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Women in calculus: The effects of a supportive setting

The purpose of this study was to investigate a multi-faceted women's calculus course designed to retain women in advanced mathematics courses. With this research, we wanted to find out, first, in what ways students were influenced by participation in the course and, second, in what ways these influences affected their mathematics learning or willingness to take additional mathematics courses. Findings from this study demonstrate that students formed a supportive group of individuals who valued being in an all women's mathematics class and took on roles that facilitated their success. In regard to learning mathematics, the students developed confidence, became comfortable in asking questions about mathematics, valued mathematics for understanding, and continued to take mathematics in order to open up career possibilities. This article describes the findings through excerpts from student and instructor interviews, student artifacts, participant observation data, and descriptive statistics.[1]

In the past 2 decades, there has been much concern about the difficulties in retaining women in college-level mathematics and science courses. Teaching at a mid-sized university in the nation's heartland, we are well aware of these trends. Statistics for our campus were consistent with national norms; in particular, the percentage of women in mathematics classes drops precipitously after Calculus

I. Ethington (1995) and Tate (1997), among many others, have written about women being outnumbered by men in advanced mathematics courses. Chacon and Soto-Johnson (2003) found that males and females enroll in high school mathematics courses with equal frequency but that women are less likely to enroll in advanced mathematics in college even though women are more likely to enroll in college immediately after graduation. This lack of enrollment in advanced mathematics courses, calculus level and higher, makes it impossible for women to pursue degrees in such fields as mathematics, physical sciences, computer sciences, or engineering (Atweh, Bleicher, & Cooper, 1998).

Because many mathematics courses are prerequisites for technology classes, enrollment in technology courses is also affected. The lack of enrollment in technology has impacted women in the workforce. According to a 2003 report by the Information Technology Association of America, from 1996 to 2002, the percentage of women in the technology workforce fell from 41% to 35%. By comparison, women make up 47% of the overall workforce in the United States. Muller, Stage, and Kinzie (2001) believe that the economic competitiveness of the United States depends on the nation's ability to educate people who are capable of dealing with scientific and technological research and development. Not only is the economic competitiveness of the United States at risk, but also the earning power of individual women. Given the increasingly technological nature of our society and the disproportionately low number of females in science, mathematics, and engineering, the gap between men and women's salaries will continue to widen, and women's standards of living will fall. The purpose of this study was to design and implement a calculus course experience to encourage women to remain in advanced mathematics courses in order to provide more career opportunities.

Theoretical Framework

Women and Learning Mathematics

In their book, *Women as Adult Learners*, Hayes, Flannery, Brooks, Tisdell, and Hugo (2000) suggested why women may not take advanced mathematics courses. They believed that educational practices had not adequately reflected the research on how women learn. For example, Hayes et al. suggested that one way women learn is through the development of "voice." Belenky, Clinchy, Goldberger, and Tarule (1986) first used the metaphor of voice to depict women's points of view in *Women's Ways of Knowing*. But they maintained that voice is more than a person's point of view. For them, the metaphor of voice applies to many aspects of women's experience and development. They found that women repeatedly use the metaphor to depict their intellectual and ethical development and that their development of a sense of voice is related to a sense of mind and self. In the interviews Belenky et al. conducted of 135 women, the women commonly talked about voice—speaking up, really talking to say what they mean, and listening to be heard.

Hayes (2000) contended that there are different meanings or uses of "voice" (p. 79) in connection to women's learning. For instance, the word voice can be used in a literal sense, to signify women's actual speech. Voice as talking can be important for clarifying ideas, asking questions, and enhancing the quality of learning. The word *voice* also can be used in a metaphorical sense to represent the expressions of women's identities. This meaning of the word focuses on how women's identity is reflected in what they say, in the ideas they express, and in the confidence they express in their own thoughts and opinions. In addition, "giving voice" (p. 92) can be important to demonstrating and getting affirmation of one's ideas and abilities and of oneself as a learner. Developing a *voice* is an act of discovery; for women *voice* implies communication and connection with other people.

Women's Ways of Knowing

Belenky et al. (1986) theorized stages of women's cognition or ways of knowing and how these ways connect to voice. Ways of knowing can be thought of as "coherent interpretive frameworks" (p. 9) that people use to give meaning to their learning. One category of women's ways of knowing is procedural knowing. This kind of knower believes reasoning is important, but the reasoning for which she searches is her own. According to Belenky et al. there are two aspects of procedural knowing: separate knowing and connected knowing. For the separate knower, knowledge is predominant; for the connected knower, understanding is predominant. At the heart of separate knowing is critical thinking; a teacher who emphasizes this type of knowing might require a student to construct arguments in which feelings and personal beliefs are excluded. Belenky et al. believed that separate knowing is essentially an adversarial form because students are challenged to prove the validity of an idea. They found in their research that many women disliked being in an argumentative atmosphere and would patiently wait until its end rather than participate.

The other aspect of procedural knowing, connected knowing, is different. Connected knowers have a need to understand the opinions of other people. They learn through making connections and forming relationships. They want to form a relationship between themselves and ideas. Becker (1996) asserted that "[c]onnected knowers focus on the context and other people's knowledge. Authority comes from these shared experiences as opposed to some external power or statute" (p. 20). The connected knower finds it helpful to maintain a group connection where she can grow. Connected knowing works best when members of the group meet over a long period of time and get to know each other well, as a cohort might in a particular course of study. Connected knowers begin with an attitude of trust and an interest in the facts of other people's lives, but they gradually shift the focus to other people's ways of thinking. They hope to understand another person's ideas as they share the experience of learning together.

Connected Knowing and Learning Mathematics

Jacobs and Becker (1997) noted that "[m]athematics has traditionally been taught in a manner more consistent with separate knowing" (p. 108). Becker (1996) explained this tendency more fully: "Given a characterization of separate knowing as embodying logic, deduction and certainty, and connected knowing as embodying intuition, creativity, and induction, we see that mathematics has traditionally been taught to conform more to the former" (p. 20). Learning mathematics has emphasized deductive proof, absolute truth, algorithms, and abstraction. In order to help students who are connected knowers become proficient in these important aspects of mathematical thinking, teachers could begin with "more intuition and experience; conjecture, generalization, and induction; creativity; and context" (Jacobs & Becker, p. 108). Having students learn in a context designed to include experience allows them to build on their intuitive understanding and helps to provide insight into the reasons why the concepts are being studied. Finding applications for mathematical concepts before learning the abstractions also provides reasons to study. Belenky et al. (1986) found evidence that women prefer a more collaborative, less competitive atmosphere in the classroom and achieve more in this type of learning climate because they can interact and build relationships with other people.

Single-Sex Schooling

Mael (1998) reviewed the literature and found some support for the view that females benefit from single-sex schooling, especially in mathematics and science. He hypothesized that women in single-sex classes were likely to experience higher self-esteem and self-confidence. Sadker and Sadker (1986, 1994) discovered in their research that males dominate co-educational classes at all levels. They found that even in universities, professors ask males more questions, challenge them more academically, and are more likely to remember men's names. Their findings agreed with a Harvard College study in which Krupnik (1985) learned that male students spoke most often in discussions in mixed classes; these imbalances were particularly apparent in stereotypically male disciplines, such as mathematics and science. Single-sex classes have been proposed as one solution to the problem of classroom inequity (AAUW, 1992; Bailey, 1993) because they remove females from settings in which they compete unsuccessfully for attention.

Purpose

With the previous findings in mind, we set out to devise a single-sex calculus course experience that was designed around connected learning and provided support structures to enhance participants' confidence and to retain them in higher mathematics courses. The intervention was part of a larger research project exploring ways to increase women's participation in mathematics. Our teaching objectives for the intervention were the following: (a) to provide a comfortable setting in which students could enjoy mathematics and genuinely understand abstract concepts, (b) to offer enrichment problems that were interesting or relevant to the students' experiences, (c) to broaden students' ideas of mathematics and its research, (d) to create a collaborative environment that facilitated interaction among students and between students and the teacher, (e) to help students improve their communication skills for discussing mathematics, (f) to increase understanding of career and academic opportunities in mathematics and related areas, and (g) to address social and cultural issues facing females students in mathematics.

We wanted to learn how students were influenced by participating in a multi-faceted women's calculus course and, second, in what ways these influences affected their mathematics learning or willingness to take additional mathematics courses. To assess our intervention, we performed both quantitative and qualitative data collection and analysis. The most complete picture of the effects of the students' participation in the calculus course, however, came from the qualitative analysis. While we will present some of the quantitative findings, this paper will focus mainly on the qualitative analysis. The qualitative analysis provided powerful insights into the personal experiences that contributed to the women's success in calculus. The paper provides the findings for the first 2 years of the calculus course and enrichment.

Methodology

Structure of the Focused Interest Group

This section explains the structure of the focused interest group as implemented during the grant project. It is similar to the discussion in another article on the project (Steele, Levin, Blecksmith, & Shahverdian, 2005). If the reader is interested, the other article provides an in-depth analysis of the experiences of two of the women in the Calculus I class and also has a detailed discussion of the statistics used here.

The calculus enrichment class at a mid-sized Midwestern university was designed to create a community of students engaged in collaborative problem-solving and other activities (both in class and in a separate support group). The women students in the enrichment section of calculus registered for 6 credit hours in a Focused Interest Group (FIG). The mathematics department provided a 4-hour calculus course and an additional 1-hour problem-solving session. Students also registered for an associated section of UNIV 101, a 1-hour orientation class planned specially around studying for mathematics classes, informing students about the importance of mathematics (and careers in mathematics) to their futures, and providing role models and mentoring. During the 1st of the 2 years of this study, the UNIV 101 class met in the university's women's center. During the 2nd year, the women met in the conference room of the women's studies program. Staff from the mathematics department and the women's studies program provided support for UNIV 101.

The FIG for women in mathematics was publicized extensively before and during registration. In addition to listing the FIG in the university's schedule book, we made program flyers available at orientation and in appropriate offices. College academic advisors were urged to encourage first-year women who planned to take Calculus I to enroll as well. As with regular Calculus I classes, students were required to pass the mathematics placement test at the A level to qualify for admission into the FIG. After many years of analyzing ACT scores, no significant difference had been found in new freshmen Calculus I students' mathematics ACT scores. Because the mathematics department decided that the requirement for admittance to Calculus for new freshmen needed to be more selective, the mathematics placement test had replaced the ACT as the admittance requirement.

For legal reasons, the FIG was open to all students, but, as anticipated, the emphasis on women's issues discouraged males from enrolling. The grant staff was primarily female, offering students role models and experts in the ways women learn. However, because of the limited number of women who teach calculus at the university, a male professor, one of the mathematics department's most valued calculus teachers, was asked to instruct the 4-hour calculus course that was part of the intervention. He showed great interest in the project and contributed greatly to it. The involvement of mathematics education personnel as well ensured that the project's goals were met.

The mathematics education personnel provided the calculus professor with existing research in developing appropriate teaching strategies related to women's ways of knowing based on connected knowing for mathematics. The professor did not lower his standards; in fact, he created a particularly challenging environment. Mathematical concepts were placed in context through problems that connected to students' interests, experiences, and relationships. Such contexts included world population growth, populations of endangered species, disposal of radioactive waste, spread of infectious diseases, and rate of absorption of drugs into the bloodstream. The professor asked and helped students to solve problems rather than lecturing to them on how to solve them. Using an inquiry approach, the professor guided students through a process of creating mathematical concepts for themselves so that mathematics made sense to them. The learning environment was less competitive and more collaborative than in traditional calculus classes. The professor used small groups in order for students to communicate with each other and to clarify or justify their thinking about mathematics. Students worked problems on the board and received feedback from each other as well as the teacher. Alternative forms of assessment, such as journals and self-critiques, were used as well. Finally, students were empowered as learners when they were asked to critique the course at certain important junctures.

In the weekly problem-solving session, the students again worked in collaborative groups to solve more extended problems using in-depth investigations. A doctoral student in mathematics taught this course; she also helped create study groups. The same doctoral student taught UNIV 101, in which she focused on issues particularly pertinent to women and helped to develop a support network. Students learned how to manage their time, read a mathematics book, and organize their study. Notable women, such as a female astronaut, spoke on campus and acted as role models. To learn more about women's achievements in mathematics, students also viewed videos about famous women in the field. Additional enrichment occurred when the women in the FIG read the Tony award-winning play *Proof* and later attended a performance of this work about a woman seeking recognition for her achievements in mathematics. They also went on field trips to a science museum and aquarium. The instructor of the weekly course acted as a mentor to the women, along with the calculus professor, a professor of mathematics education, and the director of the women's studies program. All of these mentors were available if students wanted to talk. In addition to the problem-solving sessions, the students convened for voluntary study meetings led by the doctoral student five times during the semester.

During both years of the FIG, the students requested to stay together in Calculus II. This idea had not been part of the original plan, but the mathematics department arranged for them to register for the same section of Calculus II. In Calculus II, there were other students, both male and female, but the same calculus professor. In the second semester, there were no additional credit hours for enrichment days, but students could meet voluntarily every week with the doctoral student. Most of the registered students came to these voluntary problem-solving sessions. Again, the graduate assistant conducted five study meetings during the semester. The grant staff continued to mentor the students.

The Research Method: Case Study

We used a case study research method (Stake, 1995) to catch the complexity, particularity, and details of the interaction within the FIG and to explore how or whether the FIG benefited the students enrolled. Using a case study methodology helped provide the richness and detail that was needed to understand in what ways students were influenced by participation in the multi-faceted women's calculus course.

Participants

The participants were 32 women, aged 18 to 20, who needed to pass the mathematics placement test at A level to qualify for Calculus I, regardless of their mathematics ACT scores. Twenty-eight of the 32 students were new freshmen, who had no previous college credit hours. The other four students were freshmen who had already taken some college courses. Some had already declared majors, such as mathematics education, physics, or marketing; others remained undecided. Many of the young women were the first members of their families to attend college. One woman was of mixed African American and Hispanic descent, one was Asian-American, one was Hispanic, one was Middle Eastern, and all of the other women were Caucasian.

Data Collection

To enhance the trustworthiness of the research findings, we collected data through interviews, participant observation, and artifact collection throughout the 2 years. We also compiled statistics on student achievement and mathematics course taking. The majority of the qualitative data was gathered through formal and informal interviews. We taped and then transcribed three formal interviews with each student: one at the beginning of Calculus I, one at the end of Calculus I, and one during the Calculus II semester. Each interview lasted about 1 hour. The questioner also kept a journal reflecting on the interview and describing possible future questions. The original interview included the following:

1. Tell me a little bit about your family—parents and siblings.
2. What is your major? Was this your intended major when you started college? If not, why did you change majors?
3. What are your goals? How have your goals been influenced by others? Have they been influenced by peers, parents, or teachers?
4. Do you feel as if you are/have been successful in Calculus I? Elaborate.
5. (If applicable) Do you feel as if you are/have been successful in Calculus II? Elaborate.
6. Do you plan to take another math class later? Which? When? (Why not?)
7. Is/was Calculus I difficult? More or less than you thought?
8. Is/was Calculus II difficult? More or less than you thought?
9. Compare your experiences in Calculus I to your experiences in Calculus II.
10. What has been the most rewarding part of being in the FIG for you? Why?
11. What was/is it like to be in the group?
12. Would you recommend the FIG to other women? Why or why not?
13. Do you tell others that you are taking calculus? What do you say if you tell them you are taking Calculus I or II? What is their response?
14. What have other people said to you about whether you should take mathematics courses?
15. Have you felt that others valued mathematics for women?

In addition, we conducted informal interviews with students during study sessions, enrichment time, and office hours. We also conducted formal interviews with the professor who taught the calculus courses and the doctoral student who led the problem-solving and orientation courses. Our questions included the following:

1. What is your teaching method (balance between lecture and discussion, etc.)?
2. What do you think of the idea of "bonding" with your students?
3. What do you say to others about the experiences with this FIG? What was the most important part of the experience for you?
4. Would you recommend this experience to other professors? Why or why not?

5. What changes will you make next time?
6. What can you say about the students' abilities in mathematics?
7. Based on your 2 semesters of working with these students, how would you say women learn mathematics?
8. What is your role as a teacher?
9. What are the roles of students in your class? What do you expect from your students?

Participant observation was the second form of data collection. For 4 semesters, one of the researchers observed almost every Calculus I and II class in order to examine and understand the students' interactions with the professor and with each other and to observe the professor's teaching and interaction with students. In addition, in order to understand the learning environment, at least one of the researchers observed the UNIV 101 orientation class every week. The researchers kept extensive field notes from each observation. Finally, we collected copies of student quizzes, tests, worksheets, and letters and notes to instructors and mentors. We also collected journal writings in which we asked for feedback regarding the intervention and suggestions for modifications.

Data Analysis

We systematically and rigorously analyzed, classified, and consolidated the qualitative data using the Developmental Research Cycle (Spradley, 1980) to determine patterns and cultural themes. We transcribed all audiotapes on an ongoing basis to allow for preliminary analysis and collection of additional relevant data. The researchers examined the transcripts several times for recurrent themes. Each researcher brought a distinct perspective to interpreting the data because each conducted research in a different area of study—pure mathematics, mathematics education, and gender theory. These different frames of reference meant that we could more deeply explore the data. Two of the researchers met once a week to discuss additional observations, interviews, and artifacts.

Findings

As we collected and analyzed data that showed how students were influenced by participation in the women's calculus course, patterns began to emerge. We discovered that the students bonded with others in the group and with the group as a whole. When we focused on group bonding, insights about why the women formed a supportive group unfolded. These insights all related to what students themselves did to create the group: They (a) exerted positive peer pressure, (b) supported and taught each other, (c) accepted and valued the differences among individuals in the group, and (d) assumed roles in order to influence the group. We also found that the participants valued being in an all women's calculus class. When we analyzed the ways these influences affected students' learning of mathematics or willingness to take more mathematics courses, the following themes became apparent: Students (a) developed confidence in learning mathematics, (b) became comfortable in asking questions about mathematics, and (c) valued mathematics for understanding and continued to take mathematics courses in order to open up possibilities of careers.

In What Ways Were Students Influenced by Participation in a Multi-Faceted Women's Calculus Course?

Students Bonded With Others in the Group and With the Group as a Whole

The predominant theme that emerged from our data analysis was that students formed a group that bonded together. This occurred both years but at different times during the semesters. Alison, one of the first-year students, talked about the cohesion of her group:

> There was a bond and everybody cared about everybody, and it just makes you feel worthwhile in the class. And I loved that we could all come together every single day, twice on Wednesdays, and like[2] get along so well and…just have a good time and work together and, you know, just do well together…. There is no way I would have done as well without the FIG…. It helped me develop relationships with all those girls who cared when somebody didn't understand what was going on. We cared when maybe somebody was struggling with their homework or wasn't showing up to class.

Alison's comments suggest that part of the success of the FIG was that it built upon the importance of relationships to women. She used the term "cared" three times. What was special about the FIG, however, was that it permitted the women to use this emotive response to improve learning. The women in the FIG developed a sense of belonging; as Lucy said, "You didn't need to impress anyone, and you could just be yourself…. We accepted each other."

While this bonding was critical to mathematics learning, students emphasized that the closeness initially emerged from their UNIV 101 orientation and support group. As Lucy remarked,

> During UNIV…we got to know each other the best… [C]ertain things we would share…. Other classes really don't get that kind of individualized time, where we learn about the people…. We knew when each other's birthdays were and things like that.

The FIG enabled quieter students to overcome social fears so that they could participate more effectively in their own learning. Shelia mentioned the importance of group discussions: "Well, the social aspect is really good, 'cause I'm usually really shy…not very outgoing to talk to people, and…we're all girls [so that] made it a lot easier to talk." The comfort level enabled these young women to ask questions when necessary as well as to explain their techniques of solving problems, which in turn allowed them to solidify their comprehension of important concepts.

Even as the students felt they were part of the class as a whole, some formed small groups of particularly supportive individuals. For example, when we took a field trip to an apple orchard, Ellen and Shelia paired off. They found something important in common—they were both biology majors and planning to be veterinarians. They often studied and socialized together.

The strong ties within the group enabled students to adjust better to being part of a large university. Esther particularly valued "bonding with everybody and making friends…. [It] makes that community, this huge community, just a little bit smaller." Lucy echoed Esther, appreciating "that feeling like we weren't just another face in this crowd of 20,000." Alison explained how this sense of connection led to higher academic achievement: "It was perfect for me to do it freshman year the first semester, because it got me off on the right foot…. So many of my friends that are freshmen this year did terribly last semester."

Positive effects of peer pressure. The first clue that students were beginning to care about each other occurred when Alison said, "Well, it would be great if we could all just study together, and everyone would do well on everything." Most of the students in the group were still at a developmental stage where peer pressure was an important determinant of behavior, and they exerted pressure on each other to succeed. Students seemed to feel compelled to come to class, especially on the enrichment days. When someone did not come, the next session she often apologized to Jill, the graduate assistant teaching the course, and to other students, giving a reason. It was usually a good one. Students felt it was important to attend because they relied on each other's help and would be letting the group down if they were absent.

There was also peer pressure to continue taking mathematics courses. Martha, who decided to change her major from Computer Science to Accounting, did not want to take more mathematics after Calculus II. She told us how other students were pressuring her to continue on to Calculus III, and that as a result, she was enrolling in the advanced class. Similarly, Maria tried to convince Lucy to take Calculus III, but it became too difficult with her schedule because she was required to take several chemistry courses to get into veterinary school.

Peer pressure in the course had another effect that was important to the women's success in mathematics. Jill observed that being in the FIG forced some students to focus more on academics instead of social activities:

Iris would likely have been less successful in another calculus course. I think that being in the FIG forced her to stay on track more first semester because there was more peer pressure to keep coming to class and do your homework…because they were the only people in the class, and she identified herself as one of the group, she stayed on track more than she would have otherwise.

Support and peer teaching. The students taught each other, and their relationships extended beyond the classroom. Shelia told Jill, "If you need help, you can call one of them [the students] for help…if you or Richard aren't around." This extended learning shifted the focus in part from instructor-student interactions to relationships among the students. Because teaching is one of the best ways to solidify learning, these practices enhanced the students' abilities to use their knowledge. The focus on helping each other was particularly important because all of the students needed support at some point during the year, whether they were the students with the highest mathematical ability or students who struggled.

Students' willingness to take responsibility for their learning by supporting and teaching one another was evident when Jill could not attend one of the study sessions and the students met on their own. After the session, Maria and Carmen left a note on Jill's desk saying that Esther had not been at the study session. This was not a "tattling" note, but a caring one. They were concerned that she was not doing her mathematics homework. Esther was having difficulty and needed their support and help to work out problems. They said in their note, "Perhaps we should check on her." Moreover, Maria, Carmen, and Lainey studied together every day in addition to meeting at the study sessions. These three supported each other personally. For instance, because Maria commuted, she often stayed over with Carmen or Lainey in the residence halls. And because Carmen did not have a vehicle, Maria and Lainey also took turns driving Carmen to and from her clinical observations at different schools.

The women's support was one explanation for the high number of participants who were retained in advanced mathematics classes. They encouraged each other when individuals became discouraged and considered changing their majors. Maria, one of the first-year FIG students, talked to Betty and Nicole, both second-year FIG students, because they were wavering about becoming mathematics teachers. They were discouraged because they found upper level calculus difficult. Maria told them to "stick with it" through the semester and see how they did in the end.

Collaborative learning occurred when students set up times to come to office hours together. When they came, they worked with each other. Once, Shelia, Ellysa, Melly, and Ellen were having difficulty figuring out a problem, and Betty, Carol, and Hannah went over to help. Lara, a computer science major and one of the top students in Calculus I, became frantic the second semester because she did not understand integration in Calculus II. She felt overwhelmed and started crying about how she was depressed and had been unable to work. Lara had not asked for help before and had a particularly difficult time admitting that she needed it. As a result, she did know how to go about asking a mathematical question. Betty and Ellen came in during Lara's office hour visit and helped her with her work.

Martha, one of the best mathematics students in the first-year's group, did not think that she needed to attend study sessions, but because she and Karen had become such good friends she always came to support Karen. Karen actually was also an excellent student, but needed to understand the concepts thoroughly, so she wanted to come to every study session. Martha would stay with Karen even after the study sessions because Karen always had extra questions.

Finally, the women wanted to support females taking calculus in later semesters and were eager to help recruit students for the following years' of the all women's calculus sections. Several of them attended open houses for high school students to make sure they knew about the FIG.

Accepting and valuing differences. The 2 all women's sections could be considered homogeneous because all the women had to pass the calculus placement test at the A level to enroll. In spite of this circumstance, and even though the groups were small, the students were very different from each other. Maria noted that the courses drew the women together across social boundaries and despite diverse interests. Rather than creating division, the differences enhanced group interactions and helped to dispel students' and outsiders' stereotypes of "good" mathematics students. Alison talked about how the diversity was important to the group and the students' learning about others.

> I remember walking into that class, and there are so many different people. Lisa is so different.... [S]he's totally out there.... And Iris is totally off the wall. I mean these are people that I wouldn't necessarily

be friends with in high school.... I'm definitely expanding my horizons, and...the diversity was awesome, and I loved it.

Esther, a mathematics education major, came to the university on a sports scholarship and helped dispel stereotypes with her example. Her sport was cheerleading. Iris talked about her experience of getting to know Esther as a fellow mathematics education major: "One of the things I never expected was to be friends with a cheerleader. And [now] I am really good friends with a cheerleader [they even became roommates].... I never would have talked to her in high school."

It was curious that Lisa, the serious physics student who looked like a punk rocker, had her own stereotypes to overcome. She talked about how she was with a group of friends who were making comments about cheerleaders. She had said, "There's this girl I know, and she's a cheerleader. And they do work hard, you know."

Students assumed roles that positively influenced the group. Each person seemed to assume a role that was needed for the group to shape itself into a supportive whole. For example, Maria, a student in the first-year's FIG, became the patient teacher. She was very sensitive and right away demonstrated maturity that some of the other women did not express. She was always willing to explain her solutions and work with other students.

Karen, also in the first-year's group, was *the model of the diligent mathematics student* who wanted to understand, not just work problems. Jill believed that Karen "had pulled Martha along, sort of forcing Martha to...listen to some concepts rather than only learning the mechanics of working the problems.... [I don't believe Martha would] have been willing to learn concepts otherwise."

As described previously, Esther, the cheerleader, most took on the role of demonstrating the notion of *breaking a gender stereotype*. She showed how someone can be serious about liking mathematics and be, in her own words, a "perky cheerleader."

Carmen was very much *the model of how to study*. She was much more successful in Calculus II than in Calculus I. She received a C in Calculus I and came back the second semester demonstrating that if she changed her study skills and worked the problems, she could succeed. By solving every problem in the book, she increased her chances of being able to work most problems that Richard, the instructor might discuss or ask on a test. In fact, due to her determination, she received an A in Calculus II.

Ellen was *the glue* that held the second-year's group together even from the beginning of the year. Ellen kept discussions going during UNIV 101, and she was the first willing to take risks and share her solutions to problems. From the beginning, Ellen was willing to work problems on the board. She did so even when she was not sure she was correct, saying, "This is probably not right, but I'll try it anyway."

Carrie became *the cheerleader* for the second year group. She calmed others when they became anxious about their work. During a study session for the final, she helped other students by working problems on the board and even offered hints to help others find a solution. During the semester, Carrie also moved around the room to get students to work together.

The Students Valued Being in an All Women's Calculus Class

Students flourished because they felt comfortable. Several talked about how having only women in the class made a difference in their ability to ask questions about mathematics. They also emphasized the difference in the way males and females answered requests for help. Lainey, a history major who was very shy, explained, "It was easier to talk to the other girls than trying to talk to a guy who has a completely different understanding of the problem.... Girls will tell you why, guys just tell you how." Hannah agreed with Lainey about how girls answer questions in a more beneficial way:

> In calc in high school, the guys would get it faster. Well, I didn't know if they really got it faster, or they said they got it faster. In high school if you ask a guy how to do something [he would say], "Oh, you just do this and that." That's more or less step 1, step 2, step 3, step 4. "Okay. Thanks for showing me." When I talk to other girls, they want to know why. Girls are always asking why.

Even as students criticized *how* male peers answered questions, they also remarked that they felt less comfortable asking questions if males were present. Carmen talked about how she would be afraid to ask questions if this were the case:

> I probably wouldn't be as outspoken as I am now. I probably wouldn't ask questions 'cause usually when I'm in a class with guys...if you ask a question, they always whisper things like, girls are so silly, girls are so stupid. Because my friend actually was in this calc class last semester with a bunch of guys, and she felt so dumb. She was one of the few girls in the class. I told her she should have been in our class 'cause it was all girls, and she would have been more comfortable.

For Shelia, too, men changed the classroom environment to the extent that it made it harder for her to attend class. She associated coming to a class composed entirely of women with the lack of a judgmental atmosphere: "It's like you know you can talk, and it's all girls so you don't feel like you're being judged if...you were to say something." Meredith emphasized that the female-only environment led to "less competition and fewer distractions," and Lucy stressed that having men in mathematics class could create distractions: "[I]f no boys are there, you don't have to worry about how you look. You just have to worry about understanding.… Some girls don't like to come off as smart around boys."

The women's sense of empowerment with their peers extended to their families. Martha was excited about her mother: "My mom is proud.… She's always saying, 'Martha the math genius.'" Carrie had something similar to say about her mother: "She brags to people that we're smart. I'm like, it's just calculus. She thinks we're geniuses." Patsy, her sister who was in the FIG, too, concurred: "My mom thinks Carrie and I are geniuses." Alison also glowed when describing her family's reaction: "Last Easter I came home for a day and, umm, my grandpa said, 'Oh, here comes the big genius.'"

Not all students were encouraged or received positive responses when they told others they were taking calculus. Even so, they always described these experiences in ways that demonstrated they still felt very special to be part of the FIG. Lucy had a good friend who thought she was "crazy for taking calculus." One of Lainey's friends' responded by commenting, "You are crazy. I don't know why you're taking that class."

In What Ways Did These Influences Affect Their Learning of Mathematics and Willingness to Take Additional Mathematics Courses?

Without question, the supportive influences discussed in the first half of this paper contributed to student learning. For instance, Ellen said, "I really am learning a lot about calculus. I do help some of my friends.… So I think it's just, I'm learning, but it doesn't feel as much as I am learning; it just feels like I'm kind of meeting people." Martha emphasized that the most rewarding part of being in the FIG "was probably the fact that now I understand it [calculus], and I can get an A in it." Susan, a good student who struggled in Calculus II, emphasized that while the support features of the FIG helped her to continue, her desire to learn most kept her persistent: "Understanding calculus. That's the best part."

Students Developed Confidence in Learning Mathematics

Almost all of the students began the course with upbeat attitudes and positive past experiences in mathematics. Susan liked mathematics and had been in mathematics competitions in high school. Hannah thought math was fun; she also said, "Math triggers something in me that always makes me want to learn more." For the most part, these positive attitudes did not change during the FIG.

Although the students enjoyed mathematics, most did not feel confident in their abilities in the subject. In their journals, the majority of the young women described themselves as average students because, even though they had received good grades and been enrolled in accelerated classes, they had not ranked at the top of their high school classes. Some of them explicitly questioned why they were taking college calculus in their freshman year. They were anxious before tests and unable to gauge whether they were prepared. For instance, Ellen, one of the best students in the second year, sent Jill this email message: "I don't feel as if I have learned anything yet, but I know in theory that I should have by now. I think I am going to fail." Jill, in turn, was "very surprised by the message from Ellen. Based on questions she asks and my observations from group work, I would predict that she will do well on the test and has perhaps the best understanding of the material of any student in the class." Indeed, Ellen received an A in the course.

Students were also often discouraged after tests. They had been used to receiving good grades in high school and thought lower, but still passing, marks were indications of imminent failure in the course. After the first test, students expressed their doubts about their abilities in their journals, writing such statements as, "I think I am going to drop calculus. I don't think I can pass the class," and "I just don't think I am smart enough."

By the end of the FIG, however, almost all the women felt they had been successful in working through issues of self-esteem in mathematics. Ellen summed up this achievement: "It's a real shock to me—to know that I'm really good at math and I understand it." Their new pride was evident in class discussions, for instance, when Carol commented, "You have helped give me the confidence to do calculus, which was something I wasn't sure I could do!" She continued to major in meteorology and enrolled in Calculus III. Students like Maria also learned to put grades into perspective; even though she earned a C in Calculus I, she decided to continue and major in mathematics education because "You made me believe in my abilities.... I got a C [in Calculus I] but am going to keep going." Her confidence was well placed. She got a B in Calculus II and has continued into Calculus III.

Carrie, a student in the second-year FIG who initially refused to participate in class, became engaged and confident. She began answering questions in class even when she was not sure whether her answer was correct. Moreover, Carrie's perceptions of her performance became more accurate. She emailed Jill one night to say, "I think I did an okay job on the test. I won't push it though. I know it's not 'A' material, but I think I didn't fail!" She was also very proud that she was even helping Business Calculus students on her dormitory floor.

The students' self-confidence also motivated them to work even harder. The young women became very proud of their study skills. Lucy learned what was important to succeed in mathematics: "I really worked on the homework.... I didn't miss class." Lainey, who struggled with Calculus I and II, began to help others as she gained confidence in her learning. According to Jill, "There was a guy who sat near them, and one time he didn't know how to do the problem they were supposed to turn in, and...Lainey was explaining it to him." Alison offered an excellent example of this confidence. She had perhaps the most objectionable story to tell about the first calculus review she attended. She walked in the room and started to sit down in the back. There were a bunch of men in the room, all talking, but when she walked in, they stopped talking. They all turned to look at her, and one said, "You know, this is a *calculus* [italics added] review session." Their emphasis on the word "calculus" sounded snide and superior. She responded by saying, "Yes, I know," and then walked up to the front row and proudly sat down.

They Became Comfortable Asking Questions About Mathematics

Familiarity with each other helped students ask questions and learn mathematics, as they said over and over in their interviews. Maria summarized this idea better than anyone:

> [T]here was no humiliation if you didn't understand something. You know, if you didn't get the concept, usually there was [sic] four other people that didn't get it, and we all spoke out loud.... That helped us learn calculus..... [I]f I didn't get something, I knew somebody else would [ask].

It is important to distinguish between two factors of the FIG that could have improved the women's learning. The first, without question, was the support the women offered each other, which was discussed in the first part of this paper. The second was the instructors' abilities to create an environment in which the students felt comfortable asking them questions. For example, Leeza was willing to ask questions because Richard talked to them individually about the mathematics. Ellysa stressed that having her questions addressed rather than disregarded increased her learning: "I like how questions always get answered. I feel like I'm catching on a lot quicker to some things than I have in the past 2 years."

Susan emphasized how Richard encouraged students to ask questions and minimized competition among the class members: "In this class, it kind of seems like we're more friends than just competitors." Esther stressed that Richard made the learning personal: "You can go into classes [where] they [teachers] don't care, but Richard notes all of our names."

Ellen talked about the nonthreatening environment Richard and Jill created so that students were willing to explain their thinking to their peers. Making mistakes was not embarrassing. "[I]t doesn't feel as threatening.... Here you can kind of just jump up and go to the board and try to do something, even if you know it is probably...half-way wrong." This comfort level enhanced student learning in another way as well. Maria mentioned how after becoming friends, talking about mathematics became natural to the young women. Instead of avoiding discussions of their class work, students saw class and conversations about mathematics as an extension of their friendships:

> After the first week, it was just like we had been friends forever...that kind of thing where when we got together. It was like a slumber party.... It didn't really seem like we were learning calculus; it's just, it's ten o'clock; it's time to go see my friends.

Carmen said, "We talk about our lives. We talk about math."

They Valued Mathematics for Understanding and Continued to Take Mathematics Courses in Order to Open up New Career Possibilities

Through the FIG, students increasingly understood the value of truly comprehending mathematics. Shelia became aware that understanding was really important:

> I [get] a little bit [anxious], but not as much as I used to 'cause I think I'm getting the concepts more. Calculus last year [in high school] was all about just memorizing, and this year, you've got ways to figure it out if you forget it.

Karen, too, valued a thorough knowledge of the concepts, but she went even further than Shelia. According to Jill, Karen "liked the logic behind things—what's going on."

In fact, the number of FIG students who achieved good grades compared favorably with others who took calculus. For the 2 years of the FIG (see Table 1), of all new freshmen who enrolled in Calculus I, 89% of the women who were enrolled in the FIG received an A, B, or C; 72% of the men received an A, B, or C; and 82% of the women who were not enrolled in the FIG received and A, B, or C.

It is important to mention that the professor who taught the intervention class believed that he had taught the students in more depth and expected more rigor from them in their regular hourly exams than in his past Calculus I classes. He stated that he taught the group as if they were in the honors section of calculus. The students also performed comparably to students in other sections on the common department final exam. The final exam did not include the conceptual types of problems in the context that the professor predominantly had used in their calculus class and hourly exams, yet the students' learning carried over.

Table 1 Calculus I Grades for New Freshmen

	# of Students	Percents				
		A	B	C	A, B, C	D, F
Male	214	22	27	23	72	28
Female (Non-FIG)	61	33	28	21	82	18
Female (FIG)	28	21	21	47	89	11

For the 2 years of the FIG (see Table 2), of the new freshmen students who went on to take Calculus II, the FIG women again achieved higher grades. Eighty-one percent of the women who were enrolled in the FIG received an A, B, or C; 71% of the men received an A, B, or C; and 77% of the women who were not enrolled in the FIG received an A, B, or C.

Table 2 Calculus II Grades

	# of Students	Percents				
		A	B	C	A, B, C	D, F
Male	111	18	27	26	71	29
Female (Non-FIG)	26	31	11	35	77	23
Female (FIG)	21	29	29	23	81	19

At the same time, students realized why it was crucial for them to know mathematics. Lucy talked about how her attitude about mathematics changed after taking calculus:

> I think people doing mathematics value it much more. Before I was in calculus, I really couldn't care less, but now that I'm in calculus I see how important it is. I see how you can work your way through a problem. Not just like balancing your checkbook, but if you have to make a big decision—how to think about it analytically and how to go through to get to results.

The higher value that students placed on mathematical knowledge increased students' willingness to take additional mathematics courses, as well as their confidence that they would succeed in these courses. Significantly higher numbers of the FIG women than of other qualified freshmen enrolled in Calculus II (see Table 3). During the years of the program, 75% of the FIG students enrolled in Calculus II. This percentage is 32 percentage points higher than the enrollment in Calculus II for the non-FIG women and 23 percentage points higher than the enrollment in Calculus II for the men.

Table 3 Students Enrolled in Calculus II for Spring Semester

	# of Students	Percent
Male	111	52
Female (Non-FIG)	26	43
Female (FIG)	21	75

To summarize, not only did the FIG women receive higher grades in Calculus I and II than the other new freshmen, but also they went on in higher numbers to take advanced mathematics courses. This continuation in mathematics opened up careers to students that they would not otherwise have been able to pursue. Carrie described how her major interests shifted:

> I remember in high school if I had found a career that required math, I would say, "That's got math in it. I am not going to do that." But last week when I was looking at possible majors, when I saw one with math, I realized I am not scared of it any more.

Table 4 presents the number of students from the FIG and their majors after completing the 2 years of college. By checking for their majors in their 3rd year, we found that 10 students (31%) were retained in their original choice of majors that required more mathematics than Calculus I (five retained majors that required mathematics beyond Calculus II). Also, nine of the students (28%) decided to declare majors that required more mathematics than Calculus I (eight changed to majors that required mathematics beyond Calculus II). They chose such majors as pre-computer science, mathematics education, meteorology, biology, and physics. Ten students remained in their original majors that did not require more mathematics than Calculus I. Only three students changed from majors that did not require more advanced mathematics courses.

Table 4 Students Post FIG Changes in Majors

Majors	# of Students	Percent
Remained in majors requiring more than Calculus I	10	31
Changed to majors requiring more than Calculus I	9	28
Changed to majors not requiring more than Calculus I	3	10
Remained in majors not requiring more than Calculus	10	31

Conclusions for Women Learning Mathematics in the FIG

The findings of this study have three major implications. First, students' involvement in a cohesive peer group made it acceptable to be interested in mathematics; thus, learning the mathematics itself became important. Second, the women became acculturated to mathematics and felt like "insiders." Third, by giving them a place where they could be themselves and not feel oppressed by gender roles and expectations, the FIG enabled students to relax and learn.

For many males as well as for females who are self-confident in mathematics, it can be very difficult to understand how being one of a few women in a calculus class can have a tremendous negative impact on a student's learning. But if our project validated one point, it affirmed that participating in a supportive community of learners of all women was a positive experience for young women. These supportive features included several components: the professor, the extra problem solving enrichment day per week, the graduate assistant, the extra study help, group activities, and the group itself. We modeled the experience for the women on what we had read about connected knowing. These aspects were designed to encourage this type of learning. These were all influences; we cannot isolate one that made the most significant difference. Nevertheless, being a part of this mathematics learning community affected the future mathematics course taking and decisions about majors for these women.

Students' Involvement in a Cohesive Peer Group Made it Acceptable to be Interested in Mathematics

For our students, being in a positive environment and committed to a community of peers was a fundamental precondition to learning mathematics. For most of the students, the group was fun because they were with friends, working toward a common goal. As a result, the mathematics became implicit. Learning calculus in the course's environment felt normal and occurred unselfconsciously as the young women focused particularly and explicitly on the group. The commitment to the group and the learning that took place simultaneously empowered the young women.

The women's descriptions of being in an all female section corroborated an assertion made by Belenky et al. (1986)—women learn better in a less competitive environment. By creating a plan that was centered on this theory, we found that, indeed, women do learn when they can make connections and form relationships in collaboration. One way they maintained this group connection was by discussing their lives. When they could trust each other with particulars about their lives, they could then take risks to share their mathematical thinking. As Carmen said, "We talk about our lives. We talk about math." There were indeed risks because many felt a lack of confidence that they could do the calculus.

The Women Began to be Acculturated to the Community of Mathematicians

A second implication of our study is that the women became acculturated to mathematics and felt like "insiders." The courses were taught in such a way that they began to think about mathematics and, on a meta-level, about how mathematicians approach problems. If their focus had been on learning formulas rather than larger concepts, the students might not have developed such understandings. Moreover, because the students worked problems on issues they perceived as pertinent, they valued mathematics for its "real world" uses. They felt connected enough to the course and the discipline that they were willing to take upper level calculus classes and return to advise entering students to take calculus. They saw themselves as capable mathematicians and good role models for others.

The idea of "voice" discussed by Belenky et al. (1986) and Hayes et al. (2000) is corroborated by our research. The women in our study gained their voices. There were two aspects of voice that became apparent. First, the women learned to "talk mathematically." By speaking up about how they solved problems, they clarified their thinking and created the mathematics in their minds. While justifying solutions, they often saw their own mistakes and corrected them. Through talking, they also sought to comprehend others' understanding. During this process they gave voice to themselves. Giving voice helped improve their self-esteem in learning and "finding the mathematician within" (Rogers, 1990).

By communicating their thinking, they improved the learning experience for everyone. As students began to interact, they relied on mathematical voices to do so, and thus gained a group "mathematical voice." Hayes et al. (2000) believed that this attempt to develop a collective voice adds a new dimension to learning—it takes learning from being an individual process to a group process of creating a common knowledge.

In a Comfortable Place for Learning, Women Could be Themselves and Not Feel Oppressed by Gender Roles and Expectations

Students in our FIG did not feel constrained by gender roles. They did not have to live up to or down to these roles or to be judged by them. A major in physics could learn that a cheerleader had a good brain and the capacity to understand higher level mathematics. Such realizations enabled women to accept and support their female peers better. Many of the women succeeded in changing attitudes among their friends and families as well.

The findings relating to friends and families did have sobering implications. Families in particular saw their successful daughters as either "geniuses" or aberrations. The underlying preconception that women are uncommon in higher level mathematics remained undisturbed. They continually needed to explain themselves to female and male peers, the major difference being that with their explanations they grew in self-confidence. If those who recognized the young women's abilities expressed their pride by calling them "geniuses," those who did not understand their work also alluded to their mental capacities, considering them "crazy" or "weird." Such comments underscore the way in which the public remains incapable of considering women's success in mathematics as ordinary or normal.

Implications

Findings from this study support our theory that if women are supported in learning mathematics and come to realize its value to their lives, they continue to enroll in advanced mathematics courses and choose majors or careers involving mathematics. This is not to imply that the women were somehow less capable than males, but, as Alison said, "Even though women want to try to be able to be in the real world and be independent, you need to have a starting place, and I think a small women's group like this is a good starting place."

Does this mean that we advocate single-sex mathematics classes for everyone? Absolutely not. The confidence the women showed in more advanced calculus classes with men suggests that the initial experience helped them overcome restrictive gender norms, freeing them to ask questions and build self-confidence. Yet, just as the women in our project were diverse, we recognize that certain other women would be happiest and most successful in traditional mathematics classrooms. While our research confirmed that women learn in connected ways, we also believe that some women can and do engage in separate knowing.

Nevertheless, we remain committed to the notion of bringing more women into the pipeline for careers that require higher level mathematics. Women now make up over half of the undergraduates in the United States, and it is discouraging to note that so few mathematics classes are designed around research about women's learning. From this perspective, our challenge in education is to integrate many women's needs to learn this way with the abstract and logical power of mathematics. By making women's ways of learning more visible as acceptable and important means for understanding mathematics, we contribute to building new approaches to teaching mathematics. It is important to structure the classroom as a community in which there is place for everyone—an environment that supports as it challenges. This type of community may help to increase the proportion of women who study mathematics. At our university we have continued to offer the "Women in Calculus" FIG.

References

Atweh, B., Bleicher, R. E., & Cooper, T. J. (1998). The construction of the social context of mathematics classrooms: A sociolinguistic analysis. *Journal of Research in Mathematics Education, 29*, 63-82.

American Association of University Women. (1992*). Shortchanging girls, shortchanging America: A call to action.* Washington, DC: AAUW Initiative for Educational Equity.

Bailey, S. M. (1993). The current status of gender equity research in American schools. *Educational Psychologist, 28*, 321-339.

Becker, J. R. (1996). Research on gender in mathematics: One feminist perspective. *Focus on Learning Problems in Mathematics, 18,* 19-25.

Belenky, M. R., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing*. New York: Basic Books.

Chacon, P., & Soto-Johnson, H. (2003). Encouraging young women to stay in the mathematics pipeline: Mathematics camps for young women. School Science and Mathematics, 103, 274-284.

Ethington, C. A. (November, 1995). *Navigating the pipeline: Women's interpretations of socialization influences in science, engineering, and mathematics*. Paper presented at the meeting of the Association for the Study of Higher Education, Orlando, FL.

Hayes, E. (2000). Voice. In E. Hayes & D. D. Flannery (Eds.), *Women as learners: The significance of gender in adult learning* (pp. 79-109). San Francisco: Jossey-Bass.

Hayes, E., Flannery, D. D., Brooks, A., Tisdell, E., & Hugo, J. (2000). *Women as learners: The significance of gender in adult learning.* San Francisco: Jossey-Bass.

Jacobs, J. E., & Becker, J. R. (1997). Creating a gender-equitable multicultural classroom using feminist pedagogy. In J. Trantacosta & M. J. Kenney (Eds.), *Multicultural and gender equity in the mathematics classroom: The gift of diversity* (1997 Yearbook) (pp. 107-114). Reston, VA: National Council of Teachers of Mathematics.

Krupnick, C. G. (1985). Women and men in the classroom: Inequality and its remedies. *On Teaching and Learning, 24*, 18-25.

Mael, F. (1998). Single-sex and coeducational schooling: Relationships to socioemotional and academic development. *Review of Educational Research, 68*, 101-129.

Muller, P. A., Stage, F. K., & Kinzie, J. (2001). Science achievement growth trajectories: Understanding factors related to gender and racial-ethnic differences in precollege science achievement. *American Education Research Journal, 38*, 981-1012.

Rogers, P. (1990). Thoughts on power and pedagogy. In L. Burton (Ed.), *Gender and mathematics: An international perspective* (pp. 38-46). New York: Cassell Education.

Sadker, M., & Sadker, D. (1986). Sexism in the classroom: From grade school to graduate school. *Phi Delta Kappan, 67,* 512-515.

Sadker, M., & Sadker, D. (1994). *Failing at fairness: How America's schools cheat girls*. New York: Macmillan.

Spradley, J. P. (1980). *Participant observation.* Chicago: Holt, Rinehart, and Winston.

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage.

Steele, D. F., Levin, A. K., Blecksmith, R., & Shahverdian, J. (2005). The calculus of differences: Effects of a psychosocial, cultural, and pedagogical intervention in an all women's university calculus class. *Mathematics Education Research Journal (MERJ)* 17, 22-44.

Tate, W. F. (1997). Race-ethnicity, SES, gender, and language proficiency trends in mathematics achievement: An update. *Journal of Research in Mathematics Education, 28*, 652-679.

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Footnotes

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[2] Our students, like so many of their peers, pepper their language with the word "like." We have removed many uses of this word to make the text flow better, but have made no changes to the content of the students' comments.