Chapter 2
Looking Back and Taking Stock: Reflections on the MERGA Research Review 2012–2015

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Abstract Since 2004, each edition of the MERGA Research Review has invited the previous editorial team to write a chapter that reflects on issues that have occurred since the last Review. As the editorial team for Research in Mathematics Education in Australasia 2012–2015 (RiMEA-9), we have followed suit. The reflection chapters often compare the current MERGA Review with the previous one. Given that this is the tenth MERGA Review, we have taken the opportunity to look further back from RiMEA-1 in 1984 until now (RiMEA-10). Like the previous Review, we also comment on how mathematics education research in Australasia is affected by new reforms that have occurred in the past four years. In particular, we examine the implications of recent changes in initial teacher education, STEM teaching and learning, and the assessment of research impact and engagement. We use these three areas of reform to reflect on how related issues projected in the chapters of the last review played out and urge mathematics education researchers to focus their research on implications of these reforms for the field.

Keywords MERGA history · Research assessment · STEM · Teacher education reforms

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1 Introduction

As the editorial team of *Research in Mathematics Education in Australasia 2012–2015* (RiMEA-9, Makar, Dole, Visnovska, Goos, Bennison, & Fry, 2016), we continue the tradition of reflecting on the past four years in light of the chapters we edited in RiMEA-9. Former editors (RiMEA-8) Perry, MacDonald, Greenlees, Logan, and Lowrie (2016), saw the task of this chapter as being: "to reflect on the 4 years following the publication of this review, consider the directions the review foreshadowed and provide an overview of the context for the current review" (p. 14). We continued with their ethos in reflecting on the 17 chapters in RiMEA-9. Following the introductory chapter, Chaps. 2–16 were:

- Issues and Contexts for Mathematics Education
  - Reflections on the MERGA Research Review 2008–2011: Taking stock
  - A philosophical gaze on Australasian mathematics education research
  - Researching curriculum, policy and leadership in mathematics education
  - Mathematics education and the affective domain
  - Equity, social justice and ethics in mathematics education
  - Inclusive practices in mathematics education
  - Distribution, recognition and representation: Mathematics education and Indigenous students.
- Learning and Teaching
  - Mathematics education in the early years
  - Tertiary mathematics education
  - Innovative and powerful pedagogical practices in mathematics education
  - Assessment of mathematics learning: What are we doing?
  - Transformations of teaching and learning through digital technologies
  - Research into mathematical applications and modelling.
- Teacher Preparation and Development
  - Challenges, reforms, and learning in initial teacher education
  - The education and development of practising teachers.

The concluding Chap. 17, following tradition, was a reflection on the volume, and was written by an eminent MERGA scholar from a perspective of her choice. Lyn English (2016), winner of the 2012 MERGA Career Research Medal, authored the final chapter entitled *Advancing Mathematics Education Research within a STEM Environment.* English drew on the chapters in RiMEA-9 to forecast the future of STEM education, a significant initiative that deeply affects mathematics education in Australasia.

In this chapter, we first reflect on how MERGA Review chapters have highlighted research interests over time. The analysis of chapters and their authors in RiMEA-1 through RiMEA-10 provided insights into complexities of the drivers of our research community. We also look at three policy issues that have emerged since RiMEA-9 with respect to the future that its chapters foretold. In particular, we (1) examine recent policies in New Zealand and Australia and their implications for initial teacher education, (2) question if mathematics education is sufficiently present within the STEM Agenda and (3) summarise how mathematics education research fared in the recent impact and engagement assessment conducted by the Australian Research Council.

2 Looking Back at Previous Chapters in RiMEA

The current edition of *Research in Mathematics Education in Australasia 2016–2019* (RiMEA-10) is the tenth edition of the MERGA Research Review (as RiMEA is often referred to, or simply the "Review"). To have such an ongoing review of research in the field is rare. The Review series allows scholars to follow trends, trace patterns of research and their influences from and on educational policy in Australasia and gauge fruitful emerging areas of research. Authors of each chapter in the Review were asked to identify potential future directions of research based on their account of the research in the field in which they are reporting. Looking across editions of the Review, therefore, can give insight on where research momentum was moving, and if and how it meandered through time.

Authors of previous Reflection chapters have compared the chapters that they edited to the current Review. We take the opportunity in this tenth edition of the Review to look back a little further at the previous Reviews and comment on patterns we observed. A further gaze back is timely given that the impetus for the first Review was the opportunity of having the 1984 International Congress on Mathematical Education (ICME) held in Adelaide. Subsequent Reviews continue to coincide with ICME. Fittingly, the 2024 ICME will be held in Sydney when the 11th Review (RiMEA-11) will be launched forty years after MERGA's first Research Review.

The initial two volumes (1984 and 1988) did not yet have the spread of content chapters that is familiar to RiMEA readers today; but they provided annotated bibliographies and several topical review chapters to facilitate access to Australian research. RiMEA-3, published in 1992, was the first one with 'Australasia' in its title, and included references to mathematics education research from New Zealand. It was, however, not until RiMEA-5 that the first New Zealander appeared as a chapter co-author. This slow start to diversifying author teams is in considerable contrast to RiMEA practices of the recent Reviews, where half or more of the chapters are authored by international teams. The inclusion first of New Zealand, and later more international perspectives from the region, is a result of conscious commitments within the community. In 2008, RiMEA-7 editors explicitly defined Australasia and made a greater effort to include work of authors beyond Australia and New Zealand. Similar efforts have been since reflected in increasingly international composition of chapter author teams. Table 1 lists the number of chapters with at least one co-author

Table 1 Authorship participation in Reviews across Australasia

	Year	Number of chapters	Number of chapters with at least one co-author from	
			New Zealand	Australasia (Non-AUS, Non-NZ)
RiMEA-1	1984	5		
RiMEA-2	1988	5		
RiMEA-3	1992	13		
RiMEA-4	1996	16		
RiMEA-5	2000	12	1	
RiMEA-6	2004	16	6	
RiMEA-7	2008	16	7	
RiMEA-8	2012	16	10	
RiMEA-9	2016	17	8	3
RiMEA-10	2020	14	7	2

from listed location, in comparison with the total number of chapters. (Authors affiliated only with a non-Australasian institution were not included in the counts, there were several from RiMEA-8 on.)

Returning to the structure of RiMEAs, reflections, trends, and/or future-oriented chapters became a stable presence in most of the volumes. Besides front and back matters chapters, we categorised chapters into several themes to gain a sense of changes in foci through different periods. The themes are presented in Fig. 1 and include:

- Focus on learners by age;
- Theoretical underpinnings of research;
- Educational issues;
- Teacher learning, pedagogies, practices;
- Systemic issues; and
- Mathematics domains and proficiencies.

In Fig. 1, each opaque coloured box represents a chapter, while semi-transparent coloured boxes illustrate a theme that was a substantial part in another chapter. This was most useful in capturing the structure of early volumes. For example, the 1988 annotated bibliography on *Psychology in Mathematics Education* included sections devoted to research on affect and exceptional students; the annotated bibliography on *Problem Solving* included substantial sections on research in algebra, geometry, and early arithmetic. In 2004, a chapter on *Learning to Teach Mathematics* predominantly discussed teacher education, but also included significant content related to in-service teacher professional development. Similarly, a chapter on *Social Justice and Sociocultural Perspectives in Mathematics Education* (2004) presented extensive

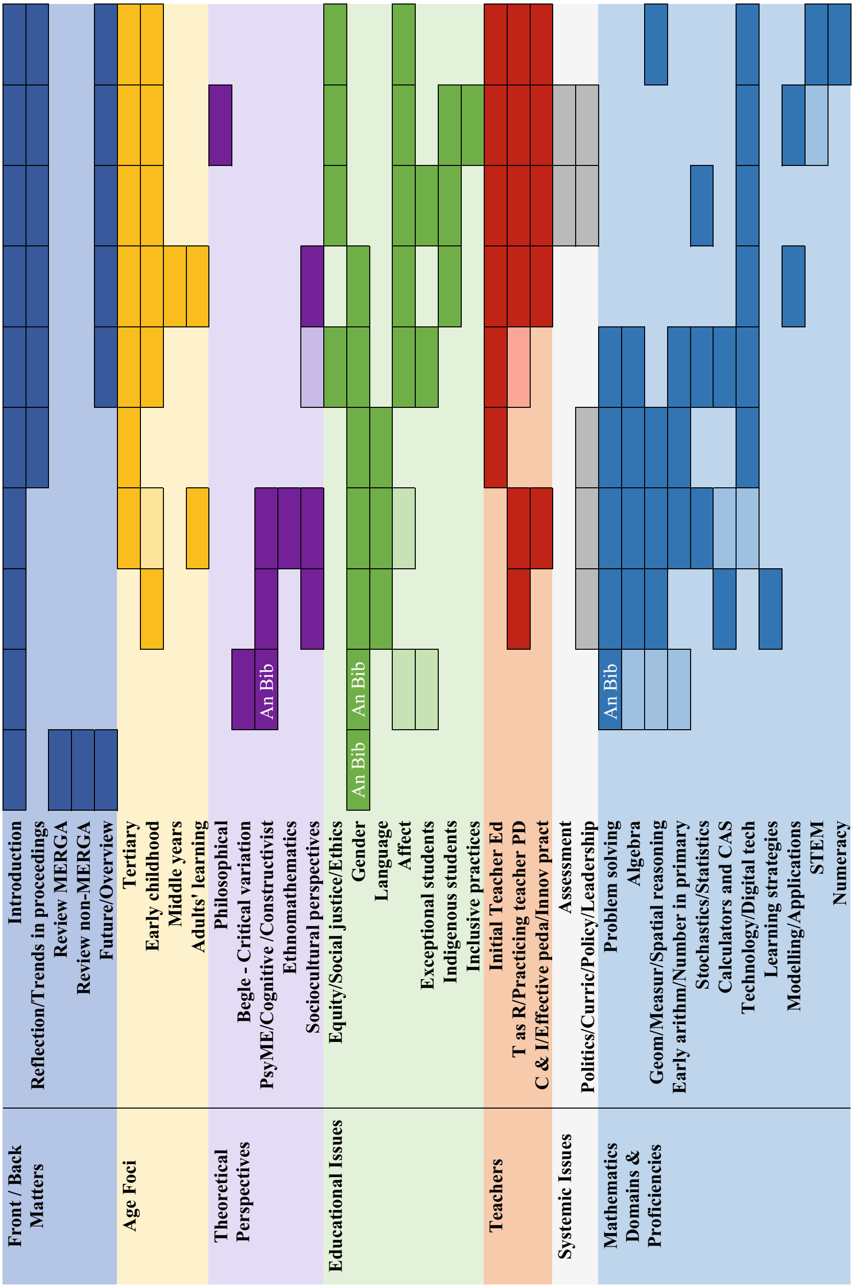

Fig. 1 Themes of MERGA Review chapters 1984–2020

discussion of various themes within social justice agenda, and then somewhat more briefly addressed the underpinning theoretical matters within sociocultural theories.

It was not always obvious where a specific chapter fits best, or which sub-section deserved to be represented independently. In making the categorising and highlighting decisions, we were guided by the aim of illustrating developments that took place over time. For example, a chapter on sociocultural theories was included in 1992, was absent in 2000 (with chapters on gender and language carrying on some of the theoretical debates), then re-appeared in 2004 and more strongly in 2008, and was subsequently subsumed within specific educational issues of equity, social justice, and ethics (with independent chapters on gender, indigenous students, exceptional students, or inclusive practices, as the distinct debates were highlighted by editors).

A changing research climate is evident in other patterns. While learning theories production and justification remains important for research in educational settings, it is less commonly the distinguishing element in a study. As theoretical research results faced limitations when attempting to guide practice, in-depth explorations of those practices became research-worthy in their own right. Student learning was initially the primary target of research; yet over time, an increasing emphasis was evident on explorations of teaching. This transition of focus from learning to teaching appears to be well illustrated in how the blue block of mathematical domain chapters ceased dominance around the same time that the red block of teachers' work chapters became firmly established. In this transition, not only did new theoretical paradigms enter the scene, but pragmatic considerations gained legitimacy for researchers to study and work to improve practices in classrooms and schools. Early signs of this transition are evident in chapters like *Teachers as Researchers* (1992). While learning theories continue to provide tools for disciplined inquiry, the drive for advances within specific educational issues might have provided new organising principles along which research work is conducted and collated. As the Philosophical chapter (2016) reminds us, even when our theoretical underpinnings are specified, philosophical assumptions are more and more likely to remain unexplored and implicit.

Tightening of accountability measures in Australia and New Zealand swung funding priorities from basic (pure theoretical) towards more practice-oriented research (see Clarke et al., 2012; Clements, 2008). The shifts in the Review chapter themes from *learning theories* towards *specific educational issues* that emerged in early 2000s, and those from *learning* to *teaching* that followed closely, appear to follow these funding changes as well as being mirrored in recent policy commitments to research with demonstrable engagement and impact that we discuss in a later section. This historical overview of RiMEA chapters demonstrates that—perhaps with an advantage to other fields of research—the mathematics education community has long carried an appreciation for the pragmatic alongside the theoretical.

Another shift, discernible in the chapters on 'Mathematics Domains and Proficiencies', is the transition from mathematical domains (e.g., number, algebra, stochastics, geometry) to mathematics as activity (e.g., statistical and spatial reasoning, modelling, STEM, numeracy). Here the transition from conceptualising the key problems as being those of how mathematics is created by the human mind, to recognising the need for addressing the problems of *how and why* mathematics might be created and sustained by collectives of problem-solvers appears highly relevant. Similar shifts can be imagined within the broader context of STEM disciplines. Approaches to teaching and learning of mathematics, science, engineering, and technology as both products of human inventiveness, and purposeful creations capable of addressing problems that humanity faces are highly consistent with the directions apparent across the Reviews. We later discuss the extent to which this is the direction taken up in recent policies regarding STEM.

The four chapters—two on assessment (2012, 2016) and two on curriculum/policy issues (2012, 2016)—are examples of how chapters in RiMEA can be prompted by policy changes. On the one hand, both assessment chapters deal with issues around NAPLAN and international tests (how high stakes accountability testing should not be the only/main focus, or how could NAPLAN become more meaningful in face of curricular goals) at the time when these became influential, and NAPLAN started shaping teaching practices. The two curriculum chapters, on the other hand, are both very strongly shaped by introduction of new curricula in Australia and New Zealand. Here, the 2012 chapter is about how the curricula were developed and 2016 more about how to think about, and research, the relationships among curriculum, policy, and leadership, especially in the space of 'bringing' the official curriculum to shape the operational curriculum effectively.

In interpreting the table, it is useful to note that it does not speak to the individual research foci taken up by the researchers in Australasia. Instead, it is useful to view the chapters as those topics where the critical mass of researchers existed at the time and was overt enough, or organised enough, that (1) a group of chapter authors was formed to propose or undertake the chapter and (2) the editorial team recognised the theme as both a significant contribution and as sufficiently different from other proposals to be accepted. The cases of statistical reasoning (2012) and spatial reasoning (2020) chapters are instructive in that regard. In spite of the seeming 'disappearance' of mathematical-domain-focused chapters, the chapters were formed around a mathematical content theme when a sizeable productive *community* of researchers existed, on which the chapter would draw. For instance, Australian and New Zealand researchers were instrumental in the work of the International Collaboration for Research on Statistical Reasoning, Thinking, and Literacy, but also in the Modelling and Applications community, each of which organise bi-annual domain-specialised international conferences. Similarly, a recent completion of a large Australian project (e.g., ELSA) on spatial reasoning generated the core of the chapter contributions.

We do not take the change in chapter foci as indicating that there is no longer interest in researching content domain learning. But where do the researchers with strong focus on a specific mathematical content domain send their work for consideration when the chapter themes are announced? It is very likely that they are oriented by the number of issues, including the pedagogical approaches used, modes of delivery, or a specific policy framing that was relevant to how the research study was framed (e.g., equity, numeracy, STEM). In this way, the shifts in the Review chapter themes might illustrate that drawing on existing insights into mathematical learning allows researchers to attend to additional problems of practice.

3 Reflection on Three Policy Developments

Since the previous review, new policy developments have occurred that impact the research landscape in mathematics education. We focus on three of these—initial teacher education, STEM teaching and learning, and recent assessment of research impact and engagement—in relation to the previous MERGA Research Review. Initial teacher education reforms were also highlighted in the Perry et al. (2016) reflection chapter, highlighting how this area of work has been under constant scrutiny by policymakers. We encourage readers to compare policy developments in initial teacher education from their chapter and how they have continued to change in our reflection below. We recognise that the Closing the Gap initiative, which Perry et al. included in their reflection chapter, is missing from ours. Perry and his colleagues commented on the slow progress made on this initiative in Australia. We found developments slowed even further, leaving little to report. Better progress on similar initiatives in New Zealand is discussed below within initial teacher education. Researchers in mathematics education have been actively urging governments to take action, as outlined in the chapters in this volume.

3.1 Initial Teacher Education

Australia and New Zealand have each had new policies affecting initial teacher education (ITE). We briefly reflect on these policies, referencing the 2016 MERGA Review (2012–2015). Implications of teacher accreditation were also addressed as an issue within the political landscape in Australia and New Zealand in the last reflection on the MERGA Research Review (Perry et al., 2016).

In a review of the existing ITE system, the New Zealand Education Council (2016) made a number of recommendations to guide the ongoing development of ITE. The recommendations spanned entry requirements, program design and accreditation, and system-wide management issues. The Education Council described the change: "[the] area of specification and assessment of outcomes from ITE is the most important long-term step it can take to strengthen the ITE system" (p. 11). From 1 July 2019, new requirements governing the approval, monitoring and review of ITE programs were introduced (Teaching Council, 2019). Standards for graduating teachers have been aligned with the *Standards for the Teaching Profession* (Education Council, 2017) and ITE providers must demonstrate how programs enable pre-service teachers to meet each standard *in a supported environment*. Interpretation of the standards extends beyond the elaborations of the Standards and includes consideration of Tātaiako cultural competencies (Ministry of Education, 2011) and Tapasā cultural "compass" (Ministry of Education, 2018) to ensure graduating teachers develop culturally responsive teaching practices that address the learning needs of students from Māori and Pasifika backgrounds, respectively. There is also a strong emphasis on demonstrating how programs enable graduates to develop inclusive teaching practices that cater for the diverse learning needs of all students, especially those from disadvantaged backgrounds and those with additional learning needs.

In their chapter in the previous MERGA review, Vale, Atweh, Averill, and Skourdoumbis (2016) noted that in many ITE programs issues of equity, social justice and ethics are dealt with in general education courses and suggest that these issues should be an integral part of all mathematics education courses. The limited research in Australasia during the previous review period on how ITE programs can support teachers to develop mathematics teaching practices that cater for diversity (Anthony, Cooke, & Muir, 2016) may reflect the lack of attention to such issues in mathematics education courses. Research is needed to assist ITE providers to design courses that enable pre-service teachers to develop inclusive practices for teaching mathematics.

A recent review was extended to the provision of compulsory schooling in New Zealand (Tomorrow's Schools Independent Taskforce, 2018) and identified a number of system-wide challenges that the current system of self-governing schools is struggling to address. In the report, authors made recommendations on eight key issues they believe need to be addressed: governance, schooling provision, competition and choice, disability and learning support, teaching, school leadership, school resourcing and central education agencies. It is unclear at this stage which of the recommendations will be adopted. However, the findings and recommendations of this review are likely to influence the content of New Zealand's Initial Teacher Education programs. It is promising to see that inclusion is a vital part of the vision for education in New Zealand. The Australasian mathematics education community looks forward to learning about this progress in the coming years.

The advent of the Australian Professional Standards for Teachers occurred in 2012 as Australia progressed towards nationally consistent accreditation of initial teacher education programs aligned with the standards. The Teacher Education Ministerial Advisory Group's (2014) position paper, entitled *Action Now: Classroom Ready Teachers—Report of the Teacher Education Ministerial Advisory Group* (now commonly referred to as the TEMAG Review), was addressed in relation to new entry requirements into initial teacher education programs associated with personal levels of literacy and numeracy. A test to measure literacy and numeracy of aspiring teachers was developed by the Australian Council for Educational Research (ACER).

The TEMAG Review has had a major impact in the last four years on initial teacher education programs in Australia, and it is predicted that this will continue. A rationale for TEMAG was to raise the profile of the teaching profession in the eyes of the public (Bahr, 2016). It appeared to level blame for Australian students' falling literacy and numeracy standards, as measured on international assessments such as TIMSS and PISA, on the poor preparation of graduate teachers, and by default, the institutions that prepare teachers. The release of the latest PISA 2018 results, and Australia's slippage in mathematics in particular, will continue to put pressure on improving the preparation and development of mathematics teachers. The media continue to highlight low tertiary admission scores for entry to initial teacher education (ITE), publishing league tables of the cut-off scores of post-year 12 students who are offered places into education by higher education providers (HEPs) across the country. The test for measuring literacy and numeracy (referred to as LANTITE—Literacy and Numeracy Test for Initial Teacher Education) is now fully implemented in all Australian initial teacher education programs. HEPs can elect to use this test as an entry requirement into ITE programs, or as a requirement for graduation. The ACER website states that "the test standard is literacy and numeracy achievement equivalent to the top 30% of the Australian adult population" (ACER, 2019). As with annual results of Australia's National Assessment Plan Literacy and Numeracy (NAPLAN) test results, the Australian media continues to sensationalise results of LANTITE and the literacy and numeracy of teacher graduates. Interestingly, there is no equivalent to Australia's national literacy and numeracy testing policy for ITE providers in New Zealand. Rather, institutions must have entry testing which reflects university entrance of literacy and numeracy requirements and HEPs must provide their assessment tools as part of the ITE programme approval process (Teaching Council, 2019).

We highlight Anthony and her colleagues' (2016) chapter in the previous Review to remind the mathematics education community of the value of examining the ongoing impact of policy associated with initial teacher education and on the field. For example, Anthony et al. reported that changes in New Zealand had resulted in two HEPs offering only postgraduate ITE programs. Pre-service teachers' numeracy, preparation for teaching both numeracy and mathematics, as well as pedagogical content knowledge has been the focus of research, as reported in the previous review period. Anthony et al.'s caveat was associated with the complexity of measuring pre-service teachers' preparedness for teaching numeracy and mathematics, and the issue of pre-service teacher confidence and enjoyment of mathematics, which was the focus of work by Young-Loveridge, Bicknell, and Mills (2012) for New Zealand pre-service primary teachers. Their exploration of initial teacher education from a mathematics education perspective spanned teacher preparation and accountability, effectiveness and policies; teacher preparation for the knowledge society, and included studies associated with curriculum, opportunities to learn within coursework, designing opportunities to learn in school settings, the continuum of teacher learning; and teacher preparation for social justice. Anthony et al. offered valuable insights into what the mathematics education community can offer and where it needs to continue to build strength:

> The politicised attention to teacher preparation and the press to institute reforms will not abate in the near future…we must 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. (p. 321)

They end their review by highlighting the large-scale national Australian project *Inspiring Mathematics and Science in Teacher Education* (see Goos & Bennison, 2018), which they state

> provides an example of collaboration between academics from different communities of practice … [that] bodes well for the opportunity for mathematics teacher educators to open up their practice, to share their practice, 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. (p. 321)

The mathematics education community has a strong history of research into initial teacher education as attested through the richness of Anthony et al.'s (2016) chapter in the previous RiMEA. The impact of national Australian policy associated with literacy and numeracy standards, and specifically the LANTITE, is a potential focus of research for the mathematics education community to improve the policy landscape in ITE. With respect to recent developments and future RiMEA chapters, we find it possible that attention to measures introduced to assess pre-service teachers would lead to return of the chapter on assessment in 2024 in this context. Would these policies impact our teaching lives and push us to develop stronger research-based arguments and advocacy in this space? The implications of measures on the upcoming generations of teachers of mathematics would be worth documenting.

3.2 STEM Agenda 2016–2026

The *National STEM Agenda 2016–2026* (Education Council, 2015) endorsed by the Australian Ministers of Education set out the priorities for the next decade in building Australian students' STEM (Science, Technology, Engineering and Mathematics) capabilities. The report argued that "STEM literacy is increasingly becoming part of the core capabilities that Australian employers need" (p. 4) as a critical driver of the future national economy. The Agenda set out goals, actions and principles to guide future initiatives undertaken by the Commonwealth. Activity in STEM has been present for a number of years, but recent momentum has accelerated. For example, the ELSA project (Lowrie & Logan, 2019) addresses STEM learning in early years. At the policy level, Toh, Kaur, and Tay (2019) outlined Singapore's response to STEM in updating the national mathematics curriculum and Anthony (2018) suggested that recent funding of research in mathematics education in Australia, New Zealand and Singapore are likely linked to government interests in STEM. Despite challenges (Timms, Moyle, Weldon, & Mitchell, 2018), the STEM Agenda is an opportunity for the mathematics education community to do more to connect to STEM initiatives in schools.

In the final chapter of the previous Review, English (2016) expressed the critical importance in mathematics education for greater connection to the STEM movement at both school and university level. Members of the MERGA community have indeed published on STEM policy and practice since the last Review and a new chapter that reviews research on STEM is given in the current Review (see Chap. 3, this Volume). Murphy, Macdonald, Danaia, and Wang (2019) examined state-level versions of the STEM agenda across the areas of STEM capabilities—STEM dispositions, STEM educational practices, Equity, Trajectories, and Educator capacities. It is concerning that they found little focus in the research on STEM dispositions and improving equity access to STEM (see Prieto & Dugar, 2017; Wilkie & Tan, 2019). Focused on the "rising premium on skills in STEM" (p. 1), Prinsley and Johnston (2015) from Australia's Office of the Chief Scientist outlined a position paper on STEM teaching in the primary schools. In its short report, the paper lists dozens of STEM initiatives and case studies that progress STEM teaching in primary schools. Within these, one key project in mathematics education has been *reSolve: Maths by Inquiry* (2015–2018, www.resolve.edu.au).

The *reSolve* project was a \$7.4M partnership between the Australian Academy of Science and the Australian Association of Mathematics Teachers, funded by the Australian Government to develop a large set of classroom resources, online professional development and to organise 300+ "Champions" in schools to build capacity and scale the use of inquiry-based learning in mathematics. *reSolve* is driven by a protocol that emphasises mathematics as purposeful, with inclusive and challenging tasks, and a productive classroom culture that embraces higher-order thinking, collaborative inquiry and dispositions that support productive struggle and confidence to take intellectual risks (Thornton, 2017). The *reSolve* project ensured that its products were significantly linked to the Australian Curriculum: Mathematics for Years F-10 (particularly Mathematical Proficiencies, which are often overlooked) and to the AITSL Australian Professional Standards for Teachers. These connections were intended to ensure that the curriculum and professional development were explicitly linked to teachers' professional work. The project has ended, but an additional \$1M in funding to 2020 was provided to continue promoting and updating the resources. *reSolve* is a significant initiative that the mathematics education community can capitalise on to further mathematics education reform, and highlight the potential contribution of mathematics education within the STEM agenda.

If policymakers, like the public, see mathematics as no more than fluency in number facts, there is little opportunity for them to see how mathematics connects to the STEM agenda. As national governments across the world see jobs of the future coming from STEM areas, there is an emphatic rise in funding initiatives focused on STEM. A recent report on 69 STEM initiatives being funded in 2018 by the Australian and state governments confirms the millions of dollars being spent on these projects, with only nine of them focused specifically on mathematics (Education Council, 2019). Panizzon and Corrigan (2017) analysed the 2016 STEM Program Index (SPI) listing published by Australia's Chief Scientist of 250 active STEM programs catering to schools and students. Only 36 of these included explicit mention of mathematics. Because innovation and entrepreneurship had been identified as recognised drivers of the economy, the authors sought to investigate the extent to which STEM promoted these and other valued characteristics. In their summary table, the contrast was striking in comparing particular characteristics to their appearance in the SPI for STEM, science and mathematics (a few of which are listed in Table 2). The table speaks to a number of areas highly valued by STEM that have been adopted in science to some extent but not in mathematics. The entries that did include mathematics were almost exclusively listed under "STEM content" (characterised by 33 of 36 programs), with "Motivation" as the second most common characteristics listed in the 36 mathematics programs (12 programs). Because SPI are funded projects, it emphasises that in some areas, innovations in mathematics teaching and learning are not being included in the national STEM conversation.

Much of the work we do in mathematics education contributes to the development of STEM, including the applications of particular curriculum content, pedagogy and

Table 2 Selection of characteristics in the 2016 STEM Program Index (Panizzon & Corrigan, 2017)

Characteristic	STEM	Mathematics	Science
Communication	4	0	10
Creativity	12	2	6
Critical thinking	3	0	3
Curiosity	0	0	1
Entrepreneurship	2	0	0
Independent thinking	2	0	1
Innovation	12	0	1
Inquiry	13	2	9

assessment. However, English (2016) argued that there is a danger within STEM that mathematics is being overlooked or sidelined, with most of the emphasis placed on science, digital technologies (including coding) and engineering, possibly because policymakers cannot envisage how mathematics could fit into their futures agenda. She advocated for more work in statistics, problem solving and modelling as places where mathematics can continue to raise its profile. These three areas foster generic, as well as mathematics-specific skills and processes that are significantly needed in STEM, yet under-developed in many mathematics classrooms. English concluded her chapter with four recommendations that are critical for the mathematics education community to engage meaningfully with the STEM agenda:

- seeking to raise the profile of mathematics in STEM through statistics, modelling and problem-solving
- capitalising on and extending national assessment items that build on rich mathematical experiences
- emphasising twenty-first century skills in mathematics: creativity and innovation, critical thinking and problem-solving, and communication and collaboration
- connecting to and engaging with mathematics related to computational thinking and coding (pp. 366–368).

These recommendations create useful avenues for the mathematics education research community to continue to connect with the international push for STEM education. We anticipate that they will orient both international research agendas broadly, and Australasian research agendas within the period leading to RiMEA-11.

3.3 Assessment of Research Impact and Engagement

In December 2015, as part of its *National Innovation and Science Agenda*, the Australian government announced the development of a national assessment of research engagement and impact. The Australian Research Council (ARC) and the Department of Education and Training (DET) released an *Engagement and Impact Assessment Consultation Paper* in May 2016 to seek feedback from stakeholders on how this assessment should be undertaken (ARC & DET, 2016). Subsequently a pilot study of research engagement and impact was conducted in 2017, and in 2018 the inaugural Engagement and Impact Assessment (EI2018) was implemented as a companion exercise to Excellence in Research for Australian (ERA).

The ARC *Consultation Paper* drew on the definition used by the Academy of Technological Sciences and Engineering to develop metrics for Australian universities' research engagement. Engagement was defined as:

> the interaction between researchers and research organisations and their larger communities/industries for the mutually beneficial exchange of knowledge, understanding and resources in a context of partnership and reciprocity. (ATSE, 2015)

However, the *Consultation Paper* noted that metrics, which are largely based on research commercialisation income and patents, may not capture the complexity of some forms of research engagement.

The Australian Research Council defines research impact as:

> the demonstrable contribution that research makes to the economy, society, culture, national security, public policy or services, health, the environment, or quality of life, beyond contributions to academia. (ARC, 2012)

While noting that there were no clearly defined indicators for research impact, the Consultation Paper referred to peer reviewed case studies—similar to those reported in the UK REF exercise—as being an appropriate means of assessment. Nevertheless, it was acknowledged that full case studies are expensive to produce. As a compromise, a template was developed for impact case studies that requested a short summary of the impact; a list of beneficiaries and countries in which the impact occurred; a narrative that clearly outlined the research impact, especially the impact made beyond academia with specific reference to appropriate evidence; and a description of the research that led to the impact. They also required an extended explanation of the "approach to impact", demonstrating how the university putting up the case study had facilitated the research to seek and attain its impact.

Altogether 38 of Australia's 40 universities submitted engagement and impact case studies in Education (FoR13; *EI 2018 Institution Report*). Of these, 21 were rated as demonstrating "high" for engagement (12 of 38), impact (17 of 38) and/or approach to impact (5 of 38). According to the rating scale used in the assessment (see https://dataportal.arc.gov.au/EI/NationalReport/2018/pages/introduction/index.html?id=ei-rating-scales), those so rated were characterised by:

- **highly effective interactions** between researchers and research end-users outside of academia for the mutually beneficial transfer of knowledge, technologies, methods and resources and research engagement that is **well integrated** into the development and ongoing conduct of research within the unit of assessment;
- having made a **highly significant contribution** beyond academia, with a clear link between the associated research and the impact was demonstrated.

Four of the high-impact case studies were in mathematics education: *Transforming mathematics education in preschool and primary school contexts* (Macquarie

University); *Improving mathematics teaching to integrate numeracy learning across the curriculum* (The University of Queensland); *Addressing the needs of at-risk learners in Numeracy and Literacy* via *the QuickSmart program* (University of New England); and *YuMi Deadly Centre (YDC) programs to improve mathematics teaching and learning in schools with a high Indigenous student population* (Queensland University of Technology). Summaries of all case studies rated as having high impact are available on the ARC website (see https://dataportal.arc.gov.au/EI/Web/Impact/ImpactStudies).

In a research symposium presented at the MERGA 40 conference, Goos, Geiger, Bennison, Dole, and Forgasz (2017) raised some key issues in undertaking this national assessment of research engagement and impact, and proposed some approaches to evidencing engagement and impact in the context of mathematics education research. In her symposium paper, Goos (2017) argued:

> …there is surely value for mathematics educators in retrospectively analysing our own research to illuminate the opportunities taken, decisions made, and relationships built in pursuing research that makes a difference. Such an analysis might help us not only to learn "where to look" for evidence of past impact, but also to plan future research projects with an eye to demonstrating potential benefits for educational policy and practice. (p. 637)

We suggest that there may be benefits for mathematics education researchers not only in learning from the results of ARC Engagement and Impact assessments over future years, but also in learning both "where" and "how" to look at their own research to plan for and evidence its impact. In New Zealand, this more prospective approach to planning for impact is illustrated by the Teaching and Learning Research Initiative (see http://www.tlri.org.nz/home), which seeks to enhance the links between educational research and teaching practices to improve outcomes for learners. Mathematics education is well represented amongst the research projects funded by this initiative (Teaching and Learning Research Initiative, 2019). For example, one project funded in 2019/2020 investigates the use of home languages as a resource for multilingual students in learning statistical probability in two multicultural classrooms, while another aims to uncover Pasifika learners' mathematical funds of knowledge. Both these projects involve partnerships with schools that are expected to improve outcomes for learners.

A number of new research projects in Australia and New Zealand funded since the last Review provide assurance that mathematics education research will continue to contribute to the policy issues that we raise in this chapter. Over a recent 3 year period (2016–2018), over 20% of ARC Discovery projects funded in education (FoR13) were in mathematics education. In 2017, a full 35% of education projects funded were in mathematics education. The *Mathematics Education Research Journal* Special Issue (Anthony, 2018) discussed these projects, the issues they sought to address, and aimed to highlight the types and methodologies of projects that are being funded in this era of research reform. The relatively strong presence of mathematics education research has significant potential to impact the issues raised above in teacher education, STEM and research impact.

4 Conclusion

We began this chapter with an analysis of patterns we have observed in the first ten MERGA Research Reviews (RiMEA-1 through RiMEA-10) to encourage researchers in our field to consider how research in mathematics education has changed in the past 40 years. We know of no other group that has documented their research history in this way. From our long look back, we next reflected on recent changes in the landscape that we think are important for us to consider as an organisation.

Indeed, since 2015 a number of policy reforms have affected mathematics education research. The persistent reforms around initial teacher education will likely continue. This is an important area for mathematics education researchers in Australasia to examine the impacts of these reforms, including on the dwindling number of pre-service teacher education students entering with significant qualifications in mathematics. Mathematics education researchers in Australasia have already been reporting on this issue in the following chapters of this Review. We were happy to see a new chapter on STEM, perhaps following the chapter written by English (2016) at the end of the last Review. We see this as an essential area of research in our field given the poor representation of mathematics in this reform (as predicted by English). The STEM (2016, 2020) and Numeracy (2020) chapters allow us to speculate that future research may increase its emphasis on inter-disciplinary research. The new Engagement and Impact Assessment in Australia, following a similar reform in the United Kingdom, reflects the increasing pressures that policymakers place on researchers to demonstrate that their research has a direct public or commercial benefit. Given the high number of impact case studies rated as “high” in education that were from mathematics education research, we are perhaps fortunate to be in a field with close ties to schools and classrooms; but it is also undeniable that attention to research engagement and impact had been cultivated in this field over several past decades. The timing of the high number of 2017 Australian Research Council Discovery Projects funded in mathematics education was perhaps serendipitous, or possibly a reflection of policymakers’ interest in the potential of mathematics education research to positively impact society (Anthony, 2018).

We believe that each of the reforms that we have outlined in this chapter will affect the future research agendas of mathematics education researchers. We also believe that we have both an opportunity and a responsibility in mathematics education research to act and seek to influence the future set of policy reforms. We look forward to reading this volume and the reflection of the current editors in the next Review: *Research in Mathematics Education in Australasia 2020–2023.*

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