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Lifting the quality and effectiveness of mathematics education provision in English-medium schools in Aotearoa New Zealand: What will it take?

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Mathematics education in English-medium schools in Aotearoa New Zealand currently reproduces inequity. There is widespread concern about overall levels of student achievement and who participates and who succeeds. Rapid, and accelerating, social and technological change impacts what students need to know in mathematics and statistics and increases its significance. There are fundamental debates about how mathematics education should respond to inequity and rapid change. Content and pedagogy are both contested spaces. Research in mathematics education tends to exacerbate rather than resolve this contestation. In this cacophony it is hard to hear marginalised voices and yet these groups are the most impacted by current practices. Mathematics education is entwined with other curriculum areas and has far-reaching consequences; therefore, policy has to treat improving system performance as a complex problem requiring intervention at multiple levels to achieve equitable outcomes for students.

Introduction

This paper addresses the question of the Special Issue – Lifting the quality and effectiveness of education provision in Aotearoa New Zealand: What will it take? – by looking backwards before looking forwards. It looks backwards to show that this question has been haunting mathematics education for many decades, and that what it will take to improve education provision is in part understanding the current issues with mathematics education in an historical context and learning from the outcomes of past attempts at lifting quality and effectiveness. The paper argues that understanding that 'Lifting the quality and effectiveness of education provision in Aotearoa New Zealand: What will it take?' is not a new question, and it is important for finding possible ways forward.

There are three important aspects of mathematics education in Aotearoa New Zealand that this paper does not cover. Each of them needs a commentary of its own to explain them properly. The first is Māori education and mathematics, which has its own history of harm, reclamation and repositioning (McMurchy-Pilkington et al., 2013; Tweed, 2021). The second is the development of statistics education in Aotearoa New Zealand, which includes the naming of the curriculum 'Mathenatics and Statistics' and the specification of statistics education in schooling that has enhanced practice at all levels (Pfannkuch et al., 2020). Finally, I am not covering changes to senior secondary mathematics education and the role of high stakes assessment in shaping senior secondary teaching and learning (Philips, 2010). This commentary therefore focuses on the compulsory years of mathematics education in English-medium schools.

Inequity is a key challenge facing mathematics education in Aotearoa New Zealand (Hunter et al., 2019): Outcomes for Māori and Pacific learners, who are underserved by mathematics education in English-medium schools in Aotearoa New Zealand, are of central concern to policy makers, educators and researchers. This concern is sometimes expressed by focusing on 'gaps' or 'tails' in achievement for these groups (Hunter, 2022). Despite good intentions, the combined focus on underachievement and equity for ethnic groups has worked to position Māori and Pacific learners as 'bad at mathematics,' or discussed in policy as a problem that needs 'fixing' (Hunter, 2022). The National Monitoring Study of Student Achievement (NMSSA) assessment programme (https://nmssa.otago.ac.nz/) led by the Educational Assessment Research Unit (EARU) and the New Zealand Council for Educational Research (NZCER) has repeatedly found since 1997 that inequitable outcomes for children in mathematics testing can be found between low socio-economic status and high socio-economic status schools (for example, Educational Assessment Research Unit & New Zealand Council for Educational Research, 2018). Undeniably, the intersection of different sources of disadvantage, such as colonisation and racism, within successive social policies throughout our history means that Māori and Pacific people are over-represented in lower socio-economic areas. The Trends in International Mathematics and Science Study (TIMSS) assessment programme (https://tinyurl.com/6cpkec) (Rendall et al., 2020; Sutcliffe et al., 2020) data shows that the difference between Aotearoa New Zealand's high and low achievers in the 2018 cycle was the widest it has ever been since testing began in 1994 (Sutcliffe et al., 2020). In a summary of Aotearoa New Zealand's participation in international testing, the Ministry of Education concludes that "the low achievers generally come from disadvantaged backgrounds, and this has not improved over time. This extends to Pacific and ākonga Māori being impacted the most" (Ministry of Education, 2023, p. 3). Any action to lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand must address this inequity.

Looking back: What have we done to try and lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand?

> In (the new syllabus) the content of the subject has been lightened by discarding some of its mechanical formality and the result is that 'sums' will occupy less space on the timetable. An attempt has been made to bring arithmetic into more intimate relation with the needs of life. 'Social arithmetic' is given prominence, with the pupils engaging in such activities as shopping, weighing and budgeting, these being impregnated with reality because they actually go on in the daily life of the community in which the child lives. (*Nelson Evening Mail*, 1943, August 10)

This quote from 1943 describes changes to the mathematics curriculum that are remarkably similar to what we might think of as modern challenges to mathematics teaching and learning, despite eighty years having passed. Concern about the contents of the curriculum for mathematics, the way mathematics is taught, and students' achievement in mathematics has been constant in Aotearoa New Zealand since schooling began.

Development of mathematics curricula in Aotearoa New Zealand 1904-2023

The first curriculum document for Aotearoa New Zealand schools was written in 1904. Mathematics was among the subjects taught, and even then teachers were instructed to link school learning to the 'facts and needs of children's daily life' (Tearney, 2016, p. 20) and to make connections among subjects, two ideas that have endured and appear in the 2023 refreshed curriculum. In 1929 a new curriculum, described as liberal and flexible, was published (Tearney, 2016). A progressive, child-centred approach to education became even more clearly articulated during the 1930s. Aotearoa New Zealand hosted a large, international conference in 1937, focused on the progressive education ideals of thinkers such as John Dewey. Tearney (2016) summarises these progressive ideals as: 'a socially relevant curriculum, a child-centred pedagogy ... more capable of meeting individual needs' (p. 24), which again are present in the 2023 curriculum draft. In 1937, the proficiency examination was abolished and 'social promotion,' where students no longer needed to pass a test to move up a year level, increased the number of students engaging with mathematics (Openshaw & Walshaw, 2010a, 2010b). From 1943, the curriculum was developed through a rolling review process. Beeby, a key figure in post-war education approaches, was appointed Director of Education in 1940. During this period the progressive ideals of the Department of Education clashed with public perceptions of decline in standards, beginning the core debate in mathematics education that continues today (Openshaw & Walshaw, 2010a). An integrated, understanding-oriented, child-centred curriculum in mathematics and mastery of the fundamentals of arithmetic and formulae were set up as opposites and this debate has ebbed and flowed ever since, peaking in the late 1950s and 1970s (Openshaw & Walshaw, 2010b).

Between 1989 and 2023 there have been three national curriculum revision processes, with mathematics curricula promulgated in 1992, 2007 and 2023. In each case there was a period of consultation and discussion, draft, and development prior to the release of the official curriculum, accompanied by critique of who is involved, how the voices of teachers are included in the conversation and the process of development (Walshaw & Openshaw, 2011). In 1992 and 2007 the consultation and initial development of the curriculum largely took place under second or third term Labour governments, while the implementation of the curriculum happened under National governments. In 2021-2022, the latest iteration has also been developed under a second-term Labour government, with an election pending in October 2023. Other initiatives, strategies, reports, and resources surround these three core documents (McChesney, 2017).

Mathematics in the New Zealand Curriculum (Ministry of Education, 1992) introduced the idea of achievement outcomes, eight levels covering all of schooling, and a strand structure. A key feature was the inclusion of mathematical processes – logic and reasoning, communication and problem solving – as a strand, to be woven into all the other content areas (number, algebra, measurement, geometry, and statistics and probability). The introduction of mathematical processes echoed developments in the United States, where the National Council of Teachers of Mathematics had released their 1989 report 'Everybody Counts,' a document that shaped mathematics education practices in many parts of the world (Walshaw & Openshaw, 2011). This curriculum document was more detailed than previous curricula and took the form of a large book, replacing two slim volumes. The increased specificity in mathematics in the New Zealand Curriculum was seen by some as evidence of neo-liberal ideals working their way into the curriculum space (Chapman, 2004), with economic competitiveness as the motivation for improving mathematics (Walshaw & Openshaw, 2011).

In 2007 the New Zealand Curriculum (NZC) (Ministry of Education, 2007) was released. From a substantial book in 1992, the mathematics and statistics part of the curriculum was reduced to an 'essence statement' and a list of broad outcomes for each curriculum level. For the first time, the curriculum area was called 'Mathematics and Statistics' rather than just 'Mathematics.' Eight levels remained, but the six strands become three: number and algebra, geometry and measurement, and statistics. Mathematical processes were no longer presented as a strand. Instead a 'stem' placed at the top of all the achievement objectives framed the content as being contextualised meaningfully, and promoting mathematical and statistical thinking through solving problems and modelling situations (Ministry of Education, 2007). Overall, the NZC (Ministry of Education, 2007) was intended to provide more autonomy for schools by being less dense and specific about what needed to be taught, as well as following international trends towards skills-based and learner-centric curricula that promoted local decision making about what was important to teach, and inquiry-based modes of learning (Priestley & Sinnema, 2014). Morrow, Rata, and Evans (2022), and to a lesser extent, Priestley and Sinnema (2014), describe this shift as removing knowledge of mathematics from the curriculum.

In 2023, the draft statement for Mathematics and Statistics was released in draft for trial usage (Ministry of Education, 2022). In line with the other curriculum areas in Te Mātaiaho (the refreshed Aotearoa New Zealand curriculum) (Ministry of Education, 2022), the Mathematics and Statistics curriculum is presented in five phases, rather than the previous eight levels, and is divided into 'understand,' 'know,' and 'do.' For mathematics and statistics this means that the content 'strands' from previous curricula appear in the 'know' column, separated into six areas: number, algebra, measurement, space, statistics, and probability. The mathematical processes return explicitly to the curriculum in the 'do' column, where they are seen as practices, or ways of 'doing' in mathematics and statistics. The practices in the draft document are: investigating situations, representing situations, connecting situations, generalising findings, and explaining and justifying findings.

Initiatives to improve mathematics education

Looking at the pattern of curriculum development, elaboration through additional initiatives and resources and then review and reform, a notable pattern emerges. While the curriculum describes what should be learned and when, in both 1992 and 2007 it was supplemented, and sometimes overcome, by additional initiatives and their associated 'curriculum adjacent' resources (McChesney, 2017). These additional initiatives were in part a response to Trends in International Mathematics and Science Study (TIMSS) testing, which publicly ranks Aotearoa New Zealand's performance in Mathematics and Statistics against other participating countries (Bobis et al., 2005). For the 1992 curriculum the initiative was the Numeracy Development Project (NDP) (Bobis et al., 2005). For the 2007 curriculum the initiative was National Standards (the Education (National Standards) Amendment Act (2008)).

The Numeracy Development Project took up one approach to lifting the quality and effectiveness of education provision: providing more research-based detail for teachers about student learning, and upskilling teachers in mathematics concepts and mathematics pedagogies (Higgins & Parsons, 2011). The National Standards initiative took a different approach to lifting the quality and effectiveness of education provision: increased accountability for teachers through reporting student progress against the new standards to the Ministry of Education and boards of trustees using a formal process, and the

language 'well below standard,' 'below standard,' 'at standard,' and 'above standard.' Both approaches – more detail and support, and more accountability – were borrowed from overseas jurisdictions and adapted for use in Aotearoa New Zealand (Bobis et al., 2005; Clark, 2010). On the measures used by policy makers, neither worked to improve either the overall achievement level of ākonga (students), or to reduce the inequity present in the system (Young-Loveridge, 2009; Ministry of Education, 2020; Sutcliffe at al., 2020).

Both initiatives also shaped the curriculum offered to primary school children. At the centre of the Numeracy Development Project were three elements: a framework that outlined key knowledge and strategies using 'stages' to describe learner progress in thinking (the Number Framework), a diagnostic interview (eventually used to assign stages to learners but designed as a professional learning tool for teachers), and a teaching model, based on the work of Pirie and Kieren (1989), which promoted a recursive path from concrete materials, to imaging materials in the mind, to using numbers and abstractions (Hunter, 2016; Higgins & Parsons, 2011). Thus, the NDP provided teachers with content, pedagogy and assessment tools related to number concepts, and became a proxy for the primary curriculum between 2001 and 2010 (McChesney, 2017), effectively narrowing the mathematics curriculum experienced by ākonga. The National Standards had a similar impact, but across the curriculum, rather than in mathematics itself (Bonne, 2016). Having National Standards for Literacy and Mathematics, that were associated with high stakes reporting, meant that schools and teachers narrowed the curriculum they offered to focus on literacy and mathematics. In 2016, two-thirds of teachers responding to a national survey reported narrowing the curriculum they offered in response to National Standards demands, while 40% of principals responded that focusing on literacy and mathematics was reducing the attention given to other curriculum areas (Bonne, 2016, p. 1).

Since 1992, alongside the curriculum documents, the Numeracy Development Project, and the National Standards there have been a raft of other government-initiated actions to try and lift the quality and effectiveness of mathematics education in Aotearoa New Zealand:

- strategy development (1997: Mathematics and Science Taskforce, 1998: Literacy and Numeracy Strategy; 2022: Literacy, Communication and Mathematics strategy)
- legislation (2000: changes to the National Administration Guidelines to prioritise literacy and numeracy; 2008: Education (National Standards) Amendment Act 2008)
- evaluation and commissioned reports (for example, 2018: Teaching Strategies that Work: Mathematics (Education Review Office, 2018); 2020: Progress and achievement in the context of mathematics and statistics learning in New Zealand (English-medium education) (Ministry of Education, 2020), 2021: Pāngarau Mathematics and Tuanga Statistics in Aotearoa New Zealand (Royal Society Te Apārangi, 2021))
- professional learning programmes (2000-2010: Numeracy Development Project; 2008-2023: Developing Mathematics Inquiry Communities; 2021-2023: Just In Time mathematics)
- programmes for students (2010: Accelerating Learning in Mathematics; 2012: Mathematics Specialist Teachers initiative)

- resource development (1999: Assessment Resource Banks commissioned; 2007: Best Evidence Synthesis – Mathematics (Anthony & Walshaw, 2007); 2011: Development of the Learning Progression Framework and Progress and Consistency Tool; development of the nzmaths website).

As noted above, none of these actions have significantly improved performance on international comparative tests, or reduced inequity in mathematics outcomes (Young-Loveridge, 2009; Ministry of Education, 2020).

Looking forward: What could we do now to try and lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand?

Education systems are complex (Davis & Sumara, 2012). A complex view of the education system contrasts with a view of the education system as complicated. A complicated system can be hard to understand, but ultimately pieces can be taken out or added, and predictable changes will happen. A complex system cannot be understood just by looking at its parts. Interactions within a complex system are non-random, but also non-linear, meaning that outcomes from a complex system are unpredictable. An example of a complex system is the weather, and an example of a complicated system is a jet aeroplane (Cilliers, 1998). Many mathematics education initiatives are based on the idea that mathematics education is complicated, rather than complex (Davis et al., 2012). A complex view of mathematics education suggests a different approach to thinking about lifting the quality and effectiveness of the mathematics education system (Davis et al., 2012).

Complex systems have special features that need to be considered when trying to lift the quality and effectiveness of mathematics education provision. As can be seen from the brief history above, the outcomes of interventions in complex systems are unpredictable. Large interventions can have small impacts; small interventions can result in large impacts (Byrne & Callaghan, 2013). All the parts of complex systems are interdependent and connected (Mason, 2008). Student factors, teacher factors, school factors, community factors, social factors and policy factors are mutually constituted and interact in unpredictable ways (Byrne, 1998). Complex systems are emergent (Davis & Sumara, 2006; Osberg & Biesta, 2007) and over time, patterns can be seen, rather than linear cause-and-effect relationships (Byrne & Callaghan, 2013). These patterns can point to conditions that are associated with positive change or suggest non-linear mechanisms that might support change within these conditions (Cochran-Smith et al., 2014), but they cannot be used to predict outcomes.

The inherent unpredictability of emergence from a complex system makes knowing the outcome of an intervention impossible (Osberg & Biesta, 2007). However, the history of a system is important in understanding its functioning (Davis & Sumara, 2006). Therefore, using the history of the mathematics education system outlined above, this section outlines three emergent patterns that could suggest ways forward for lifting the quality and effectiveness of mathematics education provision in Aotearoa New Zealand. These are: listening to local voices, depoliticising mathematics education decisions, and considering how our progressive education past impacts the way we see mathematics learning and teaching.

Listening to local voices

The two large-scale policy interventions in mathematics education outlined above – the Numeracy Development Project and National Standards – followed international trends (Bobis et al., 2005; Clark, 2010). Neither served Māori and Pacific learners, or learners in low socio-economic areas, well (Bobis et al., 2005; Ministry of Education, 2020). In the case of the NDP for example: "students at schools in higher socio-economic areas started the project at higher framework stages and made larger gains … than did students in low and medium socio-economic areas" (Bobis et al., 2005, p. 47). In fact, "the project did not narrow the 'achievement gap' as hoped, but instead widened the gap slightly" (Bobis et al., 2005, p. 47).

To lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand we should listen to the voice of Māori and Pacific scholarship in mathematics education, and to the voices of Māori and Pacific communities and learners. In addition, we should seek to better understand the ways in which material poverty impacts the learning of mathematics in our context. Future interventions should be developed in partnership with impacted groups and use local knowledge alongside international information to make context-appropriate choices. The development of Te Mātaiaho in 2022 is an example of this way of working. At the heart of the refreshed curriculum, Te Mātaiaho is a whakapapa framework, gifted to the curriculum by Dr Wayne Ngata (https://curriculumrefresh.education.govt.nz/te-mataiaho). This whakapapa embeds all learning in a connected, place-based worldview that supports and challenges mathematics education. The draft Mathematics and Statistics curriculum statement sits within this whakapapa, and links to it. Te Mātaiaho adds a dimension to mathematics teaching and learning in Aotearoa New Zealand that is of this place and has potential to suggest new ways forward for system change.

One common mathematics teaching practice in Aotearoa New Zealand has been identified as particularly problematic: grouping learners by 'ability' (Rubie-Davies, 2015; Anthony et al., 2016; Hunter et al., 2019; Tokona te Raki, 2022). There are two reasons why grouping learners this way leads to low and slow progress in mathematics. First, teachers' expectations of learners are critical to their progress (Rubie-Davies, 2015) so low expectations means low progress. Second, once you are in a 'low' group, your learning experiences deviate from those of the 'top group' by a widening margin as schooling progresses (Young-Loveridge, 1991). This process has been shown to systematically disadvantage Māori and Pacific students (Rubie-Davies, 2015, Hunter et al., 2019; Tokona te Raki, 2022). The *Kōkirihia* report from Tokona te Raki in 2022 presents a plan for removing streaming from schools in Aotearoa New Zealand. This collaboratively-written report sets out a pathway to de-streaming teaching in Aotearoa New Zealand that is authored by Māori and uses Mātauranga Māori to propose alternatives and ways forward. Mathematics is central to de-streaming efforts because it is often taught in 'ability groups' in primary schools, and in streamed classes in secondary schools (Hunter et al., 2019; Rubie-Davies, 2015). Serious engagement with ending streaming in mathematics throughout schooling, and working on equitable and productive alternatives, is a way of listening to local voices that could lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand.

Depoliticising mathematics education decisions

Close observation of the history of mathematics education in Aotearoa New Zealand since the introduction of national and international benchmark testing in the 1990s suggests

that test results trigger political responses. These responses form layers of strategies, resources and policies that build up over time to create a confused landscape for schools and teachers (McChesney, 2017). Tools that were designed for one purpose come to be used for other purposes (for example, the Progress and Consistency Tool, the Learning Progression Framework, and the diagnostic interview in the Numeracy Development Project). Documents that were designed for other purposes start to function as curriculum (for example, the Numeracy Development Project, National Standards) (McChesney, 2017). Professional learning for teachers and support for students also change in response to policy and strategy. These examples are the result of political responses to perceptions of failure in mathematics education.

Looking back to the history of mathematics education in Aotearoa New Zealand, we can see that many of the debates in mathematics education are actually cyclical and recurrent, and can be characterised as a tussle between a narrative of decline and a narrative of defence (Openshaw & Walshaw, 2010a; 2010b). The narrative of decline is associated with a set of positions about what mathematics should be learned, and how mathematics should be taught that are lined up in opposition to the matching positions of those who defend practice. When responses to mathematics education performance are political, these positions become more polarised. Schools, teachers and ākonga are in the middle of this tussle and, each time change is made, must adjust their priorities and ways of working. The clearest example of this is the implementation of National Standards, where a change of government led to National Standards being mandated over the top of a curriculum document with a different underpinning philosophy. The removal of National Standards in 2018 created a new set of challenges for schools.

If politicians, the Ministry of Education, mathematics educators and communities could together derive an evidence-based pathway for mathematics education and commit to it for a sustained period, including providing resources and professional learning, together they could lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand.

Considering our past

Despite two large interventions (NDP and National Standards), associated smaller initiatives, and a range of reports and evaluations (for example, the Best Evidence Synthesis (Anthony & Walshaw, 2007); New Zealand Initiative (Patterson, 2015); Education Review Office, 2018; Royal Society Te Apārangi, 2021), mathematics education outcomes, and inequities, have remained static on national and international measures (Educational Assessment Research Unit & New Zealand Council of Educational Research, 2018; Rendall et al., 2020; Sutcliffe et al., 2020). Complexity theory suggests that the initial conditions of the system set parameters for its functioning, and continue to influence emergence over time (Byrne, 1998). Suggestions for change often focus on changing current conditions, for example, teacher knowledge, resourcing, curriculum content, messages about pedagogy, and time spent teaching mathematics (Royal Society Te Apārangi, 2021). Alongside consideration of current conditions, thinking about how our past in Aotearoa New Zealand shapes our assumptions and practices might help provide useful insights for change. The discussion of streaming above is an example of this, where a taken-for-granted approach is being questioned and dismantled. Aotearoa New Zealand's history of colonisation, the role of schooling in our society, the assumptions and frameworks underpinning a progressive approach to mathematics education, and the ways in which our expectations are shaped by messages from the past are examples that

deserve further thought. These suggestions seem a long way from day-to-day interaction in classrooms, but they may contain insights that could lift the quality and effectiveness of mathematics education provision in Aotearoa New Zealand.

Conclusion

There is no clear cut, obvious way forward for mathematics education in English-medium schools in Aotearoa New Zealand, but there are persistent and troubling inequities that we need to address. This commentary suggests that understanding what has happened in the past and knowing that some of the issues we face are a modern version of long-term debates can help us make decisions about the future that are balanced and wise. Faced with inequity, and in a world where mathematics is an important tool for solving pressing issues, everyone in mathematics education – at all levels of our system – needs to engage with listening, learning, and making long-term change that has ākonga engagement and success in mathematics at its heart.

References

Anthony, G., Hunter, R., & Hunter, J. (2016). Whither ability grouping: Changing the object of groupwork. In B. White, M. Chinnappan & S. Trenholm (Eds.). *Opening up mathematics education research (Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia*). MERGA. https://files.eric.ed.gov/fulltext/ED572400.pdf

Anthony, G., & Walshaw, M. (2007). Effective pedagogy in mathematics/pāngarau: Best evidence synthesis iteration. https://www.educationcounts.govt.nz/publications/series/2515/5951

Bobis, J., Clarke, B., Clarke, D., Thomas, G., Wright, R., Young-Loveridge, J., & Gould, P. (2005). Supporting teachers in the development of young children's mathematical thinking: Three large scale cases. *Mathematics Education Research Journal, 16*, 27-57. https://doi.org/10.1007/BF03217400

Bonne, L. (2016). *National standards in their seventh year*. New Zealand Council for Educational Research. https://www.nzcer.org.nz/system/files/NZCER%20National%20Standards%20Report.pdf

Byrne, D. (1998). *Complexity theory and the social sciences: An introduction*. Routledge. https://doi.org/10.4324/9780203003916

Byrne, D., & Callaghan, G. (2013). *Complexity theory and the social sciences: The state of the art*. Routledge. https://doi.org/10.4324/9780203519585

Chapman, D. (2004). Curriculum: Sitting on a fault line. *New Zealand Journal of Teachers' Work, 1*(2), 74-79.

Cilliers, P. (1998). *Complexity and postmodernism: Understanding complex systems*. Routledge.

Clark, J. (2010). National standards: Are they up to standard? *New Zealand Journal of Teachers' Work, 7*(1), 15-28.

Cochran-Smith, M., Ell, F., Ludlow, L., Grudnoff, L., & Aitken, G. (2014). The challenge and promise of complexity theory for teacher education research. *Teachers College Record, 116*(6), 1-38. https://doi.org/10.1177/016146811411600407

Davis, B., & Sumara, D. (2006). *Complexity and education: Inquiries into learning, teaching, and research*. Routledge.

Davis, B., & Sumara, D. (2012). Fitting teacher education in/to/for an increasingly complex world. *Complicity, 9*(1), 30-40. https://doi.org/10.29173/cmplct16531

Davis, B., Sumara, D., & D'Amour, L. (2012). Understanding school districts as learning systems: Some lessons from three cases of complex transformation. *Journal of Educational Change, 13*, 373-399. https://doi.org/10.1007/s10833-012-9183-4

Educational Assessment Research Unit & New Zealand Council for Educational Research. (2018). *Mathematics and statistics 2018 – Key findings. Report 19*. https://nmssa-production.s3.amazonaws.com/documents/2018_NMSSA_MATHEMATICS.pdf

Education Review Office. (2018). *Keeping children engaged and achieving in mathematics*. https://ero.govt.nz/our-research/teaching-strategies-that-work-mathematics

Higgins, J., & Parsons, R. (2011). Improving outcomes in mathematics in New Zealand: A dynamic approach to the policy process. *International Journal of Science and Mathematics Education, 9*, 503-522. https://doi.org/10.1007/s10763-011-9275-2

Hunter, J. (2006). The numeracy project: Foundations and development. *ACE papers, 17*. https://hdl.handle.net/2292/25161

Hunter, J. (2022). Challenging and disrupting deficit discourses in mathematics education: Positioning young diverse learners to document and share their mathematical funds of knowledge. *Research in Mathematics Education, 24*(2), 187-201. https://doi.org/10.1080/14794802.2022.2088607

Hunter, J., Hunter, R., & Anthony, G. (2019). Shifting towards equity: Challenging teacher views about student capability in mathematics. *Mathematics Education Research Journal, 32*, 37-55. https://doi.org/10.1007/s13394-019-00293-y

Mason, M. (Ed.). (2008). *Complexity theory and the philosophy of education*. Wiley-Blackwell. https://ztcprep.com/library/TESOL/Complexity_Theory_and_the_Philosophy_of_Education/Complexity_Theory_and_the_Philosophy_of_Education_(www.ztcprep.com).pdf

McChesney, J. (2017). Searching the New Zealand curriculum landscape for clarity and coherence: Some tensions in mathematics and statistics. *Curriculum Matters, 13*, 115-131. https://doi.org/10.18296/cm.0025

McMurchy-Pilkington, C., Trinick, T., & Meaney, T. (2013). Mathematics curriculum development and indigenous language revitalisation: *Contested spaces. Mathematics Education Research Journal, 25*(3), 341-360. https://hdl.handle.net/2292/27912

Ministry of Education. (1992). *Mathematics in the New Zealand Curriculum*. Learning Media.

Ministry of Education. (2007). *The New Zealand Curriculum*. Learning Media.

Ministry of Education. (2020). *Progress and achievement and the context of mathematics and statistics learning in New Zealand (English-medium education)*. Ministry of Education.

Ministry of Education. (2022). *Te Mātaiaho: The refreshed New Zealand curriculum*. Te Poutāhū Curriculum Centre. https://curriculumrefresh.education.govt.nz/te-mataiaho

Ministry of Education. (2023). A short synthesis of findings from our large education studies. https://www.educationcounts.govt.nz/__data/assets/pdf_file/0015/221073/A-short-synthesis-of-findings-from-our-large-education-studies.pdf

Morrow, N., Rata, E., & Evans, T. (2022). The New Zealand mathematics curriculum: A critical commentary. *STEM Education, 2*(1), 59-72. https://doi.org/10.3934/steme.2022004

Openshaw, R., & Walshaw, M. (2010a). What can we learn from history? The early post-World War Two debate over literacy and numeracy standards, 1945-1962 in perspective. *New Zealand Journal of Teachers' Work, 7*(2), 125-142.

Openshaw, R., & Walshaw, M. (2010b). Literacy, numeracy and political struggle: The National Standards initiative in context. *New Zealand Journal of Educational Studies, 45*(2), 99-105.

Osberg, D., & Biesta, G. (2007). Beyond presence: Epistemological and pedagogical implications of 'strong' emergence. *Interchange, 38*(1), 31-51. https://doi.org/10.1007/s10780-007-9014-3

Patterson, R. (2015). *Un(ac)acountable. Why millions on maths returned little*. The New Zealand Initiative. https://www.nzinitiative.org.nz/reports-and-media/reports/unaccountable-why-millions-on-maths-returned-little/document/20

Pfannkuch, M., Wild, C., Arnold, P., & Budgett, S. (2020). Reflections on a 20-year statistics education research journey 1999-2019. *SET, 1*, 27-33.

Philips, D. (2010). Curriculum and assessment policy in New Zealand: Ten years of reforms. *Educational Review, 52*(2), 143-153. https://doi.org/10.1080/713664034

Pirie, S., & Kieren, T. (1989). A recursive theory of mathematical understanding. *For the Learning of Mathematics, 9*(3), 7-11.

Priestley, M., & Sinnema, C. (2014). Downgraded curriculum? An analysis of knowledge in new curriculua in Scotland and New Zealand. *The Curriculum Journal, 25*(1), 50-75. https://doi.org/10.1080/09585176.2013.872047

Rendall, S., Medina, E., Sutcliffe, R., & Marshall, N. (2020). *TIMSS 2018/19: Mathematics Year 5*. Ministry of Education. https://www.educationcounts.govt.nz/publications/schooling/timss-201819-mathematics-year-5

Royal Society Te Apārangi. (2021). *Pāngarau mathematics and tauanga statistics in Aotearoa New Zealand*. Royal Society Te Apārangi.

Rubie-Davies, C. (2015). *Becoming a high expectation teacher: Raising the bar*. Routledge.

Sutcliffe, R., Marshall, N., Rendall, S., & Medina, E. (2020). *TIMSS 2018/19: Mathematics Year 9*. Ministry of Education. https://www.educationcounts.govt.nz/__data/assets/pdf_file/0007/205693/TIMSS-2018-Year-9-Mathsb.pdf

Tearney, F. (2016). *History of education in New Zealand*. McGuinness Institute. https://www.mcguinnessinstitute.org/wp-content/uploads/2016/08/20161213-Working-Paper-2016%EF%80%A203-History-of-education-in-New-Zealand.pdf

Tokona te Raki. (2022). *Kōkirihia: The plan for removing streaming from our schools*. Tokona te Raki. https://tokona-wp.s3.amazonaws.com/uploads/2022/12/Ko%CC%84kirihia-Final-1.pdf

Tweed, B. (2021). The doing of curriculum mathematics: The case of an Indigenous Māori school in Aotearoa/New Zealand. *British Journal of Sociology of Education, 42*(5-6), 914-931. https://doi.org/10.1080/01425692.2021.1941764

Walshaw, M., & Openshaw, R. (2011). Mathematics curriculum change: Parliamentary discussion over the past two decades. *Curriculum Matters, 7*, 8-25. https://doi.org/10.18296/cm.0128

Young-Loveridge, J. (1991). *The development of children's number concepts from ages five to nine: Early mathematics learning project: Phase 2 Volume 1: Report of findings*. University of Waikato.

Young-Loveridge, J. (2009). A decade of reform in mathematics education: Results for 2009 and earlier years. In *Findings from the New Zealand Numeracy Development Projects 2009*. Learning Media. https://nzmaths.co.nz/sites/default/files/Numeracy/References/Comp09/NumeracyCompendium09.pdf

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