Carmel Mesiti · Wee Tiong Seah ·
Berinderjeet Kaur · Cath Pearn ·
Anthony Jones · Scott Cameron ·
Emma Every · Kate Copping
Editors

Research in Mathematics Education in Australasia 2020–2023

Mathematics Education Research Group of Australasia, Inc.

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Anthony Jones is Research Fellow at The University of Melbourne. His research interests include mathematics pedagogies which link mathematics to the everyday lives and experiences of students, educational applications of information technologies as well as the (mathematics) learning of hospitalised and disabled students. He was the co-editor of the Springer journal *Education and Information Technologies* for more than a decade.

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Kate Copping is Graduate Researcher and Lecturer in Mathematics Education at The University of Melbourne. Kate's research explores the nature of primary mathematics leadership; how it is conceptualised, experienced and enacted within schools. This qualitative research positions primary mathematics leaders as middle leaders. The research aims to develop a stronger understanding of the role of primary mathematics leaders and inform school policy and decision-making. Kate also researches the teaching and learning of mathematics in the primary education sector to support the development of educators in building student engagement and understanding in mathematics.

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Many thanks to all the contributors for the thorough and thoughtful preparation of RiMEA11 (2020–2023) review chapters.

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Chapter 1
Research in Mathematics Education in Australasia from 2020 to 2023

Carmel Mesiti, Wee Tiong Seah, Berinderjeet Kaur, Cath Pearn, Anthony Jones, Scott Cameron, Emma Every, and Kate Copping

Abstract This chapter offers the reader an introduction to this volume; the eleventh in the series Research in Mathematics Education in Australasia (RiMEA11). This research series, conceived and commissioned by MERGA, offers critical analyses, organised by theme, of the preceding four-year period of mathematics education research in Australasia. These review chapters play a crucial role in identifying noteworthy and persistent trends, offering potential avenues for further research. Presented within this introductory chapter is an historical perspective of the review series, an outline of the development of RiMEA11 (2020–2023), and the scope and structure of this quadrennial review.

Keywords RiMEA · Research in mathematics education research · MERGA review · Mathematics education · Review series

1 Research in Mathematics Education in Australasia Review Series

The four-yearly review series, Research in Mathematics Education in Australasia (RiMEA), is produced by the Mathematics Education Research Group of Australasia (MERGA). Publication of this volume, RiMEA11 (2020–2023), coincides with the quadrennial gathering of the International Congress on Mathematical Education (ICME), the largest international conference regarding mathematics education worldwide. In 1984, when ICME-5 was hosted in Adelaide, a review was compiled "to commemorate the occasion of ICME-5 as a gesture of intellectual sharing and international goodwill" (Briggs, 1984, p. 2). Entitled the *Summary of research in mathematics education in Australia* five sections reviewed Australian mathematics

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educational research published in the period from 1977 to 1983 identifying trends and foci; for example, an area of interest that persists today, 'girls' mathematics learning' was identified as a focus at this time. Subsequently, it was decided that a compilation and critical review of the previous four years of research publications should coincide with each subsequent ICME conference.

We find ourselves exactly 40 years on from the publication of the first review. Australia plays host to ICME once again, and the RiMEA series has since developed into a celebration of mathematics education research conducted not only in Australia, but encompassing the Australasian region as well, in line with the membership and activities of MERGA. In addition to this introductory chapter, the RiMEA11 (2020–2023) volume features 11 chapters based on research themes of significance for Australasian mathematics education research for the period from 2020 to 2023 and is bookended by a pair of reflective chapters.

The RiMEA series contributes to the work of MERGA; an academic association which "exists to provide a range of forums for raising important issues in mathematics education and sharing research findings that speak to how these issues might be effectively addressed" (MERGA, 2018). By mapping the major research themes and directions relating to mathematics education in Australasia over the recent four years, RiMEA review chapters serve to capture research efforts in addressing prevailing issues and help point the way forward.

One of the significant challenges that comes with the compilation of research review volumes, such as RiMEA11 (2020–2023), is the identification of inclusion criteria. Specifically, what is meant by 'research in mathematics education *in Australasia*'? To this end, in keeping with what has become an evolving tradition since RiMEA9 (2012–2015) (Makar et al., 2016), the following definition was included in our Call for Chapters:

> "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. (RiMEA11 Call for Chapters, MERGA newsletter to members)

2 Scope of RiMEA11 (2020–2023)

The four-year period covered by RiMEA11 (2020–2023) represents unprecedented times in human civilisation. The COVID-19 pandemic affected the entire globe, including the operation of Australian schools (OECD, 2020), from early 2020 and for much of 2021. The launch of ChatGPT towards the end of 2022 has also redefined artificial intelligence; generative AI technology is evolving quickly and ChatGPT was used by one million people in its first five days (Fried, 2023). The future impact of ChatGPT and other AI tools on education, given the speed of their evolutionary cycles, is unclear. However, whilst some are looking forward to enhancement of human productivity, others indicate some hesitancy (WEF, 2022).

These global events have affected school mathematics education in significant ways:

(i) the post-pandemic school classroom, involving synchronous and asynchronous online (mathematics) learning, appears here to stay (Engelbrecht et al., 2023);
(ii) climate change is impacting on access to and quality of school education of more than 40 million children each year (UK Foreign, Commonwealth and Development Office, 2022); and,
(iii) the use of generative AI to quickly produce a range of text types has the potential to revolutionise teaching and learning (Sabzalieva & Valentini, 2023).

Given the workload associated with development of teaching materials (Hunter et al., 2022), and the impact of lesson sequencing and resource selection on student achievement of learning outcomes (e.g., Cohen et al., 2003; Kim, 2018), AI tools may usefully support teachers when planning for effective instruction—a view also shared by the Australian Government (Department of Education, 2023).

As a consequence, the editorial team reasoned that Australasian mathematics education research in the period from 2020 to 2023 would have focussed on topics which reflected the times, not least because New Zealand and the Australian state of Victoria had some of the world's toughest (Basu, 2020) and longest (Boaz, 2021) pandemic lockdown measures respectively in 2020 and 2021. New research priorities and trends would become visible in the annual MERGA Conferences (and in its proceedings), as some of us reportedly observed in 2023. The full impact of these may be evident when the themes for RiMEA12 (2024–2027) are identified by the next editorial team. Chapters in RiMEA11 (2020–2023) nevertheless document many of these changes. For example, in Chap. 7 (this volume), Hall and colleagues document research studies pertaining to the impact of COVID-19 lockdowns on low-income families' access to equitable mathematics learning.

The very act of researching has also been affected by these global changes and challenges. Many researchers (including graduate research students) have experienced disruptions to their research work in this period (Gao et al., 2021). School closures in New Zealand, and in most states across Australia during the COVID-19 pandemic, were especially sustained across long periods of time making school-based data collection impossible. Many Departments of Education continued to restrict researcher access to school sites for months and continued after schools reopened (DET email correspondence, December 2021). Research activities impacted by the global pandemic included data collection, data analyses, as well as writing projects. The emerging trends of working-from-home and of working-from-anywhere also affected the nature of research collaborations.

2.1 Identifying Major Research Themes

The editorial team began the RiMEA11 (2020–2023) project with the intention of identifying major research themes with the use of emerging text-mining technologies.

After all, there has been an explosion in more recent years both in terms of quantity and variety of (mathematics) educational research publications, and an increase in the number of journal titles publishing them. Part of this increase may have resulted from the COVID-19 lockdown measures across many countries in 2020 and 2021; many conferences were paused, thus pushing researchers to journals to disseminate their latest findings. Text-mining technologies were utilised as a means for identifying Australasian research trends more efficiently; it supported the efficient examination of many more publication titles, abstracts and keywords all at the same time.

A total of four databases were searched: ERIC, Scopus, Web of Science, and Dimensions. The criteria applied to the publications included the following: related to mathematics teaching/learning; were identified as Australasian in the manner described in Sect. 1 above; were dated between 2020 and 2023 (inclusive); and, were readily accessible. As a result, a total of 1216 publications were identified. These publications were exported to the Covidence program, a systematic review tool, that facilitated screening of publications by title, abstract and full text to remove non-relevant publications. The resulting bibliometric text file was then fed into the VOSviewer software to generate a list of keywords corresponding to their respective frequencies of occurrences (see Fig. 1).

Keywords were organised into major themes. Labels were collapsed into others with larger grain size based on the number of occurrences. Overly broad and contextual keywords, such as 'Australia', 'mathematics education', 'primary education', and 'secondary education' were excluded. Six key themes and sub-themes that were most frequently represented were identified:

1. **Mathematical thinking and processes**
   Including sub-themes: reasoning, problem solving, modelling, generalisation, and logic.
2. **Pedagogy**
   Including sub-themes: flipped, blended and online instruction, and Covid-related instruction.
3. **Affect and motivation**
   Including sub-themes: beliefs, self-efficacy, attitude, identity, values and anxiety.
4. **Assessment**
   Including sub-themes: achievement, performance, fluency, and international comparative research.
5. **Professional learning**
   Including sub-themes: in-service professional learning, pre-service professional learning, and professional learning related to school context.
6. **Comprehensive mathematics education**
   Including sub-themes: numeracy, literacy, STEM, engagement, and inclusive education (in relation to equity, language, intervention, developmental disorder).

A call for authors and writing teams was launched in the MERGA Newsletter. The call invited proposals of reviews which would address one of the six themes, or

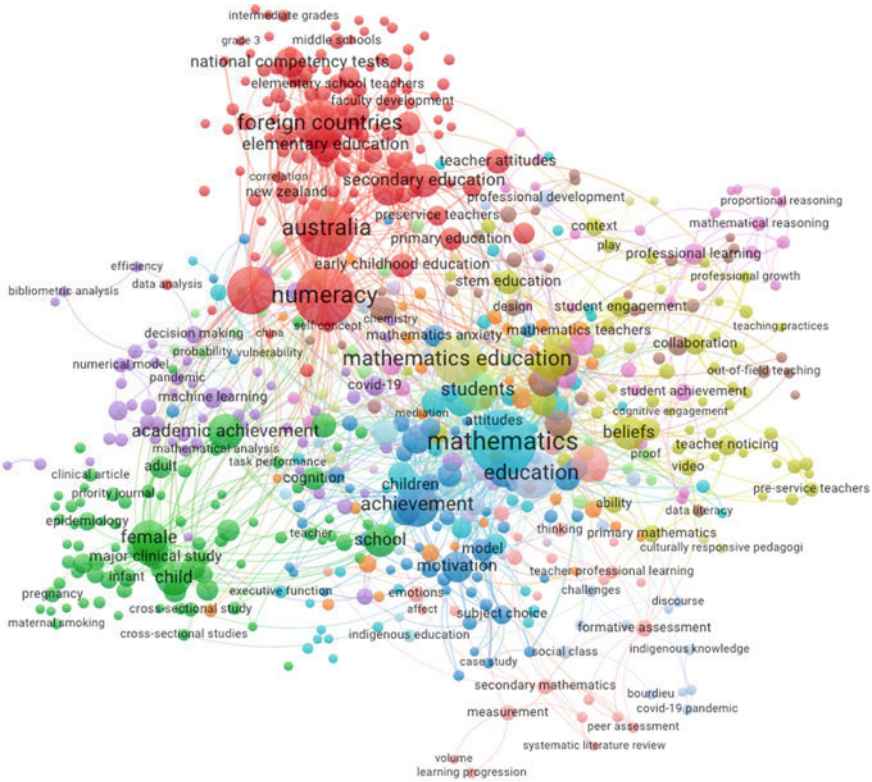

Fig. 1 Static visualisation of publication keywords (from VOSviewer software)

any of the sub-themes. This volume features 11 research review chapters. Table 1 organises the 11 chapters by the six key themes.

3 Structure of RiMEA11 (2020–2023)

Following this introductory chapter, Chap. 2, written by the editorial team of the previous RiMEA, is entitled "Yesterday, Today and Tomorrow in Mathematics Education Research". Way and her colleagues positioned themselves in the temporal viewpoint of 'today' to reflect on what was written 'yesterday' in RiMEA10 (2016–2019) (Way et al., 2020) and to stimulate thinking about 'tomorrow' in the context of what is being featured within RiMEA11 (2020–2023). At the same time, the authors acknowledge the ever-changing and fluid landscape—from the local to global—in which we design, conduct and interpret mathematics education research. This landscape reflects a continuous evolution of time, a reminder that associating knowledge, skills, values, and dispositions with discrete temporal viewpoints is an illusionary

Table 1 Chapter number and title organised by key themes

Key themes	Chapter number and title	
Mathematical thinking and processes	Chapter 3	Mathematical Modelling of Real-World Phenomena
	Chapter 5	Research on Mathematical Thinking
	Chapter 8	Advancing Mathematics Learning in the Early Years
Pedagogy	Chapter 6	Productive Pedagogical Practices: Impact on Mathematics Teaching and Learning
	Chapter 8	Advancing Mathematics Learning in the Early Years
	Chapter 9	The Teaching and Learning of Tertiary Mathematics
Affect and motivation	Chapter 8	Advancing Mathematics Learning in the Early Years
	Chapter 10	Research in the Affective Domain in Mathematics Education
Assessment	Chapter 8	Advancing Mathematics Learning in the Early Years
	Chapter 9	The Teaching and Learning of Tertiary Mathematics
	Chapter 11	Assessment of Mathematics in School and Early Childhood Settings: National, International and Classroom Perspectives
Professional learning	Chapter 12	Research on Supporting the Endeavour of Mathematics Teaching: Professional Learning and Beyond
Comprehensive mathematics education	Chapter 4	Research in Numeracy Education
	Chapter 7	Factors Impacting on Equity in Mathematics Education
	Chapter 8	Advancing Mathematics Learning in the Early Years
	Chapter 13	Highlighting Mathematics in STEM School Education

perspective. The authors identify and discuss three key themes which characterise the contexts of learning and teaching mathematics: the COVID-19 pandemic, educational ecology, and the political situation. The important message is how our research contributions reflect our agency in the changing world, and in the context of the RiMEA volumes, how MERGA as a community can contribute collectively.

Chapter 3, entitled "Mathematical Modelling of Real-world Phenomena", authored by Brown and colleagues, illuminates the use of mathematics to solve or deepen understanding of real-world problems. As mathematical modelling is

becoming increasingly evident in curriculum documents worldwide and particularly Australasia, research in this area is important. This chapter critically reviews mathematics education research, from the early years through to tertiary education. Contributions to the field are organised in six broad areas: (i) developments in curricula on the teaching of mathematical modelling intended to promote mathematical thinking and ways of working, (ii) practices of mathematics and practices of mathematical modelling, (iii) teacher preparation and professional learning, (iv) assessment of mathematical modelling, (v) interdisciplinarity and connections with data modelling, and (vi) research as design: honouring the mathematics in mathematical modelling. The review shows that, though research on mathematical modelling is present in Australasia, the (in)frequency of chapters on mathematical modelling in past RiMEA volumes suggests a lack of visibility of this important aspect of mathematical work and ways of increasing this visibility need to be pursued.

Chapter 4 focuses on numeracy education and begins with a discussion of numeracy policy and its implications for curriculum development, teacher preparation, and adult education. The following sections focus on the two key ideas that numeracy is both a life-wide and a lifelong resource. Numeracy as a life-wide resource includes both numeracy in the formal curriculum as well as beyond formal education. The life-wide numeracy context of the formal curriculum includes a cross-curricular competency or as mathematical literacy in financial, statistical and spatial contexts. The home, community and workplace are rich numeracy environments that exist beyond formal education. Lifelong numeracy considers learning, teaching, and assessment from early childhood into the school years, teacher education, tertiary, vocational and adult education. Goos and colleagues found evidence of critical perspectives on numeracy in studies of adult learners and numeracy learning in teacher education contexts as well as outside formal education. A lifelong view of numeracy development was represented from early childhood to adulthood. However, they found no studies of numeracy in senior secondary school contexts, even though vocational numeracy courses are offered at this level of schooling in most Australian jurisdictions. This chapter concludes with suggestions for future research into critical numeracy, teacher preparation, adult numeracy provision, numeracy in senior secondary school courses, and the impact of cross-curricular approaches and resources on numeracy development. One suggestion includes larger research studies to compare approaches across universities at the state and national levels. The second research opportunity might be to respond to the question of who should be responsible for providing these courses.

Chapter 5 is an inaugural chapter explicitly focusing on mathematical thinking. The chapter's focus is on research related to mathematical processes, the content, and the interplay between these. The review concentrated on key patterns in mathematical thinking research, recognition of what appears missing in the research, and highlighted areas of note. While Kontorovich and colleagues note that their search of Australasian literature for studies on mathematical thinking yielded fewer studies than anticipated, they observed that the research also tended to focus on only some kinds of mathematical thinking, for example, 'spatial reasoning' and 'multiplicative thinking'. In contrast, the areas of 'problem posing', 'proving', and emergent topics

such as ‘computational thinking’, were found to be less prominent. The authors identify the need to create a more unified and consistent foundation for future research on mathematical thinking. They intend for the chapter to serve as a guide for discussions about the future paths of research in this fundamental aspect of mathematics education research.

Chapter 6 focuses on pedagogy and the impact on mathematics teaching and learning. Using Lingard and colleagues’ (2001) framework of productive pedagogies, Miller and colleagues review Australasian research noting the clear foci of the research community on pedagogical practices and implications that serve to support mathematics teaching and learning, with similarity in the themes identified in this chapter and in the previous review. While this area is widely researched (particularly in early childhood and primary settings), and provides rich qualitative insights, the authors note that much of this research is not representative or generalisable due to the prevalence of studies with small samples. Consequently, the authors call for continued research with large and diverse samples, that serve to refine and expand conceptual frameworks proposed within smaller studies. Areas of further research include the impact and legacy of COVID-19 on pedagogies and student learning, shifts in pedagogical practice in response to curriculum reforms, approaches for building stronger connections between school and home, and approaches for research translation for policy makers and school leaders.

Chapter 7 examine factors impacting on equity in mathematics education. Hall and colleagues review and critique research regarding gender, culture and ethnicity, socio-economic status, and rural and remote location. The review explores these factors and their impacts on mathematics achievement, participation, attitudes, and lived experiences. The chapter authors noted that there was a scarcity of intersectional studies and recommended that researchers consider intersectional perspectives to better understand different experiences and outcomes across a range of equity factors. Additionally, longitudinal studies are recommended to increase depth and breadth of perspective, although the challenges of securing funding and time and resource allocation needed for such research was also recognised. Recommendations for future directions were also suggested for each of the equity areas in this chapter. Future research in gender would benefit from consistency in terminology and a more inclusive, non-binary approach, aided by theoretical frameworks which reflect progressive conceptions of gender. The chapter acknowledges the positive development of an increased presence of indigenous researchers involved in culture and ethnicity studies and the increased attention to indigenous knowledge in mathematics education practices and research. The use of mixed methods and quantitative methods is an area of opportunity to explore the impact of culturally-responsive and culturally-sustaining teaching on students. Further research is needed in the area of low SES schools and SES-based inequities impacting participation in senior mathematics studies. Research on the provision of resources and professional learning for rural and remote schools is evident. However, there is a need for research on designing professional learning for rural and remote teachers which reflects the context, or the existing socio-cultural knowledge of rural and remote students.

Chapter 8 provides an overview and critique of Australasian early childhood mathematics education research for children from birth to 3 years, preschool (3–5 years) and early schooling (5–8 years) under five themes: (i) Practices and pedagogies; (ii) Assessing mathematical competence and dispositions; (iii) Learning mathematical concepts; (iv) Teacher beliefs and attitudes; and, (v) Inclusion, equity, social justice, and student engagement. The review, by Russo and colleagues, provides information about young children's mathematical understanding, reasoning and dispositions, as well as effective practices and learning environments to best promote mathematical understanding in equitable and inclusive ways. The research demonstrates how engaging in play and stimulating environments can encourage and elicit young children's mathematical thinking. Insights are provided about useful assessment practices for understanding children's thinking and reasoning, designing instruction and curricula, or measuring and reporting student learning and growth in understanding. Other studies explored the developmental pathways for particular concepts, or frameworks for assessment. However, there has been little research that focuses on the extent to which teachers and early childhood educators analyse, document, and use the data collected to inform planning and teaching, or directions for professional learning.

In Chap. 9, Oates and colleagues note the contained strength of research on tertiary mathematics and statistics education research. A notable change in studies reported in this volume is an increased focus on the delivery and assessment of tertiary mathematics and necessitated by the COVID-19 pandemic. They examine studies with statistics as a focus in a separate section, and review the extensive body of research examining innovations in this field. They review studies that explored student perspectives in response to the pandemic, support of students in other disciplines, and school to university to work transitions. Further areas of growth anticipated to expand in the future related to the potential impact of technologies, including generative artificial intelligence, on the teaching, learning and assessment of tertiary mathematics and statistics.

In Chap. 10, Reid O'Connor and colleagues present research on the affective domain, noting the continued research interest on a range of constructs including beliefs, identity, attitude, values, dispositions and emotions. As in previous volumes, the chapter notes the continued use of affective constructs without adequate definition. The authors argue for the importance of the provision of such definitions, even if not the central focus of the research, due to the theoretical and practical overlap between affective constructs. Research on affect primarily focusses on students, teachers, and academics at the primary, secondary and tertiary levels, with an absence of research in early childhood and informal educational contexts. The current review period has seen an increased focus on the affective needs of students from diverse backgrounds, mathematical wellbeing, and teacher identity. Areas of future research include exploring the links between affect and learning outcomes, and the impact of teacher identity and beliefs on classroom practice and students.

In Chap. 11, Stephens and colleagues focus on assessment on mathematics and note that in the last RiMEA (Way et al., 2020) a chapter with this focus was absent. Therefore, they had considerable ground to survey as there are several

rapidly developing areas of assessment within the Australasian research community. They first draw attention to recent research on national and international assessments in Australia and New Zealand addressing declining performance, digitalisation of assessment and transformation of what and how we assess in mathematics. Next, a consequence of policy development in Australasia and internationally, they draw renewed attention to the importance of early childhood education and the need for relevant research-based assessments of young children's mathematical thinking that can intersect and align with the early years of school. Lastly several projects specifically directed at evidence-based learning progressions, diagnostic tools, scoring rubrics and frameworks that can provide guidance for practitioners, as well as researchers are reviewed. Notably, the assessment of the Big Ideas project by researchers in Singapore is both ambitious and likely to operate as a form of formative assessment for monitoring national progress. In the concluding section of the chapter the authors note several emerging areas of assessment research viz-a-viz the assessment of numeracy in vocational settings and the use of assessment tools to examine students' values towards and wellbeing regarding learning mathematics.

Chapter 12 concentrates on research regarding pre-service and practising teachers' professional learning (PL), development, or growth in mathematics education to support good teaching in mathematics classrooms. In this edition of RiMEA, both initial teacher education and in-service teacher education has been included in the same chapter, rather than separately as in previous editions. The combination of the two chapters limited the scope of the review, and as a result, conference proceedings were not reviewed in this chapter. Višňovská and colleagues review the purposes and drivers of PL research and how it is conceptualised. The diversity of theory and methodologies present in PL research is discussed and the resulting changes in teacher practice and student outcomes are explored. The chapter notes the importance of positioning teachers as professionals and agents of change is essential to PL research, however teacher voice is often neglected in the application of this research on policy. The authors call for clarity in language used in PL research, leading to a deeper conceptualisation of teacher learning. Although there is much research that is school-based which can impact teacher knowledge and practices, more research in the ITE context across university based contexts would be beneficial. The review noted that many of the articles referenced formal PL programs, rather than research on informal teacher learning and recommend the inclusion of more research which recognises the role of teacher autonomy in professional learning. Future directions should also include moving beyond the identification of enablers and barriers in PL to ensuring that systems and structures are in place to support productive learning for teachers to develop their knowledge and enact positive changes in their practice.

Chapter 13 builds on key issues relating to the intersection of mathematics and STEM education, that were identified in the immediately previous volume. In seeking to address these issues, Anderson and colleagues' review of the research suggests that the main benefit from an integrated STEM curriculum to support students' mathematics learning relates to increased student engagement. The review notes that questions remain about how and what learning of mathematics concepts should be

undertaken through a STEM approach particularly at the secondary level. Furthermore, research suggests that more evidence is needed to understand how mathematics learning/understanding can be made both more important and mathematically rich within integrated STEM learning experiences. A further issue explored centred on curriculum reforms although further research is needed in this area. While integrated curriculum approaches are of interest to teachers and leaders this is contrasted with challenges such as preparing students for examinations and designing an integrated STEM curriculum within a framework that is largely siloed.

Chapter 14, by Pierce and Stacey, provides reflections on the contribution of the preceding chapters, noting that a strength of mathematics education research in Australasia is the underlying goal of researchers to inform and improve mathematics teaching and learning. In contrast, contributions to inform and improve policy were less common, thus necessitating a call for researchers to further contribute to informing and improving policy. Key to this, the authors argue, is the need to consider the quality of evidence when conducting reviews such as this, and when building upon the findings of the reviews presented in this volume.

4 Concluding Comments

With the assistance of text-mining technology, the editorial team for RiMEA11 (2020–2023) identified major themes addressed by Australasian mathematics education research in the period from 2020 to 2023. Careful perusal and analysis of publications reporting on these themes was conducted by 11 writing teams, resulting in the compilation of this review volume. The chapters that follow highlight research topics that continue to attract researcher attention and new issues are identified and discussed within the chapters in this volume. This is illustrative of how sensitive and responsive mathematics education research (in Australasia) is to changing conditions in society.

Systematic reviews of recent research play a crucial role in interpreting findings in key areas. RiMEA11 (2020–2023), together with the RiMEA volumes before it, represent a contribution of this effort for the Australasian region, and our hope is that this work may influence research beyond it as well.

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Chapter 2
Yesterday, Today and Tomorrow in Mathematics Education Research

Jennifer Way, Katherin Cartwright, Janette Bobis, Judy Anderson, Heather McMaster, and Catherine Attard

Abstract As the editors of the previous edition of the Research in Mathematics Education in Australasia (Volume 10) covering the period 2016–2019, the task falls to us to make some form of reflective comment on mathematics education research within the purview of the Mathematics Education Research Group of Australasia's research reviews. We have chosen to frame our reflections from the apex of global issues currently confronting education. This provides an opportunity to reflect on the context in which research was conducted in the 2016–2019 period, and to contextualise the research that occurred in the following four years. To accomplish this task, we apply the delightfully slippery concepts of yesterday, today and tomorrow, to position ourselves at two significant points in time—the end of 2019 and the end of 2023. From each of these temporal viewpoints (the 'today'), we look back ('yesterday') and forward ('tomorrow'). We explore the notion that mathematics education research in Australasia is not sheltered from global events and that research agendas can be either empowered or thwarted by significant, and somewhat unpredictable, shifts in environmental, social, and political landscapes.

Keywords RiMEA10 · Global issues · Mathematics education · Role of research

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1 Introduction—The Role of Mathematics Education Research in the Changing Education Landscape

1.1 Looking Back from 2019

As 2019 drew to a close, the editorial team concluded the curation of the 14 chapters in the tenth volume of *Research in Mathematics Education in Australasia* (hereafter, RiMEA10 (2016–2019) (Way et al., 2020b)), that provided a critical analysis of research findings and applications in the period 2016–2019, identified current research gaps, and forecast future directions of study. In the final reflective chapter of that volume, titled *Changing Landscapes*, Professor Glenda Anthony made an insightful statement that inspired the main theme for writing this chapter: "The role of mathematics education, in our progressively interconnected global society, challenged by unparalleled social, economic, ecological, and political crises is constantly being redefined" (Anthony, 2020, p. 350). This statement echoed growing concerns about significant issues like climate change and threats to world peace that had emerged in the previous years, and the tendency for education structures to be influenced by societal pressures. Anthony (2020) noted that, looking back on the research in the four years prior to the end of 2019, researchers had been responsive to the 'changing landscape' in education, but had also contributed to 'changing the landscape'. Yet the role of research in mathematics education in the shifting landscape can be difficult to define. Indeed, what is the role of mathematics education and, more broadly, of education in the global landscape?

In 2015, just prior to the research period covered by RiMEA10 (2016–2019), the United Nations released its *2030 Agenda for Sustainable Development*. In this statement, Goal 4 reaffirmed education as a human right and positioned education as a necessary change agent, with the goal of education being to:

> ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development. (United Nations Department of Economic and Social Affairs, 2015)

Such a profound statement from the United Nations highlights the perception of the power attributed to education to somehow change students and equip them to influence the societies in which they live, and to solve the world's problems. Mathematics, as a substantial component of education curricula around the world, is entangled in the momentum of changes to the broad education landscape, and consequently research agendas are compelled by similar entanglement. One of the long-standing goals for mathematics education research has been to improve mathematics teaching and learning at all levels (Lester & Wiliam, 2002). But *why* students should learn mathematics and *how* they should use it for the benefit of humankind seems to be ever changing. The arguments for focusing on the application of mathematics learning to support citizenship and real-life problem-solving have been building across recent

decades, as evidenced by the increase in both education and research programs around critical numeracy (mathematical literacy), STEM education and twenty-first century skills and proficiencies (e.g., Geiger et al., 2015; English, 2016; Beswick et al., 2019 respectively).

1.2 Looking Back from 2023

Moving forward in time to the present day, the end of 2023, allows us to look back over the past four years and consider how the global and local landscapes have changed. We perceive an increased vigour in the questioning of the purpose of mathematics education, and even of the mathematics that should be taught. We hear an increased urgency in the voices of mathematics educators and researchers to contribute to solutions for global issues. There has been a flurry of journal special issues, articles and conference themes in response to the 'changing landscape' and as attempts to influence the global landscape. For examples:

- *Mathematics for 'citizenship' and its 'other' in a 'global' world: Critical Issues on Mathematics Education, Globalisation and Local Communities* (Research in Mathematics Education, Editors: Chronaki et al., 2021),
- *Mathematics Education in a Time of Crisis—a Viral Pandemic* (Education Studies in Mathematics, Editors: Chan, Sabena, & Wagner, 2021),
- *Innovating the Mathematics Curriculum in Precarious Times* (Research in Mathematics Education, Editors: Le Roux et al., 2022),
- *Mathematics for Global Sustainability* (46th conference of International Group for the Psychology of Mathematics Education, Editors: Ayalon et al., 2023),
- A current call for papers for *Fostering Mathematics Teachers for a New Era* (Education Sciences, Editors: Da Ponte & Chapman, 2023)

The editors and authors of these collections of papers from around the world speak of the increased pressure of techno-culture, environmental calamity, wars, pandemics, enforced migration and politically driven economies as world-changing forces (Chronaki & Yolcu, 2021). They also identify the discipline of mathematics as holding a central place in education systems and as having "… unavoidable responsibility to reflect on these issues and find ways to face them" (Da Ponte, & Chapman, 2023). Questions are raised about what mathematics is needed to understand phenomena such as interconnectivity, climate, biodiversity and wealth distribution (Chan, Sabena, & Wagner, 2021). In her keynote address to PME46, Paola Valero (2023) called on us to "… consider the ways in which the institutions and networks of mathematics education may be entangled in the distribution of power, wealth, honour and survival in the current configurations of climate change" (p. 1–55).

In writing this chapter we build upon Anthony's metaphor of 'changing landscapes' by considering the burgeoning global pressures on mathematics education research. We reflect on the extent to which shifts in the global landscape were already evident in our local research landscapes by looking back at RiMEA10 (2016–2019)

and speculate how global events since 2019 may be reshaping the Australasian research terrain. At this point, we emphasise that this chapter is not a commentary on the current RiMEA11 (2020-2023). Indeed, we have not yet read any of the other chapters and look forward with great interest to see which of our speculations emerge from the critical review of research conducted 2020 to 2023, and what the authors identify as research priorities for the next several years.

2 Reflections on RiMEA10 (2016–2019)—Looking Back to 'Yesterday' from Today's Temporal Viewpoint

As suggested in the introduction to this chapter, the complexity of global events in the last four years have not simply produced a *changing* landscape, but one that would be almost unrecognisable to the chapter writers of RiMEA10 (2016–2019). With this is mind, we draw from the changed global landscape of 2023 to frame our reflections on RiMEA10 (2016–2019) and identify three shifting local landscapes:

1. The pandemic—mathematical practices and technology
2. The new educational ecology—sustainability, inclusivity, diversity and culture
3. The political landscape—research agendas and research impact

Each of these landscapes guides the structure of this part of the chapter where, for each landscape, we first frame the global lens then present our discussion related to the continuities and discontinuities of research directions distilled from the chapters of RiMEA10 (2016–2019).

2.1 The Pandemic—Mathematical Practices and Technology

Looking back over the previous four years, we cannot ignore the momentous events that began in early January 2020 with the detection of a 'mysterious virus' in Wuhan, China. The spread of Coronavirus COVID-19 rapidly escalated in our highly interconnected world, with the World Health Organisation (WHO) announcing a 'global health emergency' on 31 January 2020, and pandemic status on 11 March 2020. The inhabitants of our planet had no idea that the COVID-19 pandemic would persist as a global health emergency until 5 May 2023, infect more than 765 million people, and kill at least seven million people (WHO, 2023). The reality of the consequences of global interconnectivity and inter-dependence was revealed, as was the disparity in access to life-sustaining resources for so many people across the globe. The disruption to everyone's lives and to education systems was a major event in modern history, and disruption to research naturally followed. Individual researchers faced ethical questions about continuing planned research programs when the participants were "experiencing high levels of stress and uncertainty" (Chan et al., 2021. p. 4), and others pivoted to explore the novel context (for example, Bakker et al., 2021).

And yet others began to re-evaluate their research priorities as being more-than-ever important, or perhaps in need of reshaping. One tool that was thrust to the frontline of education during the pandemic was communication technology. In this section we reconsider the research on mathematical practices and technology and highlight some of the potential strengthening or weakening of research pathways revealed when looking back, post-pandemic, from 2023.

RiMEA10 (2016–2019) included a chapter in which Attard and colleagues (2020) examined the 2016–2019 research on technology and mathematics education and identified trends and research needs that, in hindsight, present a pre-COVID perspective. Anthony's (2020) closing chapter *Changing Landscapes* of RiMEA10 (2016–2019) noted that, when our research is participant-driven, "… we can expect over time changes to our shared ways of behaving, our language, our habits, our values and our tool use" (p. 360). However, since 2019, a much stronger influence on changes to our research has been the global context in which we find ourselves. Anthony (2020) proposed that "… while we live in an increasingly technology enriched society, the impact on the teaching landscape is mixed" (p. 353). A society that was *increasingly* technologically enriched became *exponentially* enriched in the pandemic that immediately followed the publication of RiMEA10 (2016–2019). With many students (primary, secondary, and tertiary) spending days, weeks, months and sometimes longer in 'lockdown' during COVID-19, technology became *the* landscape for teaching and learning. Pre-COVID ideals around whether technology improved learning opportunities or provided opportunities to redefine pedagogical practices (Anthony, 2020; Attard et al., 2020), became overshadowed by the immediate need to provide students with continued access to their teachers and to learning, particularly through 'digital pedagogy' (Bozkurt et al., 2022).

Pre-COVID research suggested that, although the use of digital technologies continually evolves, teachers tended to remain in control of how technology was used in their teaching spaces (Attard et al., 2020; Hoogland, et al., 2018). This situation led to calls for more exploration of "… virtual worlds and technologies that promote student design", or "… innovative task design using emerging technologies" that reflect student-centred approaches (Attard et al., 2020, p. 340). Did the forced immersion in online learning during the pandemic help the evolution of teacher practices in schools? Sullivan et al. (2020) suggested that much of the online mathematics teaching in Australasia during the first year of COVID-19 may have remained teacher-centred, where students had substantial experiences with "procedures followed by practice" lessons (p. 551) that included demonstrations or explanations (provided via videos) and exercises to practice these skills. Although these practices are not surprising as an educational response to "emergency remote education" (Bozkurt et al., 2022, p. 883), they are nonetheless concerning if students came back to school from lockdown believing "… mathematics is something that is done to them rather than knowledge and connections that they create" (Sullivan et al., 2020, p. 552). The suggested shift away from "… learners being consumers of content authored by others towards learning authoring their own content" (Anthony, 2020, p. 352) seems to have taken a backwards step during COVID-19. In a situation that no-one predicted, practices were implemented as stopgap, 'band-aid' solutions, with little