

Investigating the Professional Learning and Development of Mathematics Teacher Educators: A Theoretical Discussion and Research Agenda

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This paper presents a theoretical framework for guiding inquiry in an emerging field of research concerned with the learning and development of mathematics teacher educators. Such research is needed for two reasons: to open up the practices of mathematics teacher educators to critical scrutiny in order to better understand the nature of their impact on mathematics teaching in schools, and to systematically inquire into how mathematics teacher educators learn from engaging in teacher education.

Improving the quality of mathematics teaching and learning in schools is an issue high on the agendas of governments, universities, and the teaching profession itself. International comparative studies suggest that the best Australian students are not performing as well as those in other countries (Thomas & de Bortoli, 2008), and that teaching often fails to develop deep understanding of mathematical concepts (Hollingsworth, Lokan, & McCrae, 2003). Many schools also find it difficult to recruit suitably qualified mathematics teachers (Harris & Jenz, 2006), and beginning teachers often report dissatisfaction with the quality of their pre-service program (Australian Secondary Principals' Association, 2007). As a means of improving the preparation of mathematics teachers in Australia, the Australian Council of Deans of Science has called on State and Federal governments, as well as secondary and tertiary education authorities, to develop international best practice in science and mathematics teacher education programs (Harris & Jenz, 2006).

In Australia and internationally, recent developments in mathematics education have called for changes in the way mathematics is taught in schools. Learning goals now go beyond the traditional emphasis on facts and skills to include mathematical reasoning, communication, and intelligent use of digital technologies (e.g., Australian Association of Mathematics Teachers, 2002; National Council of Teachers of Mathematics, 2000). For this to happen, researchers argue that there needs to be a move away from the traditional activities of the mathematics classroom – such as teacher-centred exposition and individual seatwork – towards activities that help learners develop mathematically powerful forms of thinking (e.g., Goos, 2004). These changes have profound implications, not only for school mathematics teachers, but also for mathematics teacher educators who must encourage prospective and practising teachers to teach very differently from how they themselves were taught.

Calls for reform in mathematics education are implicitly based on the assumption that well prepared mathematics teacher educators are available who can foster change in teachers' traditional beliefs and practices (Zaslavsky & Leiken, 2004). The immense challenges inherent in bringing about this type of change are well known (e.g., Remillard & Bryans, 2004). However, almost nothing is known about the professional learning or development of mathematics teacher educators who undertake the vital task of reform – a “void in the literature” (Tzur, 2001, p. 259) that researchers have only recently begun to

address. Understanding this learning is essential if mathematics teacher educators are to contribute effectively to improving the quality of mathematics teaching in schools.

Research in *mathematics teacher education* as a distinctive field of inquiry has grown substantially in status over the past ten years, as evidenced by the establishment of an international journal (*Journal of Mathematics Teacher Education*), the appearance of edited books (e.g., Lin & Cooney, 2001), the commissioning of the 15th ICMI Study on the professional education and development of teachers of mathematics (Ball & Even, 2008), and publication of the first *International Handbook on Mathematics Teacher Education* (Wood, 2008). Notwithstanding this progress, research on the *development of mathematics teacher educators* is still in its infancy, with few published studies. Even (2008) noted that neglect of the education of mathematics teacher educators, by comparison to that of mathematics teachers, mirrors earlier research in mathematics education that focused more on students' learning than on teachers' learning. Thus, the processes by which mathematics teacher educators learn – whether informally, by engaging in teacher education practice, or formally, in programs designed to educate educators – has not been systematically investigated (Llinares & Krainer, 2006).

Theoretical Approaches to Studying Mathematics Teacher Educator Development

Current theoretical approaches found in existing studies of mathematics teacher educator development are largely based on constructivist views of teaching and learning, in particular, the notion of reflective practice as a means of establishing relationships between activity and consequences to explain how human beings advance their thinking. For example, Tzur (2001) and Krainer (2008) provide reflective self-studies of their own developmental trajectories, tracing their experiences as mathematics learners, mathematics teachers, mathematics teacher educators, and mentors of fellow mathematics teacher educators to identify critical events and experiences that advanced their professional knowledge and practice. Reflection is also the tool used in meta-studies where mathematics teacher educators analyse their own learning as part of a larger teacher professional development project (e.g., Even, 2008; Zaslavsky & Leiken, 2004; see also Diezmann, Fox, de Vries, Siemon, & Norris, 2007, for a rare Australian study of this type). Further reflective accounts and meta-studies can be found in Volume 4 of the *International Handbook of Mathematics Teacher Education* (Jaworksi & Wood, 2008), a sign of the growing interest and activity in this new field of research.

Rather than appealing to cognitive or constructivist theories that treat learning as an internal mental process (as in the studies mentioned above), many mathematics education researchers have begun to draw on sociocultural theories in proposing that teachers' learning is better understood as increasing participation in socially organised practices that develop their professional identities (Lerman, 2001). Such sociocultural approaches to mathematics teaching and learning involve “frameworks which build on the notion that the individual's cognition originates in social interactions ... and therefore the role of culture, motives, values, and social and discursive practices are central, not secondary” (Lerman, 1996, p. 4).

Sociocultural research has enhanced our understanding of how teachers learn from their experiences in different contexts, such as the university pre-service course, the practicum, and the school of employment (e.g., Blanton, Berenson, & Norwood, 2001a, 2001b; Bohl & Van Zoest, 2003; Graven, 2004; Peressini, Borko, Romagnano, Knuth, & Willis, 2004). Sociocultural perspectives have perhaps been used less effectively to inform

research on improving teachers' opportunities to learn, and this has left the role of the teacher educator largely untheorised. A more elaborated sociocultural theory of *teaching* and *teacher education* is therefore needed to complement sociocultural language and concepts used to describe learning. In this regard, some researchers have turned to Valsiner's (1997) zone theory to develop stronger sociocultural frameworks for teacher education research.

Adapting Valsiner's Zone Theory to Teaching-Learning Interactions

Valsiner's (1997) zone theory re-interprets and extends Vygotsky's concept of the Zone of Proximal Development (ZPD) to incorporate the social setting and the goals and actions of participants. Valsiner viewed the ZPD as a set of possibilities for development that are in the process of becoming realised as individuals negotiate their relationship with the learning environment and the people in it. His theory proposes the existence of two additional zones, the Zone of Free Movement (ZFM) and the Zone of Promoted Action (ZPA). The ZFM structures an individual's access to different areas of the environment, the availability of different objects within an accessible area, and the ways the individual is permitted or enabled to act with accessible objects in accessible areas. The ZPA comprises activities, objects, or areas in the environment in respect of which the person's actions are promoted.

The ZFM and ZPA are dynamic and inter-related, and are constantly being re-organised by adults in interactions with children. From an educational perspective, the ZPA offered by a teacher must engage with a learner's possibilities for development (ZPD) and promote actions that the learner believes to be feasible within a given ZFM. One possible zone configuration is represented in Figure 1; others can be imagined if overlap between zones is allowed to change. This representation implies that learning takes place at the intersection of the three zones.

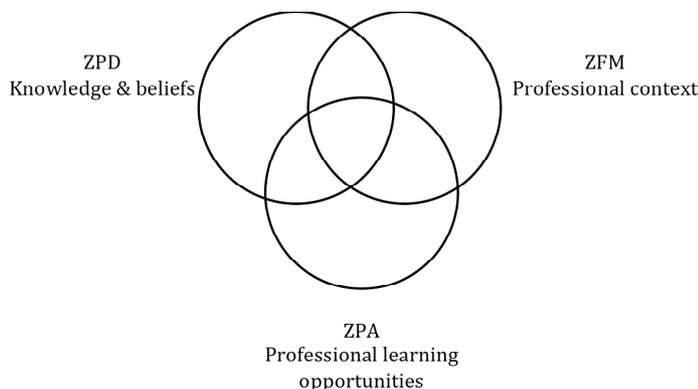


Figure 1. A possible zone configuration (teacher-as-learner)

Mathematics education researchers have taken two contrasting approaches to applying this theory to teaching-learning interactions, one of which defines the zones from the perspective of the teacher-as-teacher and the other from the perspective of the teacher-as-learner. In previous work I have proposed a third approach, which defines the zones from the perspective of the teacher-educator-as-learner (Goos, 2008).

Approach #1: Focus on Teacher-as-Teacher

A teacher's instructional choices about what to promote and what to allow in the classroom establish a ZFM/ZPA complex that characterises the learning opportunities experienced by students. This approach was taken by Blanton, Westbrook, and Carter (2005), who compared the ZFM/ZPA complexes organised by three mathematics and science teachers in their respective classrooms as a means of revealing these teachers' understanding of student-centred inquiry. It was found that two of the teachers created the appearance of promoting discussion and reasoning when their teaching actions did not allow students these experiences. Approach #1 is thus useful for explaining apparent contradictions between the types of learning that teachers claim to promote and the learning environment they actually allow students to experience.

Approach #2: Focus on Teacher-as-Learner

My own approach to the use of zone theory differs from that of Blanton et al. (2005) in that all zones are defined from the perspective of the teacher as learner (see Goos, 2005; Goos, Dole, & Makar, 2007). When I consider how teachers learn, I view the teacher's ZPD as a set of possibilities for development that are influenced by their knowledge and beliefs, including their mathematical knowledge, pedagogical content knowledge, and beliefs about mathematics and how it is best taught and learned. The ZFM can then be interpreted as constraints within the teacher's professional context such as students (behaviour, socio-economic background, motivation, perceived abilities), access to resources and teaching materials, curriculum and assessment requirements, and organisational structures and cultures. While the ZFM suggests which teaching actions are *allowed*, the ZPA represents teaching approaches that might be *promoted* by pre-service teacher education, formal professional development activities, or informal interaction with colleagues in the school setting. My previous research has shown that Approach #2 is helpful for analysing alignments and tensions between teachers' knowledge and beliefs, their professional contexts, and the professional learning opportunities available to them in order to understand why they might embrace or reject innovative teaching approaches promoted by teacher educators.

Approach #3: Focus on Teacher-Educator-as-Learner?

Zone theory is useful because it brings teaching, learning and context into the same discussion. The work outlined above shows it can be applied in two connected layers: (i) the teacher-as-teacher (TasT in Figure 2) creating classroom ZFM/ZPAs that structure student learning; and (ii) the teacher-as-learner (TasL in Figure 2) negotiating the ZFM/ZPAs that structure their own professional learning. At the latter layer the teacher-educator-as-teacher comes into the picture, providing the ZPA. Now let us imagine a third layer, with teacher-educator-as-learner (TEasL in Figure 2). This theoretical extension of the zone model opens up the possibility for investigation of how mathematics teacher educators' knowledge and beliefs define a set of possibilities for their continuing development (ZPD), how their professional contexts constrain their actions (ZFM), and how they experience and benefit from different opportunities to learn (ZPA).

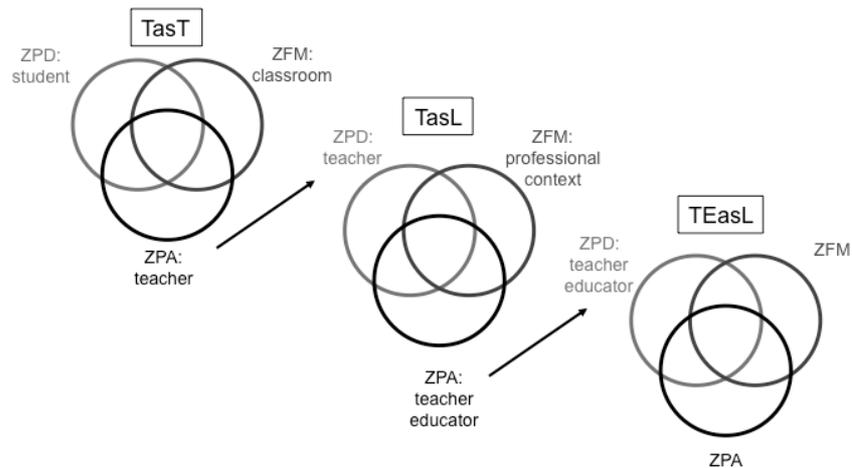


Figure 2. Three layers of application of zone theory: students, teachers, and teacher educators.

Applying Zone Theory to the Learning of Mathematics Teacher Educators

Research that develops and tests a zone theory framework to explain the learning and development of mathematics teacher educators would provide a comprehensive synthesis and sociocultural theorisation of this emerging field of inquiry. The nature of such a framework, incorporating relevant elements from existing studies, is outlined below.

Investigating the ZPD of Mathematics Teacher Educators: Knowledge and Beliefs

In many respects, the knowledge needed by mathematics teacher educators is similar to that required of mathematics teachers. According to Jaworski (2008), this includes:

knowledge of mathematics, pedagogy related to mathematics, mathematical didactics in transforming mathematics into activity for learners in classrooms, elements of educational systems in which teachers work including curriculum and assessment, and social systems and cultural settings with respect to which education is located. (p. 1)

However, mathematics teacher educators also need to know how new teaching practices are learned and the pitfalls associated with promoting this learning, as well as how to design teacher education activities, especially activities that connect prospective teachers' learning in the university and practicum contexts (Bergsten & Grevholm, 2008).

Mathematics teacher beliefs have been extensively researched, but the beliefs of mathematics teacher educators have received little attention in studies published to date. Mathematics teacher educators' beliefs about teaching and learning are likely to be influenced by theoretical studies and research (Bergsten & Grevholm, 2008). Therefore it would be necessary to investigate beliefs by identifying the theoretical and philosophical positions (e.g., constructivist, sociocultural, post-structuralist) that inform mathematics teacher educators' practice.

Investigating the ZFM of Mathematics Teacher Educators: Contexts

While university-based mathematics teacher educators have more professional autonomy than school teachers, their practice may still be constrained by the contexts within which they work, whether this involves pre-service or in-service teacher education. Significant aspects of the pre-service mathematics teacher education context might include:

- prospective teacher characteristics, such as their mathematical knowledge and their beliefs about mathematics teaching and learning;
- how curriculum and assessment requirements are influenced by professional accreditation authorities as well as university policies and course approval processes;
- organisational structures that limit the time available for teaching “methods” courses;
- access to teaching resources, including digital technologies;
- challenges in providing a quality teacher education program for large cohorts;
- challenges in finding suitable practicum placements for prospective teachers;
- an institutional culture that values research above teaching (Goos, 2008).

There may also be distinctive constraints that mathematics teacher educators experience in working with practising teachers in professional development contexts.

Investigating the ZPA of Mathematics Teacher Educators: Opportunities to Learn

Research is often a source of learning for mathematics teacher educators whose professional responsibilities include both teaching and research (Jaworski, 2001). However, some researchers have represented mathematics teacher educators’ learning as a lifelong process of growth through practice. For example, Zaslavsky and Leiken (2004) presented a three layered hierarchical model of learning, where each successive layer contains the knowledge of mathematics learners, mathematics teachers, and mathematics teacher educators respectively. A recursive relationship exists between the layers as each form of knowledge operates and reflects on knowledge in the layer beneath. There is also space for a fourth layer representing the knowledge of educators of mathematics teacher educators. Tzur’s (2001) self-reflective analysis of his own growth as a mathematics teacher educator is an example of how an individual moves through these four layers of learning mathematics, learning to teach mathematics, learning to teach mathematics teachers, and learning to mentor fellow mathematics teacher educators. Socioculturally oriented research could use this model to gather evidence of learning through socially organised practices that develop mathematics teacher educators’ professional identities (Goos, 2005).

A Research Agenda

Over time, mathematics education research has shifted in its focus from consideration of mathematical content and curriculum development, to the mathematical learning of students, to interactions between students and teachers, to the learning of teachers, and most recently to the learning of teacher educators (Krainer, 2008). This paper argues that socioculturally oriented research is needed to enhance theoretical understanding of how mathematics teachers learn and develop. Research of this type is important because it acknowledges the complex forms of knowledge needed by teacher educators and the multiple social settings in which their learning takes place.

Mathematics teacher education involves a wide range of activities in which teacher educators facilitate the learning of prospective and practising teachers. However, the notion of educating teacher educators for their professional task is relatively new and thus the practices that might support their learning and development are not well understood. Research is needed to identify the ways in which mathematics teacher educators learn – formally and informally, intentionally and non-intentionally. The findings could inform

development of a set of recommendations for supporting professional learning that is grounded in the practices of mathematics teacher educators who have varying levels of experience and work in a variety of different contexts. Such recommendations may stimulate further research on the design of professional learning activities for mathematics teacher educators.

Evidence from a multitude of research studies has demonstrated that what teachers do in classrooms influences students' learning of mathematics. It is taken for granted that the work of mathematics teacher educators similarly influences the learning of the teachers with whom they work, and hence the quality of mathematics teaching in schools. Research that develops and validates a theory of mathematics teacher educator learning and development would lead to a better understanding of how expertise is developed in carrying out this professional task. In doing so, it would provide evidence to inform discussion about what constitutes best practice in mathematics teacher education.

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