Chapter 1
Introduction: Research in Mathematics Education in Australasia 2012–2015

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Abstract This chapter presents an overview of the most recent volume in a series of reviews entitled *Research in Mathematics Education in Australasia*. Each of MERGA's four-yearly reviews proudly highlights and critiques the research in mathematics education in Australasia over the previous 4 years. In this chapter, we provide an overview of the history of the four-yearly review and explain the processes of how this review was brought together. Each chapter is briefly introduced within four key themes: Issues and contexts for mathematics education; learning and teaching; teacher preparation and development; and the future.

Keywords Research in mathematics education in Australasia · RiMEA · MERGA review · Mathematics teaching and learning · STEM

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1 The Research in Mathematics Education in Australasia Series

Research in Mathematics Education in Australasia 2012–2015 is the ninth four-yearly review of research in mathematics education organised by the Mathematics Education Research Group of Australasia (MERGA). The first review was published in 1984 (Briggs 1984) to coincide with Australia's hosting of the fifth International Congress on Mathematical Education (ICME) in Adelaide. Brigg's *Summary of research in mathematics education in Australia* was intended to showcase mathematics education research being done in Australia to the broader international research community. A compilation of themed chapters reviewing and critiquing research in the region every 4 years, to be launched in time for ICME, was continued. The volume series Research in Mathematics Education in Australasia (RiMEA) is now a well-established publication by MERGA. RiMEA (also referred to as the MERGA *Research Review,* or simply the *Review*) is a resource for the MERGA community, for those outside of the region as a focused review of recent Australasian research—and key Australasian researchers—in mathematics education and is frequently the first contact for new Australasian researchers in mathematics education.

Briggs' (1984) initial summary targeted Australia. Since then, the review summary extended from Australia to Australasia, reflecting a change in MERGA's membership. The definition of Australasia has shifted since then and the version used in the previous two RiMEAs was:

> This review, entitled Research in Mathematics Education in Australasia 2008–2011, uses the same definition of Australasian mathematics education research as the previous one did: "The editors have defined 'Australasian research' as research conducted in Australasia, about the Australasian context, or by Australasians. Australasia comprises: Australia, New Zealand, Papua New Guinea, and the Pacific Islands closely allied to Australia and/or New Zealand. (Forgasz et al. 2008, 1–2)" (Perry, Lowrie, Logan, MacDonald, & Greenlees, 2012, p. 2)

However, since 2008 Singaporean researchers have had a larger presence in MERGA, hosting the annual conference in 2012. Therefore, for the current RiMEA, the following description was given to authors to describe the regional focus:

> "Australasia" primarily refers to Australia and New Zealand. However, papers published in MERGA conference proceedings and articles published in MERGA journals by researchers from countries in the South Pacific and south-east Asian regions and with particular relevance to these regions should also be considered for inclusion in the review.

The purpose of RiMEA, as expressed by the previous editors (Perry et al., 2012), is to "highlight significant findings, demonstrate links among research, identify trends and foreshadow possible future research directions" (p. 2). As with previous RiMEA volumes, only Australasian research readily accessible (e.g., books, book chapters, national or international journal articles, papers in refereed conference proceedings, presentations at major national or international conferences and

research higher degree theses) with a publication date in the 2012–2015 window were included. Since it is impossible to report on all publications of Australasian mathematics education research in this period, chapter authors were asked to be selective in the research they reported.

Previous volumes of RiMEA were used as a model for the current volume where relevant in order to preserve a sense of continuity—past, present and future—in the series of RiMEA volumes. The previous publication dates of MERGA's four-yearly reviews and their editorial teams were:

- 2012: Perry, Lowrie, Logan, MacDonald, and Greenlees
- 2008: Forgasz, Barkatsas, Bishop, Clarke, Keast, Seah, and Sullivan
- 2004: Perry, Anthony, and Diezmann
- 2000: Owens and Mousley
- 1996: Atweh, Owens, and Sullivan
- 1992: Atweh and Watson
- 1988: Blane and Leder
- 1984: Briggs

2 Process of Development

The current editorial team was selected by the MERGA Executive from a pool of expressions of interest following a call for editors in 2013. The current editorial team are all MERGA members who (at the time of proposal) were in the School of Education at The University of Queensland. To continue the tradition of building capacity in the field, the team included three experienced editors and three early career researchers, two of which were PhD students.

The proposal by the current team contained 16 chapters: an introduction by the current editorial team; a reflection from the editorial team of RiMEA 2008–2012; 13 chapters across three key themes—Issues and contexts for mathematics education, Learning and teaching, and Teacher preparation and development; and a concluding reflective chapter by a distinguished member of the MERGA community. The selection of chapters was prioritised based on consideration of recurring topics in previous RiMEAs (important for tracking shifts in the field over time) and areas of pressing importance in the region. For example, a chapter on theories in mathematics education research (see Chap. 3, this volume) was proposed as a broader version of the chapter in RiMEA 2004–2007 on sociocultural perspectives. In the previous *Review,* there was not a separate chapter on political perspectives; however, recent shifts in the political climate combined with the new Australian Curriculum have had undeniable influences on the climate of Australasian research, prompting an inclusion of a chapter focused on this area (see Chap. 4, this volume). A single chapter originally proposed on equity was split into two chapters to accommodate strong and distinct proposals on social justice and inclusion (see Chaps. 6 and 7, this volume).

To recruit author teams for each chapter, a general call was made for author teams from the MERGA membership and encouragement of expressions of interest from key researchers. Proposed teams were urged to demonstrate their diversity in terms of experience, geographic location and gender. Some negotiations were required to balance expressions of interest against proposed chapters. Lead chapter authors met with the editorial team at the 2014 and 2015 MERGA conferences to promote discussion between chapters (e.g., potential gaps or overlaps), outline processes and clarify questions.

Chapters went through internal and external review, with each chapter receiving collated (non-blind) "collegial feedback" from three experts in the field plus at least one member of the editorial team. Final chapters were formatted and copyedited by Bronwyn Lacken, with final checks by the editorial team and authors made before being sent to the publisher. The first six volumes in the series were published by MERGA; 2008 was the first publication of RiMEA by an established international publisher (Sense Publishers). Springer was selected by the MERGA Executive to publish this volume following Springer's handling of the *Mathematics Education Research Journal*.

3 Overview of Chapters

Four sections comprise *Research in Mathematics Education in Australasia 2012–2015*:

- Issues and Contexts for Mathematics Education
- Learning and Teaching
- Teacher Preparation and Development
- The Future

3.1 Issues and Contexts for Mathematics Education

The seven chapters in this section highlight the common issues and contexts that affect researchers in mathematics education. A reflection by Perry, MacDonald, Greenlees, Logan, and Lowrie, the editorial team of the previous volume, Research in Mathematics Education in Australasia 2008–2011, provides a starting point for this section. The chapter *Reflections on the MERGA Research Review 2008–2011: Taking stock* reminds readers of the structure and themes of the previous 4-yearly review and identifies a set of major policy initiatives that provide a context for the chapters in the current review. The five policy areas discussed are (1) the early childhood reform agenda, (2) national curricula, (3) national and international assessment, (4) teacher accreditation, and (5) Closing the Gap. While the authors acknowledge that other initiatives could have been included, their selection affords

an astute and dynamic analysis of changes in the political and educational environments of Australia and New Zealand since the last review. Their discussion also highlights the extent to which these changes have influenced mathematics education research in the past 4 years, and anticipates many of the research themes emerging in the chapters that follow.

An empirical reflection on the philosophical underpinnings of Australasian research in the period of the current review was undertaken by Thornton, Kinnear and Walshaw in the next chapter. *A philosophical gaze on Australasian mathematics education research* provokes the reader to consider ontological, epistemological, aesthetic, ethical and logical questions underpinning research that are sometimes overlooked. In their "Philosophical Gaze" of research in 2012–2015, Thornton et al. took a hermeneutic approach to seek insight into authors' philosophical position. To do this, they conducted three investigations. The first analysed keywords of research reported in major international journals read by mathematics education researchers. Then, taking a sample of 26 papers across different topics in Australasian research, they used a framework to analyse and make inferences about these papers in terms of ontological, epistemological, aesthetic, ethical and logical perspectives these papers conveyed (often tacitly). Finally, the authors took a close examination of explicit use of the term "epistemology" in over 130 Australasian mathematics education research articles they collected to analyse how authors expressed this aspect of their philosophical stance and (if relevant) an implied ontological stance. What stood out in these authors' analyses was how issues of aesthetics (values), ethics and logic are often left unspoken and hence assumed. The chapter closes by reminding us to regard philosophical tensions as creative forces for our work rather than divisions.

The chapter on *Researching curriculum, policy and leadership in mathematics education* by Way, Bobis, Lamb and Higgins provides a stimulating analysis of how researchers have investigated the interrelationships within and between these topics. Recent curriculum development initiatives, particularly in Australia and New Zealand, have motivated much of this research. The chapter is framed by Remillard and Heck's (2014) model of curriculum policy, design, and enactment, which distinguishes between factors influencing the official curriculum and the operational curriculum. This model allows the chapter authors to organise their discussion of the different curriculum elements as well as to situate within this framework research on issues such as curriculum policy, assessment and testing policy, textbooks, curriculum leadership, curriculum differentiation and equity, and numeracy across the curriculum. The research reviewed in this chapter revealed many mismatches and tensions between the official and operational curriculum, which often resulted from the political motivations behind curriculum reform and national testing. Greater attention to educational leadership was urged by many researchers as a means of assisting teachers to enact the curriculum in ways that support diverse learners in different contexts. Largely as a result of recent curriculum reforms, research is now focusing on the operationalisation of the official curriculum and the demands this places on teachers. Because of the centrality of the teacher in Remillard and Heck's model, the chapter authors draw attention to the

potential role of school and classroom-based research in influencing national and system-level curriculum decisions.

Mathematics education and the affective domain is the fourth time that a chapter has dealt with affective issues in mathematics education in RiMEA. This chapter is concerned with beliefs, attitudes, identity, anxiety, and engagement and motivation. Although gender is also discussed in Chaps. 6 and 7 of this review, current concerns about the under representation of females in advanced and intermediate level mathematics subjects in schools and Science, Technology, Engineering, and Mathematics (STEM) fields led Attard, Ingram, Forgasz, Leder and Grootenboer to include a section that reviewed research concerned with the relationship between gender and affective issues. The chapter reports on increased attention to research on student engagement and attitudes towards mathematics in this review period. However, several areas were identified as having little research including affective issues about mathematics in primary and early childhood education, links between student engagement and mathematics achievement, and affective issues related to pedagogy. The influence of technology on affect was also identified as needing further research, particularly given that technology in now an integral part of teaching and learning mathematics.

In the next chapter, Vale, Atweh, Averill and Skourdoumbis critically examine theoretical stances and types of research conducted in equity, social justice and ethics in mathematics education. Socio-economic contexts, rural and remote status, and ethnic and language context of school communities, as well as gender, are rich and relevant foci of much of Australasian mathematics education research. The chapter *Equity, social justice and ethics in mathematics education* highlights that while identification and description of conditions in which mathematics education happens is indeed important if issues of social justice are to be advanced, a more proactive research agenda is also needed. Vale et al. bring attention to questions of how researchers can contribute to advancing inclusion agendas in mathematics education and discuss research designs that might be appropriate in doing so. The reviewed literature collectively illustrates that addressing this issue requires coordination of all levels at which mathematical learning is organised, including need for (a) systems to fund and support school organisational structures, resources and cultures; (b) the development of purposeful partnerships between schools and their communities; (c) including awareness of equity, social justice and ethics issues throughout the education and professional learning of teachers of mathematics and (d) creating learning environments, with the help of teachers, that would focus on mathematical learning and knowledge building.

In Chap. 7, *Inclusive practices in mathematics education*, Faragher, Hill and Clarke organised their review around the main themes of access, learning and teaching, with reference to gender, learning difficulties, giftedness, location, and cultural and linguistic diversity. In relation to access, the authors overview Australasian research into the impact upon learners of school leadership, allocation of learners to classes, socio-economic status, and school location. The second part of the chapter looks at mathematics learning experiences from the point of view of learners. The chapter authors argue that an astute teacher capitalises on the

knowledge that children bring and is mindful of listening and interpreting how children view mathematical situations. The affective domain, the use of technology and issues of assessment are addressed through consideration of diverse approaches to learning. The third section of the chapter specifically discusses inclusive teaching of mathematics. Direct instruction is critiqued, with research into differentiation through good tasks presented. The authors complete the chapter with recommendations for continued and further research, particularly around longitudinal studies to provide evidence of long-term effects of programs for inclusive practices in mathematics. The authors raise the question of out-of-field teachers, modification of assessment, the role of teacher aides and parents in the mathematics education of all learners. The chapter closes with a powerful statement about the absolute necessity of continually striving for access to quality mathematics learning experiences for all students.

The final chapter in this section, *Distribution, recognition and representation: Mathematics education and Indigenous students*, reviews the teaching and learning of mathematics for Indigenous students in the Australasia region over the last 4 years. Meaney, Edmonds-Wathen, McMurchy-Pilkington and Trinick use Nancy Fraser's (2005) model for social justice—distribution, recognition and representation—to structure the chapter through economic, cultural and political perspectives, respectively. Pedagogies to enhance learning and the language of teaching and learning mathematics are analysed using this social justice framework, including in relation to the mathematical topics of number, patterns and early algebra, probability, space and geometry. The chapter promotes building capacity in the field by reviewing research on professional development for Indigenous and non-Indigenous teachers about teaching mathematics. The authors further apply Fraser's social justice elements to evaluate research in this area and recommend that professional learning improves in being more ongoing and more collaborative. Finally, the authors discuss the importance of parent-community involvement in professional development projects to engage the representation element of social justice. A comprehensive body of Australasian literature related to the topic has been sourced and the authors have taken a deliberate and thoughtful critical stance to the often difficult and sensitive issues raised.

3.2 Learning and Teaching

The second major section of the *MERGA Research Review* includes six chapters which focus on specific aspects of teaching and learning. In previous *Reviews*, this section has focused on various ages and content areas. Indeed, the Section begins by bookmarking two age groups: early childhood and tertiary mathematics. A chapter on innovative pedagogies is followed by two topics—assessment and technology—that were in the "Contexts" section of the last Review, moved here to re-emphasise their strong links to learning and teaching. The section closes with a review of literature on modelling and applications in mathematics education.

In *Mathematics education in the early years*, MacDonald, Goff, Dockett and Perry structure the chapter around key themes of curriculum, assessment, content and contexts. Evident from this chapter is the publication of two significant edited books and the extensive research undertaken in Australasia through large commissioned projects. In relation to curriculum, the chapter emphasises political contexts of early childhood education through reference to Australia's and New Zealand's curriculum frameworks aimed at young students; it signals the slippage and overlaps between curriculum documents produced by different writers, overviewing Australasian authors who have researched in this space. Research into early years assessment highlights rich, conceptual mathematical understanding that young children bring to school, and accentuates the importance of celebrating what children can do, rather than only reporting on what they cannot. In relation to early learners' content knowledge, the review shows the research activity around algebra, measurement, number, and data, but a commensurate lack of focus on geometry. The activity around the use of inquiry for solving ill-structured problems with early learners emphasises the depth of reasoning that young children can demonstrate in such activities. Research into contexts in the early years is associated with environments (technologies, rural and remote locations, and exciting learning environments), the human context (parents), and the socio-cultural context (culturally sensitive practices). Whilst this chapter summarises intense activity in early years education research, its authors identify gaps including transitions from home to school, assessments prior to school, teacher professional learning, families, and young children's understanding of geometry and problem solving.

At the other end of the spectrum, the authors of *Tertiary level mathematics learning and teaching* document the continuing interest in and growing sophistication of research in this field. Conferences such as MERGA, Delta, ICME, OZCOTS and the ICMI Study series provide important fora for researchers at the tertiary level to share their work; an increase in journal publications and books also suggests a stronger theoretical foundation is being built. Coupland, Dunn, Galligan, Oates and Trenholm review research on the teaching of specific mathematics and statistics topics, which continues to capture the interest of many tertiary academics, while also noting where others are pursuing broader questions of curriculum and policy, for example, concerning how to embed quantitative skills in Science, Technology, Engineering and Mathematics (STEM) courses and degree programs. Likewise, tertiary mathematics research topics in education that appeared in previous MERGA *Research Reviews*—for example, learning support, service teaching, technology, and statistics education—are of continuing interest. New in this *Review* is research on the development of tertiary pedagogies and lecturer development, and a more strongly theorised investigation of transitions between school and university. The topic of transition has also been expanded to encompass transition to work, vocational education, and adult numeracy—all key policy spheres both internationally and nationally. Overall, the field is maturing through increasing involvement of cross-disciplinary teams of researchers who can share knowledge and expertise between mathematics academics and mathematics education

academics, between university mathematics teachers and school teachers, and between the university, vocational education, government, and employment sectors.

In *Innovative and powerful pedagogical practices in mathematics education*, chapter authors B Hunter, J Hunter, Jorgensen and Heng overview advances in research on the powerful and innovative pedagogical practices aimed to enable all students to learn meaningful mathematics. The chapter is structured to discuss (1) innovative and powerful mathematical learning environments; (2) innovative practices which promote mathematics teaching and learning as inquiry; and (3) mathematical tasks that promote deep learning. Drawing on recent studies, the chapter authors highlight how teachers both proactively act to establish classroom cultures which open up space for student voice, and position students' mathematical reasoning as central to the classroom mathematical activity. Impact of discursive practices that include reasoned argumentation, centrality of student engagement and persistence in all mathematical endeavours, and the use of thoughtfully selected, challenging mathematical tasks are themes addressed in most studies. Research findings are contrasted with policy directions prevalent in Australia and New Zealand and the consequences of this contentious space highlight concerns about basing such policies on behaviourist theories of learning. The authors forecast the implications this is bound to have for advancing the agenda of mathematical learning for all students.

The next chapter by Serow, Callingham, and Tout highlights Australasian research related to assessment during the review period, at the international, national and classroom-based levels. In *Assessment of mathematics learning: What are we doing?*, the authors raise questions regarding how information about students, gained through assessment, is reported and used. Results from international assessments are considered to inform possible directions for future research and to provide a current report card on Australian students and young adults. An in-depth exploration of research exploring the National Assessment Program - Literacy and Numeracy (NAPLAN), the most prominent external assessment in Australia, emphasises a number of issues concerning the impact NAPLAN has on schools and students. Research into innovative, classroom-based assessment practices ranges from research into high-stakes assessment systems in Singapore, to authentic assessment which provides rich contextualised data, and online tools. This chapter argues for a need for more research specifically addressing assessment in mathematics and suggests a possible research agenda for continued research.

The next chapter highlights how the incorporation of digital technologies in mathematics classrooms can transform learning and teaching in these contexts. Specifically, these transformations are outlined throughout *Transformations of teaching and learning through digital technologies* as cognitive, pedagogical and professional changes. The research reviewed in this chapter by Geiger, Calder, Tan, Loong, Miller and Larkin is based in a range of theoretical frameworks such as transactional distance theory; technological pedagogical content knowledge (TPACK); affordances; Roger's (1995) innovation framework; and the subsequent map of pedagogical opportunities. Drawing specifically on the map of pedagogical opportunities, technological innovations are considered at the task, classroom and

subject levels. Australasian literature exploring technological innovations in mathematics classrooms has been further organised in relation to learners and learning and teachers and teaching. Based on the critique of literature that the authors present, future directions for research into improving the learning and teaching of mathematics education through the use of technology conclude the chapter.

The final chapter in this section, *Research into mathematical applications and modelling*, establishes the leadership in this field that Australasian region researchers have provided for over two decades. Stillman, Brown, Galbraith and Ng first delineate the different perspectives on teaching through mathematical modelling and applications. Against this background, they review exemplary literature focusing on the teaching of applications, and in particular whether and how genuine problem contexts are or can be used as applications contexts. The chapter authors make a link to numeracy research as an area within which mathematics is intended to be applied meaningfully within different content domains. The rest of the chapter leads with the modelling research, commenting on applications where appropriate. The sections review in turn theoretical developments in the field, how studies in the field addressed general goals of education (such as development of students' communication and collaboration capacity), and methodological tools used across the reviewed studies. The chapter concludes by discussing the current state of research in modelling and applications and progress since the previous *Review*, with an eye to possible future developments.

3.3 Teacher Preparation and Development

The third major section of the MERGA Research Review, *Teacher Preparation and Development*, like the corresponding section in the previous review, comprises two chapters, one dealing with pre-service teacher education and the other with practising teachers. As pointed out by the editors of the previous review, these are areas of ongoing interest to Australasian researchers in both mathematics education and teacher education.

Initial teacher education (ITE) has received considerable attention from policy makers during this review period because of the widespread belief that improving teacher quality will lead to improved student outcomes. Moreover, ITE needs to prepare beginning teachers who are responsive to changing curriculum and assessment frameworks, and the increased use of technology. In the chapter *Challenges, reforms, and learning in initial teacher education programs*, Anthony, Cooke and Muir review research on teacher preparation in three areas: accountability, effectiveness, and policies; for the knowledge society; and for diversity and equity. The limited number of studies that addressed diversity and equity was identified as an area of concern. During the review period a move from research that explores existing practices to the more proactive approach of designing and trialing innovative reforms, increased attention on social activity as a part of learning, and a greater

focus on research on the work of teacher educators were noted. Anthony and her colleagues identified a need to look at ways to continue to build a sound research base on ITE, including investigating ways to scale up research projects, and to combat the potential of top-down policy mandates in the current political climate.

The importance of ongoing professional learning (PL) for practising teachers has also been the focus of increased attention over this review period as policy makers search for ways to improve student outcomes. The research reviewed in *The education and development of practising teachers* extends beyond professional knowledge and includes research on theoretical approaches to understanding professional learning for teachers and professional learning programs. Beswick, Anderson and Hurst note increased attention to theoretical aspects of PL with research contributing to understanding the nature of both teacher learning and teacher capabilities. The research on PL programs was concerned with the content foci of the PL, characteristics of effective PL, approaches to PL, and evaluation of PL. Areas that were identified as in need of further research included the potential of online delivery, cross disciplinary collaborations involving mathematicians and mathematics educators, and investigating ways to improve the effectiveness of PL. Like research on ITE, there appears to have been little attention given in the research reviewed on PL to issues of scale and sustainability. Beswick and her colleagues call for Australasian researchers to investigate ways to scale up successful PL initiatives in order to influence mathematics teaching within the Australasian context and to situate their research within broader contexts in order to have greater impact internationally.

3.4 The Future

The final section and final chapter of *Research in Mathematics Education in Australasia 2012–2015* follows the tradition of previous three *Reviews* by asking one of MERGA's most eminent scholars to write the culminating chapter. The aim of this chapter is for the author to promote a vision for the future of mathematics education in Australasia and respond to contributions of the chapters in the *Review* for elaborating this vision. The final chapter of this volume of RiMEA is written by Professor Lyn English, 2012 winner of the MERGA Career Research Medal and founding editor of the international journal, *Mathematical Thinking and Learning*. In her chapter, *Advancing mathematics education research within a STEM environment*, English focuses on the current Science, Technology, Engineering and Mathematics (STEM) environment and sets out a vision for the future of the field in negotiating our research within STEM. The chapter begins by considering possibilities for advancing mathematics education research within the current STEM environment. Noting that the current RiMEA seems to focus less on mathematical content areas than previous Reviews, English uses the chapter reviews and other research to emphasise and provide "suggestions for developing content and

processes through idea-generating problems, for promoting in-depth content understanding, and for fostering general skills and processes" with particular emphasis on modelling and problem solving as a vehicle.

4 Concluding Comments

Putting together the *Research in Mathematics Education in Australasia 2012–2015* has been a tremendous pleasure for the editorial team. The Review's 65 chapter authors have done an impressive job in casting their nets widely to generate in-depth, cogent, critical and insightful discussions of the content *and relevance* of Australasian research in mathematics education over the past 4 years. Their contributions will inform not only researchers in the field—new and experienced—but also provide support for future research agendas.

As this volume goes to press, there will already be discussions in the MERGA Executive to enlist the next team of RiMEA editors, who will construct the list of chapters and recruit the author teams, who will again cast their net across 2016–2019 for research now or shortly to be conducted, written and published. Although there are elements of tradition in each volume of RiMEA, its content is adapted according to the demands of the times. This is the call of *Research in Mathematics Education in Australasia*.

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