Teaching this Beautiful Math: A Preliminary Report

Shandy Hauk
University of Northern Colorado
hauk@unco.edu

Bernadette Mendoza-Spencer
University of Northern Colorado
bernadette.mendozaspencer@unco.edu

Allison F. Toney
University of North Carolina,
Wilmington
allison.toney@gmail.comm

Abstract. We report on analytic inductive analysis of semi-structured interviews with 10 women in doctoral programs in mathematics departments: 5 in collegiate mathematics education and 5 in mathematics. We are developing cross-case narratives that capture and communicate graduate student experiences around learning to teach college mathematics. The focus of the study is the nature of the development of agency in teaching as a part of the experience in graduate mathematics programs.

Background

Annually, 10 times as many doctorates are awarded in research mathematics as in mathematics education (approximately 1000 in mathematics and 100 in mathematics education). Though graduates in mathematics education expect their new faculty positions to involve a significant commitment to teaching, many who graduate with a PhD in mathematics do not. Nonetheless, more than 80% of people who complete a doctorate in mathematics take jobs where teaching is a significant responsibility that requires them to build expertise in mathematics teaching (Chen & Zimbler, 2002; Kirkman, Maxwell, & Rose, 2007; Reys, 2002). These same sources indicate that a majority (66%) of those who complete doctorates in mathematics education are women while the proportion of women completing PhD programs in mathematics is half as large (33%).

In "'Slaughtering this Beautiful Math': Graduate Women Choosing and Leaving Mathematics," Herzig (2004b) offered a framework for describing the experiences of women in PhD mathematics programs based on seven categories: community, visibility and guidance, moral support and encouragement, mentoring and role models, teaching quality, balancing roles, and intellectual ability. Recently, through interviews of graduate women in collegiate

mathematics education doctoral programs housed in mathematics departments, Toney (2008) extended Herzig's framework to include three new categories: self as scholar, "my teaching", and future possible selves. Email conversation with both authors indicated there was more to learn about the teaching experiences of graduate women in mathematics. In the study reported on here, we have focused on the category "my teaching." As we pursue the improvement of collegiate mathematics teaching, next steps will include expanding the participant pool to include men. However, this small study was an extension of Herzig's and Toney's work, still focused on women, and addressed the research question: *What is the nature of the teaching-related experiences of women in mathematics PhD programs and in collegiate mathematics education PhD programs?*

Methods

We designed the study around Clandinin and Connelly's (2000) strategy for constant-comparative inquiry based on the three dimensions of temporality (past, present, and future), sociality (social and personal), and place (situation). That is, in addition to the usual "thick, rich descriptions" about a particular situation or social or personal 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. The study reported here examined interviews with 10 women: 5 collegiate mathematics education doctoral students (or recent graduates) and 5 research mathematics doctoral students (or recent graduates). Average interview length was 2 hours. The women were from six different mathematics departments in different parts of the United States. The interview topics explored experiences and self-perceptions as a teacher, as a learner, and included follow-up questions about each of the ten framework categories mentioned above.

Results

Initial coding indicated that all 10 aspects of experience offered, collectively, by Herzig (2004a) and Toney (2008) were needed to describe the experiences of the graduate women in mathematics we interviewed. For this report, the focus is on the connections to the category "my teaching." This category refers to participants' experiences as a teacher of undergraduates. Interviews included assertions by participants that we classified as self-observations, reports of classroom practice, reflection on the nature of teaching and learning at the college level (including observations about others' teaching), and, for those graduate women who had developed one explicitly, a philosophy of teaching.

In our open coding we noticed participants analyze and critique the quality of teaching they may have observed others delivering (e.g., observations of other graduate students' or professors' teaching). However, when it came to examining their own teaching critically (i.e., reflecting on the quality of their own teaching, on what was evidence of student learning, or articulating a philosophy of teaching), participants struggled to articulate equally careful reflective analysis. We focus here on the connections we saw (explicitly or implicitly) between "my teaching" and the other nine categories. We present the results through two case stories, each framed as a conversation between a woman in mathematics and one in collegiate mathematics education. There are two reasons for reporting in this way. First, it allows us to foreground aspects of our interviews that were about teaching. Second, it allows us to use participants' voices to tell their own stories. Though fictionalized, each speaker is a revoicing of assertions made by a particular participant. The four "characters," Eve, Miranda, Avalyn, and Crystal, are pseudonymous. For example, Eve is not a composite or synthesis of several people. Her "character" is our effort to authentically capture and portray a particular participant.

Connecting My Teaching to Intellectual Ability and Community

The first fictionalized conversation takes place between Avalyn and Crystal, who have attended different universities for their graduate work, but have known each other for several years. Crystal has just finished her first semester as a new faculty member in a mathematics department. She took the position as ABD in her mathematics education doctorate. Avalyn, having recently completely her doctorate in mathematics, is beginning her first faculty job in a mathematics department. She has called Crystal to ask her advice. In this conversation, Avalyn comes from the position that her teaching is her sharing of her *intellectual ability* – her experience as a teaching assistant during her graduate work was to lead problem-solving sessions by demonstrating on the board how she solved problems. On the other hand, Crystal, who is in the role of mentor, has a background as a teaching assistant that involved being the instructor of record for several undergraduate mathematics courses during her graduate work; she comes from the position that one must identify the *community* and community standards, then see how to fit into that community.

> *Avalyn*: But, I'm not sure where to start with these classes because I've never
>   actually been the *instructor* before.
>
> *Crystal*: Okay.
>
> *Avalyn*: So, any suggestions or recommendations you can offer will be
>   appreciated.
>
> *Crystal*: Okay. Okay, well, um, the first thing I would do – do you have course
>   coordinators at your university?
>
> *Avalyn*: What's a course coordinator?
>
> *Crystal*: Oookaay. So, a course coordinator is, um, an individual who's designated
>   within the department to oversee a certain course. And, the coordinator is
>   there to make sure that what the department is offering for, say college
>   algebra, is uniform – across the department. And, so –

Avalyn: – Yeah, but – but, I want to, I want to do *different* things! I mean, I want to bring in *visualization* and stuff because I think – I think a lot of college algebra and, kind of low-level students, don't get the *chance* to do visualization. I'm, I'm supposed to arrive in a few weeks and they said that they have some old syllabi on hand, and –

Crystal: Right. And so you want to get *that*. You want to get the book – that you're going to be teaching out of – and compare the book and the material to the syllabus; and, look at different ones to see how people structure what they're doing. And, if you have, um, a university-wide policy you want to check into that. Because, some places require that the syllabi be uniform across the university and so there's elements that are required that come down from a higher "tier" in terms of what the structure should look like –

Avalyn: – Yeah, but I have a PhD in math! You know. It's not like I'm going to go in there and do wrong math! So, you know, I'm *sure* that the rule applies to, you know, *graduate* students who're teaching or something, but I can't imagine they're going to apply that same rule to *me*.

Crystal: You know, are you actually *saying* this? Oh my god!

Avalyn: Yeah. Go ahead.

Crystal: I'm not *offended*, but I'm horrified! – It may or may not be the case that the things you want to do are possible. Like, I don't have a specific answer to that, because I haven't taught at the institution that you're teaching – or that you're going to – and I haven't worked in that department. Someone in that department is going to have to tell you that. What I'm suggesting is that you understand the *landscape* before you make drastic *choices* about what you're going to do in your classroom.

Connecting My Teaching and Visibility

In the second revoicing conversation, Eve and Miranda are talking. Miranda is a recent PhD in mathematics and is a new faculty member at the university where graduate student Eve, who has decided to focus her PhD in mathematics education, is in her second year of graduate

work. Recently, a student in the class Eve is teaching as instructor of record approached her and

said, "I learn better if I work in groups." Eve is asking Miranda about this because she knows

Miranda has had teaching experience using group work. In drafting this conversation we hoped

to illustrate that, as a teacher, Eve felt a need to be available to her students as a knowledgeable

senior peer—someone students could rely on for the answer. In fact, Eve felt she was only *visible*

as a teacher when she was a source of information for students. In comparison, Miranda's view

of her own teaching was distant from the students and from the curriculum. She saw herself as

delivering the information but not as responsible to students (or to others, including observers)

for how that information got communicated.

> *Eve*: I remember you telling me that you don't learn well from group work. So
> why, why is that important, why would I do that?
>
> *Miranda*: As a graduate student I had to do this Lesson Study thing, where I was
> *forced* to do group, to try group work, and at the time I hated it, and –
>
> *Eve*: – Yeah, yeah. Yeah, but I, I want to try group work but at the same time my
> course captain's going to come in and observe me teach. What do I do if it
> doesn't go right? Do – How do you feel about, the course captain? How
> do you take care of it when the course captain comes to observe you?
>
> *Miranda*: I definitely do *not* like it when people observe me. It's, it's
> uncomfortable. I feel like I'm, I'm being *judged.* And, I feel very put on
> the spot. I, I don't like it when people observe me.
>
> *Eve*: So, so how do you participate in a Lesson Study then?
>
> *Miranda*: It's different. Like I said, I was *given* the lessons. These were, these
> were lessons that I was "trying out," so that when people came in to
> observe the lessons, they weren't observing *me,* they were observing the
> *lesson*.
>
> *Eve*: What happens if it doesn't work? What do you tell the students? What are
> the *students* thinking?

Discussion

The above conversations capture just a fraction of what participants said about their teaching. However, they do exemplify a key feature we identified throughout the interview data related to teaching: the interconnectedness of all 10 aspects of experience. At any given time when the women talked about their teaching, whether they spoke about the quality of someone else's teaching (professor or peer) or discussed their own experiences in the classroom as instructors, we identified comments that could also be coded as one or more of community, visibility and guidance, moral support and encouragement, mentoring and role models, intellectual ability, balancing roles, self as scholar, and/or future possible self. That is, the 10 aspects of graduate student experience for women outlined as the main result of Toney's dissertation are not mutually exclusive; we cannot talk about one single aspect of experience without talking about at least one (and usually more than one) other aspect of experience.

For example, we feel that both conversations highlight the strong connection between visibility and "my teaching." In previous work *visibility* as a category focused on whether the person was visible to those with power (e.g., faculty) in their respective departments. However, this kind of graduate experience of visibility, as a person with power in the classroom, has been under-explored in the literature. Also, mentioned briefly in Toney (2008), was the link between teaching quality and "my teaching." Although this link was clear, a specific vocabulary relating the two was not defined. As a result of the continued conversations in this research, we conjecture that critiques of (1) quality of my teaching, (2) quality of others' teaching, and (3) quality of teaching I have experienced, might define this link. Further conversations with graduate students in mathematics and mathematics education doctoral programs would provide further insight into these three evaluations.

As is indicated in both of the conversations presented above, among the implications for graduate program design and development that emerged from our interviews was the need identified by participants for preparation to work in a variety of teaching situations. Though all participants reported some experience in at least two forms of instruction (e.g., grading, tutoring, leading problem-solving or recitation sessions, teaching as instructor of record, creating assessments of student understanding, collaborating in course coordination, generating a university-compliant course syllabus, working with web-based homework), no participant was familiar with more than four of these. As discussed elsewhere (Hauk et al., 2009), effective development of the knowledge needed for teaching college mathematics includes providing graduate student teaching assistants in mathematics departments with structured and unstructured opportunities to be agents in *all* of these instructional activities. While most graduate mathematics students may discover ways to talk with peers and professors about teaching or may create their own opportunities to engage in unfamiliar teaching tasks, much greater success has been found in preparing the future professoriate through carefully planned, explicit, and reflective offerings (Austin, 2002; Pruitt-Logan, Gaff, & Jentoft, 2002; Speer & Hald, 2008).

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