

Do Women *Belong* in Mathematics?

Abbe H. Herzig

University at Albany, State University of New York

abbe.herzig@aya.yale.edu

Keywords: Women, graduate students, belonging, identity

Contact Information:

University at Albany, ED 109
1400 Washington Avenue
Albany, NY 12222
abbe.herzig@aya.yale.edu
phone: (518) 442-5032
fax: (518) 442-5008

Paper submitted to the Journal for Research in Mathematics Education.

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Abstract

The participation of women in post-graduate mathematics still lags substantially behind that of men. Drawing upon sociocultural theories of learning, I argue that success in graduate school necessitates learning mathematical content, participating in mathematical practices, and developing a sense of belonging in mathematics. While graduate mathematical education has long emphasized the acquisition of mathematical knowledge, and recently attention has been drawn to the need to train students in a range of mathematical practices, students' coming to feel that they belong in mathematics has been largely unexamined. Developing a sense of belonging in graduate mathematics is critical for all students; in this paper, I document some obstacles to belonging faced by female graduate students in particular, based on interviews with 12 women graduate students from three mathematics departments in the U.S. These women described a number of significant obstacles to belonging in mathematics, including their feelings about themselves as mathematics students, their feelings of "fitting in" in the social worlds of mathematics, and issues of balancing life as a graduate student with a life outside of mathematics. I interpret these women's stories in terms of the ways they are multiply "marked" as deviant (Damarin, 2000)—as women, as mathematically talented, and as women in mathematics; for women of color or mothers, these markings are even more complex. Enhancing the diversity of mathematics graduate students requires building more avenues for women and people of color to come to feel they belong in mathematics.

Over the past several decades, the small number of women persisting in advanced mathematics has been a subject of increasing attention among members of the mathematics disciplinary community. Despite this concern, women's participation in mathematics still lags substantially behind that of men. Women's enrollment in graduate mathematics has risen from 26% of all enrolled students in 1977 to 38% in 2001 (National Science Foundation, 2004); in 2002, women comprised only 32% of graduate students enrolled in doctorate-granting departments (Kirkman, Maxwell, & Priestly, 2003). Over a comparable period, women went from earning 33% of masters degrees (1975) and 13% of PhDs (1977) to 45% of masters degrees (2000) and 27% of PhDs (2001) (National Science Foundation, 2004). The situation is even more bleak for people of some ethnic and racial groups; since 1977, among U.S. citizens and permanent residents who earned doctoral degrees in mathematics, an estimated 81% were white. African Americans, Native Americans, and Latinos *combined* earned fewer than 3% of doctoral degrees awarded in 1977, rising to 6% in 2001 (National Science Foundation, 2004). The intersections of race, gender, and class are important as well, but no data are available on participation in mathematics in higher education based on social class indicators.

No comprehensive estimates are available of the rates of attrition from graduate study for women and men, nor of people from different racial and ethnic groups. However, in 2002, women earned 42% of bachelors degrees, comprised 35% of first-year, full-time graduate students in doctorate-granting mathematics departments, earned 32% of PhDs¹, received 22% of new doctoral jobs, and comprised 16% of full-time faculty at doctoral granting institutions (Kirkman et al., 2003; Kirkman, Maxwell, & Rose, 2004). Admittedly, these statistics give only an approximate picture of how women fare as they progress along the path from college through work in the academic world, as these statistics represent different cohorts of individuals at one

fixed point in time, but the statistical picture is compelling nonetheless, implying that retention of women in mathematics is a problem throughout and after graduate school.

Of course, there is more to women's experiences in graduate mathematics than even the numbers show. "The question is not only one of retention in doctoral study but the more subtle one of whether women have a graduate experience that is of as high a quality as that of men" (Etzkowitz, Kemelgor, Neuschatz, & Uzzi, 1992, p. 158). In order to better understand the reasons for women's lower rates of participation in advanced mathematics, it is important to consider the nature of their experiences. In the next section of this paper, I propose a framework for understanding and analyzing those experiences, based on the importance of students' development of a sense of belonging in mathematics. I then use a part of that framework to analyze the experiences of 12 women graduate students, revealing some of the obstacles they faced in coming to belong in mathematics.

Learning Graduate Mathematics

Theories of situated learning posit that learning happens through participation in social practices, and that learning is intertwined with, and inseparable from that participation (Boaler, 2002; Lave & Wenger, 1991; Rogoff, 1994; Wenger, 1998). For mathematics graduate students, learning happens as they participate in the communities of practice found in their programs and departments. This view of doctoral education poses students and faculty as co-participants in a community of learners as they mutually construct and engage in the practices of graduate mathematics education (Rogoff, 1994). Focusing on individual learning in the context of those communities draws attention to how individuals change through their involvement with the activities of their programs, and in the process become prepared to participate in related activities. "This is a process of becoming, rather than acquisition" (Rogoff, 1995, p. 143). This

learning comes through participation in the range of practices that comprise graduate education, including things such as listening to lectures and taking notes, working with other students to solve problems, reading texts, attending seminars, working as teaching or research assistants, studying for and taking exams, or any of the activities in which students engage as they pursue their studies. Each of these activities constitutes a different type of learning opportunity, and what students learn is directly related to the particular practices and activities in which they engage.

Beyond the community of practice of graduate school, graduate students are also working to engage with the practices of mathematicians. However, given that students spend the first several years of their graduate training isolated from that community of practice (Herzig, 2002), the things they learn—what they acquire through their participation—are specific to the experiences they have. For example, they appropriate skills for taking courses and exams and, in some cases, for working as teaching assistants, but many students have limited opportunities to engage in research, attend conferences, or participate in many of the other activities of professional mathematicians. Consequently, graduate school in mathematics sequesters prospective mathematicians from the genuine practices of mathematicians, which limits their opportunities to learn to work as mathematicians (Herzig, 2002).

Etienne Wenger (1998) describes three dimensions that define a community of practice: a joint enterprise, a shared repertoire, and mutual engagement. The joint enterprise is comprised of the activities in which the members of the community engage together. Although the enterprise may be circumscribed by forces that are beyond participants' immediate control, they mutually construct and define the enterprise as they pursue it. In doctoral mathematics, the joint enterprise is learning to become mathematicians, as the students interact with each other and

with faculty to appropriate and develop mathematical knowledge of all sorts. A shared repertoire is similar to what Tomas Gerholm (1990) calls “tacit knowledge,” the unspoken norms and practices by which the discipline operates. For doctoral study in mathematics, the shared repertoire includes all the practices that are inherent in enrollment in graduate school, such as studying for courses and exams, finding a research topic, and working on a dissertation. Both the joint enterprise and shared repertoire are constructed and negotiated by participants as they mutually engage in the activities of their community. These three dimensions of the community of practice of graduate school entail students’ appropriation of mathematical knowledge (entering and constructing the joint enterprise), practices (entering and constructing the shared repertoire), and sense belonging within the discipline (engaging in mutual ways with the other community members) (Boaler, 2002; Boaler, Wiliam, & Zevenbergen, 2000; Herzig, 2004a). Each of these dimensions is affected by students’ interactions with other members of the community—the students and faculty. Those relationships, in turn, are formed by and contribute to the departmental and program structure, policies, and culture.

These three dimensions of students’ learning of mathematics—acquiring knowledge, practices, and a sense of belonging—are all critical parts of students’ development as mathematicians, and provide a useful framework for analyzing women’s opportunities to learn mathematics. Students who have limited access to any of these dimensions will be inhibited in their opportunities to learn and engage with mathematics, and will be less likely to persist in mathematics. In what follows, I will argue that it is the last of these dimensions—developing a sense of belonging in mathematics—that is most often overlooked by those involved in doctoral mathematics education.

Belonging in Mathematics

Doctoral education in mathematics, at least in the first several years of graduate school, typically follows a “transmission” model of teaching (Rogoff, 1994), in which faculty lecture, students take notes and study extensively outside of class, with most interactions between the two taking place as faculty grade assignments and exams (National Research Council, 1992). Mathematics doctoral programs in the U.S. are primarily structured around providing disciplinary training in the core areas of mathematical scholarship (Bass, 2003; National Research Council, 1992). Hyman Bass (2003) argues that these programs need to do a better job of preparing students for all aspects of work within the profession of mathematics, including serious professional development for teaching, uses of technology, exposition, developing and pursuing a research program, participation in the local and broader mathematical communities, and development of a “cultural awareness in students of the significance of their discipline in the larger worlds of science and society and of the expectation that they will serve as emissaries of their discipline in the outside world” (p. 775). While there has long been an emphasis on the acquisition of knowledge, Bass’s argument represents a more recent emphasis on learning the practices of the profession. However, little attention has been paid to a student’s development of a sense that she has a place within the mathematical community.

Building students’ sense of *belongingness* in mathematics has been proposed as a critical feature of an equitable K-12 education (Alleksaht-Snyder & Hart, 2001; Ladson-Billings, 1997; National Council of Teachers of Mathematics, 2000; Tate, 1995). Martha Alleksaht-Snyder and Laurie Hart (2001) argue that when schooling facilitates all students’ sense of belongingness and engagement with mathematics, then we are more likely to achieve the goal of “mathematics for all” so often cited as a goal in reform and policy documents. Alleksaht-Snyder and Hart define

belonging as “the extent to which each student *senses* that she or he belongs as an important and active participant” in mathematics, which can be “fostered by many different aspects of classroom processes” (p. 97). A similar construct has been proposed at the doctoral level, with several authors arguing that students’ involvement or integration into the communities of their departments is important for their persistence (Girves & Wemmerus, 1988; Golde, 1996; Herzig, 2002, 2004a; Lovitts, 2001; National Research Council, 1992; National Science Foundation, 1998; Tinto, 1993). In particular, Vincent Tinto (1993) proposes that doctoral student persistence is a function of both social and academic integration within the communities of the local department or program. So, as at the K-12 level, a sense of belonging at the post-graduate level can and needs to be fostered by aspects of classroom processes, but also by other important aspects of the educational experience in and out of class. This extends Allexaht-Snyder and Hart’s (2001) definition to define belonging for a graduate student as her sense that she is an important and active participant in both the academic *and social* communities of her department and program (Herzig, in press). Students who have multiple avenues to develop a sense of belonging within mathematics (for example, through family members who were mathematicians, or involvement in mathematics since a young age) have been found to be more likely to persist (Herzig, 2002). It seems, then, that developing an identity as a mathematician, a sense that “I belong here,” is a critical component in the persistence of doctoral students. While all students face a range of opportunities and obstacles to developing a sense of belonging, women face additional obstacles, which may explain their relatively low numbers in graduate mathematics.

Women’s Experiences in Graduate Mathematics

Mathematics is generally regarded as an objective field of knowledge, in which mathematicians work to discover truths about the natural world (Maddy, 1990; Steen, 1999).

This presumed objectivity of mathematics leads to a cultural blindness to personal issues, in which students who do not correspond to the cultural norm (male, white, childless, self-assured) are at a disadvantage (Etzkowitz, Kemelgor, & Uzzi, 2000; Hinchey & Kimmel, 2000).

“Academic science presumes a taken-for-granted male model of social organization that takes little or no account of non-work related roles or social relationships” (Etzkowitz et al, 1992, p. 161). While only a small number of empirical studies have explored women’s experiences in doctoral mathematics, reports about women in the sciences more broadly have uncovered a range of ways in which women’s experiences in the sciences are distinctly different from those of men (for a detailed review, see Herzig, 2004a).

Most students face obstacles in graduate science and mathematics, including harsh weed-out policies and competition (Herzig, in press; Hollenshead, Younce, & Wenzel, 1994; Stage & Maple, 1996), pedagogy that fails to communicate the passion or depth of mathematics (Burton, 1999; Herzig, 2002; Stage & Maple, 1996), and limited or negative relationships with advisors and other faculty (Bair & Haworth, 1999; Etzkowitz et al., 2000; Girves & Wemmerus, 1988; Golde, 1996; Herzig, 2004b). Women and people of color face additional obstacles. Women in science have experienced discrimination in finding and working with mentors and been excluded from the informal social networks of their laboratories or departments, treated as “invisible,” or otherwise had their contributions marginalized (Becker, 1990; Committee on the Participation of Women, 2003; Etzkowitz et al., 1992; Etzkowitz et al., 2000; Sonnert & Holton, 1995; Stage & Maple, 1996). In mathematics in particular, women have reported blatantly sexist behavior, including unwanted sexual advances from faculty, tolerance of public sexist comments, and professors who openly state that women are not as smart, dedicated, or talented as men (Committee on the Participation of Women, 2003). These factors combine to convince women

that they do *not* belong in the male-dominated cultures of their departments and disciplines (Etzkowitz et al., 2000; Herzig, in press; Hollenshead et al., 1994).

Students in several programs have described the importance of having “critical mass” of women or students of color (Cooper, 2000; Manzo, 1994). Graduate women in mathematics, computer science and physics have reported feeling isolated or alienated in their male-dominated departments, and have described ways that they feel that they do not fit in (Becker, 1990; Etzkowitz et al., 2000; Herzig, 2004b; Hollenshead et al., 1994). Women in mathematics have few female role models to guide them; in the fall of 2002, while 31% of full-time graduate students were women, only 13% of full-time doctoral faculty were women (Kirkman et al., 2003). Unfortunately, statistics about mathematics faculty of color are not available, but so few PhDs have been earned by African Americans, Latinos, and Native Americans over the past several decades (National Science Foundation, 2004) that the number of faculty of those groups are necessarily quite small as well.

Male science students have enhanced relationships with faculty compared with women, which provide men with increased opportunities to develop a sense of belonging. Henry Etzkowitz et al. (2000) argue that this feeling of acceptance is a prerequisite for independent and autonomous work. Denied the same degree of relationships with faculty, female students in science have a more difficult time acting independently. Further, women’s socialization leads them to tend to look for interaction and reinforcement, rather than to be autonomous and independent learners (Etzkowitz et al., 2000; Fennema & Peterson, 1985). This pattern of socialization can work against them in the eyes of their advisors, especially in a disciplinary culture like that found in mathematics, where work is expected to be individualistic and independent. Consequently, women graduate students in science and mathematics have been

stereotyped as less capable and uncompetitive, and as a result they often are not taken seriously by faculty (Becker, 1990; Committee on the Participation of Women, 2003; Etzkowitz et al., 2000; Stage & Maple, 1996). In this way, obstacles to developing feelings of belongingness are circular: women have more limited opportunities to develop a sense of belonging, which makes it more difficult for them to behave independently. The perception that they are dependent results in negative judgments of their abilities by faculty, which limits their further opportunities and makes it even more difficult for them to come to feel that they belong in mathematics.

Despite the assumption that mathematics is objective and impersonal, personal issues like isolation, sexism, lack of role models, and stereotyped understandings of their interactions pose serious obstacles to women's abilities to develop a sense of belonging in mathematics. In the remainder of this paper, I explore graduate women's opportunities to develop a sense of belonging or identity within mathematics, through interviews with 12 women enrolled in three mathematics graduate programs in the U.S.

Method

This study is based on interviews with 12 women graduate students in mathematics, four enrolled in each of three mathematics departments at large, public universities in the U.S. All three departments award doctoral degrees. Interviews in one of the departments were conducted in the fall of 1999, and at the other two departments in the spring of 2004. These interviews were conducted as parts of larger and different studies, in which women and men graduate students and faculty were interviewed about their experiences in mathematics and beliefs about mathematics and graduate mathematics education. Two of the three departments were among the 25 U.S. mathematics departments with the highest percentage of PhDs being earned by women over the period 1996-2002 (Jackson, 2004).

The women included in this analysis were selected from the larger samples from which they were drawn in order to represent as broad as possible a range of experiences and identities within and beyond mathematics. Some students were in their first year of graduate study at the time of their interviews, while others had been enrolled in graduate school for more than 6 years. They had received their undergraduate training at a range of institutions from many parts of the continental United States, both public and private, both large and small. In all, their stories reflect their experiences in 15 mathematics departments (as both undergraduate and graduate students). Most had entered graduate school directly after completing their undergraduate training, although several had either attended other graduate schools or had worked for between one and more than 10 years in before entering their current graduate program. Consequently, they ranged in age from their early 20s through their early 40s. The sample included four African American women. Half of the women were married, two had young children, and two others discussed their plans to have children soon. One woman disclosed that she was a lesbian. Although all 12 women had entered the graduate program either intending to complete a PhD or considering the PhD as an option, by the time of their interviews, two of them had decided not to complete the PhD (one of the two had already left the program by the time of her interview), but to leave their programs after completing Masters' degrees.

The structure of the interviews was largely the same at all three institutions. Participants were recruited by email, and asked to participate in an interview about their experiences in mathematics. All volunteers were given outlines of interview topics in advance of their interviews, and were encouraged to add things they thought were relevant and delete things they did not wish to discuss (after (Burton, 1999)). Interviews covered participants' mathematical "autobiographies", their reasons for attending graduate school in mathematics, their interests and

goals in mathematics, and their mathematical experiences both in and out of school. The interviews were open-ended, progressing as unstructured conversations about participants' experiences, allowing them the opportunity to discuss "the web of feelings, attitudes, and values that give meaning to activities and events" (Anderson & Jack, 1991, p. 12) and to give them "the space and the permission to explore some of the deeper, more conflicted parts of their stories" (p. 13). Periodically during the interview, we glanced at the outline to see if anything important had been skipped, but participants were encouraged to guide the conversation to those aspects of their experiences that they thought were most relevant. Consequently, not all interviews covered exactly the same topics. As one focus of these interviews was to assess their experiences as women in mathematics, all participants were asked "Has it ever mattered to you, being a woman in mathematics?"

To protect the women's anonymity, interviews were conducted in a private room on each campus, outside of the Department of Mathematics. All interviews were tape recorded, and the tapes were transcribed. Interviews ranged in length from thirty minutes to two and a half hours.

Transcripts of the interviews were analyzed inductively. Transcripts were read and re-read, and initial codes were developed to reflect what these women talked about that reflected issues of belonging within mathematics. As coding progressed, new codes were developed and applied, and other codes were deleted or combined. Once the coding scheme reached a point at which it seemed to capture all relevant parts of the women's stories, an independent coder coded two interviews to check for reliability. There was a strong degree of agreement between the two coders, and any discrepancies were negotiated, resulting in several additions and clarifications to the coding scheme. Finally, all of the interviews were re-coded. The codes provide the organization for the results that follow.

Because of the small number of women interviewed and the ways that their interviews differed from one another, statistical information about their responses is not provided. The narrative that follows weaves together issues that were common among their stories, using the words of each of the women; discrepancies and contradictions are noted when they arose. Participant quotes have been edited for readability, and to obscure any personally-identifying information. All names are pseudonyms.

Results

The participants discussed four general themes relevant to issues of belonging in mathematics: the degree to which they focused on mathematics, their feelings about mathematics and about themselves as mathematics students, balancing life as a graduate student with a life outside of mathematics, and their feelings of “fitting in” in the academic and social worlds of mathematics. Each of these themes is explored in subsequent sections.

Focusing on Mathematics

Most of the women had developed a focus on mathematics in high school or earlier, sometimes as early as elementary school. Four of the 12 women had parents or siblings who had been mathematics majors in college. Several of them spoke about initially having been disinterested in mathematics, but a middle school, high school, or college teacher had motivated them or pushed them to do their best, mathematics consequently began to “click,” and they came to love doing it.

They studied mathematics in college because they realized that they were good at it, that it “came naturally” to them, or that mathematics was fun. They chose to pursue graduate studies in mathematics for a range of reasons, many of them emphasizing the happenstance that led them there. For some, graduate school was a natural next step, because they had enjoyed the

mathematics they had experienced up to that point, and did not have other things they preferred to do; however, many of them emphasized that while they were good at mathematics, it was only one of several things they were good at.

It was just something to do and something that I thought I would actually like doing. I don't think I had this burning drive to go to math grad school but I realized I could and I thought I would like it, and I didn't have anything else to do.

About half of the women came to graduate school because they wanted to teach mathematics on the collegiate level.

All of the women reported having some times when they experienced doubts about continuing with their studies, wondering whether it was worth the amount of work, energy, and the sacrifices to their personal lives that persistence would require. They described longing for some of the things they were giving up to pursue the PhD.

My friends are starting to work, starting to have their lives. They tell me they went to this concert, this show or play, and I want to go and do that stuff too. I just still have that drive to get that PhD I know it's hard, but I feel like in the long run it will be worth it.

This longing was balanced by what many of them described as sheer stubbornness that allowed them to persist in the program, despite the stress of exams, intense demands of coursework and teaching, and frustrations with research. Pressure or support from family and friends was significant for many of these women, as they discussed ways that friends helped them prepare for exams, parents were proud of them or would have been disappointed had they quit, or just the general encouragement they received from significant people in their lives.

Maybe I'm just kind of stubborn. I just thought I should keep trying until they won't let me try because if I quit I'll always wonder. Also having all my friends just saying, "No, you can't quit, you can do it, you can do it" over and over and over again.

Several of the women described the importance of the support they received from faculty in their graduate programs, whose flexibility or words of encouragement had made a big difference to them.

I think about why I haven't left, and partly it's because I am stubborn and if I start something I want to finish it. Partly it's because at the times I was thinking most about leaving, my advisor was there and basically said, "No, you shouldn't do this. You are close to finishing. I know, I do believe you can do this."

Conversely, they felt that not receiving support, encouragement, or even attention from their advisors and professors can help distance students from their study of mathematics.

Graduate school is difficult and if you're not getting . . . enough sense of is this something I can do? Is this something right for me? Do the faculty members here notice me and think that I can do this? If you aren't getting a sense that yes, they do notice and yes they think you can, it seems like it would be that much more likely that you'd say, "Eh, never mind, this isn't right."

These women understood that success in graduate school would require more than just their mathematical abilities and talents, but would require hard work, focus, persistence, and stubbornness. When asked what it takes to succeed in graduate school, one woman summarized, Perseverance. It's not all about intelligence. There are plenty of intelligent people that can't make it. There has to be a desire for the degree not just because of the money or

whatever. You have to really love mathematics or really like what you're doing. Hard work, determination, all of that cliché stuff, . . . love for math, perseverance.

Several of the women I interviewed perceived that they were not as focused on mathematics as some of other students around them. They spoke of other graduate students who were more fully absorbed in mathematics in ways that they themselves were not.

I thought it was kind of strange that my classmates would talk about different math books like they would novelists like Toni Morrison or Faulkner. That's who I would talk about if I were talking about books [I had read]. I wouldn't talk about Rotman or math authors.

I had to get used to that.

For some, this disconnect between the way that others were fully absorbed in mathematics and their own sense of themselves as more “well-rounded” led them to question whether they fit in in the social and academic worlds of their graduate programs.

When you enter grad school you realize that there are people who are really, really interested in math. I kind of figured that I had enough interest in it to do it, but then you realize that there are people that spend their extra time doing it. That's what the program is made for, I feel, for people like that.

So, while these women recognized the importance of determination, hard work, and perseverance in working toward the PhD, this required focus presented a struggle for them.

While most of them shared a strong drive to do what was required to complete the PhD, they also very clearly identified themselves as being more than just mathematics students, and were not willing to surrender to doing only mathematics. Their struggles to balance a life in and out of mathematics, parallel to this issue of balancing their identities in and out of mathematics, will be discussed in a subsequent section.

Feelings for Mathematics, Feelings within Mathematics

These women all enjoyed mathematics and to varying degrees felt at least somewhat successful at it. Most of them described a love for mathematics and an enjoyment of studying it, talking about the thrill of solving problems, the privilege of being a student, or a general love of the beauty of mathematics. However, they did not always enjoy the experience of being in graduate school.

To me, grad school is not really the happiest place . . . It's really hard, it's really discouraging. . . . You're underpaid, you're tired, you're stressed. And then you have times when you have an exam and then it's like that times four. So it never seems like it's just a place that's fun.

Although most of them acknowledged the stresses and some of the obstacles and unhappy times they experienced in graduate school, they agreed that students who do not love mathematics, who do not find its study fun, at least some of the time, will not be able to do what is required to complete the degree. As one woman summed it up, "If it's not fun, on at least a certain percentage of the days, I'm outta here. It wouldn't be worth it." While a number of the women had never had an overwhelming drive or love for mathematics, and had come to graduate school because it seemed the logical next step after completing their undergraduate degrees, two of these women had grown to hate their experiences in graduate school and were planning to leave program after completing a master's degree. They both described their graduate school experiences in very negative terms, like this woman, who acknowledged that "I pretty much hate it [I] don't want to blame it on the program, I blame it more on my disinterest Had I been interested, then it might have been completely different."

The women described the effect of graduate school as leading them to doubt their mathematical abilities. It was difficult to be among so many people who seemed so talented and capable, and for the first time, many of them had to come to terms with no longer being the best student. Seeing other students in their classes who seemed to “sail through” or who just seemed to “get it” challenged them to question whether they themselves belonged in graduate school in mathematics.

You have to learn how to humble yourself because several of us who made it this far have been the top of our class and then we get into a room where everybody’s the top of the class. It’s kind of hard getting used to getting down at the bottom of everybody. One older student also acknowledged this struggle, but attributed her ability to cope with that transition to her increased maturity as a student.

I’ve had to learn to not be the best. And to accept that. I think that in that way it’s helped me to come back to graduate school as an older student. I just have a much better perspective about that than I did when I was younger. . . . I’m less interested in comparing myself to other people than I was when I was younger.

But for many of the women, this became a constant struggle, often perceiving a competition and pressure to perform at a higher level.

We weren’t expected to be experts in undergrad because a lot of the people who were math majors in my undergrad were just math majors because they were going to teach math in high school. Everything was toned down a little bit and it wasn’t a big deal not to be great at it. But it seemed like everything in grad school hinges upon being great at it and getting everything and knowing everything. It’s embarrassing to be mediocre at anything.

Not only did they struggle with no longer being the best mathematics student around, but many of them also longed for more encouragement and positive feedback from faculty.

Probably one of the worst things about math grad school is how much it's made my opinion of my math abilities go down. . . . Going from a big fish in a little pond to the whole ocean is sort of painful. I'm not sure there's anything that math grad school here could do about that. Well, they could be more encouraging, right? They could tell you sometimes that you did well. . . . Maybe I shouldn't need . . . to have people saying, "good girl," but I would like it sometimes, it would be nice.

As I discussed earlier, the encouragement of friends, family, and faculty were critical for these women as they encountered and surmounted obstacles, including from challenging classes, qualifying exams, and the struggles of research. For some, this support helped them realize that other students were struggling as well. This realization was very important to their sense of self-confidence and ability to persevere.

I'm learning all this stuff. If I work hard enough I can learn it. And I have. I do feel like I belong. Even though I struggle and sometimes say I don't.

Balancing Life In and Out of Mathematics

These women all struggled in various ways to balance their lives, obligations, and identities in and out of graduate school. These issues of balance took different forms depending on the women's life circumstances, but they generally described the conflicts they experienced in building a well-rounded life that included both graduate school and other commitments and interests.

Most of them appreciated the flexibility of life as a graduate student, where they were mostly responsible to themselves for managing their own time. Of course, this flexibility is a

double-edged sword, as it also meant that there were times when they could fall far behind in their studies, or when they needed to put in a lot of hours to complete their schoolwork. Several of them noted that they were progressing through graduate school more slowly than the “norm” or than their advisors expected, because of decisions they had made not to “bury myself in my mathematical life to the exclusion of all else.” None of them minded the hard work, and they acknowledged the richness of their learning that came from immersing themselves in mathematics, balanced with the opportunities to learn to teach. However, they also struggled to find a place for their non-mathematical selves in their lives.

Earlier, I discussed the women’s perceptions that other graduate students were totally absorbed in mathematics. These women said that they *insisted* on having a life outside of graduate school, refusing to let mathematics become all that there was in their lives. They spoke about the need to take care of themselves and to have other interests, including time for rest and exercise, family and friends, participating in church communities, taking courses in subject areas unrelated to their studies, playing music, volunteer work, and dating—all the things that make up the lives of a varied group of people. Some women felt support from faculty for their need to meet family responsibilities. But others also felt a sense of disapproval from their advisors and professors for having outside obligations.

Sometimes I feel like I’m disapproved of for having a life outside of math. This whole idea that, why should I be wasting time doing anything else when I could be doing math? Now wonder you’re failing the qual. That type of thing. That really bothers me. I should be allowed to have a life outside of math. This whole attitude that I think a lot of mathematicians have that if you do math, you do it because you love and it’s all you want

to do every day, all day. Well no, that's not actually true for me. I like to do it sometimes but I like other things.

These outside activities were part of these women's lives, things they valued and enjoyed. For some, these activities represented explicit strategies to find time away from school, to help them "escape" or get a break from thinking and talking about mathematics. Some spoke of the need to manage frustration and stress by getting away from campus for a while, even with things as simple as "I sat down and got a magazine and I just read and ate my soup and then I came back to school." Some felt it was critical to have friends or partners who are not in mathematics, so that they could escape from mathematics for a time and talk about other things. They had other explicit strategies for getting time away from their studies, including never studying on a Saturday night, teaching exercise classes (which had the added benefit of guaranteeing a certain amount of exercise each week), or positions in their church governance. Many of these women highly valued time spent with their extended families and church communities, and they were often frustrated by how difficult it was to find the time to do this, as even a Saturday afternoon off could leave them feeling hopelessly behind in their studies. One woman cried as she said, "I just feel that I want to do everything and I just get frustrated that I'm mortal and I can't."

One woman who had gone through some difficult challenges in her personal life described school as an escape from those stresses.

I think school's a nice escape from it. As long as I'm not talking with my officemates who are my friends, it really doesn't come up so much, which is nice.

Another woman described how important it was to her, when she came to visit her current graduate school before deciding to enroll there, that

It seemed like everybody here has outside lives. They're not so consumed in doing their mathematical work. They actually have families. A lot of people here are couples and married, have children, and by me having a child and a husband I felt it was more suited toward me.

Probably like most working mothers, the graduate students who were mothers experienced a double-bind when it came to balancing motherhood with graduate school. Their family responsibilities left them feeling that they did not have sufficient time to devote to their schoolwork. This mother had had doubts about entering graduate school, because she was not sure she could do the work required while she cared for her young children.

I always envisioned getting your PhD is like preparing for an Olympic sport. You really have to throw 110% of yourself into that. And I have other obligations. I can't give 110% of myself to this goal.

Yet when devoting time to schoolwork, they felt pressure and guilt over not spending more time with their children. This mother described a stressful life balancing her needs to study and be with her child, to the exclusion of almost everything else.

I don't get to see her that much. It makes me sad because she's a child and she needs her mother, but in the long run it will be more helpful to her . . . This is how I look at it. I don't remember what happened to me before I was 5 so hopefully she won't either. But we give her lots of love.

While she imagined that other graduate students might have time in the evenings to themselves, the little time she had away from her schoolwork was devoted to caring for her daughter, so she had little time for herself, social engagements, or anything outside of her studies and her daughter. The need to work as a teaching assistant added to this pressure.

At least two of the women were considering having children soon, and understood how difficult it might be to balance the demands of a family and school. They each had seen other students who were parents, and they observed the challenges involved in childrearing while in graduate school, including the financial pressures of having a child on the limited income of a graduate student.

We plan to have children soon, and how are we going to save money and buy all the things a baby needs? . . . I couldn't imagine doing this with kids. . . . I couldn't imagine doing it with a family, I think it would be so difficult.

One of the graduate students who was also a mother repeated the advice that she had once heard:

Choose the right advisor. If your advisor accepts that your kid is your first priority and your degree is your second priority, you're going to have a much easier life than if your advisor doesn't acknowledge the existence of your family.

She spoke of times when she was scheduled to meet with her advisor, but her childcare arrangements fell through, and her advisor welcomed her to bring her child along to the meeting. Her advisor fully accepted her obligations as a parent, even re-scheduling an exam for her when she could not find childcare. In contrast, the department insisted that she be enrolled in a full-time load of 9 credits in order to receive financial support; like the other mother described earlier, this course load, coupled with teaching responsibilities, posed a significant challenge to her as a parent.

Some women really appreciated role models who demonstrated effective ways to balance family responsibilities with work as an academic. When I asked if there was anyone she would consider a mentor to her, one woman replied,

I look at balancing life and math. Sarah definitely because she has kids. The women in the department definitely because they've got their family and had kids. . . . So I look to them as people who are good at balancing. . . . I guess anybody who got a PhD would be somebody I look to, and they still have a life. Cuz I don't want to study all the time. . . . The faculty here, they didn't have kids until they were faculty themselves. Even Audrey, she had her first child during her postdoc. So [I feel I need] role models for having children in grad school and being a woman.

Students are members of a range of communities of practice, including both school and family. Their participation in these other communities can interfere with their abilities to become integrated into the communities of practice of graduate school and professional mathematics. For graduate students who are also parents, or who have other commitments or interests outside of school, the conflicting demands of time, energy, and attention can serve to make it more difficult for them to find a place in the mathematical communities of graduate school.

Belonging in Mathematics

There were a number of ways in which these women spoke about their feelings of “fitting in” or feeling that they belonged in mathematics and in graduate school. Of course, some of these were discussed earlier: their perceptions that other graduate students and mathematicians were more absorbed in mathematics than they were themselves; feeling happy or discontented in graduate school; and ways in which their lives outside of mathematics either enhanced or inhibited their graduate school experiences. In this section, I present these women's discussions of the importance of role models in mathematics, and their feelings of “fitting in” or seeing others in mathematics to whom they could relate.

Having role models. Overall, the women agreed that it was important to see women in mathematics, and that having female graduate students and faculty was important to them in several ways. First, seeing successful women in mathematics helped them believe that they could succeed as well; as I discussed earlier, mothers who were successful in mathematics served as important role models. For some, the small numbers of women mathematicians they had encountered as undergraduates or even in graduate school left them feeling that there were not people around to whom they could relate.

If there was a good female role model that I felt like I could related to that would really push me a lot better. . . . A female professor pushing me intellectually seems to be more what would actually drive me.

Each of the Black women I interviewed (in two different departments) had heard about the three African American women who had been graduated from the Department of Mathematics at the University of Maryland in 2000 (Argetsinger, 2000). They each spoke of ways that that knowledge was important to them, as a way of proving that they too could achieve this.

I read in the paper of the three Black women that [the University of Maryland] had graduated in the PhD program. I thought that was phenomenal. I was like, “Wow, if they can do it, I can probably do it too.”

One woman explained that, while she felt her (white male) advisor would talk with her whenever she needed, she generally chose not to talk with him, because she did not feel that he could relate to her experience as an African American female.

Talking to African American females in mathematics is more personal. They understand. A lot of times before I could even get it out of my mouth, [they would know that], “this is

the experience you're having." Dr. Smith won't know that. Cuz he's a man. He's older. He's Caucasian. He just won't know that. . . . I don't have time for generic [advice]. I can read it out of a book. . . . That's not to say anything bad about him, it's just who he is. He wouldn't know.

Most of the women had people they called role models or mentors, including undergraduate or graduate professors, and for many, more advanced graduate students or recent graduates. Most of them looked to, or looked for, successful women mathematicians who could help them see that they, too, could build a satisfying life in mathematics.

Being role models. One surprising issue that arose the expectation or pressure that some of these women felt as an example for other women. For some, this meant that they felt obligated to prove that women could achieve in mathematics to the same extent as men.

When I was in college, I got pressure to go to grad school because I was a woman. . . . The problem with women not going to grad school and here you are good at math and you should go to grad school and not be a gender traitor or something like that I didn't want to be a lightweight. To not go to grad school would have been lightweight, and just support the theory that women are lightweights when it comes to math.

This was particularly powerful for one Black woman, who felt motivated to achieve a PhD not just for herself, but for others who she felt she represented.

A PhD carries more weight for me as a black woman than it does for my [colleagues]. I feel that getting a PhD is not about me. . . . For me, for getting a PhD, that's for me, that's for my culture, my ethnicity, that's for [my undergrad college].

This woman was very proud to achieve a PhD in mathematics for all that it might do to reflect positively on the preparation she had received at the historically black college she had attended, and to which she felt intensely loyal.

One woman particularly admired another graduate student who she had known, who had set a personal goal to become a role model for other young women in mathematics.

It would be cool to have a lot more female role models in Math. One of my friends who was here last year and who had transferred out of this program . . . She wanted a role model but she also felt she wanted a PhD in order to be a role model for other women and that was her driving force. Which I thought was kind of neat.

Setting an example for other women, or for men about what women can achieve, also placed substantial pressure on some women, who felt that because they were expected not to succeed, they had to work to a higher standard than the male students.

The women I know that are looked at as knowledgeable people have to really, really prove themselves in order for them to gain the respect of peers and faculty. . . . I've seen examples [like] a male professor could not really handle women in the class, basically just dismiss them as incapable.

Asking questions could reveal not just one's own ignorance, but could re-affirm stereotypes of women's mathematical abilities.

If you ask a question and it reveals your ignorance of the subject that you're studying, then you're the girl who doesn't know what goes on. That's different from being somebody who doesn't know what's going on.

Fitting in. For some women, being in a program with mostly men made them feel intense competition, and was sometimes intimidating. Most of the women graduate students described ways in which they felt uncomfortable being in an environment with so few women.

I sometimes walk into a room, look around, realize I'm the only woman in the room, *again*, and it has an effect It makes me feel like on some level most of the people I interact with are missing one particular thing in common with me and I find that discouraging. . . . There are still sometimes times when it feels uncomfortable that there aren't more people like me.

The African American women felt doubly isolated, both as women in a male-dominated discipline and Blacks in a largely White discipline.

I guess like being in a room full of White people me acknowledging my Blackness, not that I'm always thinking about it but it's more aware than if I were in a room full of Black people. I'm just aware that there's no one else in the room who looks like me. And that kind of makes me, not nervous but it's kind of like, "That's strange, there should be someone else in here."

Each of the African American women had attended an historically black college as an undergraduate, and they described ways in which the transition from a primarily Black institution to a majority institution entailed an adjustment for them. They described ways that they stood out, and other ways in which they felt invisible. Some of them described this as just a cultural difference, having moved from one part of the country to another, where humor, dietary habits, social expectations, and other habits and customs were different. Some described interactions with faculty that were blatantly racist.

When we were registering to start classes. . . . [T]hree of the other [African American] students had a couple different advisors who said, “The five of you are here under Affirmative Action so you probably should start with undergrad courses first so you can catch up with everybody else.” . . . Another professor [told me], “Graduate school isn't for everybody. Maybe you should consider something else.” But we had all gone there to visit at the same time and none of these comments were said at that time. There were three African American students there when we were going to visit but by the time we got there they were gone and they didn't let us talk to them, which should have been a heads-up that maybe something's wrong.

The African American women also described interactions with professors who “stiffened up” and were much less forthcoming with help and advice with African American students than with White students, or advised them to drop classes when they were struggling, rather than offering to help them learn. Several African American women described their struggles to earn the respect of the undergraduate students they taught.

I think my color has something to do with it too, when I go in to teach the students, I guess they think I don't know as much as I do. They kind of try to second guess me. I can tell they would oppose me more than they would a White male or somebody like that, just because I'm a woman.

One woman felt that it was unacceptable to show femininity.

[The professors at a summer research program] were people that I could imagine being. As nice as the professors were at [college], I couldn't imagine being a 60-year-old white man. . . . The math department [in graduate school] was not a very comfortable place for women. . . . I remember wearing a skirt and having people tease me endlessly about it. . .

. “Oh, you’re all dressed up today.” ”Hey, did you know you’re wearing a skirt today?”
And I felt like to be female, to show my femininity, was not acceptable.

Another topic that some of the women discussed is the stereotype of mathematicians or mathematics students as being “nerds” or “uncool.” One woman spoke at length of the lack of social skills among many of the graduate students in the department, calling them a “big collection of freaks.” Another woman disliked the way that she was stereotyped as a mathematics student, and felt that this was one reason why younger students get disaffected from mathematics.

I think mathematics definitely has this stereotype which I really can’t stand that it’s dorky and I get made fun of by my non-mathematician friends a lot. . . . If somehow that could be changed, this is where I think that role models would come in. If people could look up to people who they thought were similar to them. . . . Especially in lower mathematics, [a lot of people] think math isn’t cool and it’s not interesting . . . and they don’t see themselves doing it because of the stereotype. If they had role models that they felt were more like them, weren’t dorky, then they would draw in a broader range of people. Instead of continuing this, this type of personality is mathematicians so everybody after that is only those types of personalities can become mathematicians.

Overall, these women did not feel that they fit in in mathematics. They felt uncomfortable in classes and other settings in which there were few women; the isolation was even more extreme for Black women. They felt distanced from mathematics by stereotypes of mathematical people as lacking in social skills.

Discussion

Similar to any level of mathematics education, success in graduate school necessitates

learning mathematical content, participating in mathematical practices, and coming to belong in mathematics (Boaler, 2000; Herzig, 2004a). While graduate mathematical education has long emphasized the teaching of mathematical knowledge, and increased calls have recently been made to train graduate students in a range of mathematical practices (Bass, 2003), students' coming to feel that they belong in mathematics has been largely unexamined. It has been argued that students' integration into the academic and social communities of their departments and programs is critical for their persistence in graduate study; this further supports the importance of developing a sense of belonging in graduate mathematics.

I documented some obstacles to belonging faced by female graduate students in particular, including conflicting demands of family and school, particularly the demands of childbearing and childrearing; difficulty in identifying role models; the isolation of life in a (mostly White) male-dominated discipline; and the burden of having to prove their worth and the worth of all women in mathematics. These obstacles may help explain, at least in part, the disturbingly small numbers of women entering graduate school and completing the PhD in mathematics.

Suzanne Damarin (2000) compares mathematical ability to other "marked categories" such as women, people of color, criminals, people of disability, or homosexuals. She identifies these characteristics of marked categories:

1. Members of marked categories are ridiculed and maligned, and descriptions of marked categories are used to harass, tease, and discipline members of the larger society.
2. Members of marked categories are portrayed as incompetent in dealing with daily life.
3. In institutions designed to meet the needs of all, the needs of members of marked categories are deferred, compared with the needs of the unmarked.

4. Members of marked categories are feared as powerful even as they are marked as powerless.
5. Marking serves to define communities of the marked.
6. Membership in multiple marked categories places individuals in the margins of each marked community.
7. The study of a marked category leads to the construction and study of the complementary class of people.
8. The unmarked category is generally larger than the marked category; even when this is not the case, the marked category is not recognized as the majority. (Damarin, 2000, pp. 72-74)

Damarin then presents an analysis of discourses surrounding mathematical ability, and concludes,

From leading journals of public intellectual discussion, from the analyses of sociologists of science, from the work of (genetic) scientists themselves, from the pages of daily papers, and from practices of students and adults within the wall[s] of our schools, there emerges and coalesces a discourse of mathematics ability as marking a form of deviance and the mathematically able as a category marked by the signs of this deviance. (p. 78)

In addition to being marked as women, mathematical women are further marked by the stereotypes of the mathematically talented. Mathematicians and mathematics students have commonly been stereotyped as lacking in social skills (Damarin, 2000; Campbell, 1995). Nel Noddings (1996) argues that

There seems to be something about the subject or the way it is taught that attracts a significant number of young people with underdeveloped social skills. . . . If this

impression of students who excel at math is inaccurate, researchers ought to produce evidence to dispel the notion, and teachers should help students to reject it. If it is true, math researchers and teachers should work even harder to make the “math crowd” more socially adept. Because that group so often tends to be exclusive, girls and minority youngsters may wonder whether they could ever be a part of it. But when the group is examined from a social perspective, many talented young people may question whether they *want* to be a part of it. (p. 611; italics in original)

Given the common perceptions of mathematics students as being white, male, childless, without interests outside of mathematics, and socially-inept, it may be that members of various groups recognize tangible ways in which they do *not* fit in with this group, and do not *wish* to fit in. Belonging in mathematics may not be an entirely good thing: while belonging seems to facilitate persistence and success in mathematics, it also “marks” a student as deviant, as socially inept. Women who choose to pursue mathematics must be willing to endure these multiple constructions of themselves as deviants, both as women and as mathematically competent. A desire to avoid these constructions might explain these women’s unwillingness to allow themselves to become all-absorbed in mathematics and the ways they defined themselves in contrast to those who do.

On the other hand, graduate study in mathematics is a “greedy institution” (Cosser, 1974; cited in Grant, Kennelly, & Ward, 2000), and as such demands undivided loyalty and “total commitment from participants and the relinquishing of competing commitments” (Grant et al., 2000, p. 63). The women’s unwillingness to devote themselves to mathematics “110 percent” presents an obstacle of its own, preventing them from being accepted as full members of that community.

Damarin (2000) goes on to argue that membership in the deviant category provides the “deviant” with a community with which to affiliate; being identified and marked as mathematically able allows the mathematics graduate students to form a community among themselves. Unfortunately, women are members of (at least) two marked categories, and the double marking is not simply additive; that is, it is not the case that they simply belong to a separate marked category of “mathematically able women.” Instead, they are constructed as deviant separately within each marked category. First, they are marked as women, but among women, their mathematical ability defines them as deviant. Second, given common stereotypes of mathematics as a male domain, mathematical women are marked among mathematicians as not really one of them. For women of color, the marking is three-fold and even more complex, leading them to be distanced from each of those communities to which they might otherwise belong. Consequently, mathematical women do not have access to the mainstream community of the mathematically able, as their double- or triple-marking marginalizes them from this community. Instead, women who elect to pursue mathematics are often members of smaller communities which respect and reward mathematical abilities, partly countering the discourses that label their mathematical abilities as deviant (Damarin, 2000). Students in several programs have reported the importance of having a “critical mass” of women or students of color (Cooper, 2000; Manzo, 1994). The importance of role models to the women I interviewed may represent their attempts to build these smaller communities that affirm them as women and as mathematics students, since they do not have access to other mathematical communities that might serve this purpose. Without these smaller communities, women are left without a sense that they belong somewhere, *anywhere* within the world of mathematics.

Parenthood is another greedy institution, particularly for women (Cosser, 1974; cited in Grant et al., 2000). The conflict between the two greedy institutions of motherhood and graduate school can be substantial, particularly given that so many women who pursue graduate studies in mathematics do so shortly after completing college, so that the timing of graduate school and of childbearing can coincide. Graduate school is not structured to accommodate childbearing and childrearing demands, and family responsibilities affect women graduate students more strongly than men (Lovitts, 2001; Nerad & Cerny, 1993; Sonnert & Holton, 1995). Women graduate students in science who marry or have children have been viewed as not serious about their studies, or as unreliable and not worth the investment; men who marry or have families do not face the same biases (Etzkowitz et al., 2000). In this sense, women who are both mothers and graduate students are assumed to have conflicting loyalties, and are marked as not serious students. In mathematics in particular, some women reported having left graduate mathematics altogether due to the perceived incompatibility of the life of a doctoral student in mathematics and a personal life outside of mathematics (Stage & Maple, 1996). The women interviewed here document the high costs of considering parenting for those women who chose to remain.

Graduate mathematics educators need to question whether it is necessary to give oneself over to mathematics entirely, or if it is possible to do mathematics without this total devotion. As these women described, when they are recognized and respected as complete human beings with interests and commitments outside of school, their opportunities to pursue mathematics are enhanced. It seems quite likely that at least some of these women might make valuable contributions to mathematics, and might be mathematically successful in other ways, even without devoting themselves to mathematics “110 percent.” At American University, where women of color were particularly successful, a commitment was made to “accommodating the

busy professional and personal lives of the women, many of whom are working mothers”

(Manzo, 1994, p. 40); students and graduates of that program reported that such flexibility was a critical factor in their persistence. Is there some way that graduate education in the mathematical sciences more broadly might be re-conceived to accommodate the full and busy lives of a more diverse student body?

The women whose experiences are reported here described the myriad ways that they were different from other students around them and consequently had to struggle to find ways in which they could feel that they belong in mathematics. Enhancing the diversity of mathematics graduate students requires a focused effort to build avenues for women and people of color to connect with the communities within their programs and departments, to develop communities, and to develop a sense that their mathematical abilities, their gender, and other aspects of who they are, are not deviant. Only then can women and some other groups of students come to feel that they truly belong in some part of the mathematical world.

Footnotes

I would like to express my sincere gratitude to the 12 women whose stories are reflected here, for their generosity in welcoming me into their mathematical worlds and taking the time to discuss their stories with me. I would also like to thank Diane Gusa for her careful and thoughtful assistance in the data analysis. Special thanks are due to Diana Erchick, whose patience in coordinating this project was unbelievable at times, and was certainly put to the test.

1. The inconsistency between this statistics and the one on the previous paragraph represents some of the difficulty in accurately measuring and reporting on these parameters. Different sources of data define mathematical sciences and the relevant populations somewhat differently, resulting in the inconsistency.

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