Chapter 4
Researching Curriculum, Policy and Leadership in Mathematics Education

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Abstract This chapter reviews research regarding the official mathematics curriculum and its enactment, the educational leadership to support this enactment, and the associated influential policy, such as national testing. It explores the interrelationships between inherent issues such as the potential influence of textbooks, curriculum equity, and the complexities of implementing numeracy across disciplines. Substantial research has led to the development of robust theoretical models to inform both future research and practical developments across a range of aspects of curriculum, policy and leadership. However, the seemingly diverse research perspectives are all drawn towards the teacher in the classroom as the critical context for further research.

Keywords Curriculum · Policy · Leadership

1 Introduction

In this chapter we focus on research regarding the official mathematics curriculum and its enactment, the educational leadership to support this enactment, and the associated influential policy, such as national testing. Our literature search for this

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review began with the broad topics of "curriculum", "policy" and "leadership" in mathematics education. As expected, researchers had identified issues within these topics, with clusters of studies around the policy-curriculum relationship (including national testing policy), the role of educational leadership, the potential influence of textbooks, curriculum equity, and the complexities of implementing numeracy across disciplines within the curriculum. A major goal of the review became to explore the interrelationships within and between these topics and issues.

While we acknowledge close relationships between curriculum and other enactment factors such as teacher professional development, pedagogy and assessment of student learning, this research is dealt with in other chapters of this book, and therefore not considered in depth in this chapter. Included here are studies of curriculum-related *numeracy*, in particular, the involvement of mathematical skills across other learning areas such as English and Science. We also acknowledge the importance of recent curriculum developments in early childhood education, but refer readers to Chap. 9 of this book for review of such research. Similarly, Chap. 10 is dedicated to tertiary level mathematics and so research on matters pertaining to curriculum design and implementation, and leadership in this context have been excluded. Consequently, the content of this chapter is dominated by research relevant to primary and secondary school education.

The reason for the focus of Australasian research on primary and secondary education becomes obvious when the strong influences of recent political agendas and national curricular initiatives in Australia and New Zealand are realised. Therefore this chapter begins with information about recent political-educational directions in these two countries. For background information on the preceding curriculum development or implementation phases for Australia and New Zealand, we refer readers to the curriculum chapter of the previous 4-yearly review (see Anderson, White, & Wong, 2012). As pointed out in the previous review, each country took a very different approach to initial curriculum development. New Zealand began "with a vision and principles for the whole curriculum", whereas the Australian Government began "with four subject areas including mathematics" (Anderson, White, & Wong, 2012, p. 226). The previous review also concluded that "Curriculum reform through the written or intended curriculum does not necessarily lead to reform in the enacted curriculum" (Anderson, White, & Wong, 2012, p. 238). Hence we see value in the inclusion of "leadership" in the current review. Understanding these contexts helps to reveal the complex relationships amongst policy, curriculum, educational leadership, and the teachers who are expected to bring curriculum intentions to fruition in classrooms. With the purpose of bringing some clarity to the complex system of curriculum policy, design, and enactment, this chapter is framed by a model developed by Remillard and Heck (2014)—as presented in the second section. While this model was not referred to in most of the studies reviewed here, it served as a valuable organiser for much of the chapter, and we foresee its theoretical utility for future research.

2 The Australasian Context

2.1 New Zealand

The current *New Zealand Curriculum for English-medium teaching and learning in years 1–13* (Ministry of Education) was launched in 2007 and mandated for implementation in early 2010. Underlying the curriculum are eight principles: (i) High expectations, (ii) Treaty of Waitangi, (iii) Cultural diversity, (iv) Inclusion, (v) Learning to learn, (vi) Community engagement, (vi) Coherence, and (vii) Future focus. In addition, five key competencies are identified: (i) Thinking, (ii) Relating to others, (iii) Using language, symbols and texts, (iv) Managing self, and (v) Participating and contributing. The introduction of the curriculum was soon followed by an initial evaluation of its implementation, leading to the report titled *Directions for Learning: The New Zealand Curriculum Principles, and Teaching as Inquiry* (Education Review Office [ERO], 2011). The focus of the evaluation was to "investigate how schools were using the eight principles and the teaching as inquiry process as outlined in *The New Zealand Curriculum*" (ERO, 2011, p. 1). It was found that 82 % of the schools evaluated had developed school-based curricula that reflected the principles. School leadership was found to be a significant influence, particularly in achieving the further enactment of the curriculum in classrooms. Of interest is the emphasis the review placed on the pedagogical-guidance function of the curriculum, and the importance of leadership in the realisation of curriculum aims.

The implementation of the Mathematics Curriculum component of the broader curriculum was evaluated in terms of (a) the design and review of each sample school's mathematics curriculum, (b) the use of achievement information by trustees, leaders, teachers and students, and (c) the acceleration of progress of priority learners. The published report, *Mathematics in Years 4–8: Developing a Responsive Curriculum* (Education Review Office, 2013), suggests that although some schools were highly effective in all three aspects, many schools needed increased support and leadership to achieve the curriculum implementation expectations.

2.2 Australia

Research published on school mathematics and numeracy in Australia over the past 4 years has taken place in the context of the initial implementation phase of the first *Australian Curriculum*, produced by the Australian Curriculum, Assessment and Reporting Authority (ACARA) and released in stages from 2010 to 2015. The introduction of a national curriculum has historical significance, because for the first time, the state education jurisdictions have ceded substantial curriculum responsibility to a national authority. Gerrard et al. (2013), Anderson (2014) and Stephens (2014) provide informative historical perspectives of the policy shift from state to federal responsibility for curriculum reform, leading to the release of the first

national mathematics curriculum in December 2010. It is important to note that each state and territory still holds responsibility for the implementation of the curriculum, and as pointed out by Anderson (2014), deeply held beliefs and previous practices typically produce variations in the enactment of curriculum, not only at the school level, but at system or state levels.

Some academics have questioned the political motivations and social/economic drivers that have shaped the content and inherent values in the Australian Curriculum, posing questions such as "Whose knowledge is valued? Who decides? And who benefits?" (Ditchburn, 2012, p. 268). The relevance of such questions becomes apparent when contemplating the seven *general capabilities* and three *cross-curriculum priorities* featured in the new curriculum. The general capabilities are: (i) literacy, (ii) numeracy, (iii) information and communication technology capability, (iv) critical and creative thinking, (v) personal and social capability, (vi) ethical understanding, and, (vii) intercultural understanding. The cross-curriculum priorities are: (i) Aboriginal and Torres Strait Islander histories and cultures, (ii) Asia and Australia's engagement with Asia, and (iii) sustainability (ACARA, 2015a). There are perhaps some interesting contrasts in the political orientations of the New Zealand and Australian governments to be revealed by examining the *principles*, *key competencies*, *general capabilities* and *priorities* of the two curricula.

Concerns have also been raised about the competitive "curriculum pressures" of the National Assessment Plan—Literacy and Numeracy (NAPLAN) in Australia, and publication of results on the *MySchool* website (http://www.myschool.edu.au/). These pressures, amplified by debate about school funding inequalities and political attention to ranking in international testing programs (Programme for International Student Assessment [PISA] and Trends in International Mathematics and Science Study [TIMSS]), have highlighted differences of social advantage/disadvantage in student access to the broader curriculum (Yates, 2013). Some of the issues regarding differentiation of the curriculum to support equity of learning opportunity have been investigated by researchers and are dealt with later in this chapter.

As well as attending to the mathematics content in the *Australian Curriculum: Mathematics* (ACARA, 2015b), teachers are expected to consider the teaching approaches required to develop in students the four *Proficiencies* of (i) understanding, (ii) fluency, (iii) problem-solving, and (iv) reasoning. Amongst the academics closely involved in the design of the Mathematics component of the broader Australian Curriculum are those with the optimistic view that the principles underlying its structure and presentation will provide educators with decision-making opportunities that will benefit the learning of all students (Sullivan, 2012). This view implies that teachers will take note of isolated statements, such as "It encourages teachers to help students become self-motivated, confident learners through inquiry and active participation in challenging and engaging experiences" (ACARA, 2015b), and that teachers will be able to translate this intent into specific classroom pedagogy. Some researchers argue that the pedagogical intent of the mathematics curriculum may not be communicated strongly enough to inspire the desired teaching practices (Atweh, Miller, & Thornton, 2012). Indeed, Zhang and Stephens (2013), in their study of Australian and Chinese teachers, concluded that

> effective implementation of any curriculum reform depends on teachers' subtle interpretations of official curriculum documents and their professional dispositions to act on those ideas, which go well beyond general descriptions or statements of intent that are usually embodied in official curriculum advice. (p. 499)

On another level, schools are required to attend to the development of numeracy across all learning areas (subjects)—numeracy being one of the seven cross-curricular "general capabilities". This requirement places demands on teachers from all disciplines to recognise inherent mathematics concepts and skills and incorporate their development into teaching plans, raising questions about teacher preparedness to effectively enact the numeracy development requirements. Interpreting this array of curriculum intentions, designing appropriate teaching plans and effectively implementing such plans arguably requires significant school-level educational leadership.

The implementation of new school curricula in New Zealand and Australia clearly presents a rich context for research. A substantial portion of this chapter critically explores the questions being asked by researchers and their responsiveness to the issues arising from the new curriculum context, but first we establish a framework for comprehending the relationships amongst the broad topics of policy, curriculum and leadership.

3 Relationships Amongst Policy, Curriculum and Leadership

As noted by others (e.g., Remillard & Heck, 2014), the term *curriculum* takes on different meanings around the world. It was also noted during preparations for this chapter that *curriculum* is often used in educational contexts without clarification. This lack of clarification made it difficult at times to precisely determine what was being referred to, since the term is applied to a variety of aspects comprising a broad spectrum of curriculum planning and enactment processes. Consequently, our initial search for literature was driven by the desire to establish some clarity around these aspects that might also assist in the structuring of chapter content emerging from our review. Here we present our perspectives on key constructs and processes influential in the planning, enactment and assessment of curriculum. Drawing and building upon the definitions and views of prominent researchers in the broader international field of mathematics curriculum research (e.g., Remillard & Heck, 2014; Schmidt et al., 2002) we delineate key terms and present a systematic perspective on curriculum in which research about policy, curriculum and leadership, discussed in the rest of this chapter, is situated.

The mathematics curriculum is broadly defined by Remillard and Heck (2014) "as a *plan for the experiences* that learners will encounter, as well as the *actual experiences* they do encounter, that are designed to help them reach specified mathematics objectives" (p. 707). They propose a framework that conceptualises

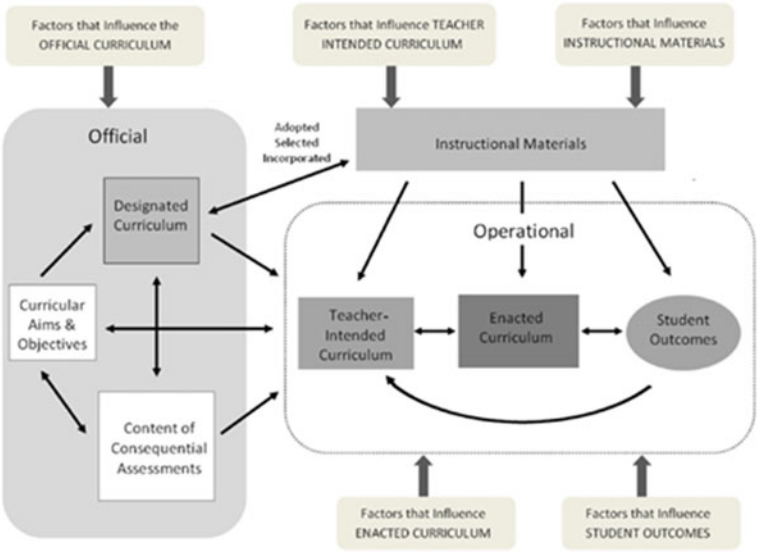

Fig. 4.1 Visual model of the curriculum policy, design, and enactment system. Remillard and Heck (2014), p. 709; Fig. 1, with permission of Springer

various curricular elements (policy, assessments, textbooks, student outcomes etc.) existing within a curriculum policy, design and enactment system (see Fig. 4.1).

The framework focuses on two components of the curriculum system. First is the *official* curriculum, specifying what should be taught. It is sometimes referred to as the "intended" curriculum (Schmidt et al., 2002). The official curriculum incorporates curriculum elements including official curriculum elaborations, curricular aims such as the achievement standards contained within the *Australian Curriculum* (ACARA, 2015a) or achievement objectives in *The New Zealand Curriculum* (Ministry of Education, 2007), and mandated assessments such as the *National Assessment Plan—Literacy and Numeracy* [NAPLAN]. It is within this domain that research relating to curriculum policy is most pertinent, as the official curriculum is heavily influenced by social, cultural and political factors—all of which are in constant flux. Herein lies a potential limitation of the Remillard and Heck (2014) model. It presents the official curriculum as absolute, rather than a more dynamic view of curriculum "in the making" that should also be informed and revised with input from experts and practitioners in mathematics and mathematics education (Kemmis et al., 2014).

The second component highlighted in Remillard and Heck's (2014) system framework is the *operational* curriculum. This component specifies what actually occurs during the enactment process—some of which exists outside the official, sanctioned curriculum. It comprises the enacted curriculum, which includes aspects of curriculum leadership, teacher development in terms of their pedagogy and knowledge, interactions between students and teachers during instruction, the tools

and resources used by teachers, and the actual mathematics presented. The enacted curriculum has the greatest potential for impacting a broad range of student outcomes—their achievement, attitudes and their motivation and engagement in mathematics (Thompson & Huntley, 2014). Hence research has mostly focused within the operational domain of the curriculum system, and particularly the enacted curriculum and student outcome components.

4 The Official Mathematics Curriculum

Two major issues regarding the *official mathematics curriculum* were identified in the research reviewed for this chapter: the official curriculum as a form of policy; and the role of student assessment and national testing in an official curriculum. A key message from the papers reviewed is that the official curriculum is a political tool, perceived as a means for ensuring the social and economic well-being of citizens and a country at large, as well as for enhancing student performance (Walshaw & Openshaw, 2011). Measurement and monitoring of student performance on a national scale is therefore a consequence of a national curriculum.

4.1 Curriculum Policy

Stephens (2014) emphasised the importance of seeing the development of an official curriculum as a socio-political process nested in political cycles of government, with curriculum development initiated as successive new governments come into power. A change in official curriculum indicates an attempt at social-political-economic change. Therefore, the curriculum embodies current imperatives and is intended to be future-focused, and reform-oriented (Anderson, 2014; Goos, Dole, & Geiger, 2012a). However, the directions chosen by the government in power at the time of curriculum development may not be in harmony with a new government's political agenda, prompting curriculum reviews as recently seen in Australia (see *Improving the Australian curriculum*, ACARA, 2015c).

A common catalyst for curriculum policy is perceived declining standards and associated declining international ranking, generated through international studies such as TIMSS and PISA. Leung (2014) warns against using country-rankings as impetus for "changes in education policies without due consideration of the nature and limitations of these studies" (p. 579). Instead, attention should be given to trends in achievement scores, differences between strands of mathematics and to the attitudes of the students (Leung, 2014). Unfortunately, it is the country-rankings that make media headlines, with attention rarely given to the informative data on variables such as curriculum, resources and instruction.

In the Australasian context, the *mathematics curriculum* is viewed as a component of the broader national curriculum. The *mathematics curriculum* refers to

both the selected mathematics content (often called the syllabus), and to the social/cultural values and pedagogical expectations communicated through the aims and principles underlying the curriculum. One of the factors specified by Remillard and Heck (2014) as an influence on the official curriculum is "Values and beliefs about mathematics and the goals of education as held publicly and by individuals and groups wielding power" (p. 714). Accordingly, the mathematics curriculum can be interpreted as a vision for the discipline (Atweh, Miller, & Thornton, 2012). The mathematics curriculum communicates its purpose and value in society, the mathematics that should be taught, the ways in which it should be taught and assessed, and the type of mathematical thinking that is important. Atweh, Miller, and Thornton (2012) critically examined the internal and external cohesiveness of the *Australian Curriculum: Mathematics*—in other words, the alignment of the broader curriculum goals (*General Capabilities* and *Cross-curricular Priorities*), mathematics *Proficiencies*, and "the rationale behind the content selection and organisation that may guide teachers and schools in their construction of their school curricula, pedagogical and assessment practices" (p. 16). They conclude that there are missed opportunities for providing teachers with sufficient guidance to achieve the goals of "inter-disciplinary approaches", "deep knowledge" and "complex problem-solving" in the intended curriculum.

Other researchers have contributed to debates about curriculum structure and content by investigating key aspects of the mathematics curriculum (such as numeracy and problem solving), looking at how the content is communicated and what mathematical knowledge is valued. For example, the focus on numeracy can be seen as reflecting the importance of social and economic well-being (Goos, Dole, & Geiger, 2012a, 2012b). It has been argued that a critical orientation to numeracy is important in developing a citizenry that is equipped for the numeracy demands of the 21st century. The inclusion of *Numeracy* as one of the General Capabilities in the Australian Curriculum suggests its importance—yet the effectiveness of its representation in each subject's curriculum (including Mathematics) has been questioned by researchers (Goos, Dole, & Geiger, 2012a, 2012b). Similarly, although Problem Solving and Reasoning are stated as two of the four *Proficiencies* permeating the new *Australian Curriculum: Mathematics*, analysis of the content descriptors reveals minimal representation of the higher order mathematical thinking depicted in the definitions of these two *Proficiencies* (Anderson, 2014; Atweh & Goos, 2011; Atweh, Miller, & Thornton, 2012). In contrast, Problem Solving is presented as the central feature and primary goal of the Singaporean curriculum (Kaur, 2014). However, in both contexts, the researchers call for more investigation of teachers' enactment of problem solving in their classrooms.

4.2 Assessment and Testing Policy

Here we refer only to national assessment imposed by policy. Chap. 11 of this book deals more broadly with research on assessment of mathematics learning. An

accountability agenda associated with curriculum policy is evident through the instigation of national assessment regimes—some testing-oriented such as *The National Assessment Program—Literacy and Numeracy* (NAPLAN) in Australia, and others standards-oriented such as *National Standards* in New Zealand. Indeed, Stephens (2014) identified national assessment and school reporting as system-level levers leading to the Australian Federal government taking greater central control of the curriculum. Although both countries have central reporting requirements for student assessment results, the approaches are very different. Australia imposes a strict testing regime for school years 3, 5, 7 and 9 and publishes school data on the public *MySchool* website. Commentary on NAPLAN, perhaps not surprisingly, dominates recent research, with very little reported about the impact of New Zealand's *National Standards* processes.

The New Zealand *National Standards* are "broad descriptions of expected achievement derived from curriculum achievement objectives" for school years 1–8 (Ministry of Education, 2011). Emphasis is placed on the value of formative assessment practices, with "the use of professional teacher judgment underpinned by assessment for learning principles rather than a narrow testing regime" (Ministry of Education, 2011). The policy is based on international research and key publications are provided for teacher professional reading, along with a range of resources, via the *Assessment Online* website. In contrast, the Australian *National Assessment Program* bypasses classroom teachers in data collection, with its purpose stated as being "the measure through which governments, education authorities, schools and the community can determine whether or not young Australians are meeting important educational outcomes" (ACARA, 2015d). National standardised tests in literacy and numeracy (NAPLAN) are administered in school years 3, 5, 7 and 9, and results are returned to schools some months later. The claimed benefits are "to help drive improvements in student outcomes and provide increased accountability for the community (ACARA, 2015d).

Concerns have been raised regarding the impact of Australian NAPLAN on teachers and students. Drawing on a survey of 8000 educators across Australia, Polesel, Rice, and Dulfer (2014) conclude that high-stakes testing has resulted in "a narrowing of curriculum, a restriction in the range of skills and competencies learnt by students and a constriction of pedagogical approaches" (p. 653). (See also the full report, Wyn, Turnbull, & Grimshaw, 2014). Contrary to the government's purported intention of supporting schools through providing data about student progress, the emphasis that has been placed on rapid gains in student performance, and the comparison of schools in terms of success or failure, has produced negative influences on the quality of learning in the majority of schools. (See Polesel, Rice, & Turnbull, 2012, for a review of literature.) However, it should be noted that some schools have more productively used NAPLAN data by analysis in conjunction with other school-based assessments to identify learning needs for both students and teachers (Polesel, Rice, & Dulfer, 2014). Hardy (2015) offers an interpretation of the difference in school responses after applying a Bourdieuian framing to the interviews of 55 participants from three Queensland primary schools. He concluded that the teachers had collectively "repurposed" the government's NAPLAN agenda

and "appropriated from solely performative and political purposes—for more educational purposes" (Hardy, 2015, p. 10). However, the capacity of most educators to effectively analyse and interpret the NAPLAN data may be a substantial barrier to many other schools.

Picking up on this issue, Chick and Pierce (2013) investigated the statistical literacy needed by government personnel, principals, and particularly teachers to interpret the results of large-scale statistical reports such as NAPLAN. Through identifying the nature of statistical knowledge needed by teachers to appropriately interpret graphical representations of data, they propose a 3-level framework for professional statistical literacy. The framework emphasises the importance of professional and local contexts, and groups the skills required to draw statistically valid conclusions under *Reading Values*, *Comparing Values*, and *Analysing the Data Set*. Chick and Pierce (2013) argue that teachers (both in-service and pre-service) need targeted professional learning to develop the required statistical understanding and critical thinking.

Other researchers have viewed the influences of NAPLAN from a social justice perspective, questioning whether the national testing policy supports the social goals of the curriculum. Lange and Meaney (2014) conducted Bernsteinian analysis of NAPLAN—that is, an analysis of the structuring of knowledge and the framing of pedagogical practice. They reflect on how "raising standards" is used as a euphemism for "social justice", and is distorted to become schools' accountability for student achievement. Children are positioned as commodities "to add value to", frequently through deficit language in the public discourse around national high-stakes testing. Lange and Meaney argue that this situation is contradictory to the purpose of mathematics education for citizenship as well as limiting what is generally understood as being numerate. A useful overview of the diversity and scope of mathematics education research associated with NAPLAN is presented in a paper by Leder (2012). She points to areas needing further investigation such as gender, Indigenous students and the needs of the highly able. The importance of considering the learning needs of particular groups of students and specific school contexts is not limited to national testing programs, but appears to extend to other national assessment approaches. Following the negotiation of a culturally responsive assessment protocol, the *Māori-medium National Standards* (New Zealand) were implemented in 2011, with a reasonably optimistic forecast for averting the anticipated negative effects of national data gathering on Maori education (Özerk & Whitehead, 2012).

Overall, commentators agree that the policy lever of high-stakes testing to increase student achievement in mathematics has a negative impact through limiting the public's understanding of the mathematics curriculum, as well as limiting what is taught in schools. There is a need for researchers to counter the drive of political leaders and policy makers for such testing regimes as NAPLAN, by providing large-scale evidence of the impact on curricula, amongst other aspects of schooling. However, there is less agreement on specific aspects of the impact of high-stakes testing and how it can be managed at different levels of the system, so targeted studies are also required to better understand specific contexts. Also lacking in the

research literature are comparative studies of the Australian and New Zealand approaches, including the cultural responsiveness of assessment programs to Indigenous students, and other groups such as recent migrants and refugees.

5 The Operational Curriculum

The operational curriculum in Remillard and Heck's (2014) framework relates to what actually occurs during the enactment process. During times of curriculum change the enactment process can be strongly influenced by the textbooks and resources used by teachers in selecting the actual mathematics being taught. One view is that the combination of the official curriculum and textbooks and resources provides opportunities for teacher development, with a view to improving learning through enhanced pedagogy and knowledge (Sullivan, 2012). However access to these opportunities relies on curriculum leadership that guides the transition from old practices to new and improved practices. This leadership can take the form of teacher leadership, principal leadership and/or system leadership (Gaffney, Clarke, & Faragher, 2014a).

Naturally, not every learner will experience the curriculum in exactly the same way. Teachers, influenced by their own knowledge and beliefs, perception of student needs, and local contexts, will transform the official curriculum through planning their *teacher-intended curriculum* (Remillard & Heck, 2014). Further transformations will occur during *instructional interactions* with students, including the *pedagogical moves* made in response to students (Remillard & Heck, 2014). Much of the research regarding instructional interactions is dealt with in the *Learning and Teaching* section of this book, but here we include studies that have focused on the redesign or differentiation of the curriculum, and scrutiny of the curriculum framed by issues of equity in its implementation. An aspect of the new Australian Curriculum that has received much attention is the enactment of *numeracy* across the range of disciplines taught in schools.

5.1 Textbooks

Textbooks and resources are usually designed to align with the official curriculum. In the Remillard and Heck framework they are considered to be *instructional materials* that often take a transitional role between the *official curriculum* and the *operational curriculum*. Frequently textbooks are revised or created in response to the advent of a new curriculum and, as Shield and Dole (2013) commented, can be a means of advancing mathematics reform in the classroom. Kaur (2014), in her article on the enactment of the mathematics curriculum in Singapore, commented that textbooks in the Singaporean setting adhere very closely to the official curriculum, and so are a critical component of teachers' enacted curriculum. However,

other education jurisdictions have considerably less influence on the development of new textbooks, highlighting the need to scrutinise their content.

Internationally, researchers have gradually developed a better understanding of the role of textbooks in operationalizing the curriculum (Fan, Zhu, & Miao, 2013). Broadly, international studies have focused on the three main areas of (a) textbook analysis, (b) the ways in which textbooks are used, and, (c) textbook comparisons (Fan, Zhu, & Miao, 2013). The main focus of recent textbook studies in the Australasian context has been to explore the potential of particular textbooks to realize the intent of the curriculum, so relate mostly to (a) textbook analysis. Various analytical models have been developed and utilised to investigate the potential of textbooks to influence the teaching and learning of mathematics. In a pro-active approach to textbook design, Debritz and Horne (2013) describe a model for developing curriculum resources that embed a guided inquiry process, with the materials intended to support teachers' interpretations of the *Australian Curriculum* and provide a starting point for curriculum planning. In another study, Shield and Dole (2013) expressed concern about the extent to which textbooks could support the development of deep and connected knowledge. They applied a framework to analyse five textbook series for middle-school mathematics and found limited support for the development of the multiplicative structures required for proportional reasoning.

Rafiepour Gatabi, Stacey, and Gooya (2012) reported a comparative study of Iranian and Australian textbooks related to problems that promote mathematical literacy. They recommended that countries adopt a framework to identify the capacity of a textbook to promote mathematical literacy, and give attention to including diversity in problem contexts. Siemon, Bleckly, and Neal (2012) also take up this call, arguing that textbooks have too many low level problems that focus on practising skills that do not advance the intent of the *Australian Curriculum*. Instead, they suggest that by focusing on connecting the "big ideas" there is an opportunity to rationalise the over-crowded curriculum.

Collectively, these studies suggest that textbooks can play an important intermediary role between the official and the operational curriculum, but they also raise concerns about the efficacy of textbooks to support teachers in realising the intended learning outcomes of the official curriculum. The variety of analytical models developed in these studies provides other researchers with tools for further investigations. However, without centralised monitoring of textbook quality in Australia, the impact of research findings on the representation of content may be limited.

5.2 Curriculum Leadership

Considerable research has also been undertaken in Australasia on teachers leading change in mathematics teaching and more specifically numeracy (e.g., see Faragher, Gaffney, & Skoss, 2014; Gaffney, 2012; Geiger, Goos, & Forgasz, 2015; Jorgensen, 2015a). These research projects have covered primary, secondary and university level mathematics across urban and remote regions and generally report changes in

teacher practice that lead the way to improved student outcomes. Moreover, the three cross-curriculum priorities in the *Australian Curriculum*, Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement with Asia, and Sustainability, each provide a wealth of opportunities for linking mathematics to other subject areas and promoting numeracy (Watson & Neal, 2012). Importantly, it has been noted across many projects that teachers are actively engaged in decision making through every step of the planning and delivery of their teaching (e.g., Sullivan, Clarke, Clarke, Farrell, & Gerrard, 2013; Jorgensen, 2012, 2015b; Miller & Warren, 2014). It is during these planning moments that teacher leaders come to the fore as they guide and support their colleagues (Hudson, Spooner-Lane, & Murray, 2013). This support can come in the form of assisting others to see the need for change, as well as facilitating the transition. However, it has also been reported that once the research team completes their project, support for teacher leaders ceases, leaving a vacuum that is often difficult to fill for other leaders within the school system (Sexton & Downton, 2014).

The search for leadership to further support the operationalisation of the curriculum is most often directed to title-holder leaders. The recent book, *Leading Improvements in Student Numeracy* (Gaffney & Faragher, 2014b) outlines the case that, for improvements to be long lasting and effective, leadership must stem from a range of sources: (a) the educational system, (b) the school principal or other title holders within the school, and (c) untitled teacher leaders. This perspective is consistent with scholarly writing in the area of educational leadership where an understanding of leadership has evolved from one synonymous with "positional authority" and the province of single individuals in those positions, to one which views leadership as an "influencing relationship" in educational settings. The latter perspective on leadership is evident in those capable of influencing others, either individually or in teams, to further student learning (Jorgensen, 2015a). The definition of leadership provided by Rost (1993) is useful because it assists in understanding leadership as "an influence relationship among leaders and collaborators who intend real changes that reflect their mutual purposes" (p. 99).

Current leadership theory is beginning to describe more comprehensively what it means to be a leader across a range of contexts. This includes being authentically "in" the group you are leading; being a champion for the group; transforming the group; and aligning the group with external expectations (Branson, 2009). Changes in the context merely change the manner by which these characteristics are enacted. In this contemporary understanding, educational leadership can and should be distributed across the entire education system (Branson, 2010). This approach to leadership ensures that all those involved in enacting the curriculum are better prepared to meet their obligations. Lamb and Branson (2015) provide a visual, Zonal Theory, representation of the possible roles for key school players in school change processes (Fig. 4.2). Important in this representation is that the actions and reactions of the principal and teachers are not independent of each other but are in fact co-constructed. Research supports the notion that a strong professional relationship between the principal and each participating teacher influences the way in which the curriculum is operationalised (Batiste, Walker, & Smeed, 2015).

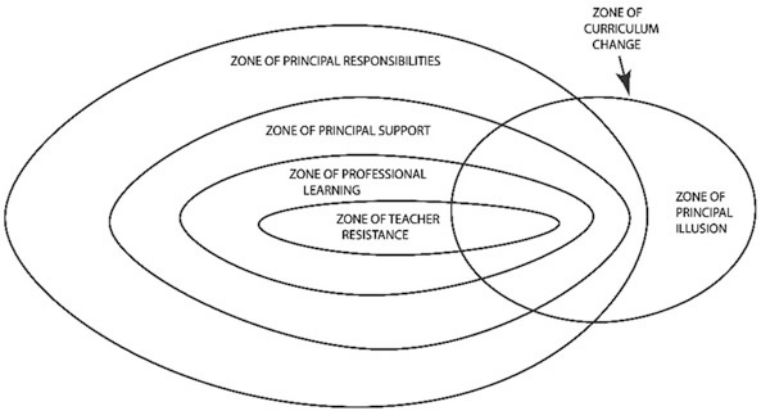

Fig. 4.2 Representation of Zonal Theory applied to introduction of curriculum change in a school. Lamb and Branson (2015), pp. 1010–1026; 21 July 2015, SAGE Publications, doi:10.1177/1478210315588840

Leadership does not stop at the school gate as system leaders have an important role to play in operationalising the curriculum (Ashhurst & Gaffney, 2014). Best outcomes for all are achieved with the alignment of thinking and practice across the education system that includes the education department, local education districts, schools and classrooms. Alignment can be strained in times of rapid curriculum change as is evident within Australia with ACARA and in New Zealand with the Education Review Office (ERO). Initial findings from a study of the introduction of the *Australian Curriculum* (English and Mathematics) reveal a lack of alignment between policy makers and schools, with "very different notions of teachers' work in relation to curriculum planning and enactment" (Gerrard et al., 2013, p. 70). There is also inconsistency in the implementation approaches across schools, with "dramatic differences in the extent to which curriculum planning is currently embedded within school processes" (Gerrard et al., 2013, p. 70). These findings resonate with the evaluation conducted by the New Zealand Education Review Office (ERO, 2011) that found much of the difference in curriculum-reform progress at the school level was due to leadership within the school. However, schools also work within a system. Mathematics education researchers are working across a range of contexts including Indigenous communities (Jorgensen, 2012; Jorgensen & Perso, 2012; Warren & Quine, 2013) with an effort to understand how systems can lead change on a large scale and how this can support the school principal to implement change within the school environment.

5.3 Curriculum Design, Differentiation and Equity

The role of language and how different languages enable individuals to engage—or not engage—with mathematical thinking, is an important theme in research

concerned with the design and enactment of the curriculum. When issues of equity are prioritised, McMurchy-Pilkington, Trinick, and Meaney (2013) argue that curriculum development can be an enabling process. The researchers contrast two iterations of mathematics curriculum development in New Zealand to reveal how it supported the revitalisation of the Maori language. They, along with Meaney, Trinick, and Fairhall (2013), describe how the development and enactment of mathematics curricula has had positive linguistic, cultural and political consequences for Indigenous language communities and recommend that the language of instruction be a consideration in future curriculum development.

Issues of equity and fairness in the curriculum also underpin Edmonds-Wathen's (2013) investigations of the challenges faced by mathematics teachers of Australian Indigenous students in remote locations of the Northern Territory. It seems that the decision to teach mathematics at a level lower than that which is officially designated as "age-appropriate" is an informed response by teachers to the learning needs of their students. While the research on the learning of mathematics by Indigenous students is discussed elsewhere in this volume (see Chap. 8), Edmonds-Wathen's findings serve to highlight the mismatch that often exists between the content contained in official curriculum and what is actually enacted in the classroom and how teachers can unwittingly work to widen the gap in achievement between various groups in the general student population. Despite the introduction of a national curriculum as an explicit attempt to provide common experiences to *all* Australian students, Jorgensen and Perso (2012) claim that "equity in provision does not guarantee equitable learning outcomes" (p. 131). They argue that a robust national curriculum is necessary in promoting high expectations and providing equitable access to mathematics for all students, but the curriculum will not be able to achieve these goals unless it is part of a multi-faceted approach.

One such approach was explored by Rampal and Makar (2012). They discuss the ideals and practicalities of embedding authenticity and cultural relevance in the primary mathematics curriculum. Using two diverse contexts—India and Australia—they highlighted how the implementation of innovative curriculum materials incorporating authentic and culturally relevant experiences familiar to students helped students connect more easily with the mathematics content. Similar to Jorgensen and Perso (2012), Rampal and Makar argue the necessity of a multi-faceted approach with united efforts from all stakeholders, including curriculum developers and providers of professional development, to achieve true curriculum reform that is both high quality and equitable.

Differentiating the enacted curriculum for students of various achievement levels is also an equity issue. Zmood (2014) outlines different drivers of high achievement and explores the main curriculum differentiation strategies schools and teachers can use with high achieving mathematics students, including acceleration, enrichment and extension experiences. She argues that teachers need strategies and resources at their disposal to enable them to maximise the mathematical potential of the most capable students. Similarly, Sullivan (2012) discusses issues surrounding some practices used by schools in their attempts to differentiate the curriculum for students demonstrating various levels of achievement. He reiterates ACARA's claim that "all

students should have access to all of the mathematics in the compulsory years" (p. 184) and is critical of "ability" streaming practices, citing past research that confirms the inequitable outcomes of such practices with only minimal or no gains for capable learners and negative attitudinal impacts for less capable students of mathematics. Sullivan continues to espouse the benefits of "extending prompts" as a teaching strategy for high achieving students (Sullivan, Mousley, & Zevenbergen, 2004). While Chap. 7 of this volume provides a closer examination of research pertaining to inclusive teaching practices in mathematics education, there was a noticeable paucity of research on the operationalization of the curriculum in classrooms that explicitly addressed the diversity of achievement and for building equitable outcomes in mathematics. For further research concerning equity in education and Indigenous education we refer readers to Chaps. 6 and 8 respectively.

5.4 Numeracy Across the Curriculum

The impetus for much of the recent research regarding numeracy has been the official *Australian Curriculum* for schools that names Numeracy as one of the *General Capabilities*. In this context, numeracy is described as

> the knowledge and skills to use mathematics confidently across all learning areas at school and in their lives more broadly. Numeracy involves students in recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully. (ACARA, 2015b)

In enacting the curriculum, teachers are expected to identify the specific numeracy demands of their discipline and design learning experiences that support application of mathematical knowledge and skills. However, there is limited information about the capacity of teachers to effectively perform these professional tasks.

Building on their previous research, Goos, Dole, and Geiger (2012b) explored the "challenges of moving from the intended outcomes framed by formal curriculum documents to the enacted practices of teaching and learning" (Geiger, Goos, & Dole, 2014, p. 489). In a series of workshops and action research cycles, ten pairs of South Australian primary and secondary teachers used the *Numeracy in the 21st Century* model (Fig. 4.3) as a basis for planning, implementing and evaluating numeracy experiences with their students.

Central to the numeracy model, depicted in Fig. 4.3, is the key element of real-life *contexts*, including work, citizenship, and personal and social contexts. Three further elements (the corners of the triangle) are the "deployment of *mathematical knowledge*, the use physical and digital *tools*, and consideration of students' *dispositions* to the use of mathematics" (Geiger, Goos, & Dole, 2014, p. 477). An important feature of the model is the embedding of the four elements in a *critical orientation* to the use of mathematical skills and concepts. Although firmly focused on numeracy development, the model captures a range of other *General Capabilities* from the Australian Curriculum, such as ICT capability, critical and creative thinking, and personal and social capability.

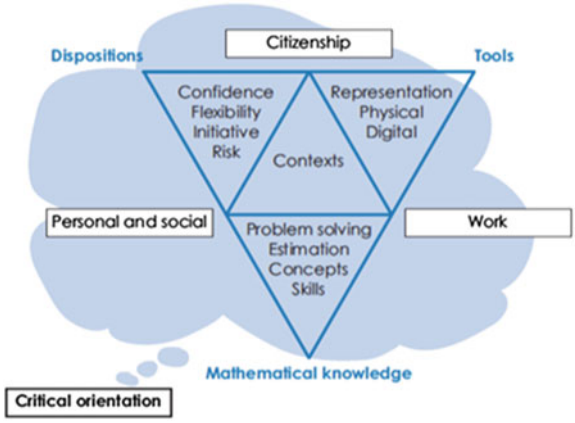

Fig. 4.3 A model for numeracy in the 21st century. Goos, Dole, and Geiger (2011); Fig. 1, with permission of Springer

The numeracy research project was strongly focused on the realities of the participating teachers' own attempts to recognise and develop numeracy within their own disciplines. Appropriately, the researchers and teachers together produced a special issue of the professional journal *Australian Mathematics Teacher* (Volume 68, Issue 1, 2012).

While the teachers increased their confidence in planning for numeracy integration, developed the use of digital tools, and influenced student dispositions, achieving the *critical orientation* in learning activities proved to be the most challenging aspect (Goos, Dole, & Geiger, 2012b). A key message is that teachers require guidance and support in planning and implementing numeracy across the curriculum—and when they receive it, rich numeracy contexts emerge that are beneficial to learners. Similarly, Callingham, Beswick, and Ferme (2015) concluded that "considerable systemic support over time is needed" (p. 559) to support teachers in decision-making about numeracy in their classrooms, particularly when they lack confidence in their own mathematical understanding. The complexity of such decision-making in the context of teacher-identity has also been highlighted through the case studies of Bennison (2015).

A potential perspective for further research is to better understand the origins of teachers' struggle with the "critical orientation" of mathematical practices within the knowledge and practices of the contextual discipline. For example, are there mismatches between ways of "knowing and doing" in Mathematics and ways of "knowing and doing" in English that create some pedagogical conflict?

6 Conclusion

The purpose of this chapter was to critically review the research pertaining to the areas of policy, curriculum and leadership in mathematics education and to explore the interrelationships between these areas. The framework for the curriculum

policy, design, and enactment system developed by Remillard and Heck (2014) proved to be highly useful in the conceptual organisation of the review. The Remillard and Heck model neatly represents the interacting components of the complex system, and supported recognition of the interrelationships amongst the seemingly disparate research directions under review. In response to the provocative context of the recent introduction of a new curriculum, both New Zealand and Australian researchers focused on aspects of the official curriculum and operational curriculum—which we grouped around the issues of: reflection of political agendas in the curriculum, national testing, textbooks, equity issues, leadership and numeracy across disciplines.

Although not entirely pessimistic, a key message from the research was a warning about inconsistencies, mismatches and tensions between the official curriculum and various aspects of the operational curriculum. For example, the timeframes and political motivations of national testing and the application of the data generated from such tests contrast with the educational motivations and shorter-term goals for assessment data of teachers. In another example, while carefully designed textbooks can be supportive of the pedagogical intent of the curriculum, other textbooks fall short in their support of aspects such as deep understanding, problem solving and reasoning. Researchers were consistent in their call for increased leadership to assist teachers in appropriate enactment of the curriculum, perhaps most importantly in making decisions about mathematics curriculum differentiation that actually achieves the desired equity goals rather than maintaining achievement differences. Similarly, non-mathematics teachers require guidance to fulfil the syllabus requirement of integrating numeracy development within their discipline areas.

While it was not the intention of this review to conduct a comparative analysis between the New Zealand and Australian curricula, comparison at a basic level served to reveal some similarities and differences that may be worthy of further investigation. For example, in comparing the principles and competencies, and capabilities and priorities of the respective curriculum documents, we see that both countries highlight cultural diversity and attention to the educational needs of their Indigenous populations, but Australia extends to an awareness of regional engagement with Asia. We know little about how these cultural themes are represented in each Mathematics curriculum, and how they are enacted in classrooms. Even allowing for different ways of expressing similar ideas (e.g., "thinking" vs "critical and creative thinking"), there are some notable inclusions and absences, such as "learning to learn" (New Zealand) and "information and communication technology capability" (Australia). How are these differing emphases reflected in the instructional practices of teachers? The New Zealand curriculum explicitly states the expectation for inquiry-based pedagogies, whereas specific teaching strategies are less clearly articulated in the Australian curriculum. We see this difference reflected in the number of Australian researchers exploring the differences between the intent of the official curriculum and the enacted curriculum in schools and individual classrooms. We also note a much stronger focus on educational leadership in operationalising the curriculum in New Zealand, from both

the government and researchers. The stronger presence of textbook-focused research in Australia also raises questions. Anecdotal evidence suggests there has been a decline in mathematics textbook use in New Zealand in recent years. If this is indeed the case, and considering that textbooks play a substantial intermediary role between the official curriculum and the operational curriculum, what now fills that role? Perhaps there is a connection to the emphasis on leadership in New Zealand.

A strength of recent research in the broad field of curriculum is the emergence of robust theoretical models with practical applications as well as research utility. In particular, the *Model for numeracy in the 21st century* (Goos, Dole, & Geiger, 2012b) shows great promise in its usefulness as a theoretical framework for further research, but also as a practical professional learning support for teachers exploring numeracy development in curriculum areas other than mathematics. Like the numeracy model, much of the research reported in this chapter has developed from earlier research noted in the previous review (see Anderson, White, & Wong, 2012). Not surprisingly, particularly in the Australian context, there is now greater emphasis on the *operational curriculum*—or rather, issues surrounding the operationalisation of the *official curriculum*. The consequential "spotlight" on the professional work of teachers highlights the incredible complexity of interpreting the official curriculum, and implementing it to serve the needs of all students. This remains a rich area of research.

As a closing comment we refer back to the Remillard and Heck curriculum system model (Fig. 4.1) and draw the reader's attention to the direction of arrows leading to, and crossing the boundary of, the *operational curriculum*. All but one arrow is uni-directional and all point inward to the teacher (and school). What then, according to this model, is the role of school and classroom research in influencing system-level and national curriculum decisions?

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