Challenging Transitions and Crossing Borders: Preparing Novice Mathematics Teacher Educators to Support Novice K-12 Mathematics Teachers

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Sixty-nine recently graduated doctoral students in mathematics education completed a survey to determine their perceptions of transitioning from a doctoral program into an academic position at an institution of higher education. Research literature for novice mathematics school teachers was also reviewed to document their experiences transitioning from a teacher preparation program into a school teaching position. Similar transitioning experiences were found across both groups using the theoretical framework of border crossings. Findings showed that novice mathematics teacher educators needed more teaching experiences during their doctoral preparation programs as well as more mentoring during their initial years as professors. These findings are consistent with research findings on the experiences of novice K-12 mathematics teachers. The article then discusses how these findings impact the teaching and learning of mathematics across K-12 and university settings and offers suggestions for improving the transition for mathematics teacher educators into their academic roles as novice professors.

Keywords · teacher education · doctoral education · mathematics teacher educator preparation

Introduction

The preparation of mathematics teachers and mathematics teacher educators who prepare them and how they are prepared is a diverse process across countries (Goos, 2009; Schmidt et. al., 2007; Wang, Coleman, Coley, & Phelps, 2003). Some countries prepare teachers through university based degree programs while other countries use school-based teacher education programs. Some countries also have a combination of university and school-based teacher education options (Wang et. al., 2003). Mathematics teacher educators, those who prepare mathematics teachers, also vary by country. Some countries pull predominantly from an experienced mathematics teacher pool to serve as mathematics teacher educators while other countries, such as the United States, use university-based mathematics and the faculty of mathematics education, who may or may not have school teaching experience.

Given similarities across countries, we believe there is much to be learned from the parallels between the preparation of mathematics teachers and mathematics teacher educators found in this study based on the US. Just as important, we believe the differences across countries deepens from others and we can learn from our findings, suggestions to improve mathematics teacher education preparation globally (e.g., do they have enough experience teaching adults

and understanding the impact of teaching adults who will then teach students, do they have adequate mentoring?).

Much research has investigated the experiences of novice mathematics teachers (MTs[1]) (Britton, Raizen, Paine, & Huntley, 2000; Brown & Borko, 1992; Ensor, 2001; Gainsburg, 2012; Raymond, 1997; Sowder, 2007) with a focus on helping them better transition into their new roles as mathematics teachers (e.g., Chappell, Choppin, & Salls, 2004; Chappell & Pateracki, 2004; Chappell, Schielack, & Zagorski, 2004; Meagher, Edwards, & Ozgun-Koca, 2013; Stockero & Van Zoest, 2013;Wasserman & Ham, 2013). However, less is known about the preparation, knowledge, and experiences of mathematics teacher educators (MTEs[2]) responsible for preparing and supporting these teachers for their roles as new MTs (Even, 2008; Goos, 2009; Masingila, Olanoff, & Kwaka, 2012; Zaslavsky & Leikin, 2004). While the knowledge base about these two groups is quite different, there are similarities in their experiences that are interesting and important to explore. For example, new K-12 mathematics teachers' "early years of teaching are often characterised by a 'sink-or-swim' or 'survival' mentality because we have often failed to provide for careful support and thoughtful development of teaching expertise over time" (Bartell, 2005, p. 3). Likewise, new MTEs must learn to navigate the often rocky terrain of their institutions, wherein they seek to find ways to strike a balance between teaching, research, and service expectations. As Reys, Cox, Dingman, and Newton (2009) point out "important aspects to be monitored are the challenges that lie ahead for these new Ph.D.s as they begin their careers in higher education" (p. 9). Other researchers have looked to these challenges to help understand how doctoral education could provide better preparation for academic careers (e.g., Shulman, 2004). In contrast, the research study described in this article sought to compare the challenges faced by new K-12 MTs and new MTEs and use what is known about supporting new K-12 MTs to begin to develop improved support systems for new MTEs.

With these similarities in mind, we believe that a comparison of experiences is valuable for understanding the preparation of both groups. We see that previous work has compared two populations as a way of gaining insight into the preparation of both groups. Easterday and Galloway (1995), investigated students' and preservice teachers' (PSTs'), university students who are studying to become teachers and an understanding of logic, to explore how PSTs think about logic as they prepare to teach similar content to students. Similarly, Thompson (2007) compared PSTs' and third graders' conceptual understanding of earth science. He found that by studying both groups, he gained insight into the role of teachers' content knowledge and offered teacher educators the opportunity to reflect on their work with PSTs. We posit that examining the relationship between the challenges faced by novice MTs as described by the research in their transition from preservice teacher to in-service teacher (i.e., full time teachers) and MTEs' perceived challenges in their transition from graduate student to new mathematics education faculty, has the potential to inform the mathematics education community on the current needs of MTE preparation in the service of teacher education. In this article, we report findings from a literature review of what is already known about the challenges faced by novice MTs along with the results from a national survey of novice MTEs. We then discuss the similarities between the two groups and how our study can inform MTEs about preparing both MTs and future MTEs. The study described in this paper was guided by three research questions:

1. What does the research literature say about transitional challenges faced by new K-12 MTs?
2. What are MTEs' perceptions of the challenges they face in transitioning into a faculty position?

[1] We use "mathematics teachers" (MTs) to include all teachers of mathematics, in early elementary, elementary, middle and high school contexts.

[2] By MTE we mean academic faculty members that are either teaching in a Mathematics Department or College/School of Education that have, as part of their work, the duty of preparing mathematics teachers (MTs) either through content, methods, or other work. The MTEs in this study were all employed in the United States.

3. How is the research literature about transitional challenges faced by new K-12 MTs similar to the transitional challenges faced by new MTEs? and what are MTEs' perceptions of the support, knowledge, and experiences they need to better support preparation and transition of new K-12 MTs?

Theoretical Framework: Border Crossings

In thinking about MT and MTE transitions into initial teaching positions, Giroux's (1992; 2005) concept of *border crossing* provided a theoretical framework for this study. In 2005, Giroux released an updated version of his 1992 seminal text *Border Crossings: Cultural Workers and the Politics of Education.* Giroux (2005) uses the concept of borders, and crossing borders, to help understand "the co-mingling—sometimes clash—of multiple cultures." He posits that the idea of borders "allows one to critically engage the struggle over those territories, spaces, and contact zones where power operates to either expand or to shrink the distance and connectedness among individuals, groups, and places" (p. 2). We see the moving from *learning to be* a teacher and teacher educator *to actually becoming* a teacher and teacher educator as a border crossing, as Giroux sees it, and therefore view it as a helpful theoretical framework well suited to inform our study.

Researchers have used the framework of border crossings to better contextualise their work and help explain the phenomena of transitions (Akkerman & Bakker, 2011; Aikenhead, 1996; Aikenhead & Jegede, 1999; Bradbury & Koballa, 2008; Jansen, Herbel-Eisenmann, & Smith, 2012; Luft, 1999). Several of these studies have been found in the science education literature with more recent research surfacing in mathematics education; therefore, we find the theory applicable to our work. Aikenhead (1996) uses border crossings to help reconceptualise science curriculum and classrooms through a cultural perspective. He sees science classrooms as cross-cultural experiences for students coming from different cultures, "from the subcultures of their peers and family into the subcultures of science and school science" (p. 2). He believes that better understanding the culture in which students make sense of the natural world and informal science would better enable educators to help those students cross the border into the culture of formal, school-based science curriculum (Aikenhead, 1996). Luft (1999) built on Aikenhead's work to investigate: (1) the borders that a PST, Jill, encountered, (2) whether any of those borders were negotiable, and (3) factors that influenced her abilities to cross those borders. Luft (1999) found that cultural borders existed at the student level, the instructional level, and the school level. For example, at the instructional level, Jill wanted to teach science "within a constructivist framework" and with "inquiry based" instruction (p. 384). However, the teachers at her internship school held different beliefs about science instruction making it difficult for Jill to navigate the borders between philosophical differences in instructional delivery. Similar to Luft (1999), Bradbury and Koballa (2008) use the idea of border crossing to discuss the complex relationships between science student teachers and coaching teachers during student teaching internship experiences.

In each of these studies, the concept of border crossings allowed a lens from which to view transitions. In Aikenhead's work (1996), students were transitioning from what some may call an informal view of science to a more formal, school-based view of science. Within that transition, students often experience varying degrees of discomfort as they try to move from the familiar to the unfamiliar. Aikenhead also argues that there may be better mechanisms and understandings of science that would contribute to smoother transitions. Luft (1999) speaks to the need to prepare students transitioning from student to student teacher to classroom teacher. Students should have a variety of field experiences in diverse settings, knowledge about the cultures (e.g., what might be the experiences of potential k-12 students, how might supervising teachers teach a certain topic) they may encounter along the way, and a sound, research based "preliminary belief framework about teaching" (p. 387). All these tools may help them navigate the borders crossed during those transitions. Finally, Bradbury and Koballa (2008) spoke to the role of the university in better preparing both the student teacher and coaching teacher for navigating their relationship and the different cultures from which they are coming, the student

teacher from a university preservice teacher program and the coaching teacher from the school-based teaching experience. In each of these studies, recommendations were made for how to better prepare individuals for transitioning between borders. In addition, the researchers shared thoughtful lingering questions about the need to think more deeply about each border and how to better utilise the knowledge and strengths of individuals on either side of those borders to also ensure smooth transitions.

With these previous studies setting the precedent—of using the concept of border crossing to examine educational situations that require individuals to move and transition between different cultural contexts, this theoretical framework proves suitable for providing a lens from which to view our findings. As MTs and MTEs cross the borders from learning to become a teacher and being a teacher, they must navigate between two cultures. This transition includes challenges of crossing the border from learning about their work to the practice of doing their work.

Novice Mathematics Teacher Educators

The discussion on the preparation of faculty members through their graduate programs has often focused on the inadequacies of their education for academic careers. For example, Prewitt (2006) found that "career preparation is not even satisfactory for the new PhDs who get tenure track positions in research universities […] they are seldom prepared for their teaching duties or their more general professional obligations" (p. 26). Golde (2006) recognised that "many PhD recipients are ill-prepared to function effectively in the settings in which they work. Many new faculty members do not feel ready to carry out the range of roles asked of them" (p. 5). In light of such acknowledgements, there have been calls from the higher education community to investigate and re-evaluate doctoral education (e.g., Walker, Golde, Jones, Conklin-Bueschel, & Hutchings, 2008).

Beyond this understanding of doctoral preparation across the academy, the preparation of mathematics teacher educators (MTEs) remains unexamined (Goos, 2009; Zaslavsky & Leikin, 2004). An in-depth understanding of the preparation of MTEs is important in this broader context of doctoral education as MTEs have a significant impact on all levels of education, given that they will teach generations of future K-12 teachers. Besides the need for in-depth knowledge of their disciplines, they must also have knowledge of the field and current advancements in research methodologies and findings, as well as national policies that impact PST education and schools. In addition, MTEs also need to be aware of their local communities and how teacher education programs can best prepare MTs. Beyond this, MTEs must also have understandings of their students' future elementary or secondary students, and how those future students come to understand mathematics (Olanoff, 2011). They must also be aware of multiple representations of and approaches to mathematical ideas, where and how students at all levels struggle with those ideas, and how to meaningfully remediate in such situations. Yet, despite the lists of theoretical and practical knowledge researchers have created to illustrate the depth and breadth of knowledge necessary for their work (e.g., Fey, 2001; Jaworski, 2008; Zaslavsky, 2008), Even (2008) recognised "there is almost no research on the education of mathematics teacher educators" (p. 58) and Goos (2009) conceded "almost nothing is known about the [...] development of mathematics teacher educators" (p. 210). The most recent study investigating MTEs pointed to the small body of research on mathematics teacher educators (e.g., Olanoff, 2011). Thus, the study described here is one effort to fill the gap of what is known about MTEs, with a specific focus on their preparation for academic careers via doctoral programs.

Researchers in the United States have begun to focus on the preparation of MTEs through various doctoral programs (Reys, Glasgow, Teuscher, & Nevels, 2008; Reys & Kilpatick, 2001; Reys et al., 2009). Such an understanding is important as academic work continues to evolve at a rapid pace and opportunities continue to grow for doctorates in mathematics education including in higher education institutions, school districts, textbook publishers, and testing companies. In addition, an understanding of the doctoral experiences of future MTEs is

important as mathematics education faculty prepare not only the next generation of themselves, but also K-12 mathematics teachers and educators. With a large percentage of the mathematics education faculty retiring (Reys, 2006), along with an increased scrutiny of teacher educators (U.S. DOE, 2011), and as Golde (2006) noted "the practice of doctoral education advances more slowly than necessary and can be out of synch with the developmental needs of students" (p. 8), the preparation and transition of novice MTEs must be more closely examined.

Reys et al. (2009) highlighted the transition from doctoral student to new faculty member for fourteen new MTEs in the United States. They shared findings from questions such as w*hat was your biggest adjustment taking a faculty position?* And w*hat is your advice to current doctoral students about pursuing a job in higher education?* Findings included the challenge of learning a new institutional system, time management, and the importance of maintaining relationships with colleagues from your doctoral institution. Few other studies or publications focus on the preparation of MTEs. The study described in this paper is one effort to begin to fill the gap in our knowledge of needs in the preparation of mathematics teacher educators and their transition into academia, a transition which Reys and Reys (2012) acknowledge as significant and viewed too lightly.

Before describing the details of the study, it is important to understand the multiple possible paths that one can take in the U.S. to become an MTE (Pope & Mewborn, 2009). Three examples are described here but this is not an exhaustive list of pathways. One possible path is one in which a person earns their bachelor's degree in elementary education and teaches elementary school for a number of years. That person might then return to the university to earn a doctorate in mathematics education, most likely in a College of Education. In contrast, another path is one in which a person earns a bachelor's and master's degree in mathematics, then earns a doctorate in a Department of Mathematics where they complete the same requirements as a mathematician, but then they complete a dissertation in mathematics education. In the first case, this person is likely to find employment in a College of Education, teaching mathematics method courses, along with other courses. In the second case, the person is likely to find employment in a Department of Mathematics where they will likely be expected to teach mathematics content courses to future elementary and secondary teachers. In both cases, the new PhDs would be classified as MTEs. In both cases, they might also engage in mathematics education research, depending on the type of institution. A third possible path is one in which a person earns a bachelor's and master's degree in mathematics, then a doctorate in mathematics education. In the U.S. context, this person would be qualified to work as an MTE in either a College of Education or Department of Mathematics, even though they had not taught school mathematics.

In the two latter paths, the MTEs might not have had any preparation for teaching or teaching experience at any level, even though their future careers will require them to teach. In the US, some universities offer additional programs or courses in teaching outside of the required coursework for degree completion but students are not required to complete them. Since doctoral education is the predominant path by which one obtains a position as a faculty member in an institute of higher education, we see doctoral education as essentially the main avenue by which future academics come to be prepared for their work as faculty members, which includes teaching, research and service. Thus, though some may question whether or not the purpose of doctoral education is to prepare someone for teaching in higher education, we posit that doctoral education must serve that function in the US context.

With regard to border crossing, there are different transitions happening in each of these cases. In the first case, the person is crossing multiple borders from being a mathematics teacher to a graduate student to MTE. In the second and third cases, the people are crossing the border from being graduate students to MTEs.

Methods and Data Sources

We began by reviewing literature on common challenges of novice MTs, to determine the prominent issues facing this group over the last few decades (e.g., Chappell & Pateracki, 2004;

Sowder, 2007). Each member of our research team completed an independent review of the research literature at the elementary, middle, high school, or post-secondary level and a table of themes was created based on the findings. Next, we determined a population of novice MTEs, and created and administered a national survey to these novice MTEs all employed in the United States. The details of the population and survey are provided below.

Population

The National Science Foundation (NSF) funded a program providing mentorship experiences for new PhDs that had been hired as MTEs in either Colleges of Education or Departments of Mathematics, generally within their first three years in an academic position. The program began in 2010 with a national pool of applicants. All program participants, a total of 81, from the first two cohorts were invited to participate in this study. Sixty-nine participants completed the survey for a return rate of 85 percent. At the time of survey administration, 98% of participants reported being assistant professors, with 2% self-identifying as a researcher. Twenty-nine participants were serving in a mathematics department, 37 in an education department, and 3 participants had a joint appointment between departments of mathematics and education. On average, participants were expected to spend 48% of their time on teaching, 36% on research, and 16% on service.

Survey

The survey constructed for this study was based on a previous survey of mathematics education doctorates (Reys et al., 2009) and a literature review of common challenges faced by novice MTs (e.g., Chappell, Choppin, & Salls, 2004; Chappell & Pateracki, 2004; Chappell, Schielack, & Zagorski, 2004; Ensor, 2001; Liston, Whitcomb, & Borko, 2006) and beginning faculty (e.g., Fennell, Briars, Crites, Gay, & Tunis, 2001; Golde, 2006; Jaworski, 2008; Tzur, 2001). A pilot test of the survey instrument was conducted with six mathematics education faculty members: five who have served as mentors for novice MTEs and one who was a first year mathematics education faculty member. These faculty members were chosen for the pilot because of their intimate knowledge of the challenges faced by novice MTEs. Based on responses to the pilot test, the research team revised the survey instrument.

The final survey instrument consisted of demographic, multiple-choice and open response questions. In particular, the items were focused on novice MTEs' beliefs about the ways in which their doctoral program experiences have affected 1) their transitions from doctoral students to faculty members and 2) their preparation for teaching in higher education. Examples of questions from the transition section of the survey included: *In what ways do you feel your doctoral program prepared you or did not prepare you for your current position? What have been your most challenging adjustments in transition from doctoral student to faculty member? What knowledge and/or experiences do you believe are essential for new PhDs in mathematics education?* Examples of questions from the teaching section included: *In what ways do members of your department discuss teaching practices? In what ways are you provided mentorship for your work as a teacher? In what ways are you given opportunities to collaborate with colleagues on departmental issues related to course development?*

Data Collection

Novice MTEs were contacted via email with an explanation of the research study. A link to the survey was provided in the email cover letter. Participants were informed that participation was voluntary and anonymous; their responses would be aggregated so that no one individual could be readily identified. Additionally, participants were informed that their candid responses would be used for research purposes only, and their participation in the survey would be an indication of consent for their information to be used.

Data Analysis

Thematic analysis (Braun & Clark, 2006) was used to analyse the data collected by the survey. Braun and Clarke (2006) describe the decisions one must make in thematic analysis. They first explain the choice between an inductive and deductive approach to coding and categorising data. Because our intention was to remain open to the respondents' experiences and how they might differ from our expectations and what we had learned from the literature, the inductive approach was chosen as it is a process that does not try to "fit into a pre-existing coding frame [...] the themes identified may bear little relation to the specific questions that were asked of the participants" (p. 83). A second choice Braun and Clarke describe is the "level at which themes are to be identified" (p. 84), in particular, a latent or a semantic approach. The semantic approach looks at "the explicit or surface meanings of the data, and the analyst is not looking *beyond* what a participant has said" (p. 84). In comparison, the latent approach, of "identifying or examining the *underlying* ideas, assumptions, and conceptualisations – and ideologies," involves "interpretive work" (p. 84). We chose the latent approach as it supports the instances of interpretation that were necessary to understand and categorise responses beyond a more than superficial level.

Beyond these two choices, Braun and Clarke name six steps to follow. The first step (verbatim transcription) was not used as our data was not recorded interviews, but participants' typed responses to open-ended survey questions. We considered the survey questions and participants' typed responses as a form of conversation and applied the next five steps of their analysis process. We first categorised participant responses to identify patterns and commonalities in their descriptions of their challenges, successes, available resources, and reflections upon their doctoral preparations. Two team members read the responses to each open response question independently, categorised each response, and compared categories across responses with one another. Differences were discussed and consensus was reached on each category. Codes were then compared across questions to reduce similar codes into themes. These themes were then compared across all questions and responses (Bogdan & Biklen, 1998), and reviewed for overlap, contrasts, similarities, and relevance.

An additional step not described by Braun and Clarke, the themes were then cross-examined against findings from research in higher education (e.g., Fennell et al., 2001; Golde, 2006) and compared with findings from the K-12 novice mathematics teacher literature, in search of commonalities. The theoretical framework of border crossings (Giroux, 1992; 2005) shed light in the discussion of the transition from preservice teacher to novice teacher and from preservice MTE to novice MTE. In the next section, we present our in findings. We begin with the results from our review of literature from the novice MT research followed by our findings from the survey of novice MTEs.

Findings

Results from Literature on K-12 Novice Teachers

Numerous challenges regarding novice teachers' transitions to their first positions have been cited in research literature. However, for the purpose of this article we will focus on two specific themes regarding the need for additional transitional support: (1) teaching experiences throughout preservice teacher education programs (Borko & Livingston, 1989; Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2007; Zeichner, 2002) and (2) subject-specific mentoring (Britton et al., 2000; Emmer, 1986; Friedrichsen, Chval, & Teuscher, 2007; Luft & Cox, 2001).

Teaching Experience

The student teaching practicum experience is often considered the most influential component of a teacher preparation program as PSTs are challenged to practice an integration of knowledge of content and pedagogy (Leatham & Peterson, 2010). This need for connecting theory to practice has been a challenge for teacher education programs for decades (Vick, 2006). Borko & Livingston (1989) suggested that the teaching experiences in teacher preparation programs be more focused, asking PSTs to teach only a few courses rather than the entire load to allow them more time to carefully plan and execute lessons. They found that PSTs with a full course load felt too overwhelmed to truly practice or understand the nuances of planning a lesson that fostered student learning. Darling-Hammond et al. (2007) speak to the importance of early practicum experiences integrated throughout teacher education programs. Such experiences help PSTs make connections between teaching theories presented in coursework and the application of those theories in classrooms. They also emphasise that these practicums, alone, do not "make perfect, or even good, performance" (p. 402). These experiences must be embedded in structured and deliberate conversations about teaching. Although valuable, student teaching and practicum experiences need to be continually revisited to ensure effectiveness. Furthermore, better collaborations are needed between universities and schools to prepare and support PTSs, as well as those transiting into novice teachers (Zeichner, 2002).

Mentoring

A second theme identified in the literature was the need for increased mentoring to help novice mathematics teachers' transition to school settings (Britton et al., 2000). Other researchers have taken this issue even further to report the need for content-specific mentoring (Emmer, 1986; Luft & Cox, 2001). Luft and Cox (2001) surveyed beginning mathematics and science teachers in one state about induction programs in their districts. In accordance with previous research, they found that novice mathematics and science teachers face challenges unique to their disciplines (Adams & Krockover, 1997), and a need for content-specific mentors who successfully implement standards-based instruction. Similarly, in a study of beginning mathematics and science teachers, Friedrichsen et al. (2007) found that mentors who shared the same content as the novice teachers they mentored were viewed as more helpful because they could offer content-specific assistance in areas such as lesson planning. Mentors also help in reducing the often-cited challenge of isolation felt by novice teachers (Hieder, 2005; Rogers & Babinski, 2002).

Results from Mathematics Teacher Educator Survey

In our analysis of survey results, MTEs described two areas of concern for transitioning into a faculty position: 1) preparation to teach and 2) mentoring. We focus on these two themes because they most closely mirrored the experiences of the literature on K-12 novice teachers.

Crossing the Border: Preparation to Teach

Survey participants felt they had good knowledge of mathematics education literature, which satisfies Jaworski's (2008) call for "strong knowledge of the professional and research literature relating to the learning and teaching of mathematics" (p. 1). However, participants felt less prepared for their roles as teachers in higher education. In some countries, the pool of MTEs are drawn from the population of K-12 school teachers of mathematics. However, in the United States, the MTE population is not drawn primarily from the population of schoolteachers of mathematics. Generally, MTEs in the United States are drawn from various populations with a range of teaching experiences. Of the 69 participants in our study, approximately 30% had been a former K-12 school teachers of mathematics, 38% had practicum experiences at the elementary, middle, and high school level during their doctoral program, 25% had experience

teaching collegiate mathematics courses for preservice teachers, 17% had supervised student teachers, and 22% had facilitated professional development workshops and/or courses for in-service teachers. Therefore, less than a third of the MTEs had previous school teacher experience with the largest percentage of any teaching experience still being under 40%. Three areas concerning their preparation for teaching that were repeatedly addressed in their responses, were teaching tools, reflections, and methods courses.

Teaching Tools

Responses described how participants felt that they had left their doctoral programs without a comprehensive toolkit for teaching. For example, one participant stated, "My program did not include any training on teaching—how to lead a discussion, construct a syllabus, or create assignments. Some faculty may have discussed this in passing. I didn't teach at all in graduate school." Another representative response: "I did not graduate with any resources for teaching. I had taught one course during one semester (a methods course), but had nothing from which to create courses on my own." Participants indicated a desire for more structured conversations about teaching including specific suggestions for concrete teaching tools such as creating a syllabus and how to facilitate an effective discussion around readings, for example.

Reflection

Connected to the need for structured conversations about teaching, participants articulated a need for opportunities to reflect on their teaching guided by more experienced university instructors. One participant wrote

> We did not focus on teaching in an immediate sense. As a graduate student, I taught introductory mathematics classes to freshmen such as College Algebra. Ironically, my degree is in Mathematics Education. This means that as a result of my degree I should know about teaching and learning mathematics. There was no discussion about what was happening in the courses where I was the instructor. Was I supposed to apply my newly acquired knowledge to my own classes?

Similar to this participant's dismay that even though the title of the degree was in mathematics *education*, there was little conversation and guided reflection about the practice of teaching, another participant shared, "I wish I had learned systematically how to teach."

Methods Courses

Participants also longed for more immersion in K-12 mathematics teacher preparation, both in terms of the literature base as well as teaching methods courses. For example, one participant did not feel well versed in K-12 mathematics

> My program didn't help me understand the world of K-12 math education in general, such as the NCTM Principles & Standards, state curriculum standards, teacher certification requirements, education associations like the Association of Mathematics Teacher Educators, math ed conferences and other professional development opportunities, etc. I felt like it was assumed that we knew these things as a first year professor.

Other participants commented they "did not have experiences teaching method courses." Another respondent had more experience teaching content courses for preservice teachers than with method courses:

> My doctoral program did not prepare me sufficiently to teach other topics in elementary methods other than content. I needed to search for various topics on my own to teach elementary methods. I also teach a content-intensive algebra course for elementary education majors, but was not prepared by my doctoral program.

New mathematics teacher educators in this study felt a need for further teaching experiences in their doctoral programs, specifically in the areas of teaching tools, reflection, and methods courses. These findings, while similar to those cited by Prewitt (2006) and Golde (2006), are

unfortunately not aligned with Jaworski's recommendation that novice MTEs know "pedagogy related to mathematics [and] mathematical didactics in transforming mathematics into activity for learners in classrooms" (2008, p. 1).

Crossing the Border: Need for Mentoring

Richardson (2006) noted, "mentoring is essential in supporting and adjusting the development of the new PhDs' practical knowledge on the job" (p. 257). While institutional support was fairly common - 58% of participants reported that their institutions offered seminars on assessing student learning and 65% reported having colleagues who openly shared student assessment materials - the results for individual mentoring were weaker. Only 25% of our participants were assigned an official mentor at the start of their academic positions with whom they have been consistently communicating. Another 20% were assigned an official mentor but have discontinued working with them or found their interactions to be ineffective. Twenty-five percent were not assigned an official mentor but had successfully found their own informal mentor. Participant responses about mentoring seemed to cluster in two areas: navigation within a new position and research guidance.

Navigation

Participants emphasised the need for doctoral students to take advantage of their advisors and mentors in graduate school before graduating and transitioning into an academic position where "you are on your own in making decisions." One participant encouraged doctoral students to "seek out advice from your faculty mentors. Talk with them about their jobs, how they're managing their time, etc." Another participant emphasised the challenge of transitioning from graduate student to faculty member: "Having a strong mentor or mentors who will help you navigate through your first few years. There are so many 'opportunities' that come your way. It's good to have some trustworthy advice regarding what to steer away from." Similarly, another participant agreed: "I think more than anything it is just learning the politics, resources, and dynamics of a new place. Even just one year later I feel I have a much better sense of how things work here and what kind of work can get done (and what cannot)." An additional participant spoke to the quick transition from being a faculty member considered a leader and expert:

> As one of just two math education people at my university, I was not prepared for how much I would be seen as a leader and expert right from the beginning. I have been in charge of programs and teacher workshops alone in my first two years.

Finally, the need for mentorship through the often rough waters of tenure and promotion was a representative response:

> Understanding the tenure and promotion[3] guidelines and exactly what is expected. Our university has a very "flexible" workload expectation, until it comes to tenure and promotion decisions. Navigating what is ACTUALLY expected versus what is in the guidelines has been frustrating.

Research

A dominant theme in terms of mentoring support was also the need for guidance in terms of developing a research agenda. One representative quote spoke to the need for strong research

[3] In the US, new PhDs are hired with the title of Assistant Professors. Typically, in their sixth year, they apply for both tenure and promotion. Tenure offers some additional security to their position in such that it cannot be terminated without just cause. Promotion means that they now earn the title of Associate Professor which generally includes a salary increase in addition to added service responsibilities and expectations.

mentoring at the graduate level: "I felt unprepared for independent research in mathematics education. I feel that my program needed more active, publishing faculty members in mathematics education to mentor me and guide me through the early years of my career." Participants recognised the limitation within some programs based on their size, however still commented on the need for research guidance:

> Another big challenge is getting a new research agenda off the ground and knowing whether or not I'm doing enough for tenure. I was also hoping for a bit greater collaboration with some of my colleagues than what has happened so far. We are mostly a junior faculty though - it would be nice if there were more senior faculty members who could serve as mentors, but part of that is just the size of our program.

Respondents spoke to their feeling prepared in some aspects of research, such as data collection, but less prepared in terms of the "before and after" aspects of writing a successful grant proposal and then publishing the results from the work. For example, one participant commented about seeking out mentoring collaborations to learn more about conducting research:

> The hardest part of the transition was that I had no graduate student community and I was not part of a research-heavy group of mathematics educators. My professors were all very active in teacher training, which gave me good experience, but I had to purposefully seek out research connections and network outside of my institution. In that vein, I have been learning how to collaborate with my current colleagues as I have very little context for how such research is commonly conducted. I worked on several grants at my institution, but I never got any direct insight into the grant-writing or grant-running processes. However, my adviser has been very supportive in this regard to help me in my new job as I pursue that end.

Similar to this MTE's experience of continued support from her doctoral advisor, many MTEs credited their doctoral-granting institution and advisors for bridging the mentor gap during the institutional and position transitions. However, they also commented on the need for stronger mentoring support at their current institutions as that person would be more familiar with the culture of that institution.

The need for strong mentoring when navigating the culture of a new institution as a new academic and for establishing an effective research agenda that includes successful grant-writing and publication of findings was evident in the data. For example, one respondent commented that she was assigned a mentor from another department across campus. Though she understood the impetus behind providing a mentor that would not also serve as an evaluator of her tenure performance, she found "this mentor has provided little help to me." She then found her own informal mentor within her department who she feels helped her in teaching but felt "her research experiences are not broad enough to fully mentor me in that respect." Another participant shared:

> I am surprised (and disappointed) by the overall lack of attention to making certain that new faculty are getting the help that they need. I feel as if everyone has been here so long that they have forgotten what a new faculty member needs. I don't even know what to ask.

This need for mentorship as novice MTEs transition from graduate school to academic positions is also supported by the literature (Richardson, 2006).

We now turn our attention to the results from the literature on novice K-12 mathematics teachers' transitional challenges in crossing the cultural border from preservice to in-service teacher, which will inform our understanding of the challenges faced by novice MTEs, as they cross their own cultural border.

Border Crossing in Teaching & Mentoring

As MTs and MTEs cross the borders between learning to become a teacher/teacher educator and becoming a teacher/teacher educator, they must navigate between two cultures and the challenges of crossing the border from learning about their work to the practice of doing their

work. In our survey study of novice MTEs and our literature review of new MTs' experiences, our findings revealed interesting similarities between the experiences of these two groups of novices. The cultural borders concerning teaching and mentoring between preservice MTs and MTEs have similarities worth exploring, in an effort to build on the already existing wide research base on how to support MTs as they transition from preservice to novice teachers. Findings from both the literature on K-12 novice mathematics teachers and our survey of novice MTEs indicated that both groups of teachers need additional and richer 1) teaching experiences, throughout their preparation programs, and 2) mentoring experiences to help them as they transition into their new positions.

Border Crossing: Teaching

With regard to teaching experiences, both groups cited not only a need for more teaching opportunities, but a need for more valuable teaching opportunities. There was a need for authentic experiences and deliberate conversations about the culture of teaching to assist in MTs and MTEs crossing the border from student to teacher. For example, the literature on novice mathematics teachers spoke to the possibility of PSTs teaching a limited number of courses to provide time for the PST to intentionally plan comprehensive mathematics lessons, upon which they could reflect, refine, and build new lessons (Borko & Livingston, 1989). Similarly, data from the novice MTEs survey found that MTEs wished for more conversations about the intricacies of teaching a course, such as syllabus development and discussion facilitation.

We see these findings as having an impact on the work of mathematics teachers at all levels. MTEs are not only called upon to prepare mathematics teachers but also future MTEs and we believe that our work preparing preservice MTEs can be informed by the extensive body of research on the experiences and challenges of novice K-12 teachers. For example, PST education programs have increased the number and variety of their early practicum experiences; according to Lambdin and Wilson (2001) the same is needed in programs preparing MTEs.

Recognising the challenge faced by smaller doctoral granting institutions in meeting this need, one recommendation is to have doctoral students co-teach an undergraduate course. For example, some institutions may only offer one section of a secondary mathematics methods course. In this case, we believe it would be beneficial for two doctoral students to co-teach the course together. Another suggestion is to have a doctoral student assist or co-teach a course with a faculty member. This arrangement not only allows doctoral students the opportunity to assist and/or teach, but also encourages the deliberate conversations about teaching among the doctoral student and faculty member that novice MTEs have requested. MTE doctoral program should also be more deliberate about determining which students have had previous teaching experiences and of what type (e.g., K-12 school teaching experience, collegiate teaching) and require additional teaching experiences in their program to develop them in areas where they lack experience.

Our K-12 literature review as well as our survey results calls for more transparency in the work of preparing teachers and teacher educators. As authors of this study, we have seen our work changed by this finding, in us being more verbal about our instructional and curricular decisions with our own preservice MTs, graduate students, and preservice teacher educators. While teaching methods courses and running doctoral seminars, we find ourselves explicitly explaining our instructional and curricular decisions to our students, so that they are aware of why we have chosen particular actions (such as selecting a specific reading or altering our instruction in the middle of a lesson). Often times, such explanations lead to conversations about the *teaching* of the content in addition to the content itself. These conversations also help to demystify some of the teaching practices that may seem common and natural to us, but are seen otherwise to our students.

Border Crossing: Mentoring

Furthermore, both groups could benefit from additional and richer mentoring. Our data supported the desire of novice MTEs to have a mentor to act as a guide as they crossed the border into their first teaching position and the value of mentors for novice MTs supports that claim (Britton et al., 2000). In our study, only 25% of surveyed novice MTEs were assigned a mentor with whom they continued to work. Similar to the novice mathematics teachers' reported a need for more content-specific mentoring (Friedrichsen et al., 2007; Luft & Cox, 2001), participants asked for more specific mentoring in the areas of research, teaching, and "navigating" academe (such as deciding which opportunities are best to "steer away from").

Although the quality of mentoring for novice mathematics teachers remains inconsistent, the importance of mentoring programs has been clearly established (Britton et al., 2000). Even though novice MTEs in our study reported seeking leadership and guidance during their first academic position, 55% were not assigned a mentor and 20% were assigned a mentor whose interactions were not helpful. The 25% who were assigned a mentor and found the relationship to be helpful speak, at least anecdotally, to the power of mentorship:

> I was assigned three wonderful mentors: 1. a former department chair who helps me navigate department politics 2. a math educator who helps me with teaching 3. a math educator in the school of education who helps me with research. I am very lucky in this regard.

With the hope that such a support system could be replicated, one suggestion that has been used to ensure specialised mentoring with rural novice mathematics teachers has been the use of telecommunications or online platforms to connect novice and experienced mathematics teachers (Thoresen, 1997). Although novice MTEs are not often in rural settings geographically, many are in isolated settings professionally, serving as the only MTE at their institution. Thus, online platforms to deliver specialised mentoring may be a way to improve mentoring opportunities for MTEs and further support a smooth border crossing.

Even with these suggestions, the work of preparing mathematics teachers and MTEs remains a difficult endeavour. One additional challenge existing in the development of MTEs is the fact that their "formal" education typically ends in a doctoral degree. Therefore, unlike K-12 mathematics teachers who often find professional development through masters and doctoral degrees, MTEs have to seek other ways to further develop their craft (Doerr & Thompson, 2004; Zaslavsky & Leikin, 2004).

Conclusion

We believe these results are important to the field because in light of the recent policy push to evaluate teacher educators internationally (Feuer, Floden, Chudowshy, & Ahn, 2013; NCTQ, 2010; Tatto, Krajcik, & Pippin, 2013) coupled with the dire need to prepare not only more but stronger teachers and researchers in the field of mathematics education (Reys & Kilpatrick, 2001). Our findings about the need for teaching experiences and mentorship for novice MTEs, much like those needs identified for novice MTs, may help improve teacher education programs while also improving mathematics teacher education programs. The perspective of the border crossing framework in the discussion of transitioning from preservice MTE to novice MTE provides a lens for the innate cultural differences between these two stages and can provide a guide for future studies in this area.

One promising practice for providing support for novice MTEs that is currently being used to support novice MTs as they cross the border into teaching, is online data bases and support communities (DeWert, Babinski, & Jones, 2003). With the advent of the Internet, teachers are able to share and find research-based lesson plans [e.g., National Council of Teachers of Mathematics' Illuminations resource (NCTM, n.d.)] and interact in real time through online communities [e.g., the U.S.-based Center for Teacher Quality's Collaboratory (CTQ, n.d.), the Australian Association of Mathematics Teachers Connect with Maths (AAMT, n.d.]. This type of online resource support could also be established for MTEs as a portal to upload effective

methods and content course lesson plans, for example, and allow for virtual professional discussions. As these resources are already in existence for novice MTs to aid in their border crossing, the MTE community have examples from which to follow. Internationally, such an online database would allow for learning and sharing at the international level to strengthen both MT and MTE preparation and development.

Such an accessible online professional space could also be used to impact the need for mentoring of MTEs. Another challenging aspect of crossing the border from doctoral student to MTE that surfaced in the data, came from doctoral students who were prepared at institutions with only a few mathematics education doctoral students (some were the only mathematics education graduates over several years) or from MTEs who were now the only or one of few MTEs at their institution. Indicated by this representative quote, "As one of just two math education people at my university, I was not prepared for how much I would be seen as a leader and expert right from the beginning," novice MTEs, much like novice MTs feel a sense of isolation (Rogers & Babinski, 2002). When MTEs graduate as the sole mathematics education graduate from an institution, they may begin their careers with few colleagues with whom they have developed a sense of trust and community with which to reach out during their beginning years as they cross the border into academia. Similarly, if MTEs begin their career as the only MTE at their university, there becomes an even greater need for a mentor and sense of community with which to come along side and learn.

This need for mentorship and a sense of community is beginning to be addressed by programs such as the U.S.-based Service, Teaching, and Research (STaR) induction program established as a one-year induction program for early career mathematics educators teaching at institutions of higher education (Reys & Reys, 2012). This project was funded in 2009 by the NSF and provides support for STaR Fellows including a 5-day summer institute, electronic academic year networking, and a follow-up meeting at the Association of Mathematics Teacher Educators (AMTE) Annual Meeting the following year. A small cadre of successful and prominent MTEs were also a part of the STaR leadership team and offered formal presentations and informal advisement to STaR Fellows as well as feedback on research manuscripts. AMTE has taken over the project and is working to secure continued funding for the program. Further development and expansion of such programs is crucial in the induction years of novice MTEs as they work to develop their professional identities while simultaneously preparing MTs.

Another idea for mentorship provided to MTEs would be to use online options for virtual mentorships—a virtual form of apprenticeship. New MTEs could be provided support as part of their start-up funds to employ a mentor at a national/international level with whom they could connect on a regular basis as well as have a "safe space" (as this mentor would not be at their institution and possibly able to impact tenure and promotion decisions, for example) to ask difficult questions. If funds allowed, novice MTEs could travel to the mentor's home institution to shadow them for a few days to learn about their daily work as an MTE in research, teaching, and service and in preparing MTs. This pairing would offer individual support and be mutually beneficial—similar to a mentor teacher/preservice student teacher relationship where the mentor teacher offers years of experience and wisdom to the preservice student teacher and the preservice student teacher is able to expand the mentor teacher's knowledge of innovative teaching practices. The novice MTE would be able to learn from the knowledge and network of the experienced MTE while the experienced MTE may be able to learn new or different research methods or teaching strategies from the novice MTE. If the number of experienced MTEs did not allow for one-on-one pairings, smaller communities of three to four novice MTEs could work with an experienced MTE, stay connected through an online discussion platform, and then gather at the mentor MTEs home institution once or twice to apprentice the mentor MTE for several days. These mentor-mentee relationships would allow for a bi-directional border crossing in a sense, allowing the novice MTEs insight into their new professional space of academia and inviting the experienced MTEs to remain connected to the newness of being a novice MTE navigating the border. Online mentorship would allow international opportunities for mentor-mentee relationships to develop as well. Given that the Internet offers both asynchronous (e.g., email and discussion boards) and synchronous (e.g.,

free online video and chat capabilities), these tools could be utilised to deepen the shared international charge to develop MTs and MTEs.

We would be remiss to not mention the responsibility of the doctoral student and novice MTE to be proactive in seeking out untapped or unoffered areas for deeper teaching support and mentoring relationships. Several respondents spoke to their own initiative in seeking out informal mentors with one participant talking of her being able to learn from experienced MTEs from simply being an observer in an online discussion group around improving secondary mathematics method courses. Just being able to virtually observe how experienced MTEs discussed the topic and articulated their thoughts and arguments in writing has been a form of professional development for this novice MTE. This aspect of novice MTE development through authentic experiences cannot be overstated, much like novice MTs speak to the importance of their student teaching experiences. Supplementing university-based training in the form of coursework with opportunities to enact that training in authentic teaching and research projects supported by mentoring is crucial before leaving a doctoral program (Drake, 2009). That said, being able to navigate the even more minute borders within doctoral programs and academic departments can still be a mystery so the support of experienced MTEs to demystify those borders is needed.

The research reported here contributes toward an understanding of the continuum of experiences necessary for preparing effective mathematics teachers at all levels. Next steps may include replication of the survey across future national and international cohorts of novice MTEs. Such replications may help determine continued areas of need and further explore the similarities and differences across the preparation of MTEs internationally. Preparing MTEs who are confident in their preparation and in their ability to prepare MTs who will help children learn mathematics is imperative. Doctoral programs preparing MTEs must listen to the voices of their graduates in offering suggestions for improvement. Novice MTEs who are now in the position of preparing future MTs and MTEs, themselves, must also listen to their own voices and remember to include in their preparation programs what they found lacking in their own. Understanding the commonalities and differences between the needs of developing MTEs and K-12 mathematics teachers will aid MTEs in developing best practices for preparing both groups and ultimately improving the teaching and learning of mathematics for all students.

References

Adams, P. E., & Krockover, G. H. (1997). Concerns and perceptions of beginning secondary science and mathematics teachers. *Science Education, 81*(1), 29-50.

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*, 1-52.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287.

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research, 81*(2), 132-169.

Australian Association of Mathematics Teachers (AAMT). (n.d.) *Connect with Maths*. Retrieved on March 9, 2015, from http://www.aamt.edu.au/Communities

Bartell, C. A. (2005). *Cultivating high-quality teaching through induction and mentoring*. Thousand Oaks, CA: Corwin.

Bogdan, R. C., & Biklen, S. K. (1998). *Qualitative research for education* (3rd ed.). Boston: Allyn and Bacon.

Borko, H., & Livingston, C. (1989). Cognition and improvisation: Differences in mathematics instruction by expert and novice teachers. *American Educational Research Journal, 26*(4), 473-498.

Bradbury, L. U., & Koballa, T. R. (2008). Borders to cross: Identifying sources of tension in mentor-intern relationships. *Teaching and Teacher Education, 24*, 2132-2145.

Braun, V., & Clark, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Britton, E., Raizen, S., Paine, L., & Huntley, A. (2000). *More swimming, less sinking: Perspectives on teacher induction in the U.S. and abroad.* Retrieved on March 9, 2015, from http://www.wested.org/online_pubs/teacherinduction/

Brown, C. A., & Borko, H. (1992). Becoming a mathematics teacher. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 209-239). New York, NY: National Council of Teachers of Mathematics.

Center for Teaching Quality (CTQ). (n. d.). *Center for Teaching Quality Collaboratory*. Retrieved on March 13, 2015, from http://www.teachingquality.org/collaboratory

Chappell, M. F., Choppin, J., & Salls, J. (2004). *Empowering the beginning teacher of mathematics in high school*. Reston, VA: National Council of Teachers of Mathematics.

Chappell, M. F., & Pateracki, T. (2004). *Empowering the beginning teacher of mathematics in middle school*. Reston, VA: National Council of Teachers of Mathematics.

Chappell, M. F., Schielack, J. F., & Zagorski, S. (2004). *Empowering the beginning teacher of mathematics in elementary school*. Reston, VA: National Council of Teachers of Mathematics.

Darling-Hammond, L., Hammerness, K., Grossman, P., Rust, F., & Shulman, L. (2007). The design of teacher education programs. In L. Darling-Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 390-441). Hoboken, NJ: Jossey Bass.

DeWert, M. H., Babinski, L. M., & Jones, B. D. (2003). Safe passages: Providing online support to beginning teachers. *Journal of Teacher Education, 54*(4), 311-320.

Doerr, H. M., & Thompson, T. (2004). Understanding teacher educators and their pre-service teachers through multi-media case studies of practice. *Journal of Mathematics Teacher Education, 7*, 175-201.

Drake, P. (2009). Working for learning: Teaching assistants developing mathematics for teaching. *Journal of Mathematics Teacher Education, 12*, 67-82.

Easterday, K. E., & Galloway, L. L. (1995). A comparison of sentential logic skills: Are teachers sufficiently prepared to teach logic? *School Science and Mathematics*, *95*(8), 431-436.

Emmer, E. T. (1986). Academic activities and tasks of first-year teachers' classes. *Teaching and Teacher Education, 2*(3), 229–244.

Ensor, P. (2001). From preservice mathematics teacher education to beginning teaching: A study of recontextualizing. *Journal of Mathematics Education, 32*(3), 296-320.

Even, R. (2008). Facing the challenge of educating educators to work with practising mathematics teachers. In B. Jaworski & T. Woods (Eds.), *The international handbook on mathematics teacher education: The mathematics teacher educator as a developing professional* (Vol. 4, pp. 57-73). Rotterdam, Netherlands: Sense Publishers.

Fennell, F., Briars, D., Crites, T., Gay, S., & Tunis, H. (2001). Reflections on the match between jobs and doctoral programs in mathematics education. In R. Reys & J. Kilpatrick (Eds.), *One field, many paths: U.S. doctoral programs in mathematics education* (pp. 41-44). Providence, Rhode Island: American Mathematical Society.

Feuer, M. J., Floden, R. E., Chudowshy, N., & Ahn, J. (2013). *Evaluation of teacher preparation programs: Purposes, methods, and policy options*. Washington, DC: National Academy of Education.

Fey, J. (2001). Doctoral programs in mathematics education: Features, options, and challenges. In R. Reys & J. Kilpatrick (Eds.), *One field, many paths: U.S. doctoral programs in mathematics education* (pp. 55-62). Providence, Rhode Island: American Mathematical Society.

Friedrichsen, P., Chval, K. B., & Teuscher, D. (2007). Strategies and sources of support for beginning teachers of science and mathematics. *School Science and Mathematics, 107*(5), 169-181.

Gainsburg, J. (2012). Why new teachers do or don't use practices emphasized in their credential program. *Journal of Mathematics Teacher Education, 15*(5), 359-379.

Giroux, H. (1992). *Border crossings: Cultural workers and the politics of education*. New York, NY: Routledge.

Giroux, H. (2005). *Border crossings: Cultural workers and the politics of education* (2nd ed.). New York, NY: Routledge.

Golde, C. M. (2006). Preparing stewards of the discipline. In C. M. Golde & G. E. Walker (Eds.), *Envisioning the future of doctoral education: Preparing stewards of the discipline* (pp. 3-21). San Francisco, CA: Jossey-Bass.

Goos, M. (2009). Investigating the professional learning and development of mathematics teacher educators: A theoretical discussion and research agenda. In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia* (pp. 209-216). Palmerston, NZ: MERGA.

Heider, K. L. (2005, June 23). Teacher isolation: How mentoring programs can help. *Current Issues in Education*, *8*(14). Retrieved April 22, 2014, from http://cie.ed.asu.edu/volume8/number14/

Jansen, A., Herbel-Eisenmann, B., & Smith III, J. P. (2012). Detecting students' experiences of discontinuities between middle school and high school mathematics programs: Learning during boundary crossing. *Mathematical Thinking and Learning, 14*(4), 285-309.

Jaworski, B. (2008). Mathematics teacher educator learning and development: An introduction. In B. Jaworski & T. Wood (Eds.), *The international handbook of mathematics teacher education: The mathematics teacher educator as a developing professional* (pp. 1-17). Rotterdam, Netherlands: Sense Publishers.

Lambdin, D. V., & Wilson, J. W. (2001). The teaching preparation of mathematics educators in doctoral programs in mathematics education. In R. E. Reys & J. Kilpatrick (Eds.), *One field, many paths: U. S. doctoral programs in mathematics education* (pp. 77-83). Providence, RI: American Mathematical Society.

Leatham, K. R., & Peterson, B. E. (2010). Secondary mathematics cooperating teachers' perceptions of the purpose of student teaching. *Journal of Mathematics Teacher Education, 13*, 99-119.

Liston, D., Whitcomb, J., & Borko, H. (2006). Too little or too much: Teacher preparation and the first years of teaching. *Journal of Teacher Education, 57*(4), 351-358.

Luft, J. A. (1999). The border crossings of a multicultural science education enthusiast. *School Science and Mathematics, 99*(7), 380-388.

Luft, J. A., & Cox, W. E. (2001). Investing in our future: A survey of support offered to beginning secondary mathematics and science teachers. *Science Educator, 10*(1), 1-9.

Masingila, J. O., Olanoff, D. E., & Kwaka, D. K. (2012). Who teaches mathematics content courses for prospective elementary teachers in the United States? Results of a national survey. *Journal of Mathematics Teacher Education, 15,* 347-358.

Meagher, M., Edwards, M. T., & Ozgun-Koca, S. A. (2013). The shift from "learner/doer of mathematics" to "teacher of mathematics": A heuristic for teacher candidates. *Mathematics Teacher Education and Development, 15*(1), 88-107.

National Council of Teachers of Mathematics (NCTM). (n.d.). *Illuminations*. Retrieved on March 9, 2015, from http://illuminations.nctm.org

National Council on Teacher Quality (NCTQ). (2010). *Blueprint for change: National summary, 2010 state teacher policy yearbook.* Retrieved on March 9, 2015, from http://www.nctq.org/stpy09/updates/docs/stpy_national.pdf

Olanoff, D. (2011). Mathematical knowledge for teaching teachers: The case of multiplication and division of fractions. Unpublished dissertation, Syracuse University.

Pope, S., & Mewborn, D. S. (2009). Becoming a teacher educator: Perspectives from the United Kingdom and the United States. In R. Even & D. Ball (Eds.), *The professional education and development of teachers of mathematics* (pp. 113-119). New York: Springer.

Prewitt, K. (2006). Who should do what? In C. M. Golde & G. E. Walker (Eds.), *Envisioning the future of doctoral education: Preparing stewards of the discipline* (pp. 23-33). San Francisco, CA: Jossey-Bass.

Raymond, A. M. (1997). Inconsistencies between a beginning elementary school teacher's mathematics beliefs and teaching practice. *Journal for Research in Mathematics Education, 28*(5), 550-576.

Reys, R. (2006). A report on jobs for doctorates in mathematics education in institutions of higher education. *Journal for Research in Mathematics Education, 37*(4), 262-269.

Reys, R. E., & Kilpatrick, J. (Eds.). (2001). *One field, many paths: U.S. doctoral programs in mathematics education.* Washington, DC: American Mathematical Society/Mathematical Association of America.

Reys, R., Cox, D., Dingman, S., & Newton, J. (2009). Transitioning to careers in higher education: Reflections from recent Ph.D.s in mathematics education. *Notices of the AMS, 56*(9), 1098-1103.

Reys, B., & Reys, R. (2012). Supporting the next generation of 'Stewards' in mathematics education, *Notices of the AMS, 59*(2), 288-290.

Richardson, V. (2006). Stewards of a field, stewards of an enterprise. In C. M. Golde & G. E. Walker (Eds.), *Envisioning the future of doctoral education: Preparing stewards of the discipline* (pp. 251-267). San Francisco, CA: Jossey-Bass.

Rogers, D. L., & Babinski, L. M. (2002). *From isolation to conversation: Supporting new teacher's development*. Albany, NY: State University of New York Press.

Schmidt, W. H., Tatto, M. T., Bankov, K., Blomeke, S., Cedillo, T., Han, S. I., … Schwille, J. (2007). *The preparation gap: Teacher education for middle school mathematics in six countries.* East Lansing, MI: Michigan State University Center for Research in Mathematics and Science Education. Retrieved on March 9, 2015, from http://usteds.msu.edu/MT21Report.pdf

Shulman, L. S. (2004). *The wisdom of practice: Essays on teaching, learning, and learning to teach*. San Francisco, CA: Jossey-Bass.

Sowder, J. T. (2007). The mathematical education and development of teachers. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 157-223). Charlotte, NC: Information Age.

Stockero, S. L, & Van Zoest, L. R. (2014). Characterizing pivotal teaching moments in beginning mathematics teachers' practice. *Journal of Mathematics Teacher Education, 16*, 125-147.

Tatto, M. T., Krajcik, J., & Pippin, J. (2013). *Variations in teacher preparation evaluation systems: International perspectives.* Paper commissioned for the National Academy of Education Steering Committee on the Evaluation of Teacher Education Programs: Toward a Framework for Innovation.

Thompson, S. (2007). *Comparing life and earth science concepts held by elementary preservice teachers and third graders*. Paper Presented at the American Educational Research Association (AERA) annual conference, Chicago, Illinois.

Thoresen, C. (1997). Early career support program: Telecommunication mentoring for rural teachers. *Journal of Science Teacher Education, 8*, 283-293.
Tzur, R. (2001). Becoming a mathematics teacher-educator: Conceptualizing the terrain through self-reflective analysis. *Journal of Mathematics Teacher Education, 4*, 259-283.
United States Department of Education (U.S. DOE). (2011). *Our future, our teachers: The Obama administration's plan for teacher education reform and improvement*. Washington, DC: Author.
Vick, M. (2006). "It's a difficult matter": Historical perspectives on the enduring problem of the practicum in teacher preparation. *Asia-Pacific Journal of Teacher Education, 34*(2), 181-198.
Walker, G., Golde, C. M., Jones, L., Conklin-Bueschel, A., & Hutchings, P. (2008). *The formulation of scholars: Rethinking doctoral education for the twenty-first century*. San Francisco, CA: Jossey-Bass.
Wang, A. H., Coleman, A. B., Coley, R. J., & Phelps, R. P. (2003).*Preparing teachers around the world*. Princeton, NJ: Educational Testing Service. Retrieved on March 9, 2015, from http://www.ets.org/Media/Education_Topics/pdf/prepteach.pdf
Wasserman, N. H., & Ham, E. (2013). Beginning teachers' perspectives on attributes for teaching secondary mathematics: Reflections on teacher education. *Mathematics Teacher Education and Development, 15*(2), 70-96.
Zaslavsky, O. (2008). Meeting the challenges of mathematics teacher education through design and use of tasks that facilitate teacher learning. In B. Jaworski & T. Wood (Eds.), *The international handbook of mathematics teacher education: The mathematics teacher educator as a developing professional* (pp. 93-114). Rotterdam, Netherlands: Sense Publishers.
Zaslavsky, O., & Leikin, R. (2004). Professional development of mathematics teacher educators: Growth through practice. *Journal of Mathematics Teacher Education, 7*, 5-32.
Zeichner, K. (2002). Beyond traditional structures of student teaching. *Teacher Education Quarterly, 29*(2), 59-64.

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