her motives for attending SummerMath. In the first interview, she disclosed, “I wasn't really attracted to SummerMath. My mom just found out about it from somebody, and she made me come.” Samantha noted her parents' motivation for sending her to SummerMath in the first interview on July 5: “Well, I guess it is because I am going to be a junior. I think [my parents] are thinking about SAT and PSATs, and they just wanted

me to prepare for these standardized tests, especially with the math section.” Both Rachel and Samantha participated in SummerMath because their parents “made them.”

What Did I Expect?

The participants walked hesitantly into the first SummerMath classes not quite sure of what to expect. Their expectations ran the gamut. Sarah expected a “math camp.” Hannah anticipated a “nonconformist” mathematics class. She discussed her initial expectations:

I wasn’t really sure what to expect. I was thinking, I hope it is not like a math camp where you have to get up and everything is about math, and it is like, “Math is fun. Math is great. You should do math.” I also thought it would be pretty laid back because Massachusetts is a very liberal place. If someone were to start this program, Mount Holyoke is a very laid back school, so I figured if the person works here and started the program, it should be relaxed. I wasn’t really sure what to expect, but I didn’t think it would be major amounts of pressure, which was nice. (Individual Interview 3, July 27)

Previously, Hannah had noted that one of her primary reasons for coming to SummerMath was “that it was kind of a nonconformist math class, where you have more freedom.” She anticipated that mathematics instruction would take an informal approach, one that broke with tradition. Echoing Hannah’s unease that SummerMath might be a “math camp,” Sarah and Rachel mentioned that their primary concern was worry over being seen by their peers and siblings as attending a “math camp” designed specifically for “nerds and geeks.” They hoped that that would not be the case. After the first three days, Sarah and Rachel’s fears were alleviated. In the first interview, Rachel stated that “it is not even like math all the time.” She also confirmed that there was a “mix” of students who attended SummerMath.

Julie and Virginia entered with high expectations for their SummerMath experience. They expected that they would learn new mathematical concepts and skills right away. Virginia commented, “I came here so I could learn more and get ahead.” Julie echoed those sentiments.

Angela held an array of expectations. She saw SummerMath as an opportunity to learn mathematics in new ways, to gain conceptual understanding of mathematics, and to learn to work collaboratively:

We have done some relatively simple stuff, so far, but I am guessing it is going to get more difficult, more in depth. I mean it is probably not so much about learning Algebra, Geometry, Trigonometry, and Calculus, but learning how to work better at learning different work habits, learning how to work in pairs without telling someone the answers, and learning the concepts behind things you already know. Like I know $A^2 + B^2 = C^2$, but why? (Individual Interview 1, July 3)

Angela's expectations seemed quite sophisticated.

On a different note, all but one participant, Hannah, expected that their learning experiences would be based upon a traditional mathematics classroom template. Discourse centered on this expectation in the first focus group interview on July 9:

Rachel: I just thought that they would just teach on the board and give us practice, and just review everything basically you need to know in Algebra and explain it.

Samantha: I didn't know what the classes were going to be like. I thought that it would be just basically lectures. We would take notes.... Well, when I first came here, I thought that this was just going to be like summer school basically; but it is not that at all.

Sarah: I was expecting a teacher to be standing at the board the whole day.... Like my [regular] math class.

These three participants entered SummerMath expecting that their mathematical learning experiences would parallel those of their regular classes. That is, a teacher lectures at the board, students take notes in their seats, and students practice numerous problems.

Angela summarized her thoughts in the first interview on this mismatch between what the participants expected and what they found: "[The way the mathematics is taught] is not standard in the least. It is new for pretty much everybody in here, and nobody is used to it. It is just so far from the norm." The participants noted striking differences between their

regular mathematics classes and the “nonconformist” mathematics classes at SummerMath. It is interesting, however, to note that the differences were not so striking in Angela’s case because her school used the IMP curriculum. Angela’s regular mathematics class resembled the FMC class more closely than those of the other participants did. As in FMC, she had opportunities to work collaboratively on hands-on activities. Furthermore, her regular mathematics class was student centered. Yet she pointed out that the pedagogy of FMC was “far from the norm” and that the role of the teacher was “a little further back.”

Benchmarks for Comparison

A Collective Portrait of a Traditional Mathematics Class

When the participants stepped onto the campus of Mount Holyoke, they all knew what it was like to be taught mathematics in a traditional classroom. Even Angela, who spoke about how her nontraditional experiences with IMP, admitted that in middle school, she had learned mathematics in a traditional classroom setting. In the first interview, she stated that “in general, when I think of math, sitting in class doing worksheets or textbook work is what comes to mind, because that is how it was when I was in middle school.” The following portrait, which is composed entirely of direct quotes from the first individual interview, highlights what the participants said collectively about prior experiences in their regular mathematics classes.

A traditional math classroom in public schools is 15 to 28 kids in a classroom, one teacher, a rigid structure, such as, “Hello kids. How are you? We are going to work on this, this, and this today, and we are going to get it all done today, and you are going to have homework on all three topics tonight, and I am going to lecture you on it.” There is no talking during the class, maybe a little bit of partner work. There is not really any interaction between you and the teacher or other people. There is a lot of competition. I don’t see my classmates as if they would share information with me. Mostly the teacher lectures at the board, draws the problems down, you take down notes that you don’t necessarily understand because the teacher doesn’t like to be interrupted while he is lecturing. Then he has a

moment at the end where, "Do you have any questions on what I just went over?" By the time you have the question-asking time, your question doesn't make sense anymore. The teacher also has to get to the board and explain things to you because we take the Regents Exam in New York; we have to cover a whole bunch of topics in one year. So we can't really learn at our own pace. There is a curriculum, so you have to get through everything so that you can pass the class. That is what a traditional classroom to me is like. That is how I have been brought up learning math.

My conventional math classroom is also really boring because basically when you are sitting there for a long time in an idle position, and you have someone talking to you, after awhile, it just becomes so monotonous that it just kind of becomes sort of like a lullaby, and you just start to daydream. You look out the window; you are not really paying attention to what the teacher is saying. I am exaggerating a little bit, but you are not really doing anything. So you are just sitting there staring blankly at a board. There are a few days sometimes when my teacher hands out things and partners pair up and do it. I am sure my teacher feels bad sitting there 5 days a week, teaching the entire time.

I have become so dependent on teachers and right and wrong answers. I am so used to turning the page and seeing the right or wrong answer, and working back to that, asking the teacher for help, just kind of giving up and having my math teacher explain in a conventional math classroom. My teacher just writes something on the board with the answer. What happens is that I don't feel like dealing with it anymore because he doesn't really make sense when he describes it. So I just kind of give up.

I have gotten to the point where I am handed a word problem and immediately I just think, "I can't do this." I get frustrated and throw my pen down and say, "I am not doing this because I don't want to and I don't like it." So I wait for someone else to explain it. I was doing so poorly that I was to the point where I was thinking that people were working against us. I had some messed up mentality of what teachers were trying to do. I felt like it was almost a competition between the student and teacher.

The first thing that comes to mind when I think of a teacher is someone who talks at you. He or she sits in front of the classroom with a chalkboard or dry erase board, talking the entire 50 minutes. He or she gives you notes and tests and quizzes and homework. The teacher plays the main role in the class. Usually the teacher is directing us, telling us how to do things. We are not on our own.

I have come to see teaching as kind of the same thing as talking at you. Teaching is like saying it to you, and saying, "Okay, I am glad everyone understands now. Let's move on. Okay, here is a problem. I will take you through it step by step. Here is the answer." That is teaching.

The participants' voices offer a critique of traditional mathematics classrooms and traditional ways of doing and knowing mathematics. They blend together to tell a story of their regular mathematics classes as places where teachers tell; students listen; and peer

collaboration rarely exists. Boaler and Greeno (2000) claimed, “To be successful participants of a traditional [mathematics] classroom, students need to give up their choice and decision making, which is reflected in the students’ comments about obedience and compliance” (p. 189). In the portrait, the participants’ voices tell of a “rigid structure” in which there is little room for choice or control in learning mathematics. The teaching practices of the participants’ (except Angela’s) regular mathematics classrooms stress isolation, competition, memorization, and dependence on a teacher. These practices mirror those of Boaler’s (2000b) research, which suggested that “dominant school practices in the mathematics classroom are memorization, reproduction of procedures, and individualized work” (p. 391).

Even though Angela could recognize this portrait because of her experiences in middle school, she painted a different portrait of her regular IMP mathematics class. In the first interview, she reported that in both IMP and FMC, students worked cooperatively to solve mathematics problems, learning took an “active, hands-on” approach, and the teacher’s role was to guide mathematical learning. Angela defined what she meant by an “active, hands-on” approach: “We do activities, basically. We had a unit on probability; we used spinners and area rugs shaded in places.” She perceived that these were aspects of her IMP class that were unlike the traditional mathematics classes that her peers had described.

Even though similarities existed, Angela noted differences between how she was taught in IMP and FMC. One difference was the role of the teacher. She perceived that the FMC teacher took a less prominent position as compared to her IMP teacher. Angela noted that, unlike her IMP teacher, the FMC teacher did not supply or confirm answers, nor did she give a way to solve a problem. Angela reported that both teachers offered support, but

only her IMP teacher provided answers. The second difference related to the nature of collaboration. Initially, in FMC, she found the pair-problem solving difficult because she could not interject her ideas on how to solve a problem, a process she was used to in her IMP class. By the midpoint of the program, she noticed that the nature of collaboration in FMC more closely resembled collaboration in her IMP class than she initially observed.

What Do I Think of Myself As a Learner of Mathematics?: Seven Initial Snapshots

This part of the tale offers seven individual snapshots of the views that the participants held about themselves as learners of mathematics when SummerMath began. Several snapshots reveal confident young women who believe that they can do mathematics. Other snapshots, however, detail the lack of confidence that colors their self-perceptions as learners of mathematics.

Angela: "I am pretty confident. It probably stems from my surroundings."

Angela entered SummerMath feeling confident in her abilities as a learner of mathematics. She attributed her fairly high degree of confidence (8 on a 10-point scale) to her "surroundings." In her world, Angela received encouragement from teachers who "all push you." She stated, "I have always been told that I can do it." Angela was surrounded by a high achieving sister who attended Phillips Exeter Academy and a supportive mother.

Angela was candid about her capabilities in mathematics. She wrote the following in her application essay: "I have always been able to catch the concepts of mathematics relatively quickly. I welcome challenging and stimulating problems." "Doing busy work" bothered her immensely. She recognized that boredom was likely when mathematics became easy or teaching methods became stale.

Angela identified herself as an “intrapersonal” learner in mathematics. That is, she needed to engage with the mathematics by reading and writing it herself. She reported:

I can read it. I can see it. I can have somebody explain it to me. But it is easier that I read it, because then I can go over it again if I need to, and I can rewrite it to make sense to me. (Individual Interview 1)

Angela made the distinction that an intrapersonal learner did not equate with the loner image of doing mathematics. She preferred to work alone but acknowledged that she was open to cooperative learning, depending on the particular group dynamics. She explained:

I can work in groups; it is not difficult. It works sometimes, but it depends on the dynamics of the group. For the most part, when I am in my math class at school, I usually work on my own, or I am working with somebody on their work. (Individual Interview 1)

Angela noted that she tended to lack initiative if the mathematics provided little challenge:

Sometimes I just don't try, but that is just because sometimes I am not required to. Sometimes it is like, “Okay, do this worksheet.” We had to take a test on slope, but he [the teacher] let us use our homework that had all the same answers. All we had to do is switch the problem. If you don't have to try, why would you? Why would *you*?

She knew that procrastination can set in when mathematics fails to be “stimulating.”

Hannah: “What I lacked most is a sense of confidence in this mind-boggling educational alleyway.”

Hannah's perception of herself as a learner of mathematics comes through in the following excerpt from her initial application essay:

I could think of so many ways to describe the way I feel about math. Although I doubt I could vocalize half of them. I never thought of myself as a “dumb” kid, but when it comes to math I just feel helpless. I guess it all started in third grade when I passed on my personality rather than my math ability. This didn't help, considering I did not know how to subtract large numbers and how to do long division. From that point on, math became a downward spiral of confusion and not knowing when to speak up. For some reason I was always put in classes with teachers who I wasn't compatible with. I have always wanted to learn math, but what I lacked most is a sense of confidence in this mind-boggling educational alleyway.

In this excerpt, Hannah pictured herself as “helpless” in mathematics and highlighted her low confidence. She reported a 3 on a 10-point scale. As Hannah’s confusion increased, she noted that she had stopped asking questions in class to avoid embarrassment and holding her classmates back. In the initial interview, Hannah spoke of herself as inept at grasping “certain” mathematics. She had convinced herself that she was unable to do certain mathematics. She stated, “I have never ever been confident in math. I have always hated it.” Mathematics was a site for confusion and a breeding ground for low confidence.

Hannah saw herself as a visual learner. She recognized that the “talking head” approach to teaching hindered her learning of mathematics. She explained:

I already knew that I was basically a visual learner, which being in this environment has given me other ways of learning, but still in a visual sense. It is very hard for me to learn just from somebody talking and talking and talking. So being in this kind of environment I have picked up on other visual ways to learn. (Focus Group 1)

She also preferred a collaborative approach to learning mathematics. She reported:

I feel better working in more or less a peer-on-peer program. Like when we work in these classrooms, and you can work with someone else who is your age, and you can talk it out together, that helps more than the adult [teacher in her regular mathematics class], because I almost feel he is condescending to me. (Individual Interview 1)

Julie: “I ask a lot of questions in high school because sometimes I am not so sure about things.”

. Julie painted an encouraging picture of herself as a learner of mathematics. She considered herself a “smart person” who caught on “quickly” in mathematics. She enjoyed mathematics because it was an “easy” subject and recognized that “the subject could be very helpful” to her future career as an architect. In her application essay, Julie wrote that she “had a lot of good experiences” in mathematics because of a positive working relationship

she had with her teachers. She noted, “Teachers and students have to make a team and stay together.” Julie saw hard work and responsibility as essential in learning mathematics. In the first interview, she attributed her success in mathematics primarily to her effort. “He [my mathematics teacher] has helped me a lot, and I get good grades with him, but it is not because he is nice. It is because I work a lot too in that class.”

Julie entered SummerMath as moderately confident in her ability to learn mathematics. She rated her confidence level in mathematics as a 6 on 10-point scale. Julie revealed her tentative confidence: “I ask a lot of questions in high school because sometimes I am not so sure about things.” She noted in the initial interview that she relied on teachers for the final answer because she was unsure of her ability to do the mathematics. Julie hoped that SummerMath would be a site for independent learning and confidence building. She reported: “By the end of the program I may not have to go to my teacher and ask him, ‘What do I have to do to solve the problem?, I will try to figure it out myself.’” She wanted to leave SummerMath with a confidence level of “hopefully a 9 or 10. I have faith.”

Julie’s primary concerns about her ability to learn mathematics related to problem solving. In her first interview, she stated, “I am not confident, because I am not good at them [word problems]. It takes me time to do them, but I like working with them because it makes you think more.” Even though Julie’s confidence as a problem solver was low, she perceived that the problems had intellectual value.

Rachel: “I am just...a normal learner.”

Rachel entered SummerMath with a perception of herself as a “normal learner” in mathematics. She did not think she was either a “slow” learner or a genius in mathematics. She entered with a moderate confidence level in mathematics (6 on a 10-point scale). She

saw herself as quick to grasp mathematics. “I think I learn it pretty fast, and I just like to do it on my own and get it done.” Finishing the task at hand was her primary goal. Her statement also expresses an element of personal responsibility as a learner of mathematics.

Rachel preferred to work alone and avoided depending on the teacher. “I usually don’t ask for help if I need it or not, because I don’t really want them [teachers] to [help me]. Usually I am okay, and I can get stuff real fast, but sometimes I don’t.” The times when Rachel did not “catch on fast,” were, she said, “when it is long word problems, or you have to do a lot of steps, or just fractions and decimals confuse me a lot.” Difficult vocabulary or extensive formulas were also stumbling blocks for her.

Samantha: “I pay attention a lot in class because I try to understand it. And some of the stuff I do; most of it I don’t”

Samantha entered SummerMath with a confidence level of 7 on 10-point scale. She perceived of herself as capable of learning mathematics in general. School mathematics had been easy throughout elementary and middle school. She noted in the first interview, “I was pretty good in math in general. In middle school I did pretty well, and in freshman year I did pretty well. I got As and Bs.” Her first major obstacle in learning mathematics appeared in her sophomore year of high school when problems arose in her Geometry Honors course. She stated, “When I started doing really badly in this [geometry] class, and I got Cs, it was really discouraging.” For the first time, Samantha doubted her ability to learn mathematics and her confidence level dropped. Up to that point, she had believed strongly in her ability. Samantha was hopeful, however, that she would do well in her second algebra course in her junior year. She also saw herself as an attentive learner who paid close attention in class.

Sarah: “I would kind of convince myself that I am bad in math.”

Sarah shared how low her self-esteem in mathematics had plummeted over the past few years. When she entered FMC, Sarah perceived that her confidence level in mathematics was a 4 on a 10-point scale. She explained:

This is a generalization. I am not saying that all conventional math classes are like this, but my math class last year, I had trouble understanding so much material that I got a really low self-esteem in math. So even if I did understand some stuff, I would kind of convince myself that I am bad in math. So I would have even more trouble understanding it than I could. I would go into the test thinking, "Oh my gosh, I am going to fail this." It would almost make me do worse than I could, because I would look back on it and think, "I knew all of this." I could do it after the test. It is just my mentality of having such a low self esteem in that area. (Individual Interview 1)

Sarah failed to persist in mathematics. She remarked in the first interview: "I tried to be persistent, but last year...but I was not persistent at all, because I pretty much gave up."

When she did not understand mathematical concepts, she gave up. "If it were my choice, probably I would just give up. I have just gotten into bad habits."

Sarah also perceived herself as a dependent learner in mathematics. She reported:

I have become so dependent on teachers and right and wrong answers. I am so used to turning the page and seeing the right or wrong answer, and working back to that, asking the teacher for help, just kind of giving up, and having my math teacher explain in a conventional math classroom. (Individual Interview 1)

In her regular mathematics class, Sarah did not want to appear "stupid." She explained:

Everyone would understand it and nod their head. So I would just kind of nod my head too, like I understood it, because I wouldn't want the teacher to sort of pick on me and call on me, and make sure that I did understand everything. So they would probably say that "she [Sarah] listens well and she tries, but she doesn't really understand the concepts that well." (Individual Interview 1)

Throughout this excerpt and many others, there is evidence that Sarah had avoided speaking in her mathematics class. Instead, she pretended to understand the teacher.

When Sarah spoke about herself outside of learning mathematics, she described herself as outgoing, fun, confident, smart, and funny. This positive picture conflicted with

her negative perception of herself as a learner of mathematics. She mentioned at one point, “I am not usually the type to conform.” Throughout the three individual interviews, Sarah painted a picture of herself as “outspoken” and “flamboyant.” She was sure of herself in most arenas. Mathematics was one arena in which she doubted her abilities.

Virginia: “Math comes fairly easy to me,” but now “I don’t think I can do anything.”

In the first individual interview, Virginia spoke of how well she did in her regular mathematics class: “In my class, I am the only one who gets it usually.” Virginia entered FMC with a confident image of herself as a learner of mathematics. She rated her confidence level as a 7 on 10-point scale. She perceived that she was “smart in prealgebra” and “average” in general mathematical ability.

By day four of FMC, Virginia’s positive image of herself as a learner of mathematics had changed. The excerpt from my field notes on July 5 provides a backdrop:

Virginia, Rachel, and Sonya began to work together. However, after a few minutes, Virginia stormed out of the class crying. She fled her partners because she did not understand any of the mathematics that was set before her eyes. Before she left crying, I noticed that her partners began to write on her paper and solve the problem for her. She entered the class about fifteen minutes later. She apparently pulled herself together. Lourdes [FMC teacher] worked with her for most of the period. Lourdes walked her through the problem and encouraged her to continue with the problem. Virginia continued to struggle with the problem and appeared very unsure of what she was doing. Lourdes did continue checking on her progress.

In her first interview, Virginia had noted that she had always been a quick learner in mathematics. Once she began working on the FMC algebra curriculum, she noted:

In my math at school, I could pick that up quickly. I thought it was very easy. So I didn’t have to go back that often. But here, I have to go back to problems that I did before and try to figure out how I figured them out, or how the teachers are figuring them out because I don’t get it right away. (Individual Interview 1)

Throughout the first week, Virginia toiled with this shifting perception of herself as learner of mathematics. In the first interview, I asked Virginia to imagine that a movie was being

made about her learning mathematics in FMC. Then I asked her, “If a stranger rented this movie, what would she or he say about you learning mathematics?” Virginia responded by saying, “They would say that ‘she doesn’t know what she is doing.’ I just don’t get anything. So they would probably be like, ‘She probably has no business in that class.’” Virginia’s perception that she did not belong had an effect on her confidence level, which had been moderately high when she entered FMC. By the fourth day in FMC, Virginia claimed that her confidence level had dropped significantly. She identified the reason for this drop: “I have never seen anything like it [the FMC mathematics] before, and the teachers are not giving us that much help.” She was optimistic, however, that with a little time her confidence would improve.

Coupled with Virginia’s declining confidence in mathematics were intense feelings of frustration, which prompted her to question herself as a learner of mathematics. In the following dialogue from the first individual interview, Virginia commented on her struggle:

Dawn: Think about your experience so far in FMC. What are some feelings that come to mind that are associated with how you are learning math, the emotions or the feelings that you are experiencing?

Virginia: Frustrated, really frustrated. It just seems I am way at the wrong level. I am supposed to be somewhere way before this.

Dawn: What is telling you that you are supposed to be at another level that you feel that you aren’t?

Virginia: Just because I don’t know anything. I don’t know the first thing about getting to what we are doing.

Dawn: What are you learning about yourself by being here in FMC?

Virginia: I don’t think I can do anything.

Much of the frustration and challenge with the FMC curriculum seemed due to her being the youngest student and having never taken a first course in algebra.

What Do I Think of Mathematics?: An Initial Snapshot

In an attempt to understand the participants' perceptions of mathematics upon entering FMC, I asked them several questions that related to this issue in the first interview. These included the following: When you think of mathematics, what is the first thing that comes to mind? What do you think is important about mathematics? If you could go back in time and capture a memorable experience that you have had in mathematics on videotape, what would it be? Why does this experience stand out for you? The participants' responses offered insight into their perceptions of mathematics.

What Mathematics Does to Me

Several participants painted a bleak picture of mathematics. They perceived mathematics as "intimidating," "scary," "boring," "difficult," or "dreadful." Hannah attributed much frustration and stress in her daily school life to mathematics. She explained:

Most of the time it [mathematics] just brings me so much frustration. I really do not enjoy the subject at all because there are so many complex forms of it. It confuses me like no other subject. I get really stressed out when I think about having to go to math class, or something dealing with math, because I don't really feel that I can do certain subjects that well. I don't like starting new math subjects, because I usually end up falling behind. Because I am a very visual learner, and teachers usually just blab the problem to you and don't really break it down and explain it. So I get really stressed or nervous when I have to think about math. (Individual Interview 1)

Hannah viewed mathematics as a "complex" and "difficult" subject that she simply "never wanted to experience." She also hinted that there was a mismatch between her learning style and the mathematics pedagogy in her regular classroom.

Samantha painted a similar view of mathematics. Her dislike was evident when she said that she "hated mathematics." This hatred stemmed from a geometry class that she had taken in her sophomore year. Samantha claimed that she had done well in the first algebra

course and in her previous school mathematics courses. She described how the tide turned when she took geometry:

I don't understand geometry because geometry is all about logic and proving things and those two-column proofs, like proving two triangles congruent. I don't really understand how to do it. I just can't look at it and just see it. But in algebra, because there are certain equations for certain problems, I just memorize those equations and solve algebraic problems really easy. (Individual Interview 1)

Samantha viewed geometry and algebra as distinct domains with no overlap in mathematical ideas. She associated “logic” and “two-column proofs” with geometry, which caused her some trepidation. She was hopeful that she would do well in the second algebra course because she could rely on memorized rules and procedures that she had learned in Algebra I.

In a similar vein, Sarah “dreaded” mathematics and built psychological blocks. “I just kind of always blocked out math classes because I didn't understand a lot of the stuff.” Sarah had not always dreaded mathematics. She said that once she had positive feelings toward the subject. Those feelings changed when she entered, what she called, a “conventional” mathematics class. She noted: “I used to love math. Math used to be my favorite subject, but we had a really good hands-on woman teacher at an all-girls' school. It was fun. Whereas here [new, private coeducational school], I dreaded it everyday.”

Sarah discussed at length the reasons for her growing disdain of mathematics. In her most recent mathematics class, she had worried that she would be placed in a lower level class if she spoke up about her poor understanding of fractions. She had had a long perilous relationship with fractions. The first thing that came to Sarah's mind when she thought of mathematics was fractions because that is what she “had the most trouble with.” She stated:

I have never really understood fractions. So each year, I think it has a lot to do with actually the conventional math class. Whenever we are going over them in class, we

don't really spend much time on it. I go to a pretty good boarding school, and everyone is pretty advanced in math. So I don't really want to hold anybody up, especially because we started doing it at the beginning of the year. I didn't want to be known kind of as the stupid person in the class. So I just kind of kept my mouth shut. Then I didn't want to go to the teacher, because I was afraid that he was going to put me in the lower class. I was in Algebra I, and I didn't want to be moved down, because he was already making arrangements to move people up or down. So almost every year I just kind of skipped over it, just thinking, "Oh well, we are almost through with it," and just pushed it. (Individual Interview 1)

The trio of participants, Hannah, Samantha, and Sarah, who spoke above expressed a disparaging view of mathematics as they entered FMC.

What Mathematics Does for Me

When I asked the participants to describe their perceptions of mathematics in the initial interview, their comments at first glance suggested that most held a one-dimensional view of mathematics. For example, Angela associated mathematics with "basic operations"; Julie commented that mathematics was "equations and word problems"; Rachel associated mathematics with "numbers"; Sarah equated mathematics with "fractions"; and Virginia stated that mathematics was "number problems."

As I further analyzed the data, I detected that all seven participants perceived that mathematics was useful in their lives in some way. They saw the utility of mathematics as two-pronged: useful in daily activities or necessary for certain careers. They understood the utility of mathematics in their daily experiences in shopping for groceries, computing discounts when purchasing clothes, and buying stocks. For example, Angela recognized that "math is in general all around you. You go to the store and it is 25% off of a dress, and you are not sure that you have enough. So there is math." Rachel understood that mathematics was necessary for her financial future: "When you grow up you need to know it so you can

do your bills. So you understand where your money is going.” Hannah added to this conversation by noting that mathematics was involved in stock trading.

“Mathematics is good to know if you want to do something mathematical in the future.” This comment, made by Virginia, illustrated a perception of mathematics held by most participants: Mathematics is a necessary prerequisite for careers such as engineering, architecture, and medicine. Angela weighed the importance of mathematics for two different career paths:

Math is important sometimes, but it depends on where you are planning on going in life. If you are planning to be an architect, then obviously math is going to be important. If you are planning to be an underground writer, taking calculus isn’t going to benefit you that much. (Individual Interview 1)

For Angela, the value of advanced mathematics depended on the pursuit of a particular career. Early in her childhood, Julie knew that she wanted to be an architect. After the first interview with her, I attempted to convey how she spoke of her career choice in my journal:

Julie was a joy to interview. She was open in her communication style and a lovely person to have a conversation with. She is genuinely a kind and sweet person. The part of the interview that stands out is when I asked her about what she saw herself doing in the next ten years. She said that she wanted to be an architect. The way that she talked about this career choice was so vivid. She had a smile on her face that reached ear to ear. There was a joy in the way that she spoke. It struck me because she was so happy and alive when she discussed being an architect. (July 4, 2001)

Julie stated, “Math is also included in real life. Let’s say in professions like architecture and engineering.” Her perceptions of mathematics included professional prerequisite and daily utility.

Even though Samantha dwelled on her negative experiences in the geometry course, she acknowledged that “mathematics is really important.” She spoke metaphorically about mathematics as the “language of the world.” She stated, “It [Mathematics] is the most important subject in school other than English because it basically is the language of the

world; everyone uses it and everyone knows you have to know it.” For Samantha, mathematics was a bridge that spanned cultures.

Hannah shared her perceptions of mathematics in the following dialogue:

Hannah: Mathematics is important because you can use it for your life. I understand how addition and subtraction, and division and multiplication are important because you have to be able to figure out certain everyday things, like how much money did I spend at the grocery store, or even in stocks, which I would never go into because that just confuses me. I just don’t like to think that any other part of math, besides the four basic objects of math, are really necessary.

Dawn: You do think they are or they are not?

Hannah: I don’t think they [other parts of mathematics] are necessary. In my particular opinion, I only like addition, subtraction, multiplication, division, and so those are the things that I can relate to life. But all the other types of math are just beyond me, I guess you could say.

Dawn: When you say beyond you, what do you mean by that?

Hannah: I mean I can do certain things like graphing. But when it comes to complex equations and fractions or truth tables or solving things like a Geometry proof or something along those lines, it just doesn’t make sense to me. I just feel that I can’t get it. I almost don’t want to get it, because I don’t see how I can apply it to real life. (Individual Interview 1)

Interestingly, Hannah perceived mathematics as useful in her life but only to a certain extent. When mathematics moved beyond the four basic operations, the value shifted from useful to unnecessary. For Hannah, a missing ingredient in her thinking was to understand how forms of mathematics other than the basic operations related to her life.

Even though several participants entered FMC reporting that mathematics looked rather bleak, they all thought that it could enrich their lives to some extent. All but one participant, Virginia, noted that mathematics was valuable for daily experiences such as shopping. Four participants perceived mathematics as essential for entrance into mathematics- and science-related careers. Three observed that mathematics was at the nexus

of professional prerequisite and daily utility. No participant regarded mathematics as a totally useless endeavor. Yet some valued the utility of mathematics more than others.

The First Moment: “You Have to Figure It Out by Yourself”

A Preliminary Portrait of FMC

By the fourth day at SummerMath, the participants had a clear picture of what they initially thought about FMC. The following portrait is composed of excerpts from the first individual interview (July 3, 4, & 5).

FMC is nonconformist because there is more than one teacher for the whole classroom, which usually you don’t find. It is also nonconformist because you don’t have a rigid structure that you have to work off of. You are given different types of math, kind of mixed in, like word problems with fractions. You can work through them with someone else. You can get up, and you can walk around, and you can use tiles, and you can draw things out.

In a way, it is fun to be in FMC because it is not a regular class. You get to learn at your own rhythm. It is not like the regular classes where you have to learn with everyone else. Here you come in and you have your problems that they give you that you have to solve. It is not basically listening to the teacher and being bored for an hour. They are not putting pressure on you to work or learn faster. They are not telling you, “This is for homework, or you have to finish this for today.”

Right now, this whole partner thing, sit and listen and not say anything, that is a little difficult. It seems like you can’t ask your partner for help. It seems that they are the listener, and they can’t tell you anything. You have to figure it out by yourself. It is really independent. You have to do a lot of things on your own because the teachers push you to figure things out on your own. They will sit there and go, “Are you confident? Are you very confident? Are you sure you are confident?” They can tell if you are fronting [pretending] and saying that you are confident, and you really don’t understand. But you are like, “Yeah, I’m confident.” The teachers say, “No, you are not. Let’s go through the problem again.” So even if you look like you know what you are doing, they can usually walk you through it again, and make sure that you actually do understand it. So you can’t really get away without understanding it. I also feel more comfortable saying, “No, wait, I don’t understand what you are saying.”

Our teachers give us a problem, and we have to solve it with our partner. I think that really works because if you don’t understand something you can just work on the problem together. There is a lot of interaction going on, and because of that, it makes learning more fun than just doing it alone and listening to some teacher try to explain it to you.

Our teacher, Lourdes, doesn’t give us the answers. She always helps us in figuring a way to solve the problem. Lourdes makes us see what we were doing

wrong, but she doesn't point out the answer. If we ask her if it is right, she says, "What do you think?" Questions like that, that actually make you think. She helps us and gives us ideas of what or how we could solve the problem. We are doing hands-on things, and she is just there to check if we are confident in our answers.

The teachers don't play a main role in the classroom; instead, you and your own group or partners do. The teachers are different because they don't actually stand in front of us and tell you to write down notes. Teachers don't really teach here. I wouldn't even call them a teacher. I see the teacher as more of an aid. They make sure that we are working. They also are kind of like a second mind. They come in when you think you are done, and they help you go over a problem again without them doing the problem. The teachers are also patient and helpful. We have a cooperative relationship.

FMC is all-girls, so there are not really any distractions. It is not competitive; girls will help each other. They give support to each other if there is something wrong. Like one of the girls would stop and tell you, "No, this is the way you do it," and they will correct you in a good way. Here it is very comfortable working with girls. Math is actually fun because of all the interaction and the different activities and exercises that you do here.

This collective portrait stands in contrast to the participants' regular mathematics classes. Based on the initial individual interview, after the first few days, the participants had quickly deduced that FMC was very different from their regular mathematics classes, which they termed "traditional," "conventional," "by the book," "normal," or "standard."

Samantha stated, "The way I learn in my regular math classroom is a lot different from the way I am learning here." They needed only the first few days in FMC to recognize that they were going to learn mathematics in what Hannah called a "nonconformist" classroom. What follows is a brief discussion of themes that the preliminary portrait conveyed. I explore these themes because they appear later in this chapter.

Agency

The participants gathered from the first few days in FMC that they were in control of their own learning. They could learn at their "own rhythm" instead of having to keep pace "with everyone else." The participants sensed that they had a choice in how they approached learning. That is, they could monitor their actions in class, choose different ways to solve a

problem, and direct how much work they completed in one class period. The fact that the participants did not have homework, tests, or grades to contend with reduced the pressure and the anxiety that many had felt daily. Overall, the participants perceived the FMC class as a site for agency where they had some say in what, when, and how they learned.

Authorship

In this initial portrait, the participants admitted that they had to take responsibility for their learning. They perceived that they had to construct and author mathematical knowledge. They said, “You have to figure it out by yourself.” They could no longer depend on the teacher for answers or for clear-cut techniques, formulas, or strategies for learning mathematics. In summary, the participants perceived the FMC class as a site for authorship where they had “to be involved” in the construction of mathematical knowledge because they were “doing the problems.” They quickly learned that they had to depend on themselves and their partners for the production of mathematical knowledge.

The participants perceived that they would have to depend on themselves to confirm their own learning. The focus was on the process, not the answer. Furthermore, there were no answer keys to be found, which initially bothered Julie. Her perception on entering FMC was that “there is usually an answer key to everything.” Julie quickly discarded this perception; she realized that she had to solve problems on her own. Some participants found the authoring process comforting. Hannah stated in the first individual interview, “I like that they don’t give me the answers. Even though I get frustrated when I don’t get the answer, it makes me feel more accomplished when I can finally figure it out on my own.”

The preliminary portrait hinted that the participants saw FMC as a place where they could voice their mathematical ideas without fear of holding up class or being embarrassed

to share solutions. In the first interview, Sarah asserted, “I feel so much more comfortable saying I really have no idea what she [the teacher] did here, rather than making an entire class stop and cater to my needs.”

Power Relations: Shifting Roles of Student and Teacher

The participants quickly noticed that power relations were different in FMC. They observed that the FMC class was student centered. No longer did the teacher take center stage; she stood “a little further back.” A teacher’s primary role was to be an “aide,” who offered support and facilitated learning. There was a sense that the participants and teachers each had power in a particular way. The participants had power in the sense that they had agentic control over their learning. The teachers had power by virtue of their refusal to tell the participants answers or methods.

The participants held the perception that the teachers were “laid back” and, as Hannah noted, “flexible in the sense that if you don’t understand something, they will start over in a different way, and explain it to you differently, until they find a way that helps you, and you can figure the problem out.”

Interestingly, even though there was one teacher, Lourdes, and two undergraduate teaching assistants, Indira and Pauline, in FMC, the participants did not make a distinction between Lourdes, Indira, and Pauline. They perceived the three as their FMC teachers.

Collaboration

The participants enjoyed working with their peers, who provided a sounding board for their mathematical ideas. Initially, learning the process of pair problem solving was difficult for the participants. The challenge came in assuming the roles of the listener and the problem solver. The participants maintained that listening without telling answers and

problem solving without asking for answers posed challenges to how they were accustomed to learning. The participants were also concerned with selecting a partner who worked at a compatible pace of learning mathematics. In the first three days, all participants experimented with new partners every day, trying to find a partner whom they could work well with. They made the following selections: Angela worked with Katherine and Marina; Hannah, Samantha, and Vivian formed a group; Julie worked with Reba; Sarah worked with Shante; and Rachel, Marilyn, and Diedra formed a group. Virginia worked independently.

An All-Girl Mathematics Classroom

The participants perceived that this all-girl classroom was supportive and noncompetitive. They could work with rather than against each other. They observed that they could receive positive feedback from their peers in an environment that posed fewer “interferences.” Samantha claimed that boys were the “interferences.” In support of fewer distractions, Julie commented that learning mathematics in an all-girl mathematics class is “fun because sometimes the guys fool around too much. Here you work quickly.” Similarly, Rachel offered her hypothesis: “It probably helps to learn better because you don’t have your attention on boys, or that is what my mom always says.” The participants saw the single-sex classroom as a positive learning environment.

Dissenting Voices: Resistance

In this preliminary portrait, the participants recognized that learning mathematics in FMC looked and felt different from their regular mathematics classes. For most participants, FMC was a site for possibility. There were, however, a few dissenting voices: Rachel, Samantha, and Virginia. For this trio, FMC was a site of resistance.

From Day 1, Rachel claimed there was a mismatch between the way FMC was taught and the way she preferred to learn mathematics. She said, “I just want the answer. Just tell me how to get the answer.” She wanted procedures and formulas given to her by the teacher because it was “easier.” In several interviews, Rachel stated, “We don’t really learn here. They just help us. They don’t teach us anything new. They just help us solve problems for ourselves.” She felt “frustrated” and “confused” with having to author her own mathematics. Even though she expressed her annoyance with the pedagogy of FMC, she participated in class. Yet her participation seemed reserved and partial.

Some resistance from Virginia surfaced in her first interview. When I asked Virginia if she wanted to continue in FMC, she commented that “I don’t want to go [back to FMC].” Virginia’s resistance stemmed from her feelings of frustration about working in her group:

I wished we could work alone. Today, whenever I did ask my partner about something, we both got frustrated, because I didn’t know anything and she didn’t want to explain it to me. I got really frustrated. I don’t want to be in this class.

Her early frustration and lack of confidence in mathematics led her to say, “I don’t like math class at all. I don’t like anything about it.”

Samantha expressed a slight bit of resistance about the length of the class sessions. Even though she enjoyed the FMC course, she thought that working on mathematics problems for 90 minutes was “too much.”

As these three voices suggest, not all the participants had an initial positive response to FMC. Even though the preliminary portrait paints a picture of excitement and newfound freedom in learning mathematics, it also contains some undertones of dissent. These three voices tell us that there may be problems in a feminist mathematics class and that not all the participants who entered FMC accepted its novelty.

The First Moment Ends

As the first moment ends, we have an understanding of the participants' initial perceptions of their experiences in FMC, which promised to be a different experience for each participant. For Angela, Hannah, Julie, and Sarah, learning in this class promised to be a site for growth as a learner of mathematics. Rachel, Samantha, and Virginia experienced frustration with FMC and with unfamiliar notions of mathematics teaching and learning.

The Second Moment: "The Teachers Don't Teach Here"

An Intermediate Portrait of FMC

The following collective portrait, composed of excerpts from the first focus group interview (July 9) and the second individual interview (July 13, 16, & 17), provides a glimpse of what the participants thought about FMC after being in the class for two weeks:

FMC was really exciting in the beginning just because it was something I had never done before. There is still some type of enthusiasm there, but not so much because now it is pretty much the same thing. It is becoming routine. We do the same thing everyday. They give you worksheets with problems to solve. On top of that, there are no examples to follow. When we are done with one, then you have to get another one. They just keep coming. Plus the classes are so long, an hour and half, and we don't even get a break. I can't deal with it.

The teachers are not really teaching us anything, like formally. They are giving us worksheets and letting us figure out [problems] on our own. Sometimes if you have no idea of the concept, you can't just figure it out on your own. You need some kind of structured instruction, like "This is how you do this." They are like, "Here is a worksheet, figure it out." That just doesn't work sometimes. On the other hand, when you figure a problem out, without needing any help, and you realize that you can figure it out without needing any help, that is confidence building. The teachers will give help if you need it and only if you need it. They are just answering questions if you have any and going around seeing if everybody understands.

The whole teacher-student relationship here creates a good classroom set up. By that, I mean the passive teachers allow for better group work, and the group work allows you to have passive teachers. You don't need the teacher there if you have other students to work with.

The smaller groups of people make it a more comfortable, confident environment. I can check my answers with my partners, and when I don't understand something they can explain it to me. Plus you are not afraid to ask questions because it is basically a two-on-one or a one-on-one situation most of the

time. The way they are doing it here is more effective than the way they are doing it in normal classrooms because of the interaction. You learn more mathematics when you are interacting with other people. Plus working with a partner makes us more independent from the teacher because we are like two minds with different ideas. For example, if you have one idea that doesn't work, your partner might have a different way to do it. You can just test out both of your ideas and see which one works. We exchange ideas.

However, you can be hindered in learning mathematics here when you are on different levels. If you are too good of friends; if you don't get along; if your partner is passive and they just let you do everything, that doesn't work because then you get to something difficult, and they don't get it, because they weren't working on the simple steps. Or aggressive partners who just do everything and don't let you say or do anything. That is why being on the same level is key.

Here I have the ability to just work on what I am working on, not have to work up to something, and [can] call a teacher over when I need help. If I want to be part of the partnership, I can ask one of my partners to explain it to me. So it has given me a kind of less rigid feeling than my normal classroom. It has made me feel competent and confident in the fact that I understand it, and that I can do it. The point in having the freedom to work at your own pace is to kind of give you a handle on your own learning style, to let you control, in a way, how you learn and your understanding of what you learn. You can absorb more when you are doing less because you can go over it and make sure you are completely confident in it before you move on to the next thing.

One of the most valuable pieces of the mathematics classrooms is the fact that we do all the work. The students lead the mathematical learning. My confidence level has gone up a little bit because when I am working on a problem during FMC, and I figure it out on my own, it makes me feel better to know that I did it without the teachers' help. Once you are frustrated and you feel stuck in place and annoyed and bored, when you finally get it right, then you are confident, and you get happy. You are just proud of yourself. You accomplished something. So you feel confident moving on to the next problem.

Here I pretty much found that you can't really compete with other people; you just have to do as best as you can. I know that sounds like a mom's speech, but I really have. It is good to see that it is noncompetitive because you are not working with anyone but yourself and your partner.

When this portrait is juxtaposed with the preliminary portrait, we see that FMC may promise some things but limit in other ways. In the following discussion, I bring to light what falls in the shadows of the portrait, i.e., dissenting voices and mounting tensions, and what is in the foreground, i.e., consensus in the group.

Ritual and Routine

The middle moment of FMC reveals dying enthusiasm on the part of six participants. After the initial novelty, ritual and routine set in. Even Sarah would lament: “It is kind of boring after awhile when they just keep handing you worksheets. I almost wish we had some sort of a syllabus or an outline of what we were going to do for that day.” The apparent lack of direction bothered most participants. However, amid the complaints about 90-minute classes and endless worksheets was a contradictory voice. Hannah preferred the “unstructured” format of the worksheets. She explained:

It is nice because it does allow you to work at your own pace since you are not working up to one final goal. You don’t have to worry about being slower than other people.... I like that there is always something for you to do, but it is not in a specific time frame that you have to do it. (Focus Group 2)

For Hannah, worksheets were a form of agency. They allowed her to work at her own pace.

Agency

In the intermediate portrait, the participants noted that they enjoyed working at their own pace. They thought they could learn more mathematics when they worked at a slower pace. The participants explained that they could control how they learned mathematics and how much mathematics they learned. As a result, the participants’ confidence seemed to improve, and they felt competent as learners of mathematics. Julie commented on the sense of satisfaction that she derived from working at her “own rhythm”:

I don’t really feel like I have to look at what other people are doing. I don’t really care if I am behind because I know I am working. I feel like I am accomplishing what I try to do in the day. (Individual Interview 2)

Julie carried a sense of agency with her throughout FMC. “If I advance quickly then I learn more things. If I just don’t do anything in class, and I talk to friends, then I don’t learn anything.” She already had some sense of agency when she entered FMC. She explained:

The role of the teacher in high school, like he teaches you stuff, and he will help you if you don't really understand it. But it is not his fault if we don't do well on the test, because we didn't ask for help. So basically I am in control of my learning in high school too. (Individual Interview 2)

In her regular mathematics class, Julie took responsibility for her own learning. The difference, however, was that she could not direct the pace at which she worked because she had to take the Regents Test, a state mandated test in New York.

Working in FMC gave the participants control over their learning of mathematics. They knew that they could take "however long they needed" to solve a problem. FMC proved a site for agency, which also played a key role in the authoring process.

Authorship

In the intermediate portrait, the participants noted that they learned mathematics because they authored mathematical knowledge; that is, they "figured things out on their own." The teachers were not telling the participants answers or giving prescribed techniques to solve mathematical problems. They could not place responsibility on their partners, either. Sarah explained how she learned this lesson:

I mean you can't let your partner do all the work. Because I know at the beginning, I felt bad about this, but I was getting kind of frustrated. So Shante would be like, "I don't understand." I would be like, "Take my word for it." Then it came to when the teachers come around and they were like, "Shante explain this." She had no idea. I was like, "Oops." So we just stopped doing that. (Individual Interview 2)

Though the participants perceived value in authoring knowledge, Angela, Rachel, Sarah, and Virginia admitted that they disliked the fact that the teachers would not tell them the answer when they were stumped on a problem. Rachel remarked, "I don't really like it because it is just annoying if you can't get the answer, and they won't tell you." Sarah joined in the conversation:

If we don't understand something, they don't flat out say, "Well, see here you were wrong in doing this." I get really frustrated when they do that because I just want them to flat out tell me whether or not what I am doing is wrong.

She conceded the value of what the teachers were doing by stating, "But I know it is helping me." In fact, the participants observed that their confidence level was on the rise. For example, Samantha stated, "I feel more confident when I am coming up with *my* answer."

Nevertheless, Sarah and Rachel could not help feeling frustrated in the midst of authoring their mathematical knowledge. Sarah stated, "Figuring things out on my own is just frustrating because if I can't get it then I don't feel like doing it anymore. So I just want to give up." Rachel used the same strategy when she became frustrated over a problem that she could not solve immediately: she gave up. Rachel and Sarah's comments indicated that they had a low level of tolerance for frustration. In the second moment, the majority of the participants had a low tolerance level for frustration. They often spoke of the frustration that came with struggling with a challenging mathematical problem.

Even when Rachel solved a problem on her own, that did not motivate her to take the authorship role. "I don't really care. Like some people get happy, but I don't care that much whether I get it on my own or somebody gives it to me." Rachel was the only participant who did not "get happy" when she solved a problem on her own. Instead, she expressed ambivalence. All the other participants expressed jubilation when they "finally" solved a problem on their own. They stated that they were proud, accomplished, satisfied, excited, or confident after they solved a challenging problem.

The intermediate portrait contained subtle indications that the participants were exercising authorship through their spoken voices. For example, Sarah mentioned that working in a partnership eased her angst over asking questions. She stated, "You are not

afraid to ask questions because it is basically a two-on-one or a one-on-one situation most of the time.” Even Angela, who had experience working in groups in her IMP class, noticed that the “whole group dynamics” allowed her to speak more freely about mathematics than in her regular class. She stated, “Sometimes it makes sense in your head, it doesn’t make sense on the paper and you don’t understand why. It is easier to talk it out.” Earlier, Virginia reported that she was speaking more as she worked independently.

Power Relations: Shifting Roles of Teacher and Student

Most participants described the teachers’ role as helper. For example, Angela said that the role of the teacher was that of a “helper” who “stands aside to let you figure out the problem out on your own or with your partner. Then they make you explain your answers to them, so that they are sure you get it, and you are sure you get it” (Focus Group 1). Sarah asserted, “In my regular math class, it is easy just to get lost in there and not be questioned whether or not you understand something. But here you can’t really get lost.” The participants recognized that even though they were not given answers or procedures, they were provided direction from the three teachers.

Angela thought that the use of the word *passive* best described the role of the teacher in FMC. She stated, “The passive teacher thing is good here because, unless you need them, the class allows you to be a lot more independent in your work, and that is more confidence building than a teacher telling you.” Hannah and Samantha also thought that having a teacher work on the sidelines encouraged confidence building and independence. Although Angela saw several benefits of having a passive teacher in FMC, she pointed out her dying enthusiasm, “In the beginning [of FMC], I was enthusiastic about the whole passive teacher thing.... It was fun because it was new, it was different, but now it is not so different

anymore.” Sarah shared her perspective on the role of the teacher: “I don’t think the teachers are annoying. They said what they were going to do in this program and that is what they are doing, and *that* [the pedagogy] is annoying. I think they are very helpful actually.” Sarah understood that the teachers were teaching in the way that they had proposed originally.

Angela, Rachel, Samantha, and Sarah, still longed for confirmation and “one way” directions to solve problems. Virginia explained:

One thing I still don’t like about what they say is like, “Do you think it is right?” Sometimes you just want to say, “Well is it right or isn’t it right?” because you want to know. You will sit there for five minutes, and you will be, like, “Yeah, well, yes, I think it is right.” Then they will say, “Well then explain it.” (Individual Interview 2)

In the first group interview, Angela, Rachel, and Sarah expressed that the “teachers are not teaching us anything.” This perception conflicted with the participants’ definitions of mathematics teaching, which rested on a traditional approach. Rachel defined mathematics teaching in the following way: “I think the concept needs to be formally taught.” Angela clarified the notion of “formally taught” by saying:

Meaning, either ‘This is how you do this,’ or ‘Give us some way to figure it out.’ Like in my math class at school, we built up to generalizations, like we made generalizations for like exponents... but we had to figure that out on our own. But then he [the IMP teacher] went over it [the problems] with us as a class. As a class, we made generalizations that we had to write down in our notebooks, but we did it on your own; but he also taught us at the same time. Here we are not really being taught.

Because the teachers were not telling the participants how to solve a problem or giving them a conceptual framework on which to build, they perceived that the teachers were not “teaching” mathematics. The participants’ definition of mathematics teaching was different from the definition enacted in FMC. This mismatch surfaced in the participants’ journals.

Lourdes, the primary FMC teacher, noted the participants’ anxiety over the non-lecture format in their journals from the first four days. On July 6, at the beginning of class,

Lourdes commented about the content in the students' journals from the previous day. Several students had mentioned that they wanted formal mathematics lectures. She explicitly stated that lectures are the antithesis of what SummerMath is about in terms of learning and teaching mathematics. She reiterated that students are responsible for their own knowledge construction and clarified that active participation is fundamental to learning mathematics. In short, she said there would never be any lectures. This occasion was the only one in which Lourdes discussed the approach she was using with the students.

Like other participants, Sarah and Angela had doubts about learning in a class in which mathematical knowledge was constructed by the students. For the most part, they could not imagine learning any new mathematical ideas without being told what to do or how to proceed. Angela reported, "If I hadn't known the slope equation... I wouldn't have been able to do the worksheets to practice. Because I wouldn't have known the basic concept, because they weren't telling us. They weren't giving us anything to build on." By the second interview, however, Sarah noted that one of the most valuable features of FMC was "just how much I feel like I am learning... I have probably learned a year's worth of math, if not two years while I am here, because I am learning so much more than did last year." This statement was far from the skeptical view that she expressed in the first focus group interview one week earlier: "I would be interested to see whether you could learn something new in this environment." She seemed to answer her earlier query.

Collaboration: Learning Mathematics in a Partnership

The intermediate portrait of FMC detailed a common theme that arose throughout the first group interview and the second individual interview: "Learning mathematics just depends on who you work with" (Rachel, Interview 2). Sarah maintained, "It all depends on

if you are going at the same pace with math and have the same background.” The participants spoke of relationships that worked and those that did not. Yet they all mentioned that they gained insight into some aspect of themselves as learners of mathematics or aspects of mathematics by collaborating with a partner, working in a group, or working without a partner, as Virginia did.

When partnerships work. The participants recognized the benefits of working with partners who they were compatible with in terms of mathematical ability and working pace. Samantha maintained that she learned more mathematics as a result of working with her fellow group members, Vivian and Hannah. She explained:

I don’t really get a chance to work with partners in my other math class, but here I can work with a group of three people. I really like working in partners and in groups because I can check my answers with my partners, and when I don’t understand something they can explain it to me. (Individual Interview 2)

She perceived collaboration as a source of motivation for learning mathematics:

I would say that I am motivated in FMC because I have other people around me to talk to about the problems. Here you don’t really have time to look out the window or to daydream, because we are with a partner. So you are basically forced to work at the same pace as them because you don’t want to hold them back. (Individual Interview 2)

Similarly, Sarah noted, “[Working with a partner] kind of keeps you on your toes.”

Two weeks into FMC, all the participants except Hannah perceived that they were working well with their partners, or in Virginia’s case, independently. Sarah described the positive relationship that had developed with Shante:

We converse and just come to an agreement on most of the things. If she is behind with her work then I help her and vice versa. So it is good having a partner. I didn’t really like it at first because I was ahead of my partner, but now we are helping each other out.... It is great because we sort of compliment each other. We don’t say, “Oh, you have such pretty eyes.” Her downfalls in math are probably my better strengths and vice versa. (Individual Interview 2)

Sarah seemed to learn about the give-and-take nature of working together.

Angela and Julie mentioned that one of the best benefits of working with a partner or in groups was the variety of ways they learned mathematics. They were exposed to new and different ways to solve mathematics problems through collaboration. Angela reported:

I am working with Katherine, the Russian girl, and she has all these different approaches to just everything. So we are teaching her the difference between the slope equation and she is teaching us how she would have done it in her school in her class in Moscow. So that is always good, because they [the FMC teachers] are always asking, "Can you do this another way?" Katherine is always doing it another way. So we go back to her way, she comes back to our way eventually, and we all learn all the materials in a different way. (Individual Interview 2)

Julie also reported that working with her partner, Reba, gave her opportunities to "see how a problem can be solved in a different way" and to become "more independent from the teacher." She noted that solving problems with a partner was easier than working alone:

To work without a partner it is easier to get stuck in a problem because usually you think of the problem in your own way, and when you can't think of a different way you just get stuck in there. If you have a partner with you, they can also make you see a different way. Let's say there is one part that she can't really solve, and you see a different way. You are probably able to solve it, so it is easier. (Individual Interview 2)

A byproduct of her partnership with Reba was a growing sense of independence as a learner of mathematics. Julie remarked, "Working with a partner makes us more independent from the teacher because we are like two minds with different ideas." She perceived that she did not have to resort first to asking a teacher for help if she was having difficulty solving a problem. Instead, she knew that "if we both don't know we will try to figure a way to solve the problem." Julie viewed her partnership with Reba as an opportunity to exchange ideas.

Julie discussed the gratification that came from working with Reba. "I work very well with her because she is quick.... She is also taking Precalculus-to-Calculus, so we are at the same level; we are both quick. It is nice to work with her." Throughout my field notes

were quotes that spoke to the positive nature of their relationship. “Julie and Reba epitomize a positive partnership where each contributes ideas and conjectures. They share the work equitably and fairly. They also have respect for and trust each other” (July 18). This description was not always true of every pair or group. Sometimes, “the whole group partnership thing” did not work well, which was the case with Hannah and Virginia.

When partnerships don't work: Hannah's story. After the first week, Hannah noticed that tensions were on the rise with her partners, Samantha and Vivian. At the close of the second week, she perceived that problems were mounting in her group:

In FMC usually I like doing the math problems. But this week from day to day, it has just been getting worse and worse with my partners, because they have just been getting edgier and edgier since we have been here. I kind of just want to break away from the group and work on my own, because I feel better about doing that. I would much rather work on my own and be able to call a teacher over and work through it with a teacher without the teacher telling me how to do it, instead of having to work through it with my partners, because that is just so difficult. (Individual Interview 2)

When I don't understand something, and I try and ask one of them, usually Samantha will help me, but Vivian doesn't help me very much. When I try and explain something to Vivian, it is like she doesn't want to listen to me in the sense that I am trying to explain it to her, because I don't understand how she is trying to do it. So I am trying to explain it to her in my way. Then everybody gets upset when we are all not done at the same times. So we all can't get the next sheet. But I think I can get through the next two weeks if we just work independently from each other, and then come together to discuss the answers. (Individual Interview 2)

Hannah perceived that tensions sprouted from working in a group of three. “It could work a lot better if it was just two people, because three people really doesn't work, because it is a lot harder to catch up, because there are three different spots that someone could be at, and there is more variety.” It is interesting to note that, at this time, Samantha perceived her relationship with Hannah and Vivian as positive.

When partnerships don't work: Virginia's story. In the second individual interview, Virginia recalled the day when she had left class crying. She noted that if a movie was being made about her in FMC, she would cut this scene:

I was having a really bad day that day. I didn't get what we were doing at all. My partners were really frustrated with me that day, because they were trying to explain to me, and I couldn't get it. I knew that they were getting frustrated, so that made me get more frustrated.

Virginia recognized that she was not up to the same level of mathematics as her peers; most had taken the first course of Algebra. Virginia entered FMC having just finished Prealgebra. On the fifth day in FMC, Virginia opted to work alone. Lourdes thought that this would be the best solution for both Virginia and the class as a whole. As Virginia worked on her own, she felt more relaxed:

I really like working by myself because I think that is what got me more into being more relaxed. Whenever I was working with a partner I don't think I concentrated as much.... I had a lot of distractions. (Individual Interview 2)

Virginia reflected on the progress that she made since the day she had left FMC crying. "I think what is helping me progress is working alone, so that I can go at my own pace. I think now I am not afraid to ask the teacher if I don't know." She also did not worry about holding up her partners because she did not have a "clue."

The previous discussion points out the complexities involved in partnerships in FMC. Most participants noted the exchange of ideas that took place and enjoyed the multiple perspectives that working in partnerships allowed. Hannah's and Virginia's stories illustrated problems that arose in their partnerships. Yet they negotiated their way through the tenuous relationships, making adjustments as needed. Hannah opted to stay in the partnership. Virginia opted to work alone.

Noncompetitive Environment

In the intermediate portrait, the participants described FMC as a noncompetitive environment. They maintained that competition was nonexistent because there was no one to compete with other than themselves. There was no imaginary clock or time schedule to compete against. At the beginning of FMC, Virginia worried that her classmates would perceive of her as “dumb” in mathematics. Halfway through, she noted a change: “Now, nobody really cares because everybody is at their own place.” In FMC, the participants were free from competing against each other or the clock. The only measure of their success was what they perceived as their personal best.

The Second Moment Ends

The following excerpt from my journal highlights key points in the second moment:

What were interesting to note were the contradictions that participants’ voices brought to light about certain aspects of FMC. On one hand, the participants described their feelings of mounting frustration with not being given answers to mathematics problems. On the other hand, the participants reveled in the confidence that they gained by solving problems on their own. The participants also enjoyed the freedom that came from a mathematics class where deadlines and certain curriculum guidelines were nonexistent. Yet having an informal curriculum where you moved at your own pace was bothersome for several participants. Four participants commented that they found comfort in teachers telling them answers to mathematics problems when they were stuck on a problem. There was a level of discomfort that many participants were dealing with as they worked in FMC. It stemmed from having little direction and no answers. The participants had to construct their own learning, build on their mathematical and nonmathematical experiences, and own the mathematics that they learned. This was different from the traditional mathematics class that the participants experienced every day. Hence, the participants were beginning to encounter frustration with the way mathematics was being taught, or “not taught,” words that they used consistently to describe FMC. (September 5, 2001)

What Do I Think of Myself as a Learner of Mathematics After Two Weeks in FMC?:

Seven Intermediate Snapshots

Angela: "I am not as patient as I thought I was."

In the initial portrait Angela perceived that she was confident in her abilities to learn mathematics. This perception had not changed. In the second interview, she commented, "I feel generally pretty confident." She also stated, "I get just confident in the progress that we are making." At this juncture in FMC, she maintained a strong belief in herself as a learner of mathematics.

Angela gained an insight about herself as a learner of mathematics. She noted, "I am not as patient as I thought I was." She realized that her lack of patience stemmed from working with partners who "may not be up to my speed." Her patience was tried when she was forced to backtrack on explanations of problems for partners who did not catch on as quickly as she did. Angela worked hard to help her partners in need, but she knew her limits. "I will push them to a certain extent, but I don't want to push them to the extent where it is taking time out of other things that we could be doing that would be interesting, that both of us would actually do."

Hannah: "I am feeling more confident in solving things on my own without having to ask other people."

Hannah noticed that working with partners who were not on "exactly the same level" helped develop her patience:

Working in a group is difficult. I work in a group and not anyone of us is exactly the same level. And sometimes me and another partner want to move on, and we can't because the other person doesn't understand it. It is very difficult to explain it to them, especially when they don't want it to be explained to them. So I have pulled patience away from it, because I am trying to be a lot more patient with explaining it to a partner. (Individual Interview 2)

Hannah's confidence in mathematics was also increasing. She reported:

I can get the problems done on my own without having to constantly say, "Is this right? Is this right? Am I doing this correctly? Did you get the same answer?" So I am finding that I am feeling more confident in what I do. (Individual Interview 2)

She remarked on the value of working alone in her group: "I am getting a more independent feel towards learning, because I am feeling more confident in solving things on my own without having to ask other people." Hannah seemed to be seeing herself as more capable of learning mathematics. In the second interview, she stated, "I know that I can do mathematics." She also noticed that her persistence as a learner of mathematics was increasing. In her regular class, Hannah had resorted to giving up quickly on problems:

Normally, I would just get frustrated as soon as I read the problem, and something tripped me up, I would just kind of get frustrated and throw my pen down and say, "I am not doing this because I don't want to and I don't like it." (Individual Interview 2)

She continued, "Now I am feeling a little better about just going ahead with it." For Hannah, "going ahead with it" translated into "I like to kind of take control of the problem, break it down into variables and givens, and just talk it out."

Julie: "I am more independent in math. I think in different ways I can solve the problem before I ask the teacher."

In the second interview, Julie recalled that her first response to doubt was to always ask for help. "In my [regular] class, when I have a doubt of something, I would just stop doing it and ask the teacher, just to get done with the problem and not to be stuck in a problem." After two weeks, Julie noticed a change in her behavior when she encountered difficulty with solving a problem. "I would notice that I am more independent in math. I think in different ways I can solve the problem before I ask the teacher." Julie perceived that

now she could rely on herself for solving a problem. She also perceived that working with her partner was integral to her growing independence as a learner of mathematics. Julie's confidence in mathematics had also increased. She stated, "Now I would say I am more confident." She clarified what she meant: "I think my confidence level is a little higher than it was in the topic that we are doing now. I can't say that my confidence level is higher in mathematics, in general, because we haven't practiced everything."

Julie held onto the belief that "problem solving helps you think more." Even though her view of problem solving had not changed—"I don't like word problems"—she attached significant value to the process: "I know they are good for me." Her confidence had grown, but she perceived that, at times, she was incapable of solving word problems. "I don't think I am ever going to get them right. I do get them right, but sometimes [I get them wrong]" She thought that the only time that she solved a mathematical problem correctly were in the Openers. When I pointed out in the second interview that she was continuously problem solving throughout the remainder of FMC, she responded, "I didn't notice that."

Rachel: "I'm confident that I can do math."

Rachel's perception of herself as a learner of mathematics remained the same as when she entered FMC. She still perceived that she was capable of learning mathematics, "I'm confident that I can do math." Though she admitted that there were "some things [she got] confused with [about] what you are supposed to do." In the second interview, I asked Rachel if her confidence level had changed since she had been in FMC. She responded, "No." Rachel had entered FMC with a confidence level of 6 on a scale of 1 through 10. She also stated, "I don't think I have gained insights about being here because I already knew how I was.... Usually I am fast unless it is complicated." As a quick learner of mathematics,

she noted, “It doesn’t take that long for me to understand.” Rachel preferred to finish mathematics problems quickly. In her words, “I am happy to get stuff done as fast as I can.” She did not like to “waste time on stuff.”

Samantha: “I think my confidence level has gone up a little bit.”

Samantha witnessed a modest change in how she perceived of herself as a learner of mathematics. First, she observed that her confidence level had slightly increased as a result of authoring her mathematical knowledge:

My confidence level has gone up a little bit because when I am on a problem during FMC, the teachers won’t tell me the answer; they won’t tell me how to do it. But when I figure it out on my own, it makes me feel better to know that I did it without the teachers help. (Individual Interview 2)

In the second interview, I asked Samantha if she had gained any insight about herself as a learner of mathematics by being in FMC. She responded, “I learn better when I am interacting [with my partners].”

Sarah: “My most insightful thing was when I realized that I do waste time thinking about how I don’t understand things.”

Sarah noted how confident she felt with the progress that she had made in FMC:

I just feel confident with all the problems I have done because I have done them all. They are sort of a review, rather than me learning things. So I almost feel overly confident. It is kind of scaring me how I feel, because I didn’t really do well at all in math this year. So I feel like I should be sort of straining with some problems, and I am not. (Focus Group Interview 1)

To her surprise, Sarah had done well in FMC. Because Sarah had entered FMC with negative perceptions of herself as a learner of mathematics, she had assumed that she would have to struggle. One week later, Sarah noticed that she was no longer enjoying FMC:

Probably [at the time of] the first interview, I was having a really good time, and in the group interview, I am having a good time. I don’t like being challenged that much. I like to sort of have a little bit of grasp on things and then be challenged. But

the stuff we started today and the end of last week, I just have no idea. So I have been really frustrated and not enjoyed the math part of this camp. (Interview 2)

She perceived that the mathematics had grown considerably challenging, enough so that she wanted to “give up.” This was a common reaction on Sarah’s part when she encountered a mathematical challenge. “When I get frustrated, I don’t get frustrated like, ‘Oh, I need to get this right.’ I just get frustrated, and then I kind of give up, which is bad.” Sarah recognized that her lack of persistence was a problem.

Sarah had devised a strategy to deal with the frustration that she encountered when solving a difficult problem. She erected a mental block, which made mathematical understanding difficult. “I get so tied up with the fact that I don’t understand something that I almost put a blockade stopping me from letting myself understand it.” She described an enactment of this strategy on July 13 in FMC:

I just kind of sat there. The whole time Lourdes was talking, I was sitting there thinking about how I had no idea what she was saying. Then she would look at me and say, “Do you get it?” I would just have this puzzled look on my face like, “Were you just talking the whole time?” (Individual Interview 2)

Sarah shared an insight into herself as a learner of mathematics: “My most insightful thing was when I realized that I do waste time thinking about how I don’t understand things, and then putting up that blockade and not being able to understand problems... That is probably my biggest downfall.” Sarah had hope, however, that she could remove this mental block to learning. I asked her what she thought she was going to do with this blockade during the next two weeks in FMC. She said firmly, “I am going to tear it down!” Sarah was beginning to understand what form her resistance to learning mathematics took, how it affected her learning, and how to begin to move through it. There was a slight change in Sarah’s confidence level, from 4 on a 10-point scale to “about a 6, not too high, not too low.”

Virginia: "Now I think I can do it [learn mathematics] every time."

During the first two weeks, Virginia's confidence level in mathematics fluctuated. When she began FMC, she reported that her confidence level was 7. On the fourth day, she said it had dropped to 0. In the second interview, it had risen. She said, "Now it has gotten better; I would say a 6." Virginia clarified this numerical value: "I don't feel that confident, confident, confident, because I really have to think. It seems like everybody is getting it faster because they have already done most of it." Through encouraging self-talk, Virginia convinced herself that the rate at which she worked was acceptable. She also recognized that she was learning mathematics. She explained:

I sort of block everybody out and just concentrate on my own. That gives me more confidence, because I am telling myself, "Well I am getting through the packet and I am learning." So now I can get through stuff faster, that way, instead of worrying about everybody else. So I think it [my confidence in mathematics] has improved. (Individual Interview 2)

After working by herself in FMC, Virginia recognized that she preferred to struggle with challenging problems:

I don't want anybody to help me, because I will look over it until I just absolutely don't have any clue of what to do, and I have tried everything. Then I will call the teacher over and just be like, "Where do I go from here?" (Individual Interview 2)

Virginia claimed that working through a problem first before she called a teacher for help identified her as an "independent" learner in mathematics. Virginia explained why she needed to be an independent learner in mathematics:

Of course I want help to get to the next step, but I don't need to depend on people. Because people aren't always going to be there, and I just raise my hand and somebody is going to come over and be like, "Oh, this is what the answer is, and this is how you do it." People aren't going to do that in my future. (Individual Interview 2)

Virginia had begun FMC perceiving herself as a fast learner in mathematics. By the end of the first week, she perceived that she was slow. At the end of the second week, after numerous struggles and challenges, she identified herself as not a “*real* fast learner.” She claimed that “most of the stuff I can catch on to right away.... Now I think I can do it [solve the problems] every time.” Virginia was regaining some confidence as a learner of mathematics.

What Do I Think of Mathematics After Two Weeks in FMC?: An Intermediate Snapshot
Angela: “Mathematics is just broader than I ever imagined.”

When Angela began FMC, she held a positive view of mathematics as reported in her application essay: “In general, I like math. I would not go as far as saying that I take pleasure from doing math, but when I solve problems I feel good about myself.... I welcome challenging and stimulating problems.” After two weeks, this view remained unchanged. Angela, however, noted a change in how she perceived mathematics. She stated, “Mathematics is just broader than I ever imagined. It is more useful than I would have thought.” However, she could not pinpoint this usefulness when I questioned her further.
Hannah: Mathematics is “a little bit easier.”

The frustration that Hannah felt about mathematics seemed to dissipate slightly. She commented that mathematics was “a little bit easier” and “not as difficult as I make it out to be in my head.” Yet she still held onto a “set image” of mathematics as “difficult and annoying, and there is no need for it.” Hannah claimed that she could not let go of the “resentment” that she held toward mathematics because of her dislike for the subject. She perceived, however, that this image was changing “most of the time in a positive direction.”

Hannah shared how her experiences in the origami workshop changed her perceptions of mathematics:

The origami class in itself is just a lot of fun. It's great because it has helped me in the fact that I will never forget what a hexagon looks like. I know dodecahedron. I know how to put these things together. I know how many sides different types of geometric shapes have. I know the certain angles that you need them to have so that they will fit together perfectly. I know how to make equilateral triangles, and just being able to make the different types of geometric shapes. But then to do something pretty is just great. It has helped me in realizing that numbers related to shapes aren't bad. They can result in really nice things. (Individual Interview 2)

Hannah saw a new mathematical world unfold literally at her fingertips. Her view of mathematics expanded to include the geometric concepts of origami.

Julie: "I have always thought that some topics in mathematics relate a lot with real life."

Julie entered FMC holding an applied view of mathematics. She perceived that mathematics was important in an engineering career and valuable as a tool for daily living. She noted that mathematics did not seem different from before: "I have always thought that some topics in mathematics relate a lot with real life because architects and engineers use them, and that is still the way I see it. I don't think it has changed." Julie also commented that she had not gained any new insights on mathematics. She indicated, however, that her experiences in FMC helped enhance her perception of mathematics as connected with "real life." "It is being enforced here because... we had just today one word problem about the perimeter of a farm. So it does let us know that it is a part of real life, that we use it." She also commented, "I have learned to do and see things [mathematics] in different ways."

In the second interview, Julie shared an additional insight about mathematics. She noted that if someone had videotaped her during the past two weeks, she would want a viewer to "know that you can't memorize certain stuff. You have to practice to become better at mathematics." For her, practice did not equate with solving 150 problems on the

same mathematical concept. She explained what she meant by “practice”: “You practice different problems that have to do with that [one] topic.” Julie’s perception of mathematics fit with a conceptual understanding of mathematics.

Rachel: “Usually when you think about math, you think of adding numbers, but we also do shapes and designs and that has to do with math also.”

Upon entering FMC, Rachel had thought mathematics was “uninteresting” and “boring,” and that it was “numbers and getting answers.” This perception remained unchanged. She said she was “uninterested in the material” and “not excited about math.” In the second individual interview, I asked Rachel if FMC had helped her think differently about mathematics. She responded, “No.” A moment later, she said that she had “never been interested in math.” I then asked, “So this isn’t helping?” Again she said, “No.” There was evidence, however, to dispute her claim. In the following excerpts from the first group interview and the second individual interview, Rachel indicated that her perception of mathematics extended beyond “numbers”:

I don’t really consider SuperLogo as a math class because it is not really math, like equations and whatnot. It is just computers, and you make designs and stuff. But I guess it could be geometry because of shapes maybe. (Focus Group Interview 1)

There are lots of types, not just basic math, things like computer math. Usually when you think about math, you think of adding numbers, but we also do shapes and designs, and that has to do with math also. (Individual Interview 2)

In the first excerpt, Rachel seemed hesitant about claiming that what she did in SuperLogo was mathematics. A week later, she modified her perceptions of mathematics to extend beyond “numbers.” Now her view of mathematics included “shapes and designs.”

Samantha: Mathematics is “more fun and effective when you are interacting with it.”

When Samantha entered FMC, on the one hand, she disliked mathematics because of her negative experiences in geometry. On the other hand, she spoke about the importance of mathematics, perceiving mathematics as the “language of the world.” The negative feelings that Samantha initially carried with her seemed to dissipate. In the second interview, she commented that mathematics was “more fun and effective when you are interacting with it.” She defined “interacting with mathematics” as “working with mathematics in a positive way.” Samantha found a new way to think about mathematics.

Sarah: “I am noticing how mathematics relates to everyday life.”

When Sarah entered FMC, she had a negative perception of mathematics. She spoke of how much she “dreaded” it and how she devised mental blocks that prevented her from learning. In the first group, however, she said, “I am noticing how mathematics relates to everyday life.” A week later, in the second individual interview, she went further:

But you always hear your friends saying, “No, math is so important, blah, blah, blah.” I would always be like, “Okay, you have just heard that from your parents and passed it down.” But now I am really seeing how it does relate to everything.

Sarah also associated mathematics with economics, an association she had never made before. As she said in the first focus group, “I really never thought of economics as having to do much with math even though the whole foundation is math based.” Sarah noted that her perception of mathematics was “sort of” changing:

Like I said, it does relate more to everyday life than I thought, but I still sort of have the same feelings of frustrations... so they haven’t really changed that much, my feelings towards math. I just know that I am learning a lot more. That is the main difference. (Individual Interview 2)

Virginia: “So I may not like mathematics, but I think it [learning mathematics in FMC] is a good experience”

Mathematics was one of Virginia’s favorite subjects in school, but after only four days in FMC, she claimed to “hate” mathematics. In the second interview, she noted, “I don’t like math as much.” Yet a spark of optimism remained. She reported: “I came here to learn new things. I didn’t come here just to go over the same things over and over again that I already know. So I may not like mathematics, but I think it is a good experience.”

The Third Moment: “FMC is Even More Nonconformist Now!”

A Closing Portrait of FMC

This collective portrait, composed entirely of excerpts from the second focus group interview (July 23) and the third individual interview (July 26 & 27), provides a look back over the previous month in FMC. It highlights some of the struggles and triumphs that the participants experienced. In the discussion that follows this portrait, I elaborate on themes that surfaced in the interviews and draw attention to themes that are missing in this portrait.

FMC is even more nonconformist now! I love it! The only way my view of it has changed is that I feel even more free in the classroom than I did the first week. I really enjoyed the freedom of the classroom, just the fact that you really can work at your own pace. I could take a break when I didn’t feel like working, when I was just not focused. I could work on a problem step by step. I could just take it as I wanted to take it because it is *my* experience. All year I felt like I had been falling behind because I hadn’t been working up to everybody else’s pace; here there is no ahead or behind. The students are running the classroom basically; however productive they want to be on that day, they will be that productive. I am only hurting myself if I don’t take advantage of working to my own level. I love that freedom!

I have come to see the teacher’s role here is that of an overseer and assistant. Overseers in that they just kind of stand off to the side and make sure you are getting things done. They are an assistant in the sense that they will come over, and they will reassure you. They are not teaching you; they are assisting you in the learning process. The teachers are just opening up your mind to different ways that you could solve the problem. The constructive criticism from the teachers was good. They didn’t say, “No, this is totally wrong.” The teachers work with what you have done and ask you questions to help solve the problem. For example, they would ask you,

“What do you think you would do next?” If you had no idea, then they would say, “If you had this and this...?” They would help you get to the answer, but they wouldn’t ever tell you the answer. So you would always get the answer yourself.

An important feature of FMC is the way that math is not really taught. I am learning math by remembering or relating what my problem is to what I have done before. If you don’t understand something the teachers will explain it to you later, but you are learning by yourself because of things you knew before. I am learning mathematics when I do the problems because the teacher doesn’t tell you how you can solve the problem; you have to solve it by yourself. Here you can’t blend into the background. You really do have to stay focused and work with your partner the whole time on the math problems. You can’t just say, “Okay, I give up.”

I wanted to give up more than anything. If I had been given the chance, I would have. I am happy that the teachers wouldn’t let us give up. I would not cut the struggles. They are important to the learning experience. Besides it is even more gratifying if you do struggle a little bit, because once you pull yourself on top, it is like, “I did this all by myself. I brought myself all the way from the bottom up to the top.” So the struggle shows the better parts of the learning experience.

Honestly, I probably wouldn’t say that FMC was the most fun thing. It was kind of a grueling process, but I know it was good for me. It was very long, hard, and tiring sometimes, just tedious, sitting there for an hour and a half working on something that either you could do really well or you didn’t know how to do it at all or somewhere in the middle. It got boring at times. But other days it was so fun. So the days that were fun made up for the days that were bad.

I would say that I learned a lot here inside the classroom and outside the classroom, because I was sharing with a lot of people. In the classroom, it was a good experience having to work with a partner and having to learn to deal with different people. I benefited from it in that we compared and contrasted answers. I just felt like sometimes I was ahead of my partner or she was ahead of me. It was just frustrating. Outside the classroom, personally, I grew in my social life.

While I was here, I grew in my confidence in math. By coming here, I know that I am capable of learning mathematics by myself. I know that I don’t always need the help of a teacher to learn new stuff. I have come to think that if you try to do a problem, then I would say you could get it almost any time. Now I am not afraid to ask for help. I know that the teachers are supposed to help me. So I am more confident in making sure that when I leave I understand what I did.

There was a lot less stress here because FMC was an all-girl math class. I really don’t care what girls think about me. So I don’t really try to be anybody. But when you are with boys and girls, it is just different because you get off topic, and you are not really concentrating on what you should be concentrating on. We got more accomplished because we did not have big disruptions.

If I had to describe my experience in FMC, I would probably say it was unique. It has given me so many different ways to look at how to figure things out. It has also given me a level of confidence that I can do things. Not everyone in the class is exactly the same; they all have different styles of learning math. Everybody has their own story of why they are here. When you put all that together and you are included in that, it makes the learning experience very unique.

Still Nonconformist

The participants perceived that FMC was nonconformist, which meant, “You work in groups. You work at your own pace. There are teachers around to help you, but they are not following you and breathing over your shoulder.... You don’t have to work to a deadline” (Hannah, Individual Interview 3). Throughout the month, the participants compared and contrasted their regular mathematics classes with FMC, noting that “we just do things completely different here.” The participants perceived that the contrast in pedagogy between their regular mathematics classes and FMC was even greater than their initial perceptions had suggested. Upon leaving, the participants recognized that their experiences in FMC were unconventional. They experienced what Sarah called a “break with tradition.” Even Angela, who had experienced learning in an IMP class, noted that her experiences in FMC were different from those in her regular mathematics class.

Agency: “The students are running the classroom basically.”

FMC provided a site for agency. The participants enjoyed the freedom that the “structure” of FMC offered. They perceived this structure allowed them to work at their own pace and to act on their own behalf. Rachel noted that “working at your own level” was one of the most important features of FMC because “you don’t always have to be at a certain spot.... There is really no ending point. Whenever you are ready to move on, the teachers give you another worksheet to work on.” Hannah noted the benefits of agency:

It makes me feel smart, that I am able to get these problems done. It makes me feel happy to be in the classroom, knowing that I am not going to have to get something done by the end of the day. I am not stressed to go to class, just happy and laid back, and ready to work usually. (Individual Interview 3)

Boaler and Greeno (2000) documented that “in discussion-based [mathematics] classrooms students were, quite simply, given more agency” (p. 189). Similarly, the participants

perceived that they had control over their learning, which supports Solar's (1995) model that calls attention to "giving women the time and means to learn" (p. 326). It also supports the claim made by Boaler and Greeno (2000) that "when mathematics learning practices places students in positions with more significant conceptual agency, it is much easier for many of them to author their identities as learners with that kind of agency" (p. 196).

Authorship: "You can't blend into the background."

The participants' role as a student was to author mathematical knowledge. Julie noted how the teacher's role played a significant part in her role as a student:

The teacher is there to help you.... Like if we are learning something new, there is always a pattern that we would have to notice. She would make it stand out for us, but we would have to get there, meaning solve the problem. (Individual Interview 3)

Because the teacher never told the participants answers or showed them how to work a problem, they had no choice but to solve problems on their own or with their partner. A consequence of the participants taking responsibility for their learning was that they authored and owned mathematical knowledge. They perceived authorship as a way to help improve their perceptions of themselves as learners of mathematics. For example, Sarah recounted her satisfaction as a learner of mathematics and her pride in her progress:

It is so much more satisfying to know that you have done the work. I just flipped through pages of the packet today, and I was like, "I have done all of this work! Oh my gosh!" It is probably ten times more than I ever did over the course of this entire school year. No joke!"

Most participants expressed an array of positive emotions (e.g., happy, excited, proud, joyful, satisfied, confident) when they solved a taxing mathematical problem on their own. Rachel, however, commented that the only feeling that she attached to authoring a problem was "relief." For her, relief opened a way to "move on" to the next problem. Her emotions indicate that not all participants reacted to the authorship role in the same way.

Authorship helped several participants develop their mathematical understanding. For example, Angela and Julie contended that solving problems on their own helped to deepen their mathematical understanding. Angela explained:

I understand mathematics better when I am the one to figure the problems out.... The math ideas really stuck in my head because the teachers made us figure it out on our own.... If they had just told me... it probably wouldn't have the same effect, it probably wouldn't have registered as well. (Individual Interview 3)

In a similar vein, Julie preferred to learn by herself because “when you learn by yourself you can remember math topics later and better than if you just learned them from the teacher.”

Angela and Julie entered FMC feeling confident about asking questions or speaking up in class. The other five participants developed their voices in FMC. In the third interview, Hannah reported that she learned to speak up about her mathematical ideas. Eventually her fear of asking for help had faded. It was replaced with a need to speak and to ask questions. Virginia shared a similar story:

I progressed a lot.... In the beginning I didn't like to speak out.... Now I have learned to ask questions, no matter what! If I don't, then I can't go any further.... I feel more confident in that way than I was before. Before I was scared to ask. Now I am not scared to ask. (Individual Interview 3)

Rachel's story paralleled those of Hannah and Virginia. Rachel perceived that she had no choice but to speak because of her perception that “mathematics is not directly taught here.” When she entered FMC, she commented, “At school, I never ask for help.” At the end, Rachel claimed that she needed to ask questions to learn mathematics in FMC. In Sarah's case, she perceived that she could voice her mathematical ideas in FMC without fear of embarrassment or ridicule and perceived that her ideas had value. The authoring process gave the participants opportunities to express their mathematical ideas. By the end of FMC, Hannah, Sarah, and Virginia perceived that they had a right to speak up. This right allowed

them to ask questions, propose conjectures, and critique ideas. They came to see that their voices were central to their mathematical understanding. Burton (1999) noted:

To be “agentive *and* transformative” shifts the agenda into the socio-cultural so that, as learners develop insight into the quality and demands of their learning, and compare its similarities and differences in the learning community, they find their voices as mathematical authors and come, critically, to evaluate these voices. (p. 30, italics in original)

As authors of mathematical knowledge, the participants eventually became “invested in participating” (Morrow, 1996, p. 6). They saw that they had a contribution to make in terms of learning mathematics and recognized that the construction of knowledge depended on their participation in the learning process. The participants authored mathematical knowledge by asking questions, testing conjectures, justifying claims, offering critiques, following intuition, using personal experiences, and embracing uncertainty. Like the students in the discussion-based classrooms that Boaler and Greeno (2000) studied, the participants were “required to contribute *more* of their selves” (p.189, italics in original).

The authoring process helped the participants confirm themselves as learners of mathematics. Eventually they had stopped asking teachers for confirmation of solutions; instead, they relied on themselves. Most of the participants grew confident in their abilities to solve challenging problems. They perceived that they were capable of learning mathematics, which helped them to develop their independence as a learner of mathematics. The data support the conjecture that “when a student can demonstrate to herself that she came to an understanding of a mathematical problem through critical inquiry, and she knows why a solution works, she becomes more confident and less teacher-dependent” (Morrow, 1996, pp. 7-8). The data also provides evidence that corroborates Solar’s (1995)

model, which proposed that “letting women solve problems by themselves” (p. 326) plays a role in their empowerment as individuals in the mathematics classroom.

Struggles Along the Way: “*We have been frustrated all summer.*”

There was no debate about who authored the mathematical knowledge; the participants did. In the third interview, Rachel stated, “We do all the work. If you don’t know the answer, the teachers will not tell you. So you have to keep working through the problem until you get an answer that *you feel comfortable with*.” Feeling comfortable with a solution to a problem was not easy for the participants, especially during the second half of FMC. About halfway through FMC, the participants began to struggle more with the problems, which had become more challenging than before. By the time of the second group interview, the participants had grown tired of struggling. On numerous occasions the participants admitted that they were on the brink of giving up. In the second group interview, Angela, Rachel, and Sarah mentioned that their most difficult times were when they spent three days on one set of problems feeling as if they had “absolutely no idea where to go.” Sarah thought, “We are getting less and less problems done each day. We are feeling that it is counterproductive.” It was during these times when the participants wanted to ask the teachers, “Please, just tell us the answer.”

Purpose of struggling. Even though the participants struggled throughout FMC, they perceived that the struggling was valuable to their learning experience. At some point in either the second group or final individual interviews, each participant explicitly stated that she would not eliminate the struggling because, as Sarah said, “it was a learning experience.” She emphasized its importance: “I want to have a chance to struggle with stuff. To me that was the point of the nontraditional math classes.” Similarly, Rachel perceived

that the frustration and struggle were simply “part of the SummerMath experience.” She also thought that gaining authorship was a purpose for the struggle: “You can learn how to do your own problems without getting help all the time; just doing it yourself.”

Benefits of struggling. Even though the participants often complained that they were frustrated, they identified several benefits of struggling with a problem for an extended period. First, as Rachel mentioned above, the participants perceived that they had an opportunity to gain authorship of mathematical knowledge. Second, Virginia noted that she saw the struggling as part of “a new learning experience for learning mathematics, to help you get ahead.” For her, it was one way to help her advance in mathematics. She also saw the frustration as a way to learn more about herself as a learner of mathematics. She added:

Even though I had some really, really frustrating times, it was good for me to go through that experience. At my school, I am usually the first one done. I know everything. I get everything way before everybody else. Here I was at the bottom. So it was good for me to experience being both ways. (Individual Interview 3)

The participants cited a third benefit of struggling with a mathematical problem. They reported that their confidence in themselves as learners of mathematics improved. Hannah noted that working through a difficult problem helps “you become more confident especially when you get the right answer. If you ever run into where you have to solve a problem on your own, you know you can do it, if you just sit and work at it.” The struggle empowered her to believe that she was capable of solving mathematics problems.

Angela reported a fourth benefit of struggling with a problem:

It helps with the whole patience issue. I am not the most patient person in the world. So when I had to spend three days on this one paper, I got pretty frustrated and bored and just stopped working for awhile. Then I realized that we weren’t going to get anywhere, so we ended up doing it. (Focus Group 2)

The frustration and struggle prompted her to take action and ultimately, to progress. She seemed to gain patience as a learner of mathematics. Morrow (1996) claimed that when learners struggle for mathematical understanding, they become confident and persistent learners of mathematics. Data from this study support her claim. They also corroborate the proposition made by the National Council of Teachers of Mathematics (2000):

Students should view the difficulty of complex mathematical investigations as a worthwhile challenge rather than as an excuse to give up. Even when a mathematical task is difficult, it can be engaging and rewarding. When students work hard to solve a difficult problem or to understand a complex idea, they experience a very special feeling of accomplishment, which in turn leads to willingness to continue and extend their engagement with mathematics. (p. 21)

Several participants, Angela, Hannah, and Rachel, speculated that a future benefit of the struggling they had done would be an increased tolerance level for frustration when they encountered challenging problems in their regular classrooms. Rachel conjectured, “It might be helpful when we go back to school. When we get stuck on problems, it will be easier for us to get it and not get frustrated.... I will stay with a problem longer than I usually did, because usually I just stopped.” She reasoned that “we have been frustrated all summer. We are used to having challenges.” Rachel perceived that the struggling was preparation for future encounters with difficult mathematics problems.

The Role of the Teacher: “To guide and to teach, those words are not interchangeable.”

The closing portrait illustrates the role of the teacher as two-pronged. First, the participants perceived that the teacher was an overseer who took a secondary role. This perception did not imply that students ran wild, having no direction or guidance, nor did it imply that the teachers wandered haphazardly around answering questions. In fact, the participants perceived that unwritten rules existed. These rules stipulated that they work to the best of their ability and they respect each other. Second, the participants perceived that

the primary role of the teacher was to “guide” them in the learning process. This did not mean that the teachers offered methods or answers; instead, they offered guidance by asking students questions. These questions helped them to determine the students’ misconceptions and to formulate a questioning strategy that addressed their misconceptions.

The shift in power relations prompted the participants to revise the role of a mathematics teacher. The participants saw a clear distinction between the role of their regular mathematics teachers and the FMC teachers. Upon entering FMC, the participants perceived that the role of their regular mathematics teachers was to *teach*, which meant that the teachers directed mathematical instruction and learning. They perceived, however, that the role of the FMC teacher was to *guide*. In the third interview, Sarah noted the distinction between a teacher who “teaches” and one who “guides.” “To guide and to teach, those words are not interchangeable. Teach is you tell them what to do. Guide is you take their ideas and point them in the right direction.” In the final interview, Samantha voiced her preference for a teacher who plays a helping role: “I am a better learner when a teacher isn’t basically teaching to me, but they are actually helping me.” Rachel stated several times, “FMC is not a teaching class.” The participants often commented on how they were not being taught, because the teachers were not standing up in front of the classroom lecturing, confirming methods, or telling answers.

The participants often spoke of the positive feedback that they received from the teachers. They mentioned that they felt comfortable expressing their mathematical ideas regardless of their accuracy. In their final interviews, Samantha and Sarah claimed that their confidence in mathematics improved partly due to the positive feedback and respect that they received from the teachers. Sarah noted, “They never talked down to you.... They

treated you equally.” Similarly, Samantha asserted that the one thing that helped to increase her confidence was “the teachers wouldn’t lower your self-esteem or make you feel bad by telling you that you were wrong. They would help you with it [a problem]. They wouldn’t do the problem for you. They would let *you* figure it out.” The teachers provided positive feedback in ways that signaled to the participants that they had a valuable contribution to make in knowledge construction. Confrey (1995b) contended:

When the classroom norms are developed in such a way as to promote the exchange of student methods with mutual tolerance and respect, the children themselves become increasingly confident in their contributions and the system becomes self-reinforcing. (p. 41)

Collaboration: “Working in a partnership can go either way depending on who your partner is.”

FMC class was a site for collaboration. Though the participants struggled for understanding, they did not do so in isolation. They maintained that partnerships that worked depended on two variables: how well they related to their partner and the paces at which they worked. Rachel summarized the benefits and limitations of working together:

Sometimes you want to move on, but one person still doesn’t understand, and you have to wait for them to get it... But it is also helpful because... you can get different ideas. If you have one idea that doesn’t work, your partner might have a different way to do it. You can just test out both of your ideas and see which one works. (Focus Group 2)

Benefits of partnerships. For all the participants except Virginia, forming and maintaining partnerships proved beneficial in one way or another. First, Julie and Rachel thought that the learning process was significantly “easier” than learning in their regular mathematics classes because they could work with partners. In the final interview, Rachel commented that learning mathematics with a group was “easier because you don’t have to do all the work by yourself. If you don’t know how to do it, you can just ask your partner.”

Second, partnerships provided the participants with an opportunity to interact and collaborate. The collaboration allowed them to compare and contrast answers and test conjectures. As the participants interacted, they had an opportunity to “see everybody’s different opinion on how to get the answer.” In the second group, the participants claimed that one of most important features of learning mathematics in FMC was the chance to share ideas, explanations, and solutions with their partners. This finding supports Solar’s (1995) model of inclusive pedagogy in which sharing in the mathematical learning process promotes active participation (p. 326).

Third, as the participants spent time collaborating, they noticed that they were depending more on themselves and each other for confirmation and solutions. Julie explained how her partnership with Reba provided a way for her to nurture her independence from the teacher:

Working with a partner is helpful. I like working with a partner. I think I am better with a partner than by myself, because if I am by myself I would go to the teacher a lot more. If I get stuck on little things I don’t see, I can’t just keep going with a problem, I would have to ask the teacher so she could tell me what I am doing wrong. When you are with a partner, you have her right there, since you are doing the same problem. If they are the same level as you are, it is better to work with a partner. (Individual Interview 3)

Julie’s voice supports Morrow’s (1996) contention that when learners work collaboratively on challenging mathematical problems, they become independent learners. Even though the participants learned to view themselves as independent learners, they saw themselves as part of a group or partnership. They did not have to sacrifice their independence to be part of a community of learners.

Limitations of partnerships. Other than Virginia, who worked alone, the participants claimed that a disadvantage of working in a partnership was the chance for variation

between partners' working pace. If one partner worked faster than another, then the other partner would be left behind, or the faster partner would be forced to wait for the slower partner. Hannah observed that the problem of unequal pace mainly resided within her group. She spoke of the tensions that were building in her group because all three were at different "spots." Hannah did not give up on the idea of collaboration. In the final interview, she said, "Working with a *partner* is really helpful because I do have someone who can help explain things to me, and I can help explain to them as well." Throughout SuperLogo, she kept a positive relationship with her partner, Katherine. It was working in a *group* that Hannah found "difficult" because "not anyone of us is at exactly the same level. Sometimes I and another partner want to move on and we can't because the other person doesn't understand it." Hannah was never opposed to working with one partner; she was opposed to working in a group of three because there was a greater chance of "variation between levels."

Even though problems occurred in the partnerships, most of the participants saw value in collaboration and preferred to work in partnerships rather than alone. In particular, they preferred to work in pairs as opposed to groups of three. They perceived that the chances for variation between the paces at which each partner worked was smaller when working with two people as compared to working in a group of three.

An All-Girl Mathematics Class: "There was a lot less stress here."

The participants perceived that learning mathematics in an all-girl class provided a less stressful environment and posed fewer distractions. Julie noted, "When there are boys around you can't really talk about everything, so you tend to work more." Angela added, "There is more reason to get off topic when there are guys in the classroom."

The closing portrait hinted at an element that the participants perceived as present in an all-girl mathematics class, that is, self-acceptance. Sarah explained, “You don’t feel like you have to impress anyone; you can be yourself in the classroom. You are so much more comfortable because you don’t feel like you have to prove something to anyone.” FMC provided the participants with a supportive environment where they felt comfortable to express their mathematical ideas without rebuke from their male counterparts.

Hannah brought to light a possible source of friction from learning in an all-girl mathematics class. She stated, “Girls tend to have bigger attitudes than guys and that can really clash when you are trying to work.... It can get really bad. So that is one thing that disrupts being able to work.” Hannah thought that working with someone who had an attitude might possibly hinder her learning mathematics. Even though she voiced this opinion, she thought that learning in an all-girl mathematics class was a positive experience. *A “Unique Learning Experience”: “This is a nice escape from the ‘This is how you do it’ traditional lecture mathematics class.”*

The participants perceived that FMC was “a nice escape” from their regular mathematics classes. They saw it as part of a “program” that was “only a month long.” They thought that its shortened length helped them to endure. When I asked them, in the second group interview, if they would want to be taught mathematics in their regular classrooms in the same way as in FMC, all of the participants except Sarah said no. All of the participants seemed to have a difficult time grasping the notion of learning in an FMC class “all year round.” Angela stated, “I don’t know if this is how I would want to be taught in school, because I think I need more structure in school.” For her, structure meant more teacher-directed instruction. Similarly, Julie remarked, “It is better that a teacher explains it to you

and then you do a lot of problems in different ways.” Even though Julie thought that the FMC pedagogy was “a good way to learn mathematics,” she could not conceive of this pedagogy working in her regular classroom because “the teacher has to get to the board and explain things to you because we take the Regents. We have to cover a whole bunch of topics in one year. So we can’t really learn on our own pace.” Even Hannah, who “loved the freedom” in FMC, said, “I don’t know if I could have this amount of freedom.” She opted for a “mix” of pedagogies from her regular class and FMC:

You would still get to work independently but the teachers would help you a little bit more than the teachers help you here. For example, if you really don’t understand the mathematics problems, the teachers would show you how to do it. If you are really getting stressed out and you don’t understand how to do it, you are not going to learn a new way to do it; so a mediation between the two would work.

Not every participant preferred the instruction that was associated with her regular class.

Sarah said, “I could deal with it [the FMC approach] being year round.” Her only stipulation was that the length of the class be shortened to 50 minutes. She voiced her hesitancy:

Everyone is scared of the unknown. I know this sounds bad, but it would be such a break in tradition. I would want it. It is just scary to think that classrooms would change that much. It is just intimidating and weird to think about.

The Third Moment Ends

The final collective portrait provides a glimpse of the participants’ perceptions of their experiences in FMC. Themes such as agency, authorship, power relations, and collaboration became salient. When the participants spoke about these themes, they also spoke about their perceptions as learners of mathematics.

What Do I Think of Myself as a Learner of Mathematics After Four Weeks in FMC?:

Seven Closing Snapshots

Angela: "I am more confident in my independence."

When Angela entered FMC, she had a positive image of herself as a learner of mathematics. She thought that she was "pretty confident coming into it." Nevertheless, she found that the challenging nature of the mathematical problems proved "confidence-building experiences." Angela claimed that she "built more confidence" as a learner of mathematics because she thought that the problems were "challenging, but not in a discouraging way." In short, they were "doable." She conjectured, "There are always two extremes, not challenging enough or too challenging. If it is right in the middle, then that is where there is confidence building." Angela perceived that she was "right in the middle."

Angela had an additional insight about herself as a learner of mathematics. She remarked, "I am more confident in my independence. I am more confident that I will be able to do things on my own, without going to the teacher to have them explain everything." Angela learned to depend more on herself to solve a problem. She noted, "I had no choice but to do it on my own. I realized that I could do it on my own, and that was confidence building." When Angela was "pushed" to author mathematical knowledge, she found that she was capable of this authorship, which, in turn, helped improve her confidence. Angela left FMC perceiving that she was more capable of learning mathematics independently and collaboratively, more patient, and more confident in herself as a learner of mathematics.

Hannah: "I am a very different person upon leaving here, but in a good way."

Hannah walked away with a renewed sense of herself as a learner of mathematics. Like Angela, she perceived that she was a more patient learner than when she entered FMC.

This patience was an outgrowth of having to work in a group. Hannah reported that her confidence “definitely changed,” which she attributed partly to having a variety of ways to solve a mathematical problem. “My confidence has gone up a lot because I know several different ways of solving problems, which is really helpful. If I don’t understand something one way, I can always break it down into another type of problem.”

When Hannah entered FMC, she knew that she was a visual learner in mathematics. She asserted, “I always knew how I learned mathematics. I have just never been in an environment where it complied with the way I learn mathematics.” What she did not realize about herself was that she was more capable of learning mathematics than she had originally thought. In the third interview, I asked her, “What have you learned about yourself as a learner of mathematics that you didn’t know at the beginning of FMC?” She replied:

I have learned that I am capable, which is a very gratifying thought that after eleven years of school, I am able to do math problems at a complex level, which is a really, really great thought when I almost didn’t pass math this year.

Hannah came to think differently about herself as a learner of mathematics. She noted:

I was really unconfident and not very happy with myself when I came here. After being in this environment for four weeks, I just feel ten times better from where I was before I came here. Through each week of this math program, it has just helped me learn different styles, meet different people, and feel that I am not alone in the way that I learn. It has made me very, very, very confident in who I am and what I do. So I am a very different person upon leaving here, but in a good way.

Hannah left FMC believing in herself as a learner of mathematics. Hannah perceived that she could do most mathematics problems because she was confident, capable, and patient.

Julie: “I have learned that I can be more independent from the teacher.”

Julie noticed that her confidence grew, and she recognized her need for independence in learning mathematics. When Julie entered FMC, she admitted that she

relied heavily on her teacher when she was stuck on a mathematical problem. This reliance diminished in FMC:

I learned that I don't need anybody. Here my partner and I go over the problem. We try to find several ways, and go back to what we have done. I have learned that I can be more independent from the teacher.

The last focus group and individual interviews contained several indications that the notion of authorship played a part in how Julie perceived of herself as a learner of mathematics. For example, in the third interview, I asked Julie if she noticed any changes in how she thought of herself as a learner of mathematics during FMC. She replied, "I am more capable of doing things because my confidence in math grew, because here I saw that I could do things by myself without the help of my teacher."

Rachel: "Since we all had to work together, I gained patience."

Rachel reported that she gained patience because she had to work with her partners:

Usually I like to work by myself; it is just easier for me. I don't have to wait for anybody or explain to anybody how I did it. Here I had to wait because you can't move ahead that much until everyone is caught up. Since we all had to work together, I gained patience. (Individual Interview 3)

Rachel clarified what she meant by patience: It was patience in "working with people," not in learning mathematics. She noticed, "I still do rush [with the mathematics]." When I asked Rachel whether her confidence level changed as a result of participating in FMC, she responded, "No. It is not that I don't think I can't do it; I just don't want to do it." She pointed to laziness as one source for her resistance. Even though she said she was "uninterested" in FMC and in mathematics in general, she pointed out, "I do my work. I don't just *not* do it because I am not interested. I still do it because I have to, because my mom wants me to get the most out of this." Her admission that she did not take advantage of every opportunity that FMC offered was evidence of her resistance. She explained: "I didn't

do a lot of stuff that I could have done. I just didn't want to." Rachel cited one reason for her resistance. She said she was "uninterested in school and math." I conjectured another reason: the pressure from her mother to participate in SummerMath. The fact that Rachel participated on some level revealed her persistence as a learner of mathematics.

Samantha: "I am not so dependent on teachers or other people."

Samantha reported two changes in herself as a learner of mathematics. First, she noticed that her confidence improved. She identified a 1-point increase in her confidence level in mathematics; it increased from 7 to 8 on a 10-point scale. She attributed this increase partly to the encouragement that she received from the teachers. She noted, "I feel more confident because the teachers wouldn't try to put you down in any way. They wouldn't tell you that you were wrong." Samantha added:

I have become more confident while I was here, because the teachers don't give me the answers. They wouldn't tell you if you were right or wrong. They would ask you if you were confident in your answer. You would be like, "Yes." Even if you were wrong they wouldn't tell you that you were wrong, they would just ask you if you could do it another way. (Individual Interview 3)

Samantha stated, "I can be more confident in myself and my answer when I do it on my own." Second, Samantha's dependence on teachers lessened. She explained:

In school when I didn't know a question or understand a problem I would always ask either the teacher or the person next to me. But here I am kind of forced to figure the problem out on my own, which is really helping me, because I am not so dependent on the teachers or other people. (Focus Group 2)

The authoring process seemed to play a role in increasing Samantha's confidence and independence as a learner of mathematics.

Sarah: "I realized my capabilities."

Sarah admitted that upon entering FMC she had made a promise to herself, "I am not going to take this for granted." She kept that promise. She said that she took every

learning opportunity that was available to her in SummerMath. She left with a feeling of pride: “I was really happy with my accomplishments. I was proud of myself and how I stuck to everything.”

Sarah thought differently about herself as a learner of mathematics. First, she spoke about how she managed to forge ahead when she felt like giving up. She perceived that she had no choice but to keep learning. She left FMC with the perception of herself as a persistent learner of mathematics. Second, Sarah confirmed that she “realized her capabilities” in mathematics because of her experiences in FMC. She said, “I am more capable than I thought in mathematics.” Third, Sarah witnessed an improvement in her confidence in mathematics. Her confidence level increased from 4 to 9 on a 10-point scale. Sarah viewed that increase as the “most prominent” change “because with confidence you can pretty much do anything.” Fourth, Sarah seemed to crave independence as a learner of mathematics. In the third interview, Sarah reported, “I want somebody to sort of guide me, but then I want to take it all from there and learn and explore.” Sarah seemed to have moved away from the perception of herself as a learner of mathematics that she entered FMC with, which was a reliance on teachers for solutions and confirmation. At the same time, however, she recognized that she still wants guidance from a teacher.

Virginia: “I am proud of myself that I got this far. I just kept going. I didn’t give up.”

Like Sarah, Virginia spoke about her accomplishments in FMC. In the third interview, she claimed that her progress was due to the authoring process. “I got this far because here they [the teachers] made you go further.” She noted that there were a few times when she wanted to stop working and go home. She admitted that, on several occasions in the beginning, she told herself, “I just didn’t want to be here at all. I just wanted

to go home.” In the end, her willingness to persist overrode her short-term need to leave. Persistence seemed an important part of Virginia’s accomplishments.

Virginia traced the development of her confidence and independence in FMC. She reported that there was a large drop in her confidence level in the first week because she was learning unfamiliar algebraic concepts with partners who were further advanced. After she began to work independently, Virginia found that she was capable of learning the algebraic concepts; thus, her confidence rose again. During the last two weeks, Virginia was often frustrated but remained on task, making considerable progress. At the end of FMC, Virginia spoke of a change in how she perceived of herself as a learner of mathematics:

Before I liked working in groups because I knew that if I didn’t get the problem then I could just ask somebody else, “Oh, do you have the answer?” I would just get it, but I didn’t know how. But the way they do it here, sometimes I don’t like it because it is frustrating. But it is good for me, because then I know the answer. I know each step in how to get the answer. (Individual Interview 3)

Virginia shifted her perception of herself from a dependent learner of mathematics to greater independence. She noted how the frustration had helped her. Virginia left FMC noting that she could handle most any mathematics problem that she might face in the future.

What Do I Think of Mathematics After Four Weeks in FMC?

In this section, I present the findings as four lines of discussion. First, I describe how several participants’ attitudes of mathematics improved in FMC. Second, I discuss the difficulty that several participants had in making the distinction between the nature and pedagogy of mathematics. Third, I describe metaphors that the participants used to describe their perceptions of mathematics in FMC.

Positive Images of Mathematics

The participants who entered FMC with disparaging views of mathematics left with positive views. In the third interview, Sarah spoke of a change in how she perceived mathematics: “I definitely have a much more positive attitude towards it. Definitely. That is the biggest change, the most significant. I don’t dread it anymore. I just have much more of an interest in it too.” She partly attributed her increased interest in mathematics to her participation in the workshops. In the workshops, she learned to “associate math with other things than just a classroom. I know how cliché this will sound, how it is in everyday life.” Sarah left FMC seeing how mathematics is connected to daily life. Hannah also experienced a change in how she perceived mathematics. She spoke about that change:

It is not as scary to me anymore. Now I know that I actually can get a problem done if I just sit down and work on it, instead of giving up and getting frustrated. Mathematics is a little more fun for me now. (Individual Interview 3)

Like Hannah, Julie spoke of mathematics as fun because of her experiences in FMC. Julie wanted outside observers to know that “when you get the hang of doing things by yourself, mathematics is fun in a way. When you see that you can solve problems by yourself, it feels good to know that you can do it by yourself.” Authorship appeared to be a site for not only building confidence but for giving her a new way to think about mathematics.

Mathematics as Pedagogy: Mathematics in FMC Is the Way That It Is Taught

One of the most difficult issues to unravel was guiding the participants to speak about their perceptions of mathematics. Angela, Hannah, and Rachel had a difficult time distinguishing between what mathematics was in FMC and how mathematics was taught in the class. An excerpt from the third interview with Angela illustrates the difficulty she had:

Dawn: What would you want the viewer to know about mathematics in these classes, the subject itself?

Angela: That it is not really anything standard, that everyone works on their own level. It is pretty separate; but when you are working with pairs it doesn't seem as separate. You don't really care about or worry about another group, where they are at, or what they are doing. It is really independent. You have to do a lot of things on your own because the teachers push you to figure things out on your own.

In this excerpt, Angela connected the mathematics in FMC to nonstandard ways of teaching it. Hannah and Rachel also had trouble making the distinction. The difficulties that these participants had in making a distinction between the nature and pedagogy of mathematics in this context provided insight into how they viewed mathematics. For the most part, Angela, Hannah, and Rachel seemed to associate mathematics, the subject itself, in FMC with the way that it was taught in the class.

Mathematical Metaphors

Mathematical metaphors provided a means for the participants to express their perceptions of mathematics in FMC. The primary metaphors that some participants used suggested that mathematics was variable and random. The following dialogue pertained to Hannah's metaphor for mathematics in FMC and SuperLogo:

Dawn: I wanted to bring up one other thing, it was the math metaphor activity you had talked about: [quoting Hannah] "For me mathematics in FMC and SuperLogo is most like a summer day, because it can be very enjoyable and fulfilling, but at the same time it can switch in an instant. When it switches, I feel upset and bummed out and discouraged, but when you get past the discouragement it can be cool and you feel so great about that you made it through to sunnier skies." Can you just talk about that and where that came from?

Hannah: It is like a summer day because a summer day can be beautiful and sunny, and then in five minutes it can be raining. You never know; that is what the summer is like. I was thinking about that, because that is what the weather is always like here. So, it really does relate to the way the classroom is. I had a really bad day in FMC when we had the interview, but on Friday it was fine. You could be doing really, really well, and be happy, feel confident and everything, feel accomplished. Then all of a sudden a thunderstorm comes in and you feel frustrated. You don't know what to do. You just want to scream at the world. You don't know how to

handle it. Then all of a sudden it clicks. It is like the storm goes away, and the sun comes back out, and everything is good again.

Dawn: And was this view achieved by being in the math classes? Did you hold that view of mathematics before you came here?

Hannah: No. It was always just stormy before I came here. (Individual Interview 3)

Hannah seemed to see mathematics in a new light. The fact that she saw pockets of sunshine in mathematics was a hopeful sign.

Angela used a similar metaphor of weather:

For me, mathematics in FMC and SuperLogo is most like the weather in New England. I don't really know what to expect on any given day, and my feelings about the classes are like flashfloods. I have good days and bad days. I can sometimes sense which they will be as the skies may change midday. Sometimes I feel really good about class and what we are doing in class, sometimes I don't. I have good days that come and go.

Rachel and Virginia used similar metaphors that suggested unpredictability and change.

Rachel used the metaphor of “mood swing.” Virginia used a train ride to describe mathematics in FMC: “Sometimes you have trouble in FMC, like a bumpy train. Sometimes everything just comes to you and you really understand. Just like sometimes you get a train that runs nice and smooth.” Like Virginia, Samantha used a transportation metaphor. Yet her metaphor of a “long bus ride” suggested predictability even boredom: “Mathematics in FMC is most like traveling long distance on a bus. It is slow and seems almost endless, occasional boredom is always present and wanting to go faster, but having someone or something holds you back.”

Sarah and Julie used different metaphors. Sarah’s metaphor was “running track”:

You know running track is good for you, for your body and heart, and is sometimes even therapeutic. Nevertheless, it is not one of my favorite activities. [There is] relentless fatigue, hoping for the finish line to meet you half way, watching the clock to see where you are in the race against yourself. When you are finished, you are either happy or sad with your accomplishments.

Julie employed a metaphor of “climbing a big mountain”:

Mathematics gets harder every year. Everything you do you have to relate it with what you have done before. A lot of people don't keep studying math because they don't like it, or because they see that it is very difficult. So, all those people get left behind. Let's say they start climbing, but they don't reach the top. So what I meant is that since it gets difficult, less and less people are trying to study math.... Well math is big. It is not like one thing that you can say, “Math is this,” because it keeps on going. You keep learning things about math everyday. So I meant climbing the mountain is like learning new things. So you are actually never going to reach the top because you are never going to learn everything about mathematics, unless you are like a genius. But math, it is a big mountain, it is big.

For Julie, previous mathematical knowledge was a building block for new knowledge. She convinced herself that some people ended their relationship with mathematics because the subject grew challenging and they lost interest. She saw mathematics as an infinite body of knowledge that only a “genius” could grasp in total. Julie pointed out that her perceptions of mathematics had been “enhanced” by her participation in FMC and SuperLogo.

Julie's metaphor related more to the nature of mathematics than those of the other participants. Most participants' metaphors illustrated their perceptions of learning mathematics in FMC, which is like the difficulty they had distinguishing between the nature and pedagogy of mathematics in FMC. Nevertheless, the participants had new ways to think about mathematics. Speaking metaphorically, some of the participants had a new lens with which to view mathematics.

CHAPTER 6

LEARNING FROM THE VOICES OF ADOLESCENT GIRLS IN A FEMINIST MATHEMATICS CLASSROOM

And where the words of women [and girls] are crying to be heard, we must each of us recognize our responsibility to seek those words out, to read them and share them and examine them in their pertinence to our lives. (Lorde, 1984, p. 43)

In this chapter, I attempt to glean insights from the voices of Angela, Hannah, Julie, Rachel, Samantha, Sarah, and Virginia for mathematics education. Their voices shed light on the complexities of teaching and learning in a feminist mathematics classroom. They also provide mathematics educators an opportunity to understand what it was like for these seven girls to learn in a classroom that was remarkably different from their regular mathematics classrooms. The “lessons learned” from their perceptions of their experiences, of themselves as learners of mathematics, and of mathematics in a feminist mathematics classroom fall into eight broad categories, which I discuss below.

Lesson One: Power Relations at Work

The first lesson that the participants’ voices teach us is that different forms of power relations are at work in a feminist mathematics classroom. In FMC, power was redefined, which had implications for redefining the roles of the students and teachers. The participants perceived that their role was to author mathematical knowledge, and the teachers’ role was to guide mathematical learning. The participants no longer viewed the teacher as the

deliverer of knowledge; rather, they saw themselves as playing a role in knowledge construction. The student-teacher relationship was built on cooperation and encouragement. Sarah went so far as to say that the teachers treated her “equally,” which meant that “they never talked down to you.” She understood the teachers’ show of respect to mean that they valued her ideas and considered her an equal. Yet power relations within FMC, or any classroom, are not so unproblematic.

The participants and teachers each had power based on their position in FMC. The participants had power in the sense that they had agency. That is, they perceived that they controlled how they learned mathematics and how much mathematics they learned. The teachers had power by virtue of their refusal to tell the participants answers or to show them methods. They also facilitated students’ learning by implementing the curriculum, controlling the flow of worksheets, and keeping the students on track. Sarah may have perceived that the “students were running the class basically,” but it is not true that they were in total control. The participants’ were not privy to the amount of work that the teachers put into their practice outside of FMC (e.g., how much time the teachers spent planning curriculum for the students as they progressed and how much time they spent discussing and responding to students’ needs). The present study contributes to an understanding of power relations such that there is not one pot of power where every member shares equally. Rather, power relations are about a reconfiguration of power, where each member has power in a different way, ways that do not necessarily carry the same weight. As hooks (1994) stated, “The classroom should be a space where we’re all in power in different ways” (p. 152).

Though the present study sheds light on the different kinds of power in a feminist mathematics classroom, mathematics educators must also be mindful of the implicit and explicit power relations that are always at work inside and outside the classroom (e.g., the power that teachers hold depending on their race, class, and gender, the hierarchical structures within schools and how these structures maintain, reproduce, or alter social inequities), which is an issue that seems to be missing in the discourse on the reform-based mathematics classrooms (e.g., National Council of Teachers of Mathematics (NCTM), 2000; National Research Council (NRC), 2001). Even though there is an ongoing discussion about equity issues and meeting the needs of a diverse group of learners in teaching and learning mathematics in the reform-based literature (NCTM, 2000; NRC, 2001), the discussion is not embedded within a discourse of power relations. If the mathematics classroom is to be a site of empowerment and social justice, then mathematics educators need to address the following questions, questions that are paramount in a feminist mathematics classroom: Who controls what mathematical knowledge is authored? What are the various forms of power in a mathematics classroom? How are those positions of power exercised in a mathematics classroom?

Lesson Two: The Complex Nature of Agency

The participants' voices teach us about the complex nature of agency in a feminist mathematics class. At first glance, the participants appeared to have agency. They reported that they controlled their mathematical learning by defining their working pace. Even though the participants claimed that they were in control of their learning, I still wondered about how much agency the participants *really* had in FMC. The participants expressed their perceived agency with statements like, "The teachers let you figure the problems out on

your own.” Yet, it was clear that the participants had no choice in the matter. The feminist teaching practices in FMC required the participants to act and respond in a certain way. The fact that the FMC teachers did not supply answers or confirmation forced the students to rely on themselves and, in some cases, their partners, for solutions and confirmation. Samantha even used the word *forced* on several occasions to illustrate that she had no other option but to assume the authorship role. Authorship came at the expense of agency. Though students gained agency, it was limited to develop authorship. The notion of agency in FMC raised the following dilemma: By attempting to empower students in a feminist mathematics classroom, feminist pedagogy might be implicated in forcing students to act in a given way regardless of their wishes or feelings. This dilemma poses the question, “How can authorship be enacted and exercised in a feminist mathematics classroom without simultaneously limiting students’ agency?”

Lesson Three: The Costs of Authorship

We learned from the students’ voices that the first cost of authorship is limited agency. The second cost of authorship is invisibility in the classroom. Sarah noted, “You can’t blend into the background” in FMC. The student’s role as author places them at the forefront of knowledge construction. What happens is students “no longer remain outside, but become part of the inner circle of knowers, with their own power base” (Morrow, 1996, p. 7). Some students, however, may prefer the invisibility that a traditional mathematics classroom offers. Students may resist the authorship role because they want to remain anonymous, they prefer to take less responsibility in learning mathematics, or they prefer to depend on a teacher for structure, confirmation, methods, and solutions. Taking away this security may cause anxiety for these students, making them less responsive and open to

learning mathematics. Morrow (1996) contended, “Structure can provide a sense of security for both teacher and student in the short run, but it can be alienating in the long run if the structure provided is not balanced with a sense of freedom to explore” (p. 9). Mathematics educators need to find ways to help students cope with the discomfort of being visible in the learning process.

The third cost of authorship is frustration and struggle. On many occasions, the participants shared their frustrations and struggles that came with the authorship role. Several participants spoke of giving up because they were tired of struggling with problems. By the end of FMC, all the participants claimed that they would not want to eliminate the struggling. In other words, they did not want to be rescued from the discomfort that came with struggling. They saw value in the struggle as a way to gain authorship or to improve confidence, patience, or persistence as a learner of mathematics. Researchers and teachers need to pay more attention to how to help students, especially girls, learn to struggle and to understand the value of the struggle. We need to learn how to help students address anxiety and frustration and to cultivate persistence.

Lesson Four: A New Perspective on the Role of a Mathematics Teacher

The participants’ voices teach us a new way to think about the role of a mathematics teacher. Freeman (1996) wrote, “Although there are people who ‘teach’ in every society, the term ‘teacher’ will have different meanings within those societies reflecting tacit, de facto social agreements about the boundaries of the term” (p. 745). The participants saw a “different meaning” for a mathematics teacher based on their experiences in FMC. They saw the FMC teachers as those who guided learning and fostered exploration of ideas. Virginia explained the kind of guidance that teachers provided in FMC:

If you are trying to figure out a variable, then they will tell you, “Okay, what is the first step?” If you don’t know what it is, then they will tell you the first step, but they won’t tell you the answer. They will go, “How do you do the first step?” Then you will do it, but they don’t tell you the answer. If you are doing something else, then they will be like, “Okay. How do you think you set it up? Read the problem. What do you think?” But they never tell you, “Okay, first you put the X here, then the Y here.” (Individual Interview 2)

Even though the participants perceived that the teachers never taught mathematics, they thought they learned a great deal of mathematics and furthered their mathematical understanding. The “boundaries of the term” for a mathematics teacher were changed for the participants’ through their experiences. They had to broaden their notions of a mathematics teacher to include room for a definition of a mathematics teacher as one who guides learning and promotes exploration and free expression of mathematical ideas.

Lesson Five: Rethinking Collaboration

We learn from the participants’ voices the complex issues connected with working collaboratively. Their voices told us about the possibilities of learning in a group or partnerships. The participants perceived that partnerships gave them opportunities to exchange ideas and test conjectures, to depend on themselves for confirmation as a learner of mathematics, and to see multiple ways to solve problems. Partnerships enabled the participants to solve challenging problems in a supportive environment in which they felt free to take intellectual risks. They also freed the participants to become more independent learners but not at the expense of relationship or community building.

Even though the FMC teachers paid close attention to the formation and maintenance of the groups, problems still arose in them, as was illustrated with Hannah’s case. The participants alluded to the importance of being teamed with someone who had a similar working pace. A vast difference may lead students to disengage from the group, as

Hannah and Virginia did, leaving them in a position where they perceive that they have little to offer or learn.

Another lingering problem with collaboration is the possibility of *social loafing* (Latané, Williams & Harkins, 1979), that is, the dependence of some members on others for doing the majority of the work within a group. This might take the form of one or more of the less involved students taking on the role of a traditional passive learner and one or more of the engaged students taking on the role of a traditional teacher. In essence, such a group becomes a micro version of a traditional mathematics classroom, which obviously interferes with the goals of FMC. If the group members are recreating the traditional roles of a student and teacher, then the students taking on the teaching role might be developing agency but the others may not. Thus successful collaboration requires that a teacher be skilled at identifying the development of hierarchy in a group and must work toward intellectual involvement of all group members.

Virginia's case illustrates the complex nature of collaboration in a feminist mathematics classroom. Virginia opted to work by herself because she perceived that she was lacking in prior preparation in algebraic concepts and skills and therefore could not learn at the same pace as her partners. Working alone in a feminist mathematics classroom appears inconsistent with the notion of a community of learners in feminist pedagogy. On July 10, I spoke with Lourdes about how she reconciled the issue of Virginia working alone. Lourdes responded by saying that she realized that allowing Virginia to work alone at first appeared to be contradictory to teaching from a feminist perspective. She noted that she considered the whole class when she made this decision. She thought that if Virginia worked in a partnership then she might prevent her partners from working to their optimal level.

Lourdes also considered Virginia's feelings when she made her decision. She knew that Virginia was adamantly opposed to working with a partner or in a group. Lourdes perceived that she made the best decision for both Virginia and the students in FMC. Even though Virginia worked alone, she had an opportunity to work collaboratively in the Openers and SuperLogo. Not only was Virginia's choice to work independently an act of resistance, it served as an enactment of her agency.

The way in which Lourdes handled this situation reveals a willingness on her part to construct a learning environment that she thought best suited the needs of a diverse community of learners. It was an example of how one might use a theoretical model in spirit rather than in rule. Lourdes's decision complied with feminist teaching principles in that she considered the needs of the class members as well as the individual needs of Virginia. Her decision, however, seemed inconsistent with the principle of including each learner in a community of learners. Even though she developed authorship, she lost an opportunity to participate in collaborative discourse. This compromise required me to alter my vision of a feminist mathematics classroom to include room for individualized work in which the learner works collaboratively with the teacher. Virginia's resistance to the collaborative spirit in FMC and Lourdes' response illustrates the importance of maintaining a flexible notion of feminist mathematics teaching.

Lesson Six: Using a Feminist Approach to Teaching and Learning Mathematics in Schools

The sixth lesson teaches us about the difficulties of letting go of traditional notions of mathematics teaching to imagine new ways of being in a mathematics classroom. In the second focus group, all the participants except Sarah reported that they would not want to be taught in their regular mathematics classrooms in the way that they were taught in FMC.

Angela reported that she preferred a more structured classroom with teacher-led instruction to her less structured, student-centered classroom in FMC. The other participants confirmed Angela's comment by nodding their heads yes. Julie reported, however, that she liked the teaching approach in FMC, but she could not see how it would work given that she had to take the New York Regents Exam. Her concern raises the following question: In what ways does work in a feminist mathematics classroom hinder or help student performance on standardized mathematics tests?

Sarah, who liked the pedagogy of FMC, summed up the challenge of learning in FMC as being "such a break in tradition." She explained, "It is just scary to think that classrooms would change that much." The differences between the pedagogy of FMC and the participants' regular mathematics classrooms were so striking that they had a difficult time seeing how to operationalize a feminist approach to learning mathematics into their regular classrooms. Hannah, however, suggested that a "mix" of pedagogies might work in her school.

Some of the participants preferred a traditional approach to mathematics teaching because a feminist approach seemed like too much work, too much of a challenge. As research by Boaler and Greeno (2000) suggested, the participants had to give more of themselves as learners of mathematics. Knowing and doing mathematics in FMC meant that the participants played multiple roles. They acted as authors, agents, and collaborators. It seems reasonable that such complex and demanding roles require more work. Mathematics educators need to learn more about these roles and how they shape learning.

Lesson Seven: Resistance to Feminist Mathematics Teaching Practices

The participants' voices teach us about the resistances to feminist mathematics teaching practices. Initially, the participants exhibited a moderate degree of resistance because their traditional notions of teaching and learning mathematics were not met in FMC. Resistance to learning was primarily in the form of complaints. For example, most participants entered FMC thinking that there would be a focus on finding answers. Most spoke about how they depended on the teacher to confirm their learning. After the first few days, the participants realized that the focus was on the process of solving mathematics problems, and they were expected to confirm their own learning. This caused discomfort for several participants.

The acts of resistance on the part of the participants highlight the need to recognize that a feminist mathematics classroom poses problems for some students. In particular, Rachel resisted by not fully participating and by not taking advantage of the opportunities that were available to her. She seemed resistant to learning in FMC for two reasons. First, she discussed how the FMC pedagogy did not fit with how she preferred to learn mathematics. She wanted a teacher to tell her when she was right or wrong. She had many of the characteristics of a received knower in mathematics (Belenky et al., 1986). She did not enjoy the struggle associated with authorship. Rather, she preferred to rely on the teacher for confirmation and solutions. She noted numerous times how the teachers were not teaching because a teacher was not up front "directing" her learning. A second reason for Rachel's resistance was that she had grown accustomed to learning in a classroom that required little from her in terms of engagement with mathematics. Thus she found it difficult to negotiate her way in a class that required her to take control of her own learning. Rachel's

story describes the nature of one student's resistance and illustrates the problems that coexist with the advantages of a feminist mathematics classroom.

Lesson Eight: Knowing and Doing Mathematics Differently

The participants' voices teach us about the new ways that they came to know and do mathematics in a feminist classroom. The participants continuously made comparisons between FMC and their regular mathematics classes, always noting how "different things were here." Embedded in this discourse were the ways in which the participants' ways of knowing and doing mathematics were challenged in FMC. They saw that they came to know and do mathematics differently in FMC than in their regular mathematics classes. Their epistemological stance on mathematics began to change as a result of their experiences in FMC.

The notion of authorship appeared to play a role in the participants' production of mathematical knowledge. The participants perceived that they learned mathematics because they had agency and authorship. The authoring process encouraged them to exercise agency and to validate knowledge internally. The mathematical knowledge that they acquired was not "externally provided or validated knowledge but, itself, a product of the authoring process" (Burton, 1999, p. 31). Burton suggested that in a narrative-based mathematics classroom, "the purpose of schooling in mathematics, then, shifts from the acquisition of knowledge 'objects' to the acquisition and usage of a reflective process of coming to know within a learning community where discourse is paramount" (p. 31). This purpose applied to FMC in that both the authoring process and the collaborative environment encouraged continual reflection on doing and knowing mathematics.

The classroom discourse in FMC centered on the participants making sense of mathematics; the focus was on conceptual understanding as opposed to memorization of techniques or formulas. They perceived that they gained a conceptual understanding of mathematics when they had agentive control, when they were authors of mathematical knowledge, and when they worked in partnerships. These conclusions support the assertion made by NCTM (2000): “Students learn more and learn better when they can take control of their learning by defining their goals and monitoring their progress” (p. 21).

The participants saw that the mathematics problems they were solving typically had more than one way to arrive at an answer, and sometimes the problems had more than one answer. They saw a wide array of possibilities for solving mathematical problems. The questions that the participants asked of themselves changed from “Is this answer correct?” to “How confident am I with how I solved this problem?” The participants’ view of the acquisition of mathematical knowledge shifted from goal-oriented to process-oriented. As Burton (1999) proposed, “Measurement of success is calculated not in the reproduction of quantities of externally authored, disconnected facts or skills, but in the mathematical ways through which the learners demonstrate their knowledge and skills in authoring their own mathematics” (p. 31). The authorship role provides mathematics educators with a new definition of success, one that depends on authorship and ownership of mathematics.

The ways in which the participants came to know mathematics in FMC reflected those proposed by Burton (1995). She defined a feminist epistemological framework of mathematics as relating to “its person- and cultural/social-relatedness; the aesthetics of mathematical thinking it invokes; its nurturing of intuition and insight; its recognition and celebration of different approaches particularly in styles of thinking; and the globality of its

applications” (pp. 220-221). In support of her epistemological framework, the participants came to know mathematics through the validation of their previous mathematical experiences, a reliance on intuition and insight, a recognition and celebration of the diverse ways of doing mathematics, and an awareness of the application of mathematics. The participants had to negotiate new ways of working in the mathematics classroom, ways that contrasted with their regular mathematics classrooms.

Future Lessons to Be Learned

I wondered how much of the participants’ perceptions of themselves as learners of mathematics and their perceptions of mathematics were stable. In some cases, change may be long lasting. In other cases, change may be strictly limited to learning in FMC. For example, Hannah’s perceptions of mathematics now included positive images. In FMC, she learned to solve mathematics problems in different ways and to see beyond the dichotomy of the right answer versus wrong answer. Her perceptions of herself as a learner of mathematics also improved. She perceived that she was capable of learning mathematics. These may be elements of her experience that she could hold onto in her regular mathematics class more easily than, say, agency or authorship, two constructs that are more dependent on the type of classroom and teacher. It may be that the participants will retain parts of their experiences in FMC that they can control, such as perceptions of mathematics and perceptions about themselves as learners of mathematics. It might be very difficult, however, to retain aspects of FMC that they had less control of such as agency, authorship, and collaboration.

I also wondered to what extent the regular classroom might affect the participants’ altered perceptions about mathematics and themselves as learners of mathematics. For

example, what impact will a negative performance have on the participants' perceptions of themselves as learners of mathematics? What might happen if the participants return to their regular mathematics classrooms and attempt to exercise their newfound agency, authorship, and voice? How will they be perceived by their peers and teachers? Will the teacher view the participants' agency, authorship, and voice as threats to her or his teaching practices or as opportunities to engage students? How will the students fit into the existing power structure in the classroom? To document how much the participants held onto their revamped perceptions of mathematics, the stability of their changed views of themselves as learners of mathematics, and how their perceptions of their experiences in FMC informed their future learning experiences in mathematics, I recommend a follow-up study with the participants to be conducted two years after they left SummerMath. This follow-up study could establish the stability of the fragile changes in the participants' perceptions of mathematics and their perceptions of themselves as learners of mathematics.

Closing Thoughts: The Possibilities of Feminist Pedagogy in a Mathematics Classroom

The classroom, with all its limitations, remains a location of possibility. In that field of possibility we have the opportunity to labor for freedom, to demand of ourselves and our comrades, an openness of mind and heart that allows us to face reality even as we collectively imagine ways to move beyond boundaries, to transgress. This is education as the practice of freedom. (hooks, 1994, p. 207)

This research speaks to mathematics educators as well as educators in other fields who are interested in critical, liberatory, or progressive pedagogies, including feminist pedagogy. It holds significance for mathematics educators in that it informs their practices about adolescent girls' experiences in a feminist mathematics classroom. Knowing how adolescent girls experienced learning mathematics in a feminist classroom provides insight on how the mathematics classroom can be a site of empowerment, where students can

perceive that their ways of knowing and doing mathematics are valued. Their perceptions of their experiences provide clues for imagining a new vision of a mathematics classroom. Perhaps if the climate of the mathematics classroom changes to one that values girls' experiences and knowledge, then more girls might continue to persist in the study of mathematics at both the undergraduate and graduate levels of college mathematics. Becker (1995) argued, "If the way mathematics is currently taught alienates many women because it does not appreciate or validate their ways of knowing, then many women may choose not to pursue mathematics and mathematics-related careers" (p. 172).

As a mathematics educator interested in gender equality in mathematics, I see value in a feminist pedagogy that empowers adolescent girls to rethink their perceptions of themselves as learners of mathematics and their perceptions of mathematics. One possibility of a feminist mathematics classroom is that it is one way to attack a link in the cycle of gender inequality in mathematics education (Ernest, 1995). By investigating the experiences of adolescent girls in a feminist mathematics classroom, I had an opportunity to understand the link between how girls perceive of themselves as learners of mathematics and how these perceptions might influence their participation in the field. Most of the participants saw that a mathematics classroom could be a site for empowerment rather than a site for disempowerment. The feminist mathematics classroom provided an opportunity for the participants to claim authority over the production of mathematical knowledge, a practice that was often denied to them in their regular classrooms. FMC prompted a wide array of choices for learning mathematics and encouraged new roles and responsibilities for the participants and teachers. Ultimately, the reconfiguration of power relations within FMC provided the participants with new ways to view mathematics teaching and learning and

new ways to see themselves as learners of mathematics. As empowered learners of mathematics, who perceived themselves as confident, capable, independent, and persistent, the participants have an improved chance of participating and remaining in mathematics.

The End of a Feminist Tale in Three Moments

As the participants packed up their belongings and said their goodbyes, I sensed that their experiences in FMC left an impression on who they were as learners of mathematics, what their perceptions were of mathematics, and what their perceptions were of learning in a feminist mathematics class. I suspected that the imprints would become permanent for some and fade for others. I can only surmise the depth and magnitude of the impressions. I am confident about a few lasting impressions that are embedded throughout Hannah's reflections on her experiences at SummerMath. These impressions tell of the possibilities of learning in a feminist mathematics classroom. Her voice offers possible imprints that a feminist mathematics classroom may have on the lives of adolescent girls, boys, and the mathematics education community.

What I would say to my best friend if she asked, "Why should I come to SummerMath?" I would say that SummerMath is such a diverse group of girls. If you are looking for some place to help you feel better about being your own person, this is a great program. I am just more comfortable with being who I am. I would tell her that it doesn't matter whether she likes math or she hates math. I would tell her that the program is for her, no matter what. If you enjoy math, then it is a great program. A lot of the math we do is really interesting and there are great workshops where you can apply the math to something fun that you can use in real life. It is really neat to see how you can put the math together. If you don't enjoy math, it is a really great experience because the teachers will help you, maybe not enjoy it, but they will help you feel better about doing it. The teachers give a lot of real positive feedback. If she wants an experience that will help her expand on who she is, this is a really good place to go. (Individual Interview 3)

REFERENCES

- Barnes, M. (1994). Investigating change: A gender-inclusive course in calculus. *Zentralblatt fur Didaktik der Mathematik*, 25(2), 49-56.
- Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice, and mind*. New York: Basic Books.
- Becker, J. R. (1995). Women's ways of knowing in mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 163-174). London: Falmer Press.
- Becker, J. R. (1996). Research on gender and mathematics: One feminist perspective. *Focus on Learning Problems in Mathematics*, 18(1, 2, & 3), 19-25.
- Boaler, J. (1997). *Experiencing school mathematics: Teaching styles, sex, and setting*. Buckingham, UK: Open University Press.
- Boaler, J. (2000a, August 1-4). *So girls don't really understand mathematics: Dangerous dichotomies in gender research*. Paper presented at the International Congress on Mathematics Education, Japan.
- Boaler, J. (2000b). Mathematics from another world: Traditional communities and the alienation of learners. *Journal of Mathematical Behavior*, 18(4), 379-397.
- Boaler, J., & Greeno, J. G. (2000). Identity, agency, and knowing in mathematical worlds. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 171-200). Westport, CT: Ablex.
- Bogdan, R. C., & Biklen, S. K. (1992). *Qualitative research for education: An introduction to theory and methods*. Boston: Allyn & Bacon.
- Brew, C. (2001). Women, mathematics and epistemology: An integrated framework. *International Journal of Inclusive Education*, 5(1), 15-32.
- Briskin, L. (1994). *Feminist pedagogy: Teaching and learning liberation*. Ottawa: Canadian Research Institute for the Advancement of Women.
- Briskin, L. (1998b). Negotiating power in the classroom: The example of group work. *Canadian Women Studies*, 17(4), 23-28.
- Buerk, D. (1982). An experience with some able women who avoid mathematics. *For the Learning of Mathematics*, 3(2), 19-24.
- Buerk, D. (1985). The voices of women making meaning in mathematics. *Journal of Education*, 167(3), 59-70.
- Buerk, D. (1990). Writing in mathematics: A vehicle for development and empowerment. In A. Sterrett (Ed.), *Using writing to teach mathematics* (pp. 78-84). Washington, DC: Mathematical Association of America.
- Buerk, D. (1996). Our open ears can open minds: Listening to women's metaphors for mathematics. *Focus on Learning Problems in Mathematics*, 18(1-3), 26-31.
- Burton, L. (1995). Moving towards a feminist epistemology of mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 209-225). London: Falmer Press.

- Burton, L. (1999). The implications of a narrative approach to the learning of mathematics. In L. Burton (Ed.), *Learning mathematics: From hierarchies to networks* (pp. 21-35). London: Falmer Press.
- Burton, L., Damarin, S., Koblitz, A., Ruskai, B., & Kilpatrick, J. (1995). Feminist perspectives on gender and mathematics. In B. Grevholm & G. Hanna (Eds.), *Gender and mathematics education: An ICMI study* (pp. 377-392). Lund, Sweden: Lund University Press.
- Butler, J. (1995). For a careful reading. In S. Benabib & J. Butler & D. Cornell & N. Fraser (Eds.), *Feminist contentions: A philosophical exchange* (pp. 127-143). New York: Routledge.
- Campbell, P., & Greenberg, S. (1993). Equity issues in educational research methods. In S. K. Biklen & D. Pollard (Eds.), *Gender and education*. Ninety-second yearbook of the National Society for the Study of Education (pp. 64-89). Chicago: University of Chicago Press.
- Code, L. (1991). *What can she know?: Feminist theory and the construction of knowledge*. Ithaca, NY: Cornell University Press.
- Coffey, A. & Atkinson, P. (1996) *Making sense of qualitative data*. Thousand Oaks, CA: Sage.
- Coffey, A., & Delamont, S. (2000). *Feminism and the classroom teacher: Research, praxis, and pedagogy*. London: Routledge.
- Collins, P. H. (1991). *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*. New York: Routledge.
- Confrey, J. (1994). A theory of intellectual development: Part I. *For the Learning of Mathematics*, 14(3), 2-8.
- Confrey, J. (1995a). A theory of intellectual development: Part II. *For the Learning of Mathematics*, 15(1), 38-48.
- Confrey, J. (1995b). A theory of intellectual development: Part III. *For the Learning of Mathematics*, 15(2), 36-45.
- Confrey, J. (1999). Voice, perspective, bias and stance: Applying and modifying Piagetian theory in mathematics education. In L. Burton (Ed.), *Learning mathematics: From hierarchies to networks* (pp. 3-20). London: Falmer Press.
- Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.
- Damarin, S. K. (1990). Teaching mathematics: A feminist perspective. In T. J. Cooney & C. R. Hirsch (Eds.), *Teaching and learning mathematics in the 1990's*. 1990 Yearbook of the National Council of Teachers of Mathematics (pp. 144-151). Reston, VA: National Council of Teachers of Mathematics.
- Damarin, S. K. (1995). Gender and mathematics from a feminist standpoint. In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 242-257). New York: Cambridge University Press.
- Eisenhart, M. A. (1991, October 16-19). *Conceptual frameworks for research circa 1991: Ideas from a cultural anthropologist; Implications for mathematics education researchers*. Paper presented at the meeting of the North America Psychology of Mathematics Education, Blacksburg, VA.
- Ekeblad, E. (2001). Book Review of *Radical In<ter>ventions: Identity, Politics, and Difference/s in Educational Praxis*. In *Mind, Culture, and Activity*, 8(2), 200-204.

- Erchick, D. B. (1996). Women's voices and the experience of mathematics. *Focus on Learning Problems in Mathematics*, 18(1-3), 105-122.
- Erchick, D. B. (2001). Developing mathematical voice: Women reflecting on the adolescent years. In P. O'Reilly & E. Penn & K. deMarrais (Eds.), *Educating young adolescent girls* (pp. 149-170). Mahwah, NJ: Lawrence Erlbaum.
- Ernest, P. (1991). *The philosophy of mathematics education*. London: Falmer Press.
- Ernest, P. (1995). Values, gender, and images of mathematics: A philosophical perspective. *International Journal of Mathematics Education, Science, and Technology*, 26(3), 449-462.
- Fennema, E. (1995). Mathematics, gender, and research. In B. Grevholm & G. Hanna (Eds.), *Gender and mathematics education: An ICMI study* (pp. 21-38). Lund, Sweden: Lund University Press.
- Fennema, E. (1996). Mathematics, gender, and research. In G. Hanna (Ed.), *Towards gender equity in mathematics education* (pp. 9-26). Dordrecht: Kluwer.
- Fennema, E., & Hart, L. (1994). Gender and the JRME. *Journal for Research in Mathematics Education*, 25(6), 648-659.
- Fisher, B. M. (2001). *No angel in the classroom: Teaching through feminist discourse*. Lanham, MD: Rowman and Littlefield.
- Flax, J. (1983). Political philosophy and the patriarchal unconscious: A psychoanalytic perspective on epistemology and metaphysics. In S. Harding & M. B. Hintikka (Eds.), *Discovering reality: Feminist perspectives on epistemology, metaphysics, methodology, and philosophy of science* (pp. 245-281). Dordrecht: D. Reidel.
- Freeman, D. (1996). "To take them at their word": Language data in the study of teachers' knowledge. *Harvard Educational Review*, 66(4), 732-761.
- Frye, M. (1996). The possibility of feminist theory. In A. Garry & M. Pearsall (Eds.), *Women, knowledge, and reality: Explorations of feminist philosophy* (2nd ed., pp. 34-47). New York: Routledge.
- Fuss, D. (1989). *Essentially speaking: Feminism, nature, and difference*. New York: Routledge.
- Gibson, H. (1994). "Math is like a used car": Metaphors reveal attitudes toward mathematics. In D. Buerk (Ed.), *Empowering students by promoting active learning in mathematics: Teachers speak to teachers* (pp. 7-12). Reston, VA: National Council of Teachers of Mathematics.
- Goetz, J., & LeCompte, M. (1984). *Ethnography and qualitative design in educational research*. Orlando, FL: Academic Press, 1984.
- Harding, S. (1987). *Feminism and methodology*. Bloomington: Indiana University Press.
- Harding, S. (1991). *Whose science? Whose knowledge?: Thinking from women's lives*. Ithaca, NY: Cornell University Press.
- Hartsock, N. (1983). The feminist standpoint: Developing the ground for a specifically feminist historical materialism. In S. Harding & M. B. Hintikka (Eds.), *Discovering reality: Feminist perspectives on epistemology, metaphysics, methodology, and philosophy of science* (pp. 283-310). Dordrecht: D. Reidel.
- Hartsock, N. (1998). *The feminist standpoint revisited and other essays*. Boulder, CO: Westview.
- Hooks, b. (1994). *Teaching to transgress: Education as the practice of freedom*. New York: Routledge.

- Hooks, b. (1996). Choosing the margin as a space of radical openness. In A. Garry & M. Pearsall (Eds.), *Women, knowledge, and reality: Explorations in feminist philosophy* (2nd ed., pp. 48-55). New York: Routledge.
- Kimmel, E. (1999). Feminist teaching: An emergent practice. In S. N. Davis, M. Crawford, & J. Sebrechts (Eds.), *Coming into her own: Educational success in girls and women* (pp. 57-76). San Francisco: Jossey-Bass.
- Kitzinger, J., & Barbour, R. S. (1999). Introduction: The challenge and promise of focus groups. In J. Kitzinger & R. S. Barbour (Eds.), *Developing focus group research: Politics, theory, and practice* (pp. 1-20). London: Sage.
- Koch, L. C. (1996). The development of voice in the mathematics classroom. *Focus on Learning Problems in Mathematics*, 18(1-3), 164-175.
- Latané, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology*, 37, 822-832.
- Lather, P. (1991). *Getting smart: Feminist research and pedagogy with/in the postmodern*. New York: Routledge.
- LeCompte, M. D., & Preissle, J. (1993). *Ethnography and qualitative design in educational research* (2nd ed.). San Diego: Academic Press.
- Leder, G. C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 597-622). New York: Macmillan.
- Leder, G. C., Forgasz, H. J., & Solar, C. (1996). Research and intervention programs in mathematics education: A gendered issue. In A. J. Bishop (Ed.), *International handbook of mathematics education* (pp. 945-985). Dordrecht, Netherlands: Kluwer.
- Lorde, A. (1984). *Sister outsider: Essays and speeches by Audre Lorde*. Freedom, CA: Crossing Press.
- Maher, F. A., & Tetreault, M. K. (1994). *The feminist classroom: An inside look at how professors and students are transforming higher education for a diverse society*. New York: Basic Books.
- Merriam, S. B. (1988). *Case study research in education: A qualitative approach*. San Francisco: Jossey-Bass.
- Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.
- Morrow, C. (1996). Women and mathematics: Avenues of connection. *Focus on Learning Problems in Mathematics*, 18(1, 2 & 3), 4-18.
- Mura, R. (1995). Feminism and strategies for redressing gender imbalance in mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 155-162). London: Falmer Press.
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.
- National Research Council. (2001). *Adding it up: Helping children learn mathematics*. J. Kilpatrick, J. Swafford, B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.
- NUD*IST (Version N5) [Computer software]. (2000). Bundoora, Victoria, Australia: QSR International.

- Pasztor, A., & Slater, J. J. (2000). *Acts of Alignment: Of women in math and science and all of us who search for balance*. New York: Peter Lang Publishing.
- Piercy, M. (1999). *The moon is always female*. New York: Alfred A. Knopf.
- Reinharz, S. (1992). *Feminist methods in social research*. New York: Oxford University Press.
- Richardson, L. (2000). Writing: A method of inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 923-948). Thousand Oaks, CA: Sage.
- Rogers, P. (1995). Putting theory into practice. In P. Rogers & G. Kaiser (Eds.), *Equity in mathematics education: Influences of feminism and culture* (pp. 175-185). London: Falmer Press.
- Rogers, P., & Kaiser, G. (Eds.). (1995). *Equity in mathematics education: Influences of feminism and culture*. London: Falmer Press.
- Rose, H. (1983). Hand, brain, and heart: A feminist epistemology for the natural sciences. *Signs: Journal of Women in Culture and Society*, 9(1), 73-90.
- Secada, W. G. (1995). Social and critical dimensions for equity in mathematics education. In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 146-164). Cambridge: Cambridge University Press.
- Shrewsbury, C. M. (1987). What is feminist pedagogy? *Women's Studies Quarterly*, 15(3 & 4), 6-14.
- Smith, D. (1988). *The everyday world as problematic: A feminist sociology*. Boston: Northeastern University Press.
- Solar, C. (1995). An inclusive pedagogy in mathematics education. *Educational Studies in Mathematics Education*, 28, 311-333.
- St. Pierre, E. A. (1997). Methodology in the fold and the irruption of transgressive data. *Qualitative studies in education*, 10(2), 175-189.
- St. Pierre, E. A. (2000). Poststructural feminism in education: An overview. *Qualitative Studies in Education*, 13(5), 477-515.
- SummerMath. (n.d.). Retrieved April 10, 2001 from <http://www.mtholyoke.edu/proj/summermath/>
- Tanesini, A. (1999). *An introduction to feminist epistemologies*. Malden, MA: Blackwell.
- Tate, W. F. (1997). Race-ethnicity, SES, gender, and language proficiency trends in mathematics achievement: An update. *Journal for Research in Mathematics Education*, 28(6), 652-679.
- VanMaanen, J. (1988). *Tales of the field: On writing ethnography*. Chicago: University of Chicago Press.
- Walden, R., & Walkerdine, V. (1985). *Girls and mathematics: From primary to secondary schooling*. London: University of London Institute of Education.
- Walkerdine, V. (1998). *Counting girls out: Girls and mathematics*. London: Falmer Press.
- Walshaw, M. (2001). A Foucauldian gaze on gender research: What do you do when confronted with the tunnel at the end of light? *Journal for Research in Mathematics Education*, 32(5), 471-492.
- Weiler, K. (1988). *Women teaching for change: Gender, class, and power*. Westport, CT: Bergin & Garvey.

- Weiler, K. (1994). Freire and a feminist pedagogy of difference. In P. L. McLaren & C. Lankshear (Eds.), *Politics of liberation: Paths from Freire* (pp. 12-40). London: Routledge.
- Weiner, G. (1994). *Feminisms in education: An introduction*. Buckingham: Open University Press.
- Whimbey, A., & Lochhead, J. (1980). *Problem solving and comprehension*. Philadelphia, PA: Franklin Institute Press.
- Wilkinson, S. (1999). How useful are focus groups in feminist research? In J. Kitzinger & R. S. Barbour (Eds.), *Developing focus group research: Politics, theory, and practice* (pp. 64-78). London: Sage.
- Wolcott, H. F. (1992). Posturing in qualitative inquiry. In M. D. LeCompte, W. L. Millroy, & J. Preissle (Eds.), *The handbook of qualitative research in education* (pp. 3-52). San Diego, CA: Academic Press.
- Wolcott, H. F. (1994). *Transforming qualitative data: Description, analysis, and interpretation*. Thousand Oaks, CA: Sage.
- Wolcott, H. F. (1999). *Ethnography: A way of seeing*. Walnut Creek, CA: AltaMira Press.

APPENDICES

APPENDIX A

EXAMPLES OF FMC MATHEMATICS PROBLEMS

Example 1:

In order to consider what is characteristic about quadratic functions, explore the following problem.

- a. If a pizza with a 12" radius costs \$4.80, can you predict how much a 16" pizza should cost? SHOW WORK.
- b. How much should an 8" pizza cost?
- c. Draw a picture to scale of the three pizzas and label them by their predicted costs. Do your predictions seem reasonable?
- d. Can you write an equation which predicts cost from the radius?

Example 2:

- A. At a certain bakery, five apple pies are sold for every four cheesecakes sold.

Let x = the number of cheesecakes sold

Let y = the number of pies sold

Make a data table, draw a graph, and write a mathematical equation that expresses the relationship between the number of cheesecakes sold and the number of pies sold.

- B. Assume that at the beginning of each day the bakery sells 500 pies (but no cheesecakes) to the grocery store down the street. After that, five pies are sold for every four cheesecakes sold.

Write a mathematical equation that expresses the relationship between pies and cheesecakes that are sold, draw a graph, and make a data table.

- C. What are the slopes and y-intercepts of the graphs in parts A and B?

APPENDIX B

DAILY SCHEDULE FOR DATA COLLECTION

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
June 24 D Examine SM applications PO staff preparation	June 25 D Examine SM applications PO staff preparation	June 26 D Examine SM applications PO staff preparation	June 27 D Examine SM applications PO staff preparation	June 28 D Examine SM applications PO staff preparation	June 29 D Examine SM applications PO staff preparation	June 30 D Examine SM applications PO staff preparation
July 1-Day 1 Meet participants Participant initial selection	July 2-Day 2 Participant final selection PO FMC PO SuperLogo PO Daily	July 3-Day 3 PO FMC PO SuperLogo PO Daily I 1	July 4-Day 4 PO FMC PO SuperLogo PO Daily I 1	July 5-Day 5 PO FMC PO SuperLogo PO Daily I 1	July 6-Day 6 PO FMC PO SuperLogo PO Daily	July 7-Day 7
July 8-Day 8	July 9-Day 9 PO FMC PO SuperLogo PO Daily FG 1	July 10-Day 10 PO FMC PO SuperLogo PO Daily	July 11-Day 11 PO FMC PO SuperLogo PO Daily	July 12-Day 12 PO FMC PO SuperLogo PO Daily	July 13-Day 13 PO FMC PO SuperLogo PO Daily I 2	July 14-Day 14 PO Daily
July 15-Day 15	July 16-Day 16 PO FMC PO SuperLogo PO Daily I 2	July 17-Day 17 PO FMC PO SuperLogo PO Daily I 2	July 18-Day 18 PO FMC PO SuperLogo PO Daily	July 19-Day 19 PO FMC PO SuperLogo PO Daily	July 20-Day 20 PO FMC PO SuperLogo PO Daily	July 21-Day 21
July 22-Day 22	July 23-Day 23 PO FMC PO SuperLogo PO Daily FG 2 Mathematics Metaphor Activity	July 24-Day 24 PO FMC PO SuperLogo PO Daily	July 25-Day 25 PO FMC PO SuperLogo PO Daily	July 26-Day 26 PO FMC PO SuperLogo PO Daily I 3	July 27-Day 27 PO FMC PO SuperLogo PO Daily I 3	July 28-Day 28

Key:

Participant observation (PO), Individual Interview (I), Focus Group (FG), Document (D)

APPENDIX C

INDIVIDUAL INTERVIEW 1 PROMPTS

Introduce myself. Explain purpose of study. Discuss their role in the research. Ask for their consent. Ask participants to create their own pseudonym.

1. Can you tell me about yourself, such as where you are from, what grade you are in, how old you are? What is your race/ethnicity?
2. When you think of mathematics, what is the first thing that comes to mind? Tell me about that. What do you think is important about mathematics?
3. Tell me what it is like to take mathematics classes at your high school.
4. Do you think that SummerMath will be different from your high school mathematics classes that you are used to taking? If so, how?
5. What attracted you to come to SummerMath?
6. Did you have any concerns about coming to SummerMath? If yes, can you tell me about these concerns?
7. What are your expectations of coming to SummerMath?
8. Which FMC class are you taking? How did you make that choice?
9. Imagine a movie made about you learning mathematics. If a stranger rented this movie, what would she or he say about you learning mathematics?
10. If you could go back in time and capture a memorable experience that you have had in mathematics on videotape, what would it be? Why does this experience stand out for you?
11. If you had to find an ideal learner of mathematics to videotape, what would she or he be like? To what extent are you like that?
12. Pretend we have a crystal ball that looks into the future. What do you see yourself doing over the next 10 years?
13. What do you like about the mathematics classes at SummerMath so far?
14. What do you dislike about the mathematics classes at SummerMath so far?

15. Thinking back over the first few days here in the mathematics classes at SummerMath, what stands out for you? Tell me about that in more detail.
16. What has surprised you about the mathematics classes at SummerMath?
17. What feelings do you have when you are learning mathematics here at SummerMath?

APPENDIX D

INDIVIDUAL INTERVIEW 2 PROMPTS

1. Pretend that a famous director has been making a movie about you and your experiences in the mathematics classes at SummerMath. Halfway through production, the director stopped filming to allow you to review the contents of the movie and to make a few observations.
 - What would you notice about how you are learning mathematics while at SummerMath?
 - What would you notice about how you do mathematics?
 - What would you want the viewer to know about mathematics?
 - What would you notice about you?
 - What would you notice about you and your partner?
 - What would be your favorite scene in the movie? What does this scene say about you as a learner of mathematics?
 - What scene would you like to cut from the movie?
2. How does what you are doing here in the mathematics classes at SummerMath compare with your high school mathematics classes back home?
3. Does mathematics seem different to you now that you are half-way through SummerMath? Explain.
4. Have you gained any insights about how think of yourself as a learner of mathematics by participating in the mathematics classes at SummerMath? If so, explain.
5. Have you gained any insights about what you think of mathematics by participating in the mathematics classes at SummerMath? If so, explain.
6. What do you see as the teacher's role in the mathematics classes at SummerMath?
7. What has been the most valuable part of the mathematics classes at SummerMath?
8. What impact has the classes at SummerMath had on your confidence level in mathematics? Explain.

APPENDIX E

INDIVIDUAL INTERVIEW 3 PROMPTS

1. Your best friend calls you on the phone the day that you get back home after attending SummerMath. She asks you all sorts of questions about your experiences at SummerMath.
 - What would you say if you had to describe your experiences in the mathematics classes here at SummerMath to your best friend?
 - At the end of the conversation, your best friend asks you for help in choosing something to do next summer. How would you help a friend decide whether or not to go to SummerMath?
2. Remember the movie that was being made about you and your experiences in the mathematics classes at SummerMath. The filming of the movie has just finished. The director gives you a copy of the movie to watch. She wants you to provide a review. Here is your chance to make comments and suggestions. You are excited to watch the movie in its entirety. So, you watch the movie made about you and your experiences in the mathematics classes at SummerMath.
 - What scenes stand out for you?
 - What scenes would you cut?
 - What would you say about how you learn mathematics?
 - What would you want the viewer to know about mathematics?
 - What would you say about you?
 - What would you say about you working in a group or with a partner?
 - Would you notice any changes in how you think about yourself as a learner of mathematics? Explain.
 - Would you notice any changes in how you think about mathematics? Explain.
 - Would you notice any changes in you over the course of the movie?
3. Looking back over the past four weeks, what have you enjoyed about the mathematics classes at SummerMath?
4. Looking back over the past four weeks, what bothered you about the mathematics classes at SummerMath?
5. Has coming to SummerMath had an impact on your future career goals? Explain.
6. Has coming to SummerMath had an impact on your confidence level in mathematics? Explain.

7. What did you learn about yourself as a learner of mathematics?
8. What do you know about yourself in terms of learning mathematics that you did not know at the beginning of SummerMath? Explain.
9. You came to SummerMath with certain expectations about yourself and learning mathematics. Have your expectations been met? Explain.
10. Over the course of the next year, I will be writing a story about you and your experiences in the mathematics classes at SummerMath. What story would you like me to write about you and your experiences in the mathematics classes at SummerMath?
11. Ask questions related to observations of individual participants.

APPENDIX F

FOCUS GROUP INTERVIEW 1 PROMPTS

At the beginning of the interview, I will introduce myself; provide a rationale for the focus group interview; discuss group confidentiality issue and how it will be maintained, and give one index card to each participant.

1. On one side of an index card, write a response to the following statements:
 - Describe the features of the mathematics classes at SummerMath which help you learn mathematics. Be prepared to explain your responses to the group.
 - Describe the features of the mathematics classes at SummerMath which interfere with you learning mathematics. Be prepared to explain your responses to the group.
2. On the opposite side of the index card, describe your feelings associated with learning mathematics here at SummerMath. Be prepared to explain your responses to the group.
3. Have you gained any insights about how think of yourself as a learner of mathematics by participating in the mathematics classes at SummerMath? If so, explain.
4. Have you gained any insights about what you think of mathematics by participating in the mathematics classes at SummerMath? If so, explain. In other words, do you see mathematics differently now that you are here?

APPENDIX G

FOCUS GROUP INTERVIEW 2 PROMPTS

1. On your own index card, write a response to the following question:

What are the most important features of the mathematics classes at SummerMath? Be prepared to explain your response to the group.

2. Looking back over the past three weeks of being in the mathematics classes at SummerMath, what experiences stand out? Explain.
3. What have you learned about yourself as a learner of mathematics by being in the mathematics classes at SummerMath? Explain.
4. Can you talk about what you thought about learning in an all girls' mathematics class?

APPENDIX H

Mathematics Metaphor Activity

Part 1

Pretend that you have to describe what you think of mathematics in FMC and LOGO to someone. List all the words or phrases you can think of. Spend about five minutes on this part.

Part 2

Imagine you doing mathematics in FMC and LOGO. What does doing mathematics feel like in these mathematics classes? List all the words or phrases you would use to describe what doing mathematics feels like in FMC and LOGO. Spend about five minutes on this part.

Part 3

Think about the things that mathematics in FMC and LOGO is like. List all the things or objects that you think mathematics is like in FMC and LOGO. List each object you choose on a separate line on your paper. Spend about five minutes on this part.

Let me suggest some categories that you might want to think about to extend the list of things that you think mathematics is most like in FMC and LOGO. It is not necessary that you answer each of these questions. These questions are only suggestions and are designed to help guide your thinking.

- If mathematics in FMC and LOGO were weather, what kind of weather would it be?
- If mathematics in FMC and LOGO were a food, what food would it be?
- If mathematics in FMC and LOGO were a food, how would you eat it?
- If mathematics in FMC and LOGO were something you can do in your free time, what free-time activity would it be?
- If mathematics in FMC and LOGO were a way to travel, what means of travel would it be?
- If mathematics in FMC and LOGO were a color, what color would it be?
- If mathematics in FMC and LOGO were a way to communicate, what form would it take?
- If mathematics in FMC and LOGO were an animal, what animal would it be?
- If mathematics in FMC and LOGO were a building, what kind of building would it be?
- If mathematics in FMC and LOGO were a plant, what kind of plant would it be?
- If mathematics in FMC and LOGO were music, what kind of music would it be?

Now go back over your list of things that mathematics is like in FMC and LOGO and comment briefly or reflect on why each thing is like mathematics in those classes for you.

Part 4

- A. Read over your three lists that you created in Parts 1, 2, and 3 thinking about what you are saying about mathematics in FMC and LOGO.
- B. Choose the object on your list from Part 3 that best fits what you think about mathematics in FMC and LOGO. Think about the ways that mathematics and this object are alike for you.
- C. Write a paragraph(s) beginning with "For me, mathematics in FMC and LOGO is most like a(n) _____." In that paragraph discuss the ways in which your object and mathematics are similar.

For me, mathematics in FMC and LOGO is most like a(n)...