A Portrait of a Feminist Mathematics Classroom: What Adolescent Girls Say About Mathematics, Themselves, and Their Experiences in a "Unique" Learning Environment

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A Foundation for Inquiry: Rationale and 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 123)

Boaler 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" (110–24). Boaler contends that the traditional way that mathematics is taught enhances boys' learning experiences in mathematics and hinders those of girls. She argues 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. Applying feminist pedagogy, a type of progressive and/or liberatory pedagogy, to the teaching and learning of mathematics is a relatively new idea with little supporting research.

In light of Boaler's findings and this void in the research, 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. To that end, 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.

A Context for Inquiry: Establishing Theoretical and Conceptual Frameworks

The literature on feminist standpoint theory and how it can be applied to mathematics education (Damarin) formed the *theoretical* framework for the study. 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. At the heart of a 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 and Hart 655). A feminist standpoint in mathematics education accepts that the multiple identities of our students aid in the ways they come to know and learn mathematics; recognizes the importance of a mode of knowledge acquisition that values both

teacher and student as learners; fosters agency—the process through which a learner acts on her or his behalf; promotes the development of authorship/mathematical voice—what mathematical knowledge is valued and the process through which this valuing takes place; and posits that knowing in mathematics must be viewed in terms of "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" (Burton, "Moving" 220–21).

I strategically deployed *essentialism* (Fuss) to form a collective frame in 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.

The literature on feminist pedagogy and how it can be applied to mathematics education provided the *conceptual* framework for the study. 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 the feminist mathematics classroom, one sees a classroom in which teachers honor students' voices and experiences, build their curriculum and lessons around the mathematical knowledge that each student brings to the classroom, expect students to construct their own knowledge and to be responsible for their own learning, value intuition—that is, the process through which a learner takes risks to follow leads in mathematical exploration—and find ways to validate students' mathematical knowledge. Students play with their mathematical ideas, take risks, spend time in cooperative learning groups, and value one another as doers of mathematics. Students and teachers alike challenge the received notion of mathematics as purely objective, value- and culture-free. Multiple perspectives on mathematics are accepted.

The notion of mathematical voice (authorship) is pertinent to a feminist perspective on learning mathematics. Erchick defines *mathematical voice* as

> "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" (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" (Charlene Morrow, personal communication, April 12, 2001). This notion of voice also leaves room for silence in the classroom. Students 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.

I also used Solar's Model of Inclusive Pedagogy in Mathematics Education and Morrow's Model of Connected Teaching in Mathematics as frameworks for understanding and analyzing what I saw in a feminist mathematics classroom.

A Methodological Approach for Inquiry: Case Study

SUMMERMATH: REFORM IN A FEMINIST FRAMEWORK

Overview Using a case study design, I conducted this study from 24 June through 28 July 2001, at SummerMath, an intensive, four-week, summer mathematics program for high school girls. In 2001, fifty-eight eighth- through eleventh-grade girls from various mathematical, geographic, racial, and socioeconomic backgrounds participated in the program. Entrance into the program was neither competitive nor based on mathematical achievement. Girls attended SummerMath because of interest in mathematics, desire to increase confidence or ability in mathematics, encouragement from teachers, and parental pressure. SummerMath took place on the campus of Mount Holyoke College, which provided partial funding of the program and use of the campus facilities. Since 1982, SummerMath has provided an alternative learning community in which adolescent girls can experience and learn mathematics and computing in an environment that promotes collaboration, connection, problem posing, and problem solving.

The twin pillars of SummerMath are constructivism and feminist pedagogy. These two ideologies guide the structure and program. Girls learn mathematics in a classroom where 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). The SummerMath co-directors, Charlene (Char) and Jim Morrow, and teachers 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 SummerMath.

I chose SummerMath as the research site 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 Morrow, who provided me access to the program.

Staff Preparation For the past eighteen summers, Char and Jim have integrated their respective disciplines—clinical psychology and mathematics—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 numerous staff members, including two co-directors, 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.

Prior to the girls' arrival, staff members participated in a weeklong series of activities designed to prepare them for their responsibilities. Staff members engaged in mathematical and computer activities, explored constructivist and feminist principles of teaching and learning mathematics, prepared for their particular responsibilities, discussed equity issues relevant to teaching, and examined their own beliefs about these critical issues.

Curriculum. 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 Mathematics Concepts (FMC), Computer Programming (SuperLogo), and Workshops.

Fundamental Mathematics Concepts. FMC was the "heart" of SummerMath. For ninety 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 twelve to sixteen girls. In the midst of students solving mathematical problems on the board, at their desks, or on the floor, the teacher and assistants circulated around the room offering encouragement and guidance.

Each girl chose one of four FMC classes, each of which centered on a specific mathematical topic: 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 for examples of the problems) using the *pair problem-solving method* developed by Whimbey and Lochhead. 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 continued to use 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 teachers' 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. During the first three days, the teachers observed students, making notes regarding the groups who seemed to work well and ensuring that students were matched according to ability and working pace. Adjustments to the group formations were made in the first week.

For the first fifteen 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 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 mathematical concepts using the computer in order to confront and alleviate any anxiety or fear attached to computer use. For ninety 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. While the students used Logo, two teachers and two teaching assistants circulated around the classroom and assisted the students with the computers. The teachers' roles that applied in FMC also held true in the SuperLogo class.

Workshops. Along with FMC and SuperLogo, the girls participated in two, two-week workshops. 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. Workshop topics included: Introduction to Economics, Biology, Origami, Art of Making Anatomical Comparisons, Architecture and Mathematics, Statistics, and Robotics.

An additional workshop on confidence building was available for those girls who perceived themselves as having little confidence in mathematics and identified mathematics as a source of extreme anxiety. This workshop focused on helping them explore ways to become more confident in mathematics. For example, the girls examined their mathematical histories, how those histories were shaped, and explored their feelings and beliefs about mathematics. The workshop participants learned strategies for confidence building and maximizing their learning in mathematics, and explored anxiety issues in learning mathematics. The workshop functioned as a support group for "mathematically abused" students who perceived their experiences in mathematics as emotionally and physically disabling.[1]

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. The girls engaged in various activities outside of the mathematics and computer classes such as social events, workshops, and speaker presentations, all with a focus on empowering adolescent girls. The purpose of the residential program was to build a safe and trusting community where each girl felt accepted, nurtured, and empowered.

A Typical Day at SummerMath. From 1 July through 28 July, the girls followed a weekday schedule as summarized in Table 1. The weekends were set aside for the girls to take Saturday field trips, explore the local area and campus, and participate in independent leisure activities.

Table 1. SummerMath Weekday Schedule

Time	Activity
7:30–8:30 a.m.	Breakfast
8:30–10:00 a.m.	Fundamental Mathematics Concepts
10:00–10:15 a.m.	Break
10:15–11:45 a.m.	SuperLogo
11:45 a.m.–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

I selected participants using a criterion-based sampling approach (Goetz and LeCompte). I selected seven girls who varied in race and ethnicity, geographic location of home, scholarship status, age, confidence in mathematics, choice of FMC class, and level of sociability. Table 2 provides a succinct summary of the characterization of the diverse participants. It also provides the reader with a straightforward reference to the participants' background.

A brief character sketch of each participant highlights 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. Her leadership abilities were particularly admirable.

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 lifelong 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 herself 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

Table 2. 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

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 guarded in her responses and was cautious in how much she revealed about herself. 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. I admired her honesty and her willingness to share her life story with me. Sarah gave much credit to her mother 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 spoke 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 of the people around her.

DATA COLLECTION AND ANALYSIS

For four weeks, Monday through Friday, I observed the participants in their FMC class. I collected participant observation data for nineteen days, which totaled nineteen, ninety-minute classroom observations. I interviewed the seven participants individually at the beginning of SummerMath, during the second or third week of the program, and at the end of SummerMath. The purpose of these three individual interviews was to explore the participants' perceptions of their experiences, their perceptions of mathematics, and their perceptions of themselves as learners of mathematics at that particular time in FMC. I also conducted two focus group interviews one-quarter and three-quarters of the way through the program. The purpose of the 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. I collected data from the participants' SummerMath applications, which contained relevant biographical and demographic information, an essay about a significant experience in mathematics, and information on the participants' confidence level in mathematics. I also collected data from the participants' daily journals for FMC. Lastly, the participants completed the Mathematics Metaphor Activity, which provided data about their perceptions of mathematics in FMC.

I analyzed the data using a thematic analysis (Bogdan and Biklen; Coffey and Atkinson).

RESEARCHER ROLE(S)

During my observations of FMC, my role was that of an observer, which meant that I gathered field notes by strictly observing. The participants were aware of my presence in the FMC, but I did not interact with the participants during those classes.

In the activities outside of FMC and SuperLogo, my role as a researcher was that of a participant, which meant that I made observations while I participated in various activities. 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. I 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. My daily presence also established rapport between the participants and me.

During the first two weeks of SummerMath, I participated as a student in the origami workshop. For ten days, I learned how to 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 students without a field notebook or laptop. Making the switch from observer to participant translated to a higher degree of researcher involvement and allowed for more interaction with students. I worked side by side with students, asking for their insight on a particular origami project. This interaction helped forge a more positive relationship with students.

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.

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,* I participated in the meetings by providing input and sharing ideas. No longer was I strictly an observer; instead, I was an active participant. 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. All in all, I think this study is stronger and better informed because I had to move between the roles of observer and participant as I taught the Confidence Building Workshop. This teaching experience forced me to examine my role as researcher in ways that I might not have had to otherwise.

A Portrait of a Feminist Mathematics Classroom

What follows is a collective portrait[4] of the participants' perceptions of their experiences in a feminist mathematics class. These reflections provide a look back over the previous month in FMC and highlight some of the struggles and triumphs that the participants experienced.

LOOKING BACK ON A "UNIQUE EXPERIENCE"—A CLOSING PORTRAIT OF FMC

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 just keep coming back to this, but 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 had no time limits. 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. The teachers give you the chance to think about what you have done already. I am learning math by remembering or relating what my problem is to what I have done before. If you don't understand something they 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."

Over the last four weeks, I wanted to give up more than anything. If I had been given the chance, I would have. Above all, 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.

Looking back over the past month, 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 always felt like the problems were meant for kids our age and they were solvable. It was challenging, not impossible. I know I learned so much. It was definitely worth it.

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. I know I can do better in math. By coming here, I know that I am capable of learning mathematics by myself. I know that with the things I know already, I can learn and do more things for 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 now not afraid to ask for help. I know that the teachers are supposed to help me. If I need help I should ask for help. 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.

Looking back over the past month, if I had to describe my experience in FMC, I would probably say it was unique. Even though I got frustrated a lot, I really enjoyed it here. It has given me so many different ways to look at how to figure things out. It has also given me a level of confi-

dence 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.

Learning from the Voices of Adolescent Girls in a Feminist Mathematics Classroom

The voices of Angela, Hannah, Julie, Rachel, Samantha, Sarah, and Virginia shed light on the complexities of teaching and learning in a feminist mathematics classroom. The participants' voices teach mathematics educators eight lessons about learning in a feminist mathematics classroom.

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 that 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 bell hooks has stated, "The classroom should be a space where we're all in power in different ways" (152).

Although 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, as well as the hierarchical structures within schools and how these structures maintain, reproduce, or alter social inequities). This is an issue that seems to be missing in the discourse on 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 meeting the needs of a diverse group of mathematics learners 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 in order 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. Students "no longer remain outside, but become part of the inner circle of knowers, with their own power base" (Morrow 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 contends, "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" (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 expressed the frustrations and struggles that came with the authorship role. Several participants spoke of giving up because they were tired of grappling with problems. By the end of FMC, all the participants claimed that they would neither want to eliminate the struggling nor want to be rescued from the discomfort that came with it. Instead, they ultimately viewed it 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 its value. We need to learn how to help students address anxiety and frustration and to cultivate persistence.

Burton (1999) contends 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 asserts:

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. (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. (32)

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 writes, "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" (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 mathematics teachers 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 in partnerships. The participants perceived that partnerships gave them opportunities to exchange ideas and test conjectures, to depend on themselves for confirmation as learners 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 and mathematical ability. Vast differences in these two factors 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, and Harkins), 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 fostering the intellectual involvement of all group members.

Virginia's case illustrates the complex nature of collaboration in a feminist mathematics classroom. Because Virginia was the youngest student, she had not taken a first course in algebra, unlike her peers. Even though Virginia entered SummerMath with a relatively high confidence level in mathematics, when she was placed in a group with her peers who had already completed a full year of algebra, her confidence level plummeted because she realized that she was at a comparative disadvantage. Thus 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 10 July, I spoke with Lourdes, the FMC teacher, about how she reconciled the issue of Virginia working alone. Lourdes responded by acknowledging this apparent contradiction. She noted that she considered the whole class when she made this decision. She thought that if Virginia worked in a partnership, 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 best suited to 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 Virginia 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 of FMC and Lourdes's 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? It seems feasible that students would learn a depth of mathematics in a feminist classroom, given its emphasis on conceptual understanding and problem solving. Yet additional research is needed to investigate the relationship between students' mathematical achievement on standardized tests and their participation in a feminist mathematics classroom.

Sarah's thought on this topic provide a response to the previous question. 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 implement a feminist approach to learning mathematics in their regular classrooms. Hannah, however, suggested that a "mix" of pedagogies might work in her school. If a feminist mathematics classroom is allowed to flourish, the current focus on standardized testing in education must be reconsidered. At this time, teachers are preparing students to take tests rather than encouraging them to learn more about particular topics.

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) suggests, 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, Clinchy, Goldberger, and Tarule). 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 that 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 FMC's challenges to the participants' ways of knowing and doing mathematics. Participants 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, "The Implications of a Narrative Approach" 31). Burton suggests 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" (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. Participants 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" (21).

The participants saw that the mathematics problems they were solving typically had more than one way to arrive at an answer, and sometimes 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) proposes, "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" (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" (220–21). 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 the 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 on to 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.

I also wondered to what extent their return to the traditional 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 and their own changed views of themselves as learners of mathematics, and to analyze 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 several years after they left SummerMath. This follow-up study could establish the stability of the fragile changes in the participants' perceptions of mathematics and of themselves as learners of mathematics.

Educational Importance of the Study: A Feminist Mathematics Classroom as a Site for Empowerment

> 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 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 persist in the study of mathematics at both the undergraduate and graduate levels.

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). By investigating the experiences of adolescent girls in a feminist mathematics classroom, I had an opportunity to understand the link between how girls perceive 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.

Closing Remarks

As the participants packed up their belongings and said their goodbyes, I sensed that their experiences in FMC left an impression on their identities as learners of mathematics, their perceptions of mathematics, and their assessments 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. Hannah's words 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)

NOTES

1. I was privy to students' perceptions of themselves as mathematically abused because I taught the Confidence Building Workshop. Later in this article, I discuss how I became the teacher of this workshop. I comment on my role as the teacher in this workshop and the implications that this role had on my role as researcher.

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 ten-point scale, where one represented the lowest level of confidence and ten represented the highest level of confidence.

4. The collective portrait is composed entirely of quotes from the participants in the second focus group interview and the third individual interview. Each participant's voice is incorporated into each collective portrait at least once. I created the collective portraits by choosing quotes that reflected common themes.

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APPENDIX

Examples of FMC Mathematics Problems

Example 1:

In order to consider what is characteristic about quadratic functions, explore the following problem.

If a pizza with a 12" radius costs $4.80, can you predict how much a 16" pizza should cost? SHOW WORK.

How much should an 8" pizza cost?

Draw a picture to scale of the three pizzas and label them by their predicted costs. Do your predictions seem reasonable?

Can you write an equation that predicts cost from the radius?

Example 2:

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.

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.

What are the slopes and y-intercepts of the graphs in parts A and B?