Women with Advanced Degrees in Mathematics in

Doctoral Programs in Mathematics Education: A Preliminary Report

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*Abstract.* We report on analytic inductive analysis of experiences and recollections gathered through interviews of nine women at three universities. Each woman had an advanced degree in mathematics and chose to move into a doctoral program in collegiate mathematics education housed in a mathematics department. The focus of the two-interview protocol was exploring and extending the framework for doctoral mathematics student experience suggested by Herzig (2004a, 2004b). Preliminary results indicate the emergence of additional themes not previously suggested in the literature (self as teacher, self as scholar, and future possible roles), as well as a need to refine the scope of the existing categories.

Each year the attrition rate for graduate students in doctoral mathematics programs is estimated to range between 30% and 70% (Bowen & Rundenstine, 1992; Cooper, 2000; Golde, 1996; National Research Council, 1992, Zwick, 1991). Of the more than 1000 people who do complete mathematics doctorates every year, about 30% are women (American Mathematical Society [AMS], 2006). Meanwhile, each year, an average of fewer than 100 individuals graduate with doctorates in mathematics education, 65% of whom are women (Reys, 2003). In the last decade, about half of mathematics education doctoral graduates have sought employment in higher education and recently only 3 out of every 5 university faculty positions available for mathematics education doctorates have been filled (Reys, 2006). On the other hand, for the past 20 years higher education positions for those with research mathematics doctorates have been inundated with applicants, leaving many recent Ph.D.s in mathematics un- or under-employed (AMS, 2006). Though doctoral graduates in *mathematics education* expect their new faculty positions to involve a significant commitment to teaching, most doctoral *research mathematics* graduates do not. Nonetheless, each year more than three-quarters of

new Ph.D.s in mathematics end up with college positions that require them to build expertise in mathematics teaching and learning (Kirkman, Maxwell, & Rose, 2006, 2007; Reys 2006). We have a national problem: Though the human resources available for the teaching and learning of mathematics at the undergraduate level are developed in collegiate mathematics education doctoral programs, they *are not* developed in doctoral research mathematics programs in ways that meet the needs of higher education. In particular, given the high departure rate of women from mathematics Ph.D. programs, and the high graduation rate of women from mathematics education doctoral programs, our question is: What is the nature of the graduate school related experiences of women who leave advanced mathematics programs to pursue the Ph.D. in collegiate mathematics education in a mathematics department?

*Theoretical Framework*

Clandinin and Connelly (2000) propose a strategy for naturalistic research based on a three-dimensional framework that attends to temporality (past, present, and future), sociality (social and personal), and place (situation). That is, in addition to the usual qualitative "thick, rich descriptions" about a particular experience, situation, or setting, one also considers temporality—the historical implications associated with current behaviors, actions, and words and their anticipated or possible projection(s) into the future. In addition to this framing for our data analysis, we designed data-gathering interview protocols based on the research literature on graduate student experience. The goal of the study reported here was exploring and refining the following research-based theoretical framework about doctoral student experience.

*Mathematics doctoral student experience.* Seven aspects have been identified in the literature as significant categories for those choosing and leaving doctoral programs in research mathematics: (1) community, (2) visibility and guidance, (3) moral support and encouragement,

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(4) mentoring and role models, (5) graduate course teaching quality, (6) balancing graduate student responsibilities with other life roles, and (7) intellectual ability (Herzig, 2002, 2004a, 2004b, Hollenshead, Younce, & Wenzel, 1994; Stage & Maple, 1996; Tinto, 1993). The first of these categories, *community*, refers to graduate students' feelings of membership within a department—both with faculty members and with fellow graduate students. *Visibility and guidance* refers to the ways students felt they were noticed or acknowledged by the faculty in their respective departments; that is, graduate students reported feeling "visible" when faculty members took note of their research interests and began to assist them in identifying a research topic. *Moral support and encouragement* refers to the kinds of influence and positive feedback offered by people (teachers, professors, family members, peers, etc.) either prior to or during graduate school. *Mentoring and role models* describes how graduate students viewed access to a person from whom they sought (or who offered them) mentoring or to a relationship with a person upon whom to model their own intellectual and personal growth. *Teaching quality* identifies perceptions of students about the nature of the teaching offered in graduate courses. *Balancing roles* refers to the tension people felt because they were a graduate student while at the same time also having a role as a spouse or significant other, a parent, or a member of another community. *Intellectual ability* was a category that appeared in much of the literature and, though not well-defined, appeared to involve one or both of a graduate student's own perceptions of their intellectual ability or the perceptions someone else had about their intellectual ability; for some researchers, this category could include things that a faculty member might say to another faculty member about the intellectual capacities of a graduate student (Herzig, 2002; Stage & Maple, 1996).

*Methods*

We conducted two detailed interviews with each of nine women – at least two participants at each of three large state universities in the United States. We refer to these as Big Urban University (BUU), Medium University (MU), and State Teachers College (STC). Table 1 summarizes some of the key characteristics of the schools (values are approximate).

Table 1. *Characteristics of Participants' Doctoral Program Institutions*

| Institution and Location | Total Enrollment | Graduate enrollment | Mathematics Graduate Enrollment (master's & PhD) | Collegiate Math. Ed. Ph.D. student enrollment (# of women) |
|---|---|---|---|---|
| BUU – Urban West | 25,000 | 6000 | 120 | 20 (9) |
| MU – Suburban Midwest | 25,000 | 5000 | 100 | 10 (7) |
| STC – Suburban West | 12,000 | 2000 | 100 | 15 (9) |

All nine participants had advanced degrees – either a master's degree in mathematics or in mathematics education with 80% or more of the coursework in advanced mathematics. Five women had completed mathematics coursework beyond the master's degree, one working for several years on a Ph.D. in research mathematics before moving to a collegiate mathematics education doctoral program. All were either currently in or, in the case of one woman, had recently completed collegiate mathematics education Ph.D. programs in mathematics departments. Also, because this project was autoethnographic-informed, the first author of this report, Toney, was one of the nine participants (she was interviewed by the second author).

Each interview was 45 to 90 minutes in length and audio or video recorded. The first interview focused on the pre-doctoral mathematics education program experiences of each woman. The second interview, conducted within 3 weeks of the first, was about her experiences in doctoral program(s) in mathematics departments. Specifically, we probed for

information in and outside the contexts of the seven aspects already identified in the literature, encouraging participants to discuss (1) the ways in which these characteristics affected their experiences in mathematics and in mathematics education, (2) did not affect those experiences, or (3) open up discussion to topics chosen by participants as a space for new characterizations of their experiences to emerge. We used a conversational approach to the interviews to honor the uniqueness of the responses of each participant, as well as to allow a level of flexibility in each interview for new information to emerge.

Additionally, Toney kept two detailed journals: one on her role as a co-participant and one as a researcher. In the first, she reflected on her graduate experiences both in mathematics programs and in a collegiate mathematics education Ph.D. program. Using a cyclic approach, she began by writing her responses to the interview questions, making note of new topics that emerged for her. She then wrote about her experiences with each new topic, making note of other new relevant topics, and so on. The second journal was her reflections as a researcher and about the research process. After each interview she wrote an interpretive synopsis of the interview, in which she summarized what was discussed during the interview and wrote preliminary thoughts on its implications for the research and research process. This assisted in the preparation for participant debriefing sessions, follow-up interviews, and later reporting. Each of these journal entries also addressed questions about the effectiveness of the interview in eliciting information in the framework areas (across time, location, and social aspects).

Our inductive hypothesis for data analysis was that the seven aspects were necessary and sufficient to describe the doctoral experience for graduate women in collegiate mathematics education. We used constant-comparative methods to identify evidence of the seven categories and other themes (i.e., experiences reported by the participants that did not fall

into one or more of the seven categories). Our cycles of data gathering, analysis, review, and formalizing results have followed a multistage writing process extrapolated from Clandinin and Connelly (2000, pp. 130-135). This multistage approach constitutes the first 3 steps of a 4-step analytic induction process (Patton, 2002, pp. 55-58; see Table 2, below).

Table 2. *Four-Step Analytic Induction and Multistage Writing Cycle*

| Step 1 | From separate interpretive summaries, generate a narrative case for each participant. | |
|---|---|---|
| Step 2 | Open and axial coding for pattern matching with the existing theory, new theme identification, and the identification of centers around which ideas are connected. | |
| | Passes 1-4 through Data and Generated Materials | Pass 5 through Data and Generated Materials |
| | Narrative coding for dates, places, names, events, actions, and topics, as well as sorting for temporal, social, and locational discussions. | Develop interim texts. |
| Step 3 | Conjecture a revised theory. | |
| Step 4 | Falsification of conjectured theory. | |

In this preliminary report we focus on the additional themes that have emerged from our analysis so far in Steps 1 and 2. Because the women in this study come from a fairly small professional community, we have chosen not to profile them here. All names used, with exception of the first author, are pseudonyms and all readily identifiable participant traits have been fictionalized to protect the confidentiality of the women who provided us with interviews.

*Results*

Though much of what participants said could be readily described in the language of the seven characteristics of experience, three new aspects of experience appeared to be coming out of our analysis. One of these was personal teaching ability. A participant's *perceptions of herself as a teacher* were quite frequent in the interview data, in spite of the fact that no interview question asked about it explicitly. This category of *self-as-teacher* experience is

largely absent from the research literature, the one significant reference to teaching appears in Herzig's (2002) category of perceived teaching quality—but that category is about the instruction graduate students experienced as a student. Participants in our study all cited their enjoyment of teaching as a primary reason for deciding to pursue the Ph.D. in collegiate mathematics education. Sue and Dale both noted that the local community colleges were increasing the requirements for a job and that having the Ph.D. would increase their chances of solidifying a permanent full-time community college position. Eve said she did not want to "sit alone in an office creating mathematics" in order to teach upper level college mathematics. Maureen commented that her reason for the switch from mathematics to mathematics education was because as a master's student she taught for the first time and enjoyed her interactions with the students and felt she was not getting the same enjoyment from her graduate mathematics classes. Lena was offered a research assistantship in a Ph.D. research mathematics program, but she turned it down and entered a collegiate mathematics education Ph.D. program where she had been offered a teaching assistantship. The above examples are all fairly positive. However, some participants had mixed feelings about wanting to spend more time on teaching than on doing mathematics. Allison echoed two other participants in noting:

> My own experiences as a college math instructor were definitely influential in my deciding to pursue the collegiate math ed. Ph.D. Teaching was the only thing I left my master's program confident about. In the first few weeks of my master's program I went from feeling confident to defeated about becoming a mathematician. Teaching class every day was what I looked forward to, and that was all I was eager about other than going home. Teaching was the one place I could go where I felt my mathematical knowledge was respected, even admired. When I go back to that horrid essay I wrote

to accompany my application to the collegiate math ed. Ph.D. program, it is obvious

that I viewed it as leading to a "teaching degree," a place to hone my teaching skills, a

place where failed mathematicians went to be teachers. I neither knew about what else

might come in the degree package nor knew enough to question what I did not know.

A second area of experience, the idea of women's perceptions of themselves as scholars

emerged in our analysis. Though this category may be related to the loosely defined *intellectual*

*ability* category in the research literature, *self-as-scholar* seems to be narrowly defined as the

set of experiences graduate women reported about connecting their intellectual efforts to their

professional (teaching) efforts through learning about and beginning to do research. The

category of *self-as-scholar* started from what we initially identified as *self as student*, where

participants discussed experiences as students but were *not* talking about other people (e.g., the

teaching quality they were receiving, or the encouragement they felt they were or were not

getting). They talked about themselves as learners in the mathematics classes and mathematics

education classes they were taking. There was also something else that we initially called *self*

*as researcher*, where the women talked about their research interests, the research ideas they

were working on, and how they were taking those ideas into the classrooms where they were

teaching. The women were reflecting on themselves in their educational experiences across the

whole timeline of their education. That is, this emerging category might be temporally

powerful and may be about the transition over time from a student relying on teacher-regulation

to a scholar relying on herself for self-regulation of learning, suggesting this new category we

have entitled *self as scholar*. It may be that negotiating and learning to know oneself as a

scholar is a *consequence* of balancing roles. That is, it may involve first finding balance among

personal roles and *self as student*, which we might assume is not a huge stretch for people who

have already spent many adult years in university. When asked about life outside of school during the master's and early in doctoral programs, all of the women talked about a kind of ease in balancing roles, in maintaining outside of school involvements. Dale was newly married and talked about feeling like she had plenty of time in the evenings and on weekends to "hang out and watch movies" with her husband. Maureen was a pianist and hiker, Sue was a cyclist, Lena was also newly married and had time to spend with her husband, and Allison often went spelunking or did not hesitate to go to the movies or to a party on Saturday night.

A temporally-based shift seemed to occur in the balancing of roles for the women who were not taking many classes and were working independently on research. Of the women who talked about themselves as researchers (other than briefly describing their dissertation research interests), most linked that discussion to some frustration about how research tied into other areas of their lives. Maureen was struggling with finding ways to reincorporate the piano into her world, Crystal put her church-related work on hold to focus on her dissertation, Perry felt time with her friends and family was suffering, and Allison abandoned the idea of romance and limited her time with friends. On the other hand, Lena seemed to have resolved the tension. She said she had assigned time amounts to get balance. This, she said, was because she was juggling being a student-scholar, wife, and mother of two. For 20 hours each week she was a researcher, when the 20 hours had passed, she was done. All other time was spent as a wife and mother and she did not think about her role as a researcher anymore. She said that because she only allotted 20 hours each week, she quickly learned to fully utilize every one of those hours.

Nell also seemed to find satisfaction in moving from student to scholar. Though she had not begun her dissertation work, she was working on multiple research projects with faculty members and other graduate students. Dale called Nell a "superstar" because she never seemed

to have conflict balancing her different roles (we were not sure if Dale was complementing Nell with this label). Nell also said she "came to [her] math ed program with the attitude… I'm going to change the face of mathematics education." She felt like the program had been a reassurance of what she was already thinking. Nell also noted that when she had been teaching middle school mathematics she was "making things up on the fly," but when she started coursework for the Ph.D. she found there were names for the things she had been doing in the classroom. When Nell had questions about things in her college classroom, she formed research groups, worked on the questions, and presented the results at conferences.

A third category, one that is still developing as we write this, is also related to the temporal aspect of our analysis framework: future possible roles. Our evolving definition, based in our continuing analysis of interview data, is based in part on the work of Markus and Nurius (1986) which considers the self as a collection of "possible selves" including who one has been, is now, and may potentially be in the future. In the many forms of research that led to the seven categories that form the foundation of this study, the focus was on *current* self with some attention to participants' previous conceptions of themselves. Here, because of the centrality of attention to the temporal continuity of experience in our theoretical framework, we have the opportunity to foreground the ways the graduate women in our study may be viewing and revising possible future selves as they move, in time, through their graduate experiences.

*Conclusions and Future Work*

In preliminary coding of interviews we found the participants either talking explicitly in the language of the seven characteristics outlined in the existing literature or we have had to stretch our understanding of them – some of what participants' said related to the existing themes in ways that could not justifiably be coded as something completely different.

Specifically, *mentoring and role models* and *teaching quality* appear to need the most careful review and further exploration. Also, we have identified three potential new categories, all of them arising from the attention to temporal aspects of graduate women's reported experiences.

During our presentation of this work at the RUME conference in March 2008 we asked audience members to read and respond to three vignettes. One excerpt exemplified *balancing roles* (among other things) and two were based on interview data illustrating *self as teacher*. Because most of the audience members had themselves completed advanced degree work in mathematics before entering a doctoral program in mathematics education, they were members or near-members of the group under study. Comments from the audience included universal validation of the self as teacher construct and provided some additional food for thought. In particular, one person wrote: "How to balance work/life to achieve tenure—seems to be hard to do" as well as "End stages of my dissertation broke my spirit, hard to get my research going again." We plan on follow-up questions to our participants around these two quotes in order to explore the temporal, social, and situational nature of the link between the two statements. We suspect, based on our reading of the research literature, our own research, and our conversations with others in collegiate mathematics education research, that balancing roles is a temporally stable category of experience and that it may also be socially and situationally stable. An area for further development of our research is analysis of the nature of all categories (the seven we started with, plus any potential additions) in terms of the nature of their stability or volatility to perturbation along the three dimensions. That is, in the context of graduate study in mathematics departments, how might graduate student experience in a given category relate to experience in a category being sensitive to temporal, social, or situational change? And, more generally, how might knowing more about these categories, their stability, and the nature

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of graduate student experience of them help us reshape graduate programs in mathematics departments (in research mathematics and collegiate mathematics education) to better serve the future possible roles of our doctoral students?

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