Chapter 15
Challenges, Reforms, and Learning in Initial Teacher Education

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Abstract This critical review of Australasian research concerns initial teacher education published in the period 2012–2015. The contribution to the field is organised into four broad areas: (a) research on teacher preparation: accountability, effectiveness, and policies; (b) research on teacher preparation for the knowledge society, which forms the bulk of the reviewed research; (c) research on teacher preparation for diversity; and (d) research focused on the work of teacher educators. Situated within educational settings that are undergoing continuous change and politicised attention, we note, in particular, research efforts to critically explore, design, and trial pedagogies, tasks, and partnerships associated with occasioning productive learning opportunities for prospective teachers to learn both the knowledge and the core practices of ambitious teaching.

Keywords Initial teacher mathematics education · Pre-service · Teacher preparation · Teacher knowledge · Teacher educators

1 Introduction

This critical review of Australasian research concerns initial teacher education (ITE) published in the period 2012–2015. During this review period directions in ITE have been influenced by the widespread belief that improving the quality of school systems and student outcomes can be achieved by enhancing the capabilities

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of teachers (e.g., Teacher Education Ministerial Advisory Group [TEMAG], 2015). Regaled by policy makers as both the cause of and a solution for education problems, teacher education has been criticised for not producing teachers of sufficient quality while simultaneously being viewed as "an ideal site for increasing teacher quality, providing it is subject to reform" (Ell & Grudnoff, 2013, p. 79). In an era of unprecedented attention to teacher quality and accountability, Cochran-Smith and Villegas (2015) noted that "changing conceptions of how people learn and what they need to know to thrive in a knowledge society" coupled with "growing social and school inequality" (p. 9) exert a major influencing role on current research priorities and directions for teacher education. This chapter considers how research in Australasia has responded to and informed calls to ensure the preparation of quality teachers.

We draw on Cochran-Smith and Villegas' (2015) recent international review of the "sprawling and uneven field" (p. 8) of research on teacher preparation and certification to structure our chapter. Following their lead, we organise our discussion of the Australasian contribution to the field into the three broad areas: (a) research on teacher preparation: accountability, effectiveness, and policies; (b) research on teacher preparation for the knowledge society, which forms the bulk of the reviewed research; and (c) research on teacher preparation for diversity and equity. We note also that calls for more accountability within ITE inevitably impact on teacher educators and add an additional section focused on the work of teacher educators, inclusive of research that investigates teacher educator identity, professionalism, and learning.

We conclude our chapter by reflecting upon the overall contribution of the studies to furthering the field as measured against the recommendations posed by Anthony, Beswick, and Ell (2012) in the previous review period. Based on our analysis of the strengths and weaknesses in the existing field, we also frame a set of recommendations regarding the potential future contribution of Australasian research to the research agenda of initial mathematics teacher education both locally and internationally.

2 Teacher Preparation: Accountability, Effectiveness, and Policies

Across the review period the challenge of improving the quality of schooling outcomes and the closely linked influence of the quality of teachers and their teaching has increased in scale and urgency (Hattie, 2012). Associated with calls for accountability, mathematics teacher education research has both informed and been shaped by issues concerning program design, entry and graduating standards of pre-service teachers. For example, mirroring an earlier trend in Australia, New Zealand funding exigencies have seen several universities reconsider their commitment to teacher education, with two major universities moving to postgraduate

options only. While we do not see the shift to largely school-based teacher education programs as mandated by the Teacher Training Agency in England, there is a significant move towards ITE programs that partner with schools. Indeed, from 2014 the New Zealand Ministry of Education has prioritised funding to Masters-level ITE programs that involve close collaboration between partner schools and universities. In addition there was a requirement that these programs demonstrate a commitment to a teaching as inquiry stance (Aitken, Sinnema, & Meyer, 2013) and a focus on quality pedagogy for diverse learners. Meanwhile in Australia, the trend towards postgraduate qualifications has stabilised, with a mix of undergraduate and postgraduate options common within the larger educator providers.

While ITE innovations have focused on quality "teaching"—with teacher educator exponents viewing this as the key to school improvement (Australian Council of Deans of Education [ACDE], 2012), a focus on accountability and quality "teachers" continues to pervade policy. In Australia, the Australian Institute for Teaching and School Leadership (AITSL, 2013) has established an expectation that ITE programs develop processes that ensure prospective teachers have sufficient numeracy and literacy skills to engage with their course, with the added specification that pre-service teachers are in the top 30 % of the population prior to graduation. This expectation has been operationalised with national testing; the first phase of national Numeracy (and Literacy) testing commenced in late 2015, with full national implementation from mid-2016. With regard to graduate exit testing, Leder, Forgasz, Kalkhoven, and Geiger (2015) noted the need to ensure that pre-service teachers have the capacity to meet numeracy demands associated with teaching beyond their teaching domain. Their exploratory study indicated that pre-service teachers currently underestimate the numeracy demands within teaching, for example in relation to interpretation of assessment data.

These policy and associated program initiatives are driven, and in some cases informed, by a range of studies concerning prospective teachers' mathematical knowledge. Notably, as in the previous review, studies (e.g., Linsell & Anakin, 2012; Norton, 2012) highlight weaknesses in prospective primary teachers' entry mathematical content knowledge. Forgasz, Leder, Geiger, and Kalkhoven's (2015) exploratory study of 151 pre-service teachers (both primary and secondary) provided an alternative perspective—claiming that most of the respondents were able to solve numeracy items considered suitable for 15 year-olds. However, these researchers also noted that only just over half of the respondents "believed that they had studied enough mathematics to be a competent teacher" (p. 319). In response to concerns about access to ITE for school leavers from regional, rural, and remote locations, where school achievement is generally described as lower than in metropolitan areas, de Silva Joyce, Feez, Chan, and Tobias (2014) examined the nature of numeracy knowledge and skills demanded of prospective teachers as they engaged in a regional university 4-year Bachelor of Education (Primary) program. In challenging a deficit view of prospective teachers, their findings point to lack of coherence and relevance of assessment activities and inadequacies in academic support.

In addition to mathematics content knowledge, Young-Loveridge, Bicknell, and Mills (2012) took the stance that attitudes to mathematics were also important entry attributes. From tests with 319 prospective primary teachers, using a Mathematics Thinking and Reasoning tool combined with attitudinal Likert measures, Young-Loveridge et al. reported that mathematical knowledge was relatively weak with fewer than half of the prospective teachers liking mathematics. They noted that those prospective teachers with positive attitudes tended to perform well on mathematics tasks.

An Australian study (Beswick & Goos, 2012), involving 294 prospective primary teachers, drew on the conceptual framework used in the Teacher Education and Development Study in Mathematics (TEDS-M) (Tatto et al., 2008) to investigate different aspects of prospective primary teachers' knowledge for teaching mathematics. In comparing these outcome measures for groups of participants based on a range of future teacher characteristics and teacher education performance characteristics, it was found that measures of mathematics content knowledge (MCK) and overall teacher knowledge were linked to teaching efficacy. In another attempt to link entry and graduate competencies, Norton (2012) investigated the capacity of prospective teachers' prior study of mathematics to predict 122 primary graduating teachers' success on tests of mathematics and pedagogical content knowledge (PCK). Norton found that graduating teachers who were proficient at mathematics were also effective at explaining how to teach it.

What these studies have in common are concerns about the sufficiency and nature of teacher mathematics knowledge. Collectively these studies provide empirical support for the relationship between mathematics content and teaching knowledge and contribute to the establishment of an evidence-base for ITE.

3 Teacher Preparation for the Knowledge Society

This review period was marked by national goals for all learners to have sufficient mathematics capability for meaningful employment and engagement in our knowledge-based technological society. As English (2015) noted, developing competencies in the Science, Technology, Engineering and Mathematics (STEM) disciplines is "regarded as an urgent goal of many education systems, fuelled in part by perceived or actual shortages in the current and future STEM workforce and also by outcomes from international comparative assessments" (p. 3). However, preparing students for future knowledge work requires new ways of teaching that are consistent with changing conceptions of how people learn and what they need to know (Cochran-Smith et al., 2015; Jorgenson, 2014; Timperley, 2013). Reforms in mathematics education—variously described as "ambitious" (Lampert et al., 2013), "dialogic," "responsive" (Stylianides & Stylianides, 2014), "inquiry-based" (Stillman, 2013), and "responsible" (Ball & Forzani, 2011)—require different approaches to teacher education that involve a shift in the kind of learning experiences provided for prospective teachers (Anthony & Hunter, 2012; Sullivan,

2015). In reviewing the research about "what and how" prospective teachers are supported to learn we have organised our discussion around the broad, and sometimes intersecting themes of (i) curriculum; (ii) opportunities to learn within coursework; (iii) opportunities to learn within field experience/practicum; and (iv) learning to teach over time. Within these themes, we prioritise those studies that explore curricula and pedagogical innovations and directions that align prospective teachers' beliefs and understandings with ambitious teaching practices and the development of professionals who are focused on better learning for themselves and their students—adaptive experts.

3.1 Curriculum

Both in Australasia and internationally, the review period was noted for an increased focus on (re)defining the curriculum of teacher education in terms of what teachers should learn and be able to do. Using Hammerness, Darling-Hammond, and Bransford's (2005) curriculum framework—a vision of practice, knowledge of students and content, dispositions for using this knowledge, and a repertoire of practices and tools—it is clear that for our community, attention to knowledge of students and content (be it mathematical or pedagogical) is central to many researchers' agendas. This is possibly because many researchers are themselves involved in teaching with prospective teacher knowledge at the fore of their attention. Thus we begin this section with a review of studies that relate directly to teacher knowledges for mathematics teaching.

Following on from reviews of teacher quality and associated concerns about sufficiency of entry and graduating knowledge, researchers have advocated for increased focus within ITE on areas of numeracy (e.g., Cooke, 2015)—inclusive of mathematical skills and disposition towards mathematics, and statistical literacy (Chick & Pierce, 2013). Prospective teachers' mathematics knowledge linked to the school curriculum strands (e.g., number sense, multiplication, place value, decimals, proportional reasoning, fractions, geometric properties, circles and ellipses, perimeter, area, measures of centre, and probability) is evidenced in a number of MERGA and PME conference papers and journal articles (e.g., Chinnappan & Forrester, 2014; Livy, Muir, & Maher, 2012; Muir & Livy, 2012; Murphy, 2013, Wright, 2013). Collectively, authors of these publications expressed concerns that the strong emphasis on procedural knowledge displayed by prospective teachers would negatively impact on their capacity to develop appropriate conceptual and pedagogical content knowledge (PCK). Beswick (2015), in exploring pre-service teachers' PCK provided an interesting analysis of a pre-service teacher's interview around a PCK scenario test item to illustrate the interrelationship between beliefs and knowledge. In other interview studies (e.g., Chinnappan & White, 2015; Maher & Muir, 2013) pre-service teachers' capacity to identify errors in student work samples and to determine appropriate approaches to address those errors was clearly linked to levels of mathematics content knowledge (MCK).

The assessment of prospective teachers' knowledge base combined with reported school-based experiences linked to repetition and recitation of procedures raises concerns about how to deepen prospective teachers' mathematical understandings and challenge their beliefs that procedural understandings are sufficient for teaching. As Klein (2012) noted, it is not enough for "novice teachers to know and understand mathematical ideas, they must also be able and willing to implement new interactional patterns that allow their students to sense proficiency in energetic participation with and in mathematics" (p. 35).

Several studies explored learning opportunities to advance prospective teachers' MCK in ways that align with the notion of mathematical proficiency. Exploring the prevalence of mathematics anxiety among pre-service teachers, Hurst and Cooke (2014) found evidence that these teachers were often unaware of what they needed to know. These researchers concluded that the need to develop a conscious awareness of incompetence preceded the development of conscious competence. Perkins (2015) found that the novel approach of utilising a classroom teacher, independent of the practicum mentor, as mentor proved successful in developing pre-service primary teachers' confidence, and alleviated mathematics anxiety.

Chinnappan and Forrester (2014) found that the use of a model-based teaching approach enhanced prospective teachers' conceptual knowledge of fractions: they attributed this improvement to using visual forms for the representation and interpretation of the operations of fractions. Daniel and Balatti (2013) provided an example of a collaborative (prospective teacher and researcher/teacher educator) analysis of videoed episodes of prospective teachers teaching a task involving area concepts. The simulated review activity revealed both prospective teachers' areas of strength and omission in terms of utilisation of MCK. While the collaborators viewed the activity as a positive learning experience, the issue of time to effectively provide follow-up learning activities was raised. Also looking at the affordances of knowledge building communities, Nason, Chalmers, and Yeh (2012) studied the growth of prospective teachers' understanding about teaching geometry as they engaged in a study that investigated teachers' lesson planning within a computer-supported collaborative learning environment. Using a teaching experiment design Nason et al. documented how teams of prospective teachers "engaged in extensive knowledge building activity and made considerable advances to their repertoires of PCK about teaching primary school mathematics at both theoretical and practical layers" (p. 238). Changes to participants' repertoires of PCK (made through comparisons of each teams' initial and final lessons plans) focused on changes to teacher interventions within lesson plans and structuring of lesson content. Factors that influenced the growth of PCK included the nature of the lesson planning task, the cognitive scaffolds, the meta-language scaffolds, and the provision of both private and public discourse spaces.

Beswick and Goos (2012), like others, contend that MCK remains important for the development of PCK. As noted in their study involving 122 graduating primary teachers (see previous section), they found a lack of any relationship between pedagogical content knowledge (PCK) and level of prior education or highest mathematics or statistics studied. Beswick and Goos cited this finding as evidence

of the central place PCK development must take within the teacher education curriculum. However, taking a different and somewhat novel approach, Ell, Hill, and Grudnoff (2012) analysed entry pre-service primary teachers' ability to recognise the key features, as an expert would, of a range of student responses to mathematical tasks. They found that approximately half of the teacher candidates "recognised the key features outlined by the experts" (p. 59). Although based on a limited sample from one institution, Ell et al. argued that these findings offer a challenge to the widely espoused view that prospective teachers bring largely conservative views of teaching and learning mathematics based on their own experience. Additionally, their study provides an exemplar of how teacher educators can themselves develop an inquiry-based approach as a way of increasing responsiveness to prospective teachers' prior knowledge.

Collectively, these studies endorse Goos' (2013a) claim that "content knowledge apparently learned during secondary schooling is not necessarily secure, and it needs to be revisited during teacher preparation" (p. 982) in conjunction with new learning associated with knowledge for mathematics teaching.

3.2 Opportunities to Learn Within Coursework

In designing learning opportunities, mathematics teacher educators are well aware of the importance of prospective teachers' attitudes and beliefs concerning mathematics, mathematics learners/learning, and mathematics teachers/teaching (see also Chap. 5, this volume). Dayal's (2013) and Wilson's (2015) exploration of prospective teachers' recounting of "good and bad" teachers reaffirms the importance of acknowledging prior learning experiences. However, the trend evident in the previous review (Anthony et al., 2012) to look closely at teacher beliefs has generally been replaced by a more holistic approach to changing and challenging beliefs. This approach is informed by theoretical arguments around social theories of learning (Goos, 2013b) and represented by the growth in attention to coursework design that affords opportunities for prospective teachers to develop attributes of professionalism associated with inquiry, collective responsibility, and knowledge co-construction (Afamasaga-Fuata'i & Sooamalelagi, 2014; Lane, McMaster, Adnum, & Cavanagh, 2014).

Explorations of opportunities to learn within online environments focused on prospective teachers' emergent identity and professionalism. Goos and Geiger (2012) investigated the social and multimodal affordances associated with online group assessment tasks that required the creation of a video presentation and set of questions that would engage primary school students in mathematically rich learning. Conceptualising digital mathematics performance "as a way of transforming mathematical identities" (p. 709), Goos and Geiger found the use of technologies supported the creation of an original performance that illustrated the use of mathematics in a real life context. Moreover, the technologies also afforded opportunities to participate in some of the "practices of a professional community in

that they [pre-service teachers] created and evaluated teaching resources and engaged in professional discussions with peers" (p. 713). Larkin and Jamieson-Proctor (2015) used the theoretical framework of transactional distance theory to analyse dialogical interactions within an online course. In seeking to understand the relationship between pre-service teachers' pedagogical practices and the development of teacher knowledge and attitudes, Larkin and Jamieson-Proctor argued that the use of virtual classrooms and forums provided opportunities for high levels of dialogue comparable to traditional courses. Pre-service teacher feedback indicated the presence of the online community of practice supported students' development of positive attitudes towards mathematics.

Addressing professionalism, Klein (2012) argued that teacher change involved the constitution of a vision of teaching that embraces "new interactional patterns that centre the mathematics and learner in dynamic, productive interaction" (p. 25). Applying a bifocal lens containing psychological and poststructuralist constructs to examine prospective teachers' identity and potential to teach in innovative ways, Klein offered her experiences of teaching a mathematical inquiry course as a way to challenge the prevailing humanist inspired discursive practices that suggest nurturing and having fun are paramount. In a similar vein to Klein's efforts to provide prospective teachers with experiences that support authorship over a learning process of knowledge construction, Hunter and Anthony (2012) and Bailey and Taylor (2015) explored the provision of opportunities for prospective teachers to work on mathematical problems in small groups followed by teaching groups of children in schools. Collectively, these studies concluded that experiencing collaborative problem-solving approaches led to significant shifts in prospective teachers' thinking about what it means to do mathematics and support the learning of mathematics.

In looking at new spaces for "learning the *work* of teaching" (Lampert, 2010, p. 21, emphasis in original), other researchers have aligned with the international trend towards practice-based teacher education and associated pedagogies (Zeichner, 2012). With the goal to support prospective teachers to learn not just about teaching but also how to use knowledge of teaching in action, pedagogies of practice comprises three elements: (i) representations of practice (e.g., video records of lessons or records of student work); (ii) decompositions of practice (e.g., core or high-leverage practices such as professional noticing, building on learners' thinking, leading a discussion of solutions to a mathematics problem, and positioning students as competent); and (iii) approximations of practice (e.g., simulations of certain aspects of practice through activities such as role play and rehearsal) (Grossmann, Hammerness, & McDonald, 2009).

Several emergent studies focused on the use of representation and decomposition of specific core practices. For example, using video excerpts of mathematics teaching as representations of practice, Beswick and Muir (2013) explored teacher learning in terms of inclinations and abilities to identify and focus on the development of students' mathematical understanding. Analysis of the tutor-led discussions of each video indicated that the "pre-service teachers struggled to see beyond readily evident aspects of teaching, such as the use of concrete materials"

(p. 27). Disappointed with the limited challenge to the pre-service teachers' beliefs, the researchers conjectured that more foundational work around "what constitutes evidence of understanding and how teachers can elicit such evidence from students" (p. 49) would be beneficial as a precursor to this type of activity. Another video study, by Muir, Allen, Rayner, and Cleland (2013), investigated the use of *Second Life* as a simulacrum of a teaching environment. The virtual environment, acting as an approximation of practice, provided the opportunity to focus on particular topics, misconceptions, learning difficulties, and pedagogical approaches. Although the technology was cumbersome to master, the prospective teachers appreciated the alternative way to learn the work of teaching and receive feedback from their peer community.

Cavanagh, Bower, Moloney, and Sweller (2014) also studied the use of videos of teaching, but this time using secondary pre-service teachers' own simulated practice as examples. Cavanagh et al. concluded that the iterative process of viewing and reflection improved the teachers' communication processes across cognitive, behavioural, and affective domains, with the peer critique and support via blog postings considered a valuable part of the learning process. Likewise, Prieto et al. (2015) explored the effectiveness of video analysis of prospective teachers' own teaching episodes. A teaching rounds process based on the Quality Teaching model (see NSW Department of Education and Training, 2003) generated focused reflections on micro-teaching conducted in an after-school homework context. As with other practice-based studies, participants expressed unanimous approval for the targeted opportunities to practise teaching in a safe and approximated setting. Analysis of the 40 pre-service secondary teachers' abilities to plan lessons and reflect on their practice-based experiences led the researchers to conjecture that those teachers with poor MCK were limited in their capacity to develop PCK—a finding also noted in Beswick and Goos' (2012) study of pre-service primary teachers.

In a larger practice-based study, researchers across two universities (Anthony, Hunter, Anderson, et al., 2015) collaborated in a 3-year design-based study. Key to pedagogical and curriculum change was the use of purposefully designed "instructional activities" (IAs)—containers of core practices, pedagogical tools, and principles of high-quality teaching (Kazemi, Franke, & Lampert, 2009). Within their mathematics method courses, pre-service teachers regularly planned and taught IAs to a group of peers in the format of public rehearsals with teacher educator coaching. Analyses of rehearsals within a range of mathematics methods courses have explored pre-service teachers' perceptions of the learning activity (Averill, Drake, & Harvey, 2013), opportunities to practise and learn about how to listen and respond to students' mathematical thinking (Anthony, J. Hunter, & R. Hunter, 2015a), and the development of cultural competencies (Averill, Anderson, & Drake, 2015).

These reviewed studies reflect changes in pedagogies and associated opportunities to learn within ITE programs. With many of the studies focused on discrete learning activities, research concerning the integration of opportunities for learning the work of teaching into a more comprehensive set of experiences, both within the ITE setting and across the school setting, should be a next step.

3.3 Designing Opportunities to Learn with School Settings

It is well known that much of what pre-service teachers learn about teaching and learning occurs in a school based context, and interest in how this learning can be supported has typically focused on mentor partnerships with the pre-service teacher. For example, Livy (2015), drawing on two contrasting cases, reported how differential support and expectations by school-based mentors around teacher planning impacted on prospective teachers' development of MCK. In particular, opportunities to co-plan with a mentor teacher and to experience teaching across a wide range of class levels were significant factors that supported the development of MCK.

In line with the growing trend for new partnerships between teacher education institutions and schools, this review period has seen the emergence of studies that focus on partnerships that are inclusive of a wider community of support. In the practice-based study discussed above (Anthony et al., 2015) prospective teachers taught the Instructional Activities with small groups of students in schools. Following each teaching session video records of that work were discussed in the university setting. Cavanagh and Garvey (2012) researched a university course that included extended opportunities for mentor teachers, mathematics teacher educators, and pre-service teachers to engage in co-teaching experiences within secondary mathematics classrooms. Participant responses suggested that "everyone developed a greater appreciation of the importance of mathematical problem solving as a practical way of implementing the reform agenda for secondary mathematics" (p. 71).

Possibly because of the trend to integrate university and school learning environments, this review period was notable for the relative absence of studies that focus on the practicum experience per se. Instead, researchers involved in studies that involved partnership arrangement have argued that the co-teaching activities were valued as a way of promoting quality evidence-based discussions around effective pedagogical practices and reciprocity among the learning community members. Further research is needed to look at ways these partnerships can support engagement in theory building and development of shared conceptual framework aligned to adaptive teaching expertise (Anthony, Hunter, & Hunter, 2015b)—the hallmark of the professional teacher (Aitken et al., 2013).

3.4 The Continuum of Teacher Learning

Mathematics educators have for some time had their eye on the goal of preparation for "teaching that is more socially and intellectually ambitious than the current norm" (Lampert et al., 2013, p. 241). To dampen the effects of enculturation into existing modes of teaching, beginning teachers need to be able to take up an agentic

position towards improving practice. However, Nolan and Walshaw (2012) question how realistic it is to expect beginning teachers to make significant shifts from a traditional practice to a teaching practice centred on inquiry approaches. Applying Bourdieu's social field theory they illustrate how Toni, a pre-service teacher, developed a set of hybrid pedagogies. "Steeped in the as-yet-still-developing habitus as inquiry teacher, she tapped into both fields [inquiry and traditional practices] that, operating to some extent below her conscious awareness, vied for position to constitute her as a teacher of mathematics" (p. 360). Nolan and Walshaw argue that "the challenge lies in persuading pre-service teachers to take risks and consider trying an uncomfortable habitus on for size" (p. 360).

Enabling prospective teachers to take risks was the focus of a Classroom Inquiry course in which pre-service teachers taught groups of students rich mathematical tasks. Anthony et al.'s (2015b) analysis of a series of journaling activities and pre and post course interviews were used to illustrate pre-service teachers' shift in focus from self to student and towards more complex understandings of teaching and learning—representative of shifts from routine to adaptive expertise. They argued that the teaching as inquiry model (adapted from Timperley, Wilson, Barrar, & Fung, 2007), focused on linking teacher actions to student learning outcomes, combined with the use of research frameworks aligned to the orchestration of productive classroom discourse (e.g., Hunter, 2008; Smith & Stein, 2011) supported prospective teachers in developing expertise.

Building on earlier studies of teacher learning across the boundaries of ITE and the classroom, Goos (2013b) frames taking risks as "productive tensions between teachers' thinking, actions, and professional environments" (p. 521)—tensions that can become opportunities for change. In reflecting on the nature of the researcher-teacher relationship within studies involving transitions from university to the school-based workplace, Goos (2014) argued that while both researcher and pre-service teacher are learners, for the pre-service teacher the relationship facilitates entry to a professional community of mathematics teaching. Building on an established research relationship, Anthony, Hunter, Hunter, and Duncan (2015) explored the impact of a beginning teacher's emergent adaptive expertise (Hatano & Oura, 2003). Their analysis highlighted how the beginning teacher's responsive, reciprocal power-sharing relationships with her learners supported the continuous co-construction of knowledge for herself and her students.

These studies acknowledge the tensions and challenges—both for prospective teachers and teacher educators—in working across boundaries. They serve to remind us that in striving for a more ambitious vision for learning, we must continue to work towards designing learning environments that attend to the ways in which learners are entitled, expected, and obligated to act. In particular, in looking to develop teacher graduates as agents of change, it is important that we seek to position them as sense-makers in dialogue about the challenges of ambitious mathematics teaching.

3.5 Summary

The reviewed studies in this section contribute to understanding how we might better prepare teachers to learn the work of teaching. In doing so, these studies focus on how mathematics teacher educators might support both the learning of knowledge and repertoires of practices alongside the development of dispositions for using this knowledge in a way that contributes to professionalism. In looking for a third space (Zeichner, 2012), the approximation of practice afforded by instructional innovations such as pedagogies of rehearsal and simulacrum learning environments are worthy of further investigation.

4 Teacher Preparation for Social Justice

This section considers research that focuses on how teacher preparation has responded to the challenges associated with an increasingly diverse population, the differences in lived experience between many prospective teachers and their students, and the disparities in educational opportunities and outcomes for socially disadvantaged groups. The deep commitment by Australasian mathematics teacher educators/researchers to social justice is evident in large scale professional learning and development projects with indigenous and socially disadvantaged communities (see Chaps. 6 and 7, this volume). In this section we review research that adds to that agenda—looking at innovations in ITE programs that focus on supporting prospective teachers to develop cultural awareness and responsiveness.

Nicol, Bragg, and Nejad (2013) explored pre-service teachers' ability to make mathematical problems more accessible and challenging for diverse learners. Results from their study indicated that while participants were able to draw upon a range of strategies to vary the mathematical content, the context, and the questions asked, participants were less likely to notice or attend to how their adaptations changed the mathematical structure of the problem. These insights into the lack of thought about the mathematical implication of changes suggest that task adaption may indeed be a core practice that needs explicit attention for learning the work of inclusive teaching practices.

Owens (2014) reported on a study involving pre-service teachers from Papua New Guinea. Curriculum exemplars drawn from a range of local contexts prompted teachers to "reflect upon their cultural heritage and recognise that it was valuable and relevant to school mathematics" (p. 202). In turn, teachers reported that their increased awareness of ecocultural pedagogy positively impacted on the learning and development their students' sense of worth. Afamasaga-Fuata'i and Sooamalelagi (2014) also turned to culture to investigate ways to make mathematics learning more meaningful for pre-service teachers. Aligned with curriculum reforms in Samoa, the course they reported on provided opportunities for pre-service teachers to engage in mathematical investigations of authentic contexts.

That some, but not all, students reported positive attitudinal changes provides evidence of the difficult task involved in shifting understandings of and attitudes toward mathematics.

Averill, Anderson, and Drake (2015) looked at how the teacher educator modelling and coaching roles associated with public rehearsals of teaching might support pre-service teachers to develop cultural competencies (see *Tātaiako—Cultural competencies for teachers of Māori learners,* Ministry of Education, 2011) associated with enhancing equity of access to achievement in the mathematics classroom. Retrospective analysis across rehearsal activities from two mathematics methods courses illustrated how the processes inherent in modelling and decomposition of core practices (Grossman et al., 2009) provided opportunities to professionally notice culturally responsive teaching in action. For example, wānanga—participating with learners in dialogue for the benefit of learners' achievement—was evident through modelling how the teacher could talk with learners about their learning and through listening to their ideas. Ako—a concept that suggests that each member of the learning setting brings knowledge with them from which all are able to learn—was exemplified through the reciprocity of teaching and learning and the modelling of high expectations, risk taking, and collaboration.

These studies document innovative ways to support prospective teachers in their development of equitable and culturally responsive practices, with explicit links to lesson planning and rehearsal activities. However, we cannot be complacent with our efforts. Jorgensen (2014), in advancing a new approach to equity reforms, argued that we need research that can shape "new agendas to support teachers' work in bringing about deep mathematical knowledge making … for ALL students" (p. 317). Reform efforts require that we understand how to include pedagogies that support prospective teachers' learning of culturally responsive and responsible mathematics teaching, and we actively research what effects, if any, such practices have on pre-service teachers and ultimately their diverse students.

5 Research on and with Teacher Educators

Internationally there is increasing recognition that research in ITE needs to be inclusive of research concerning teacher educators (Knight et al., 2014). With intensified calls for accountability and performance indicators in ITE, the need to know more about the learning, practices, and preparation involved in "teacher educator education" is all the more pressing. Understanding and articulating the knowledge and skills that mathematics teacher educators need to prepare teachers for the challenges of ambitious mathematics teaching and determining how teacher educators can acquire this expertise has the potential to make a significant difference to the field of mathematics education in general.

A small number of studies which focus on teacher educator knowledge, identity, and learning are highlighted in this review, which occurs at a time when special issues are underway on this topic (e.g., *Journal of Mathematics Teacher Education,*

Journal of Teacher Education). In relation to the knowledge types identified by Shulman (1987) and others (e.g., Ball, Thames & Phelps, 2008), the knowledge required by mathematics teacher educators goes beyond MCK and that required of a classroom mathematics teacher. According to Beswick and Chapman (2015), mathematics teacher educators require a kind of meta-knowledge—described as knowledge for teaching knowledge for teaching mathematics. Building on a PCK framework conceptualised by Chick, Baker, Pham, and Cheng (2006), Chick and Beswick (2013) adapted the framework, with pre-service teachers taking the place of students, and school mathematics teachers PCK (SMTPCK) taking the place of mathematics as the teaching domain. Their framework provides a useful set of filters for examining the PCK of a teacher educator who teaches mathematical PCK. Indeed, using this framework, Marshman and Porter (2013), linked pre-service teachers' difficulty with identification of student misconceptions in fractions with the need for teacher educators to be more specific in terms of identifying the cognitive demands of tasks.

In addition to teaching prospective teachers PCK, for many mathematics teacher educators, a large part of their role involves teaching mathematics, particularly when working in early childhood and primary ITE. There have been some attempts to measure both teacher educators' mathematical content knowledge (MCK) and PCK. Callingham et al. (2012), for example, used an online survey to measure teacher educators' MCK and PCK. Their findings indicated that teacher educators found the items addressing PCK more difficult than mathematics content questions but that the question of what mathematics teacher educators need to know in order to develop quality mathematics teachers is still unanswered. Another survey study (Getenet, Beswick, & Callingham, 2015) designed to measure mathematics teacher educators' knowledge highlighted the importance of investigating how knowledge of technology was integrated with other knowledge needed for mathematics education.

In addition to knowledge, the beliefs of mathematics teacher educators have also been investigated. Beswick and Callingham (2014), for example, reported on the beliefs of mathematics teacher educators compared to experienced and prospective mathematics teachers. Mathematics teacher educators were found to be less likely than all other groups to agree that students learn by practicing procedures and methods for performing mathematical tasks and tended to hold views aligned with a problem solving view of the discipline. In conclusion, the authors called for more exploration into these issues, recommending also that the extent to which mathematics teacher educators are perceived as being out of touch with classroom realities be investigated.

Given the specialised nature of mathematics teacher education, it is not surprising that the work of teacher educators is generally researched and reported by teacher educators; indeed, the papers considered in this review period concerned several self-study projects. Chick and Stacey (2013), for example, explored the idea that mathematics educators teaching mathematics act as applied mathematicians in applying mathematical knowledge to the resolution of teaching problems. In addition, Chick and Beswick (2013) used their newly developed mathematics

teacher educator PCK framework to study the PCK used by Helen in working with pre-service teachers in an online environment. The analysis focused on teaching scenarios in which the character of Boris, a puppet who represented a hypothetical student, provided stimuli to encourage prospective teachers' questioning of students. The data were examined to identify when Helen, as the mathematics teacher educator giving voice and action to Boris, appeared to use some form of knowledge for decision-making that was intended to develop prospective teachers' PCK. Different SMTPCK types that were identified included teaching strategies, prospective teachers' thinking (e.g., misconceptions), cognitive demands of tasks, and prospective teacher goals for learning. Bragg (2015) also used self-study to explore how to improve an on-line assessment task. Bragg noted that the close examination of her practice, although challenging, was productive in "developing a stronger professional eye" (p. 294) for both herself and her students.

A number of studies have examined the role of teacher educators' practices, and the influence these practices have on prospective teachers' learning. For example, Anakin and Linsell (2014) challenged the "tacit habit of teacher educators seeing learner knowledge as lacking" (p. 723). Taking pains to emphasise that mathematics teacher educators are in a privileged position to nurture the teaching and learning of mathematics, these researchers called for a rethinking of the role from a transmitter of knowledge to a learning resource. Similarly Klein (2012), in an examination of her own teaching, found that if the "teacher educator is positioned as the one who knows" (p. 29) then this positioning is unlikely to provoke change in teaching practices.

Looking to provoke change through a greater understanding of the theory-practice nexus, Cavanagh and Garvey (2012) found that the establishment of a community of practice involving pre-service teachers, supervising teachers, and mathematics teacher educators working together supported a more productive role for the teacher educator than as a knowledge expert. Learning new roles and associated pedagogies was a feature of Anthony, Hunter, Anderson, et al.'s (2015) design study that trialed the use of public rehearsals of instructional activities within methods courses. To enhance their learning, some of the mathematics teacher educators deliberately sought out classroom experiences to develop expertise in teaching instructional activities while others engaged with colleagues in reflective critiques of videoed teacher educator coaching moves.

In summary, this section has looked at the research in ITE which has focused on the teacher educator as practitioner. While Lerman (2014) suggested that the identity of mathematics teacher educators is regulated by structural factors such as the values of education embedded in government policies, there is value in pursuing the agenda set by Beswick and Chapman (2015) and others. For example, "How does the knowledge needed by mathematics teacher educators differ from that required by mathematics teachers?" "How is knowledge for mathematics teacher education acquired?" and "Why is it important to articulate knowledge for mathematics teacher educators?" It appears that this is an area that is ripe for further research, with the potential to contribute to making a difference in the field of teacher education. In addition to studies that investigated mathematics teacher

educator knowledge, the field is represented by small-scale self-studies in which mathematics teacher educators aim to advance the quality of course-based ITE learning experiences.

6 Conclusions: Looking Back and Looking Forward

Graduating teachers will begin their teaching careers in educational settings that are undergoing continuous change, at local and national levels. As beginning teachers they will need to respond to broad developments in national curricula and assessment frameworks, and to the increased use of technology in all aspects of education and social/work settings. While concerns around recruitment and graduation of quality teachers continue to drive policy initiatives within ITE, there is a real sense that the research agenda is being driven by teacher educator/researcher awareness of the need to address three related aspects of program design and implementation: "organizational structures and policies, content and curriculum, and teacher education pedagogy" (McDonald et al., 2014, p. 501).

Research reviewed in this period represents the consolidation of the groundswell of studies from the previous review (Anthony et al., 2012). However, in contrast to the previously tentative explorations of "*practice*—and the problem of doing it effectively" (Ball & Even, 2009, p. 255, emphasis in original), we now see deliberate moves to design and trial innovative practice-based teacher education reforms. Previous attention to the commonly touted divide between practice and theory has to some extent been displaced by the turn to practice-based education (Zeichner, 2012). Research (e.g., Anthony, R. Hunter, Anderson, et al., 2015; Muir et al., 2013) offered a range of innovative instructional activities designed to support prospective teachers learn the work of complex relational teaching practices associated with communities of mathematics inquiry.

While many of the studies that created new learning opportunities for prospective teachers sought to address the challenge of preparing teachers to teach in new and ambitious ways, the limited number of studies that specifically addressed issues of diversity and equity was of concern. To make inroads on meeting the "grand challenge" of providing equitable learning opportunities in the mathematics classroom (National Council of Teachers of Mathematics [NCTM] Committee, 2015) this is one area that needs heightened attention.

Critical efforts to interrogate the ITE curriculum include a focus on teacher knowledge and identification of core or high-leverage practices for mathematics teaching. However, this review has identified that there is still much to learn about the relationship between knowledges for teaching (e.g., Beswick, 2015) and about core practices such as professional noticing of students' mathematical reasoning that are crucial to equitable and culturally responsive teaching practices (Averill et al., 2015). A way forward ought to involve studies that develop a common language and a framework for aggregating explorations on teacher knowledge and pedagogical tools and opportunities for learning the work of ambitious teaching.

In line with current focus on social learning theories (Morgan, 2014), it was notable that those studies that offered innovation, for the most part, featured collaborative and reflective activities, be it with peers (e.g., in planning rehearsal activities, in experiencing problem solving activities, in critiquing online assessment and presentation) or with a wider community involving teachers, teacher educators, and prospective teachers. Likewise, with the normalisation of online learning environments and access to technological tools and representations, there was an increased awareness of the role of the performance and social activity within the learning process (Goos, 2013a, b).

This review period has seen a considerable strengthening of research involving teacher educators. Notably, practice-based teacher education innovations offer an alternative way for developing pedagogies of enactment that support prospective teachers to learn the work of teaching while simultaneously placing the teacher educator in contexts where they can learn from and with their prospective teachers. However, studies such as Goos and Geiger's (2012) and Anthony, R Hunter, Anderson, et al.'s (2015) remind us that change carries significant implications for the teacher educator. In many of the reviewed studies involving innovation, teacher educators noted the risks involved in making changes to curriculum, assessment, and pedagogies—citing pressures of space/time and challenges to identity associated with their new learning.

The politicised attention to teacher preparation and the press to institute reforms will not abate in the near future. A sound research base will be crucial if we are to avoid being at the whim of top-down policy mandates, and potentially mitigate the scenario endured in England where the research community experienced limited input into debates about reforming or improving mathematics teacher preparation (Brown, Rowley, & Smith, 2014). With evidence-based teacher education a current political priority, we must continue to build on the existing large-scale studies concerning mathematics teacher entry and graduating knowledge/testing to address concerns around accountability, equity, and access for teacher candidates.

In addition, we must look to scale-up research projects from single site studies to large-scale, national and international projects. The current *Inspiring Mathematics and Science in Australian Teacher Education* (see Goos, 2015) that provides an example of collaboration between academics from different communities of practice bodes well for the opportunity for mathematics teacher educators to open up their practice, to share their practices, and learn in, from and for practice. Only then will mathematics teacher educators be able to experience the benefits of a learning community of practice that we so readily advocate for teacher and student learning.

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