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Inquiring into Mathematics Teacher Education

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The work of mathematics teacher educators has never been more important than in this era of accountability. Mathematics teachers (both preservice and inservice) grapple with ways to support their students in developing mathematical proficiency (as defined by the National Research Council, 2001) in classroom environments where students' learning is focused on sense-making, mathematical authority is shared, and students have the opportunity to learn important mathematics. As researchers have documented (e.g., Sowder, 2007), it is difficult for mathematics teachers to "unlearn" how to teach mathematics (Ball, 1988), given the "apprenticeship of observation" (Lortie, 1975) they have undertaken in their own K-12 mathematics schooling.

Across the United States, mathematics teacher educators (MTEs) have undertaken this charge of working to improve mathematics teaching (which, in turn, will improve K-12 students' opportunities to learn mathematics). Many MTEs implement novel and innovative approaches to mathematics teacher development with preservice and/or inservice teachers, constantly seeking to understand those practices and their impact on mathematics teacher education (MTE) students. In an effort to share what we learn about our practices, MTEs have begun to heed the advice that we give to K-12 mathematics teachers – we too are opening up our classrooms and practices for others to consider. As evidenced by the number of submissions we had for this monograph (45) as well as the increasing number of applications to speak at the AMTE Annual Meetings, our community is responding to the call to share what we are learning through inquiring into our MTE practices.

In this opening chapter of the 5th AMTE Monograph, we argue for the necessity of coordinating our efforts and bringing coherence to our common knowledge. As a community, MTE is relatively "young" when compared to other educational communities. The *Journal of Mathematics Teacher Education* (*JMTE*) was established in 1998; the AMTE constitution was ratified in 1994.

As we continue to seek avenues for coordinating what we are learning into a more coherent whole, building on the work of another community may be a good starting point for our efforts. In the next section, we present work done in the area of knowledge bases for the teaching profession and then present an adaptation of those ideas for the MTE profession.

Practical Knowledge and Professional Knowledge

Hiebert, Gallimore, and Stigler (2002) assert that the knowledge base for the teaching profession consists of two domains: *practical knowledge* and *professional knowledge*. Practical knowledge, as defined by Hiebert, Gallimore, and Stigler, consists of "the kinds of knowledge practitioners generate through active participation and reflection on their own practice" (p. 4). Professional knowledge encompasses practical knowledge and also includes research-based knowledge – knowledge that is based on empirical research studies about teaching. These authors argue that teachers often make instructional decisions based on their practical knowledge and rarely seek out the research literature to inform their teaching, even though the research literature contains findings that could inform their practice. This situation creates a need to find ways to link research and practice more effectively. Hiebert and his colleagues ask the question, "Is there a road that could lead from teachers' classrooms [practical knowledge] to a shared, reliable, professional knowledge base for teaching?" (p. 4).

We contend that the same two domains exist for the knowledge base for mathematics teacher education. We have MTE practical knowledge – knowledge that we build on a daily basis while actively participating and reflecting on our practices as mathematics teacher educators. We often share that knowledge with each other while chatting in our offices (e.g., "Let me tell you what happened in my methods class today!") as well as in venues such as the AMTE Annual Meetings and the AMTE Monograph series. Many of the chapters contained in this monograph could be described as MTEs sharing their practical knowledge with other MTEs.

In addition, in the mathematics teacher education community, we also have knowledge that the research community establishes (see, for example, articles published in the *JMTE*). The studies presented in venues like *JMTE* play an important role in the MTE community, adding to the professional knowledge base for mathematics teacher education. As MTEs we learn from others' practical and professional knowledge. However, we contend that our MTE community does not have a "shared, reliable, and professional knowledge base" (see the Hiebert, Gallimore, and Stigler quote above). A possible direction for the MTE community is to build from the work of one of the authors in this monograph – Hilda Borko. In the next sections, we present a way that we could, as a community, frame our work of inquiring into mathematics teacher education, and begin to coordinate the knowledge base for MTE.

Framing Inquiries into Mathematics Teacher Education

At the 2004 annual meeting of the American Educational Research Association, Hilda Borko focused her Presidential Address on research in teacher professional development. Subsequently, she wrote an article titled "Mapping the Terrain in Research on Professional Development," which appeared in *Educational Researcher* (Borko, 2004). In that article, Borko identified four key elements that comprise any professional development system:

- The professional development program;
- The teachers, who are learners in the system;
- The facilitator, who guides the teachers as they construct new knowledge and practices; and
- The context in which the professional development occurs. (p. 4)

Borko then presented a three-phase framework for considering research on professional development (see Table 1).

Table 1: *Phases of Research on Teacher Professional Development* (Borko, 2004, p. 4)

Phase of Professional Development Research	Context of Research Study	Research Focus
1	Researchers focus on an individual professional development program at a single site.	Researchers typically study the professional development program, teachers as learners, and relationships between these two elements of the system. The facilitator and context remain unstudied.
2	Researchers study a single professional development program enacted by more than one facilitator at more than one site.	Researchers explore the relationships among facilitators, the professional development program, and teachers as learners.
3	Research focus broadens to comparing multiple professional development programs, each enacted at multiple sites.	Researchers study the relationships among all four elements of a professional development system: facilitator, professional development program, teachers as learners, and context.

Borko's description of the elements of a professional development system can also be used to describe preservice mathematics teacher education:

- The mathematics teacher education program;
- The preservice mathematics teachers, who are learners in the system;
- The mathematics teacher educator, who guides the preservice teachers as they develop new knowledge and practices; and
- The context in which the mathematics teacher education program occurs.

Similarly, Borko's phases of research on professional development easily map onto research on preservice mathematics teacher education (see Table 2).

Table 2: *Borko's (2004) Three Phases Adapted for Preservice Mathematics Teacher Education*

Phase of Research on Preservice Mathematics Education	Context of Research Study	Research Focus
1	Researchers focus on an individual preservice mathematics teacher education course or program at a single university or site.	Researchers typically study the preservice mathematics teacher program, preservice teachers as learners, and relationships between these two elements of the system. The mathematics teacher educator and context remain unstudied.
2	Researchers study a single preservice education course or program enacted by more that one mathematics teacher educator at more than one university or site.	Researchers explore the relationships among mathematics teacher educators, the mathematics teacher education program, and preservice teachers as learners.
3	Research focus broadens to comparing multiple preservice teacher programs, each enacted at multiple universities or sites.	Researchers study the relationships among all four elements of a professional development system: mathematics teacher educator, mathematics teacher education program, preservice teachers as learners, and context.

If we are to make progress in coordinating all of our work in MTE (and establishing a deeper, more connected professional knowledge base), then extending Borko's framework for research on professional development to include all of the work of those who are inquiring into mathematics teacher education may be useful.

However, despite the progress made in the whole of mathematics education research over the last fifty years, the vast majority of the work in mathematics teacher education fails to surpass Phase 1, a situation confirmed by the work of the National Mathematics Advisory Panel (2008), which argued that little is empirically documented, and thus known, about the practices of MTEs and the results of those practices. This situation was also confirmed in a study of the literature on mathematics methods courses (Taylor & Ronau, 2006). This trend toward Phase 1 inquiries is also evident in the chapters in this monograph. As important as it is that we share our MTE practical knowledge, we also need to be looking to the future and how we can address our critics.

In the following section, we present the chapters contained in this monograph by making explicit the connections that we see among the authors' inquiries into MTE. We present the chapters in this manner to suggest that the authors, who might – on the surface – appear to have done very different inquiries into mathematics teacher education, could establish enough common ground to form AMTE Study Groups in order to develop collective inquiries at Borko's Phase 2 and/or Phase 3.

AMTE Monograph 5 Chapters

Authors of seven of the chapters in this monograph focus on the use of mathematical tasks as a launching point to help teachers better understand the content as well as the pedagogy related to that specific content. The differences between these chapters lie in the specific focus within the area of mathematical tasks as well as the teacher education model authors implemented around learning about and through mathematical tasks.

Goodman and Campbell tell the story of a statewide professional development academy for elementary teachers. Although the fundamental focus of the work within the academy stemmed from solving mathematics problems, collaborative investigations of those problems, and implementing those problems in their schools, the emphasis of this chapter is on the structure of the academy. In this chapter, Goodman and Campbell present a model for mathematics professional development that can be replicated at several sites around the country. An extension of the work they have presented in this chapter would be to conduct a study of teacher learning in several sites.

Goodman and Campbell could also seek to establish connections between their work and the work of Evans, Bean, and Romagnano. Similar to Goodman and Campbell, Evans and her colleagues report on a course in their rural schools program also revolves around specific mathematical tasks with the goal of increasing content knowledge while simultaneously focusing on pedagogy. The

contexts of these two MTE programs differ, but the basic goals and methods appear to have more similarities than differences. Working together would cause the need for both sets of authors to examine and refine their underlying framework, potentially strengthening both models and creating a study at a higher Phase. Others who have an interest in distance education could team with Evans, Bean, and Romagnano to replicate their model for study at multiple sites.

Chval, Lannin, and Bowzer use some of the same theoretical constructs as Evans, Bean, and Romagnano, emphasizing the situated nature of the experience of implementing mathematical tasks as a launching point from which teachers learn mathematics and pedagogy. These authors suggest framing concepts that could influence others' choices of tasks to use with their MTE students, and in fact argue that we need this common framework in order to advance our MTE practices. Again, authors of these three chapters (and other interested MTEs) could utilize Chval et al.'s framework across several sites and study the impact on preservice teachers' learning.

An AMTE Study Group focused on the implementation of mathematical tasks might also consider working with the framework developed by Van Zoest and Stockero. These authors focus on the use of concentric task sequences, a structured approach to moving from a mathematical task to student thinking about that task and then to teacher thinking. Could other MTE's enactment of this model produce results similar to those of Van Zoest and Stockero?

Van Zoest and Stockero's notions of this structured approach bears some important similarities to the ideas underlying the problem solving cycle approach advocated by Koellner, Schneider, Roberts, Jacobs, and Borko. Here, however, video clips and student work stimulate the mathematical discussion that crosses over into student thinking and eventually into teacher thinking. Another model that encourages MTE students to travel through the cycle from mathematical task, through student work, and into teacher thinking is represented in the chapter by Hughes, Smith, Boston, and Hogel. This team of MTEs used written case stories and student work to launch the investigation. Here we have three sets of authors who are implementing similar trajectories to influence teacher knowledge. Could they join forces in an AMTE Study Group to design common data collection instruments that would allow an inquiry into learning at different sites with different, but somewhat similar, MTE models?

Clark presents a different model for engaging MTE students in learning about teaching – through learning about how to use the history of mathematics in secondary mathematics teaching. She provides enough detail for her model to be replicated at multiple sites. An AMTE Study Group on preservice teacher course design could support MTEs across the nation in designing and implementing the same course and then inquiring into what preservice teachers learn. This Study Group could also contain members who design and implement activities within a mathematics methods or content course, much as Hjalmarson and Suh did, and study their impact on teacher learning.

In more closely examining the MTE community's propensity for conducting Phase 1 inquiries, a few things are noteworthy. First, Phase 2 and Phase 3 inquiries require reaching across institutional boundaries. Some key barriers that

will need to be circumvented include proximity, context, and theoretical constructs. Inquiries that have been conducted on teachers' collegiality and opportunities to collaborate indicate that lack of physical proximity as well as the structure of the work day (Rosenholtz, 1989; Taylor, 2004) constrain collegiality by limiting opportunities to meet face-to-face. The convenience and communication constraints found in this work on teacher collegiality apply to university/college faculty and other teacher educators as well. Proximity, however, can be purposefully bridged through the use of technology.

MTEs also cite the context of inquiries as negating the possibilities for collaboration. Contextual differences, such as course structure and program structure, can be overcome by focusing on what can be common across sites and reporting differences as the context of the study. These contextual differences add richness to a multi-site study by helping to sort out what aspects might be directly transferable to other contexts.

The theoretical and conceptual constructs, however, are another matter. Academic freedom and the need to publish original research both contribute to the scattered nature of the literature in mathematics teacher education. Academic freedom is important to innovation, but does not excuse the need to collaborate across institutional boundaries to enhance our MTE professional knowledge. Such inquiries would not only move the community towards adding reliable and generalizable knowledge to our profession, but also challenge inquirers to find common ground in terms of theoretical and conceptual constructs. Discussions that move inquirers to common ground are a place where the ideas of all researchers involved are refined, with the outcome of a purer and more useful lens. Such discussions could occur in AMTE Study Groups.

Overarching all of our work is the notion of MTEs' learning. In his chapter, Steele reports on his effort to model what it means to be a reflective practitioner, including open discussion of his pedagogical dilemmas and choices with those he was teaching. Cady, Hopkins, and Hodges focus on their own learning through a lesson study on one of the lessons that they implemented, one with preservice teachers and one with inservice teachers. Authors of both of these chapters could work together in an AMTE Study Group focused on MTEs' learning, collaborating to design inquiries across their contexts.

This monograph also contains chapters that contribute to our understanding of MTE in which the authors do not present information about inquiries into MTE. Instead these authors illustrate critical components of one aspect of MTE. Watanabe, Takahashi, and Yoshida carefully outline the nuances and critical understandings necessary to the study of instructional materials and the role of this process in one model of teacher development, Japanese lesson study. Niess, Ronau, Driskell, Kosheleva, Pugalee, and Weinhold discuss a much larger aspect of MTE: How do we prepare mathematics teachers to teach in an environment that is technologically saturated and constantly evolving in terms of technology? Both sets of authors provide detailed frameworks (or aspects of frameworks) that could be adopted by other inquirers and used to study mathematics teacher learning on a broader scale.

This monograph ends with a chapter about scholarship in mathematics teacher education, written by Reed and Mathews. In this chapter, the authors discuss the relationship of one's work in mathematics teacher education and the processes/standards for promotion and tenure, raising several issues with regard to our work as MTEs. Although different university/college contexts may employ very different standards and processes, many commonalities also exist. Building on the discussion started here by Reed and Mathews, an issue for future discussion in MTE, and a charge for a possible AMTE Study Group is: Are some university and college promotion and tenure committees more likely to reward inquiries that lie in different phases in Borko's framework? If so, what materials are necessary for educating department, college, and university colleagues of MTEs as to the value and constraints of inquiries at each phase of Borko's framework?

As editors of AMTE Monograph 5, we have enjoyed working with the chapter authors during the process of review, revision, and publication. We appreciate their patience and understanding as we worked to serve AMTE in this fashion. We are proud of this monograph and believe that it contributes to the effort of MTEs to share their work with each other. We hope that you find the contents helpful in reflecting on your practices as a mathematics teacher educator.

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