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Women Belonging in the Social Worlds of Graduate Mathematics

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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. Using an institutional ethnography approach, I interviewed 12 women graduate students from three mathematics departments in the U.S. to document their experiences within the social relations of graduate mathematics. They described both intrinsic and extrinsic obstacles to belonging, including a tension between their desire to belong and their needs to distance themselves from what they perceived to be the mathematical culture. These women's stories are interpreted 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.*
Keywords: belonging, graduate students, institutional ethnography, women

1. Introduction

Despite increasing attention over recent decades, women's participation in advanced mathematics in the U.S. still lags substantially behind that of men. In the U.S. in 2006, women earned 41% of bachelors degrees and 43% of masters degrees, comprised 32% of first-year, full-time graduate students (30% of total full-time students) in doctorate-granting mathematics departments, earned 32% of PhDs (among U.S. citizens, women earned only 27% of PhDs), received 22% of new doctoral positions in PhD granting departments, and comprised 12% of full-time tenured or tenure track faculty (25% of non-tenure-track faculty) at doctoral granting

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institutions (National Science Foundation, 2008; Phipps, Maxwell, & Rose, 2007). 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 the persistence 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 this paper, I use an institutional ethnography approach (Smith, 2005; Campbell & Gregor, 2004) to examine the nature of women's experiences in graduate mathematics. It is not the goal here to compare women's experiences with those of men; indeed, many of the obstacles and issues women face likely affect men as well. However, particularly in the context of recent public concern about the small numbers of women persisting in mathematics and the sciences, this analysis was undertaken to add depth to our insights about women's experiences in mathematics and the reasons for their relatively slow progress into advanced positions in the field.

1.1 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. 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 often 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 a sense of belonging within the discipline (engaging in mutual ways with the other community members) (Boaler, 2002; Boaler, Wiliam, & Zevenbergen, 2000; Herzig, 2004a). Students who have limited access to any of the three dimensions of learning of mathematics—acquiring knowledge, practices, and a sense of belonging—will be inhibited in their opportunities to learn and engage with mathematics, and will be less likely to persist in mathematics. 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.

Beyond the communities of practice of graduate school itself, graduate students are also working to engage with the practices of mathematicians. 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). Although there are some notable exceptions, the first several years of doctoral education in mathematics typically follow 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). Consequently, many graduate students have few opportunities to participate in many of the activities of professional mathematicians. To the extent that a graduate program sequesters prospective mathematicians from the genuine practices of mathematicians, it limits their opportunities to learn to work as mathematicians (Herzig, 2002; Lave & Wenger, 1991). 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 graduate students' need to learn the practices of the profession. However, little attention has been paid to students' development of a sense that they have a place within the mathematical community.

1.2 Belonging in Mathematics

Building students' sense of *belongingness* in mathematics has been proposed as a critical feature of an equitable K-12 education (Allexsaht-Snider & Hart, 2001; Ladson-Billings, 1997; National Council of Teachers of Mathematics, 2000; Tate, 1995). Martha Allexsaht-Snider 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, and define *belonging* as "the extent to which each student *senses* that she or he belongs as an important and active participant" in mathematics (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. This extends Allexsaht-Snider 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, 2006). In interviews with 18 graduate students in one mathematics doctoral program in the U.S., students who had 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) were found to be more likely to persist through the Ph.D. (Herzig, 2002). It seems, then, that developing an identity as a mathematician, a sense that "I belong here," is one critical component in the persistence of doctoral students.

1.3 Obstacles to Belonging for Women

Many students face obstacles in graduate mathematics, including harsh weed-out policies and competition (Herzig, 2006; 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, Kemelgor, & Uzzi, 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).

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 in the U.S. have few female role models to guide them; in the fall of 2006, while 30% of full-time graduate students were women, only 12% of full-time doctoral faculty were women (Phipps et al., 2007).

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 may lead them 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.

A community of practice imposes certain cultural practices and implicit expectations on students (Lave and Wenger, 1991). The isolation, sexism, lack of role models, and stereotyped understandings of women's interactions in graduate school can combine to demonstrate to women ways that they do *not* belong in the male-dominated cultures of their departments and disciplines (Etzkowitz et al., 2000; Herzig, 2006; Hollenshead et al., 1994). In this sense, the communities of practice of graduate school and of mathematics may set expectations which some students are unable or unwilling to meet. It is therefore possible that people who persist in mathematics are those who are able or willing to adapt themselves to those cultural practices; that is, they learn, or are self-selected, to work within the existing structure, to play by the existing rules (Stage & Maple, 1996). In a study comparing the careers of women and men scientists, Sonnert and Holton (1995) found

> little evidence that women in science follow or believe in a radically different epistemology or methodology that some feminist theorists of science have suggested. It may, of course, be proposed that women (and men) with alternative methodological and epistemological approaches do not flourish or survive in the science pipeline for very long, so that the scientists who are reasonably successful under the current system of science are predisposed to it, or at least have learned to accept it. (p. 156)

Individuals whose talents, values, skills, or interests make it difficult or undesirable for them to adapt to that structure may not be able to successfully negotiate the educational and professional systems that are necessary to allow them to do mathematics. In this study, I examine the social and cultural practices that are implicit in graduate mathematics education, and how those practices impact the experiences of women trying to become mathematicians.

1.4 An Institutional Ethnography Approach

Institutional ethnography is a method of investigation that explores how social settings

(in this case, mathematics graduate programs in the U.S.) are organized, and the web of social relationships that are the basis of those settings, through individual's experiences. This approach "attempt[s] to uncover, explore, and describe how people's everyday lives may be organized without their explicit awareness but still with their active involvement" (Campbell, & Gregor, 2004, p. 43). The focus of an institutional ethnography is to "learn to think, hear, and talk about the setting as various participants know it, but . . . also attend to . . . how a setting is organized" (Campbell & Gregor, p. 50). In this study, I attempt to use women's stories to reveal the social relations of mathematics graduate study, and how those relations organize women's experiences and opportunities within mathematics.

> Institutional ethnography begins by locating a standpoint in an institutional order that provides the guiding perspective from which that order will be explored. It begins with some issues, concerns, or problems that are real for people and that are situated in their relationships to an institutional order. Their concerns are explicated by the researcher in talking with them and thus set the direction of inquiry. (Smith, 2005, p 32).

In this study, I begin "in the local actualities of the everyday world, with the concerns and perspectives of people located distinctively in the institutional process" (Smith, 2005, p. 24), with the perceptions of women graduate students. From their perspectives, I examine how their experiences are situated in the institutional order of graduate study in mathematics, with a focus on the opportunities and obstacles they face to developing a sense of belonging in mathematics.

The importance of belonging and the obstacles women face in developing a sense of belonging in graduate mathematics form the *problematic* (Campbell & Gregor, 2004) of the present study. I investigate this problematic through interviews with 12 women graduate students in mathematics in the U.S. As these women's experiences and stories unfold, we see the ways that the social order of graduate mathematics leads them to both seek and resist belonging in mathematics.

2. Method

This study is based on interviews with 12 women graduate students in mathematics, four enrolled in each of three PhD-granting mathematics departments at large, public universities in the U.S. 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 as a purposeful sample from the larger samples from which they were drawn, using maximum variation sampling (Patton, 1990). They were selected order to represent as broad as possible a range of experiences and identities within and beyond mathematics. In this way, the relatively small sample size can be turned ". . . into a strength by applying the following logic: Any common patterns that emerge from great variation are of particular interest and value if capturing the core experiences and central, shared aspects of impacts of a program" (Patton, 1990, p. 172). Some participants 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 U.S., 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 before entering their current graduate program. They ranged in age from their early 20s through their early 40s. Four of the women were African American and the remaining eight were White. 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 leave their programs after completing Masters' degrees (one of the two had already left the program by the time of her interview); as of this writing, 4 of the 10 other women had completed the PhD, and 6 were progressing within their programs.

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; see Appendix I). 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). 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.

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 concerning issues of belonging within mathematics, including obstacles they experienced. 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 each interview was unique, statistical information about their responses is not provided. The narrative that follows weaves together issues that were common among the women's stories about belonging in mathematics, 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. In order to protect participants' anonymity, only limited information is provided about individual women.

3. Women's Experiences of Developing a Sense of Belonging

Through these open-ended interviews, the participants discussed three general themes concerning their experiences developing a sense of belonging in the social worlds of mathematics graduate study: the importance of having and being role models, the challenges they felt "fitting in," and their unwillingness or inability to focus on mathematics to the exclusion of

all else. Each of these themes is explored in subsequent sections.

3.1 Having and being role models

Most of the women had people they identified as 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 and graduate students who could help them see that they, too, could build a satisfying life in mathematics. For some, the small numbers of women mathematicians they had encountered as undergraduates or 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 relate to that would really push me a lot better. . . . A female professor pushing me intellectually seems to be more what would actually drive me.

Seeing successful women in mathematics—particularly women who were mothers—helped them believe that they could succeed as well. Some women really appreciated role models who demonstrated the possibility of balancing 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. . . . 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.

Each of the four Black women I interviewed (in two different departments) had heard about the three African American women who had earned PhD's from the Department of Mathematics at the University of Maryland in 2000 (Argetsinger, 2000)[2]. They each spoke of ways that those women's examples were 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 was readily available to 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.

One surprising issue that arose was the desire and expectation that some of these women felt to *serve* as role models for other women. This sentiment was expressed particularly eloquently by 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 [classmates]. I feel that getting a PhD is not about me. . . . For me, 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 work toward 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, to which she felt intensely loyal. Another woman described her admiration for another graduate student whom 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.

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 . . . . To not go to grad school would have been lightweight, and just support the theory that women are lightweights when it comes to math.

Serving as a role model for other women, or for men about what women can achieve, was a double-edged sword for these women, placing substantial pressure on them to work to a higher standard than the male students in order to disaffirm stereotypes and prove what women could do.

> 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.
>
> 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.

Having role models, and being role models for others, helped these women identify others with whom they could affiliate in mathematics, and supported their beliefs that they could succeed. As I will discuss later, these affiliations helped these women construct a mathematical community in which they felt they belonged, countering some of the isolation they otherwise felt in their programs. However, these affiliations also carried burdens within the social relations that organize their graduate programs, as they felt pressure to prove their worth and invalidate negative stereotypes of mathematical women.

3.2 Fitting In

As one woman described above, being some women felt that they stood out as different from the other students. There were a number of ways in which these women spoke about their challenges in feeling that they belonged in mathematics and in graduate school. 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.

One woman described how she felt that it was unacceptable to show femininity.

> 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.

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

> I guess 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 four 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 primarily White institution entailed an adjustment for them. They felt that they stood out in some situations, and felt invisible in others. These adjustments were described as a combination of 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; and sometimes intolerance, describing some 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. They also 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.

Another topic that some of the women discussed is the stereotype of mathematicians or mathematics students as being "nerds" or "uncool." 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 [mathematics] 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)

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. I 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 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 or for women who were mothers. They felt distanced from mathematics by stereotypes of mathematical people as lacking in social skills. In each of these ways, these women faced explicit obstacles and clear messages about ways that they did not belong in mathematics.

3.3 Being unwilling or unable to become engrossed exclusively in mathematics

Most of the women interviewed majored in mathematics in college because they realized that they were good at it, that it "came naturally" to them, or that mathematics was fun, but many of them explained that mathematics was only one of several interests they might have pursued. They chose graduate studies in mathematics for a range of reasons, including the desire to teach, a passion for learning more mathematics, and even "nothing better to do," many of them emphasizing the happenstance that led them there. This advanced graduate student, who is now an assistant professor of mathematics, summarized the feeling of many, emphasizing that while she was good in mathematics, it was only one of many things she was 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.

All of the women reported having some times when they experienced doubts about continuing with their graduate studies, wondering whether it was worth the sacrifices to their

personal lives that persistence would require. Like this first year student, who was also the mother of a young child, the women described 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.

The women's longing for a life outside of mathematics 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. Many women acknowledged that they had to have a love for mathematics in order to find the motivation to continue. However, the women also reported that they were not as focused on mathematics as they perceived the other students around them to be, as this first-year student explained:

> 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.

The woman who made the following statement had entered graduate school to earn a Ph.D., but at the time of her interview was preparing to leave after completing her Masters degree:

> 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.

While these women generally felt they had the determination, will to work hard, and perseverance required to complete the PhD, they also placed limits around their commitment to mathematics, and they clearly identified themselves as being more than just mathematics students. They described their desire *not* to be totally identified with mathematics, and

emphasized that they belonged not only to mathematics, but were well-rounded individuals with other interests and obligations.

Their stories highlight a tension between being mathematics students and their need to fit in, through which their desire to be more than "only" mathematics students was confronted with a social order in which they felt that total devotion was required of them. For some, this disconnect between the way they perceived 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 graduate school, and presented an intrinsic obstacle their development of a sense of belonging in their graduate programs.

Suzanne Damarin (2000) compares people with mathematical ability to other "marked categories" such as women, people of color, criminals, people of disability, or homosexuals, and 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 pubic 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)

If students in advanced mathematics are indeed marked as "deviant" because of their mathematical talent, women students are marked within this group, and may suffer the double stigma of not being "real" mathematicians because of their gender, and not being "real" women because of their work in mathematics. 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. Thus for some students who already feel marginalized in some communities, belonging in mathematics may not be an entirely good thing: while belonging facilitates 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. The women in this study described ways that they worked to distance themselves from some of these common constructions of mathematical deviance, which, paradoxically, led them to resist belonging in 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 the women 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 can backfire, as it also meant that there were times when they could fall far behind in their studies. Several of them felt 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." One fourth-year student lamented how competitive she perceived graduate school to be; she hated the emphasis she heard repeatedly on how long it took various students to earn their degrees and the pressure that imposed on her.

None of them objected 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. This woman described how the satisfaction of learning and focusing on her own progress worked against these frustrations:

> 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.

This woman had had very difficult struggles in her family life, including health challenges, which interfered with her ability to engage fully in her studies for some periods of time and made it difficult for her to engage in the social and academic worlds of her program. However, she persisted, has progressed in her program, and hopes to finish soon. Like many of the women, balancing their lives as graduate students with their other responsibilities was a significant challenge, and she expressed her frustration at not being able to devote herself fully to either her family life or studies.

Earlier, I discussed the women's perceptions that other graduate students were totally absorbed in mathematics. The women I interviewed struggled to find a place for their non-mathematical selves in their lives, *insisting* 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 other subject areas, playing music, volunteer work, and dating—all the things that make up the lives of a varied group of people. Some of the women who were mothers described ways that their professors and advisors supported their need to meet family responsibilities. But others also felt a sense of disapproval from their advisors and professors for having outside obligations. This fourth-year student was studying a world language in order to connect herself more strongly to her ethnic heritage, and was committed to volunteer work she did in her community:

> 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? No 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.

In addition to describing these outside activities as essential parts of their lives that they valued and enjoyed, 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, or 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, volunteer work, teaching exercise classes, or positions in 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. For example, this third-year student had gone through some difficult challenges in her personal life. She 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." Paradoxically, she went on to describe 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.

This African American woman was the mother of a young child, and described how important it was to her, when she came to visit her 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, like this mother of two 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.

Conversely, when devoting time to schoolwork, they felt pressure, stress, and guilt over not spending more time with their children, like this mother:

> 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.

Graduate study is a "greedy institution" (Coser, 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). These women described an unwillingness to devote themselves to mathematics "110 percent," and ambivalence about whether or not they *wanted* to belong in mathematics, which represents an intrinsic obstacle to belonging in mathematics.

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 parenting while in graduate school, including the financial pressures of having a child on the limited income of a graduate student. One fourth-year student, who was beginning to work on her dissertation, said:

> 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 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.

Her advisor fully accepted her obligations as a parent, inviting her to bring her child along to meetings or re-scheduling an exam when she could not find childcare. At the same time, the department insisted that she be enrolled in a full-time load of 9 credits in order to receive financial support. Several mothers described how this course load, coupled with teaching responsibilities, posed a significant challenge to them as parents.

Parenthood is another greedy institution, particularly for women (Coser, 1974; cited in Grant et al., 2000). The conflict between the two greedy institutions of motherhood and graduate school can be substantial. Of course, while some fathers are involved in child care and male students may also experience conflicts between school and parenting, women experience the additional pressure about the concurrent timing of graduate school and their childbearing years. 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 have 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 in the present study describe the high costs of considering parenting for those women who chose to remain, and the high cost of graduate study for those who are parents.

Students are members of a range of communities of practice, including school, family, and other communities. 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 become integrated in the mathematical communities of graduate school. Of course, many of these obstacles may affect both women and men; what is noteworthy about these women's experiences—even if not unique to them—are the intentional choices they described to distance themselves from mathematics, despite their passion

and dedication to their studies.

4. Conclusion

The need to belong is perhaps among the most fundamental human needs (Flinders, 2002). Carol Lee Flinders (2002) searched extensive anthropological and archeological records, and provided an historical analysis to argue that prior to humankind's mastery of agriculture ten thousand years ago, what she calls the "values of belonging"—such values as cooperation, intuition, balance, deliberateness, mutuality, affinity for alternative ways of knowing, and inclusiveness–were fundamental to the organization of many cultures around the globe. For foraging peoples, there was no motivation to compete, to exclude, or to acquire; instead, the values of belonging were the foundation of social organization. But, with the advent of agriculture, a new culture of acquisition and competition began to develop, and social divisions based on status and domination evolved. Cooperation and belonging became a lower-order priority, as the notion of privilege itself became privileged;

As I argued earlier, success in graduate school necessitates learning mathematical content, participating in mathematical practices, and coming to belong in mathematics (Boaler, 2000; Herzig, 2004a). 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; further supporting the importance of developing a sense of belonging in graduate mathematics. 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.

I documented some obstacles to belonging faced by female graduate students in particular. Many of these obstacles are not surprising: difficulty in identifying role models; the burden of having to prove their worth and the worth of all women in mathematics; conflicting demands of family and school obligations, particularly the demands of childbearing and childrearing; and the isolation of life in a (mostly White) male-dominated discipline. These obstacles may help explain, at least in part, the small numbers of women entering graduate school and completing the PhD in mathematics.

Damarin (2000) argues 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. Women graduate students who are parents also suffer the multiple markings of being mathematically talented, being women, and being parents, and need to develop strategies to cope with these conflicting labels and their demands. Consequently, mathematical women do not have access to the mainstream community of the mathematically able, as their multiple markings marginalize them from this community.

Instead, women who elect to pursue mathematics are sometimes 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 doctoral 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 and the presence of other women students to the women I interviewed may represent their attempts to build 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.

Graduate mathematics educators need to question whether it is necessary to give oneself over to mathematics entirely, or if it is possible to do quality work in mathematics without this total devotion. In the famous remarks made by former Harvard President Lawrence Summers, he claimed that

> the most prestigious activities in our society expect of people who are going to rise to leadership positions near total commitments to their work. They expect a large number of hours in the office, they expect a flexibility of schedules to respond to contingency, they

> expect a continuity of effort through the life cycle, and they expect-and this is harder to measure-but they expect that the mind is always working on the problems that are in the job, even when the job is not taking place (Summers, 2006).

Despite these expectations, it may not actually be the case that this "near total commitment to their work" is necessary to enable productive contributions to scholarship. 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. 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. Leaders in graduate mathematics education need to consider whether graduate programs might be re-conceived to accommodate the full and busy lives of students with a more diverse set of commitments and identities.

The institutional ethnographic approach used in this study used the reported experiences of 12 women to illuminate aspects of the institutional and social relations of graduate mathematics that present the women with an important and difficult tension. On the one hand, they described the myriad ways that they were socially isolated from other students around them and consequently had to struggle to find ways in which they could belong in mathematics. On the other hand, they described ways in which stereotypes of mathematics students and the multiple constructions of themselves as deviant as women, as mathematicians, and for some, as parents or people of color, led them to *choose* not to identify with 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. This requires more than just bringing women and people of color into existing mathematics communities, but also requires a re-consideration of prevailing stereotypes and conventions among those involved in mathematics. As Noddings (1996) argued, mathematics educators need

to find ways to make the social world of mathematics more accessible to a broader range of people. Only then can women and some other groups of students come to feel that they truly belong in some part of the mathematical world.

Notes

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1. These three women were the first African American women to earn the PhD in Mathematics from the University of Maryland, and were half of the only six African American women who earned PhDs in the mathematical sciences *nationally* in that year. Their ground-breaking accomplishments were covered in the national media (e.g. Artsinger, 2000).

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Appendix I

Graduate Student Interview Outline

The questions below are intended to give a direction to our discussion, but are not requirements for how it will develop. Feel free to delete anything from the list that you do not wish to discuss, and to add anything else that you feel might be relevant.

About your interests in mathematics:

- When did you first become interested in math? How did that interest develop?
- Have there been any people who have been influential to you in mathematics?
- What experiences have you had with mathematics, either in or out of school? How did those experiences affect you?
- Do you feel successful in mathematics?
- Why did you decide to come to graduate school? Why at [name of university]?
- What did you initially hope to do with the degree?

About your experiences in graduate school:

- Which aspects of graduate school met your expectations? Which didn't? Why?
- What have you enjoyed most about your experience here? What have you enjoyed least?
- What are the most important things you have learned? How did you learn those things?
- What relationships do you have with other students? With faculty?
- How have you learned (or are you learning) to do mathematical research, and to work as a mathematician?
- Are you involved in the department or the broader mathematical community outside of class?
- What does it take to succeed in graduate school?

About your current goals in mathematics:

- What are your current goals in mathematics?
- Did you ever have doubts about continuing? When did you first start having doubts? Why?
- Which factors have been the most helpful in helping you to stay in the program, and to succeed to this point?

If you left the program, plan to leave, or are thinking of leaving without finishing:

- At what point in your program were you when left or will you be when you leave?
- If you could change anything about the math department or program here to make it a better experience for you, what would you change? Are there things the faculty could have done to have made you more likely to stay?
- Do you have any second thoughts?
- What will you do/are you doing after graduate school?