

Early **Education**



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- *Reo Rua Pukapuka Pikitia: Strategies for developing Te Reo Rangatira*
- *Talanoa, vā and picturebook pedagogy to support Pacific identities in a kindergarten setting*
- *Using social stories as an intentional teaching strategy*
- *Children's mental health in the context of the COVID-19 pandemic*
- *Exploring the current climate of mathematics in early childhood education*
- *A data-informed look at sustained shared thinking*





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Early Education welcomes:

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Exploring the current climate of mathematics in early childhood education

Karen Mackay and Linda Clarke

Introduction

In early childhood, mathematics is viewed as being everywhere throughout the curriculum, yet children continue to enter school with varying degrees of mathematical thinking (Ministry of Education, 2022a). Research highlights that when children are confident and competent in mathematics, they are more successful throughout their education and, as adults, have more employment opportunities and can positively contribute to society from an economic perspective (Ministry of Education, 2022a). It is important that as teachers we get it right as early childhood is an optimal time for children to develop positive mindsets towards mathematics (MacDonald & Murphy, 2021). There is a significant amount of research that signals that early competence in mathematics positively impacts competence at school and into adulthood (Duncan et al., 2007).

Specifically, Duncan et al. found competence in mathematical learning at school entry also positively impacted children's reading confidence and competence through middle school alongside their maths skills. In the recently released Literacy & Communication

and Maths Strategy significant concerns are highlighted as to whether learners in New Zealand are likely to become confident and competent in mathematics (Ministry of Education, 2022a). One area identified in this strategy to focus on is professional development to strengthen teachers' content knowledge alongside the introduction of progress tools to foster the progression of children's mathematical learning (Ministry of Education, 2022a). Examination of empirical mathematical research reveals the limited availability of quality research available to inform teacher content knowledge from a professional development perspective, particularly within a New Zealand context (Linder & Simpson, 2018; MacDonald & Murphy, 2021). Alongside strengthening teachers' content knowledge through professional development other key areas need to be addressed to support all children to enter school confident and competent in mathematics (Ministry of Education, 2022a). Of particular importance is a focus on assessment as teachers notice, recognise and respond to the progression of children's mathematical learning. This article is intended to provide leaders and teachers with a critical lens on the current climate of children's mathematical learning in Aotearoa New Zealand alongside

information and practical ideas about fostering children's mathematical learning in ECE.

What does maths look like within ECE in Aotearoa New Zealand?

Within an Aotearoa New Zealand context, there is a range of terms used related to mathematics, including numeracy. Numeracy has often been attributed to a focus on numbers, however, the recent Literacy & Communication and Maths Strategy describes numeracy in a more broad sense as “encompassing the knowledge, skills and behaviours that are needed to be able to use mathematics and statistics purposefully in a wide range of situations including real-life contexts” (Ministry of Education, 2022a, p. 21). Incorporated within Te Kāhano and Te Whāriki online, six mathematics strands are highlighted, including pattern, counting, locating, measuring, sorting and shape (New Zealand Government, n.d). However, McChesney (2017) cautions against a narrow focus on only six strands, describing how this limits the possibilities for mathematics within early childhood, reminding us that the original intent behind Te Kāhano was to provide a broad perspective of mathematics (2017).

Mathematics is evident in the early childhood curriculum Te Whāriki (Ministry of Education, 2017) specifically within the Communication and Exploration strands and resources such as Te Kāhano and Mathematics Pāngarau (Book 18 of Kei Tua o te Pae, Ministry of Education, 2004). Like all resources, Te Whāriki, Te Kāhano and Pāngarau are reliant on teachers having the skills and support to be able to transfer the information within the resources to teaching practice, through daily interactions with children. Teachers' interactions are an integral part of a maths-rich environment and Torbeyns et al. (2021) remind us that although maths can be viewed as being everywhere, it is only when teachers intentionally highlight the mathematics within an experience or activity with and alongside children that it truly comes to life. Research suggests that some teachers find it challenging

to confidently explore mathematical concepts and extend children's mathematical thinking.

What are the challenges teachers face?

Teachers' own educational experience of maths, as well as their values, beliefs, content knowledge and competence in mathematics, have been identified as impacting teaching and children's opportunities to effectively learn mathematics (Education Review Office, 2016; Knaus, 2017). In Knaus's (2017) Australian study, 18 out of the 21 teachers involved reported a lack of confidence and knowledge of the mathematical curriculum in early childhood. Teachers' confidence and limited mathematical content knowledge mean opportunities to extend children's mathematical learning are not utilised to their fullest (Ministry of Education, 2022a). Research that has sought to find solutions for these challenges includes a New Zealand teacher-led research project (Haynes et al., 2007), which found that increasing teachers' content knowledge led to a positive disposition towards extending mathematical learning in early childhood. Other research highlights that having time for pedagogical discussion contributes to deeper knowledge and skills (Whyte et al., 2018). While increasing teacher knowledge and skills seems like a logical solution to more effective mathematics pedagogy, a key issue is that there is a disparity across the Aotearoa New Zealand early childhood sector in relation to sufficient 'non-contact time' for teachers to engage in pedagogical discussion. As noted, “ERO finds that there are insufficient tools and support resources to lift teacher knowledge and practice in early learning settings. It highlights the importance of professional learning and development (PLD) and effective pedagogical leadership” (Ministry of Education, 2022b, p. 9).

The importance of overcoming the challenges

Recognising the challenges teachers face in delivering a curriculum that supports quality mathematics learning for all children, the Ministry of Education released the Literacy & Communication and Mathematics Strategy in March 2022 with a vision “to deliver equity and excellence in literacy & communication and maths teaching and learning” (Ministry of Education, 2022a, p. 5). This strategy is holistic in its intent encompassing early childhood through to secondary education. The impetus for this strategy is the ongoing decline of New Zealand's achievement levels compared to learners overseas (Ministry of Education, 2022a, b). From an early childhood perspective, the Ministry of Education identified that there is limited data and research focused on children's mathematical learning and progression (Ministry of Education, 2021). This is consistent with findings overseas as Linder and Simpson's (2018) and MacDonald and Murphy's (2021) research also identified a significant gap in international mathematical empirical research in early childhood. Key points from the accessible research and data highlighted the following points. Firstly, children are starting their schooling with varying degrees of confidence and skills in literacy, communication and mathematics (Ministry of Education, 2022a). Secondly, international research has found that maths anxiety is developing prior to children starting school (Ministry of Education, 2022a). Finally, only “75 percent of 4½-year-old children can count to 10 – there is a correlation between the level of socioeconomic deprivation and demonstrated ability to perform this task” (Ministry of Education, 2022a, p. 8). These research findings are significant as if not addressed will further perpetuate the reality that children arrive at school with varying mathematical skills and confidence. These data clearly signal a need for further investigation and support for mathematics pedagogy in the early years and beyond.

Professional development

Professional development can enhance teacher capability or have a minimal impact depending on its design (Knaus, 2017). Research recommends a move away from one-off workshops and greater focus on long-term professional development that incorporates coaching with opportunities for reflective discussion, along with specific examples of what effective teaching looks like in practice (Björklund, 2012; Helenius et al., 2017; Knaus, 2017). Coaching is an effective strategy for supporting teachers' implementation of new knowledge into their practice with an emphasis on what happens for the learner as a result (Clarke et al., 2020). Coaching can help teachers transfer knowledge and skills to practice, helping embed teaching into day-to-day interactions, experiences and activities with children. Embedding teaching into day-to-day interactions is also highlighted by Whyte (2018), who advocates for teachers to have opportunities to discuss what teaching mathematics looks like through a play-based curriculum. Whyte's thinking is reinforced by Parks and Wager's (2015) push for professional development to provide examples of quality mathematical interactions between children and teachers through video.

Currently, New Zealand's professional development approach specifically focused on mathematics can be accessed via the Ministry of Education (MoE), through a programme called SELO (Strengthening Early Learning Opportunities for children, whānau, families and communities) (Ministry of Education, 2022c). Professional development focused on mathematics sits within programme 2 of SELO and requires leaders to first recognise the need for professional development for teachers at their service and then apply to their regional MoE lead for support. This allows for services to receive professional development that is targeted to their services' needs (Ministry of Education, 2022c). The description of the programme via the Ministry of Education's website outlines that the programme will support teachers to “Deliver Te Whāriki whilst

valuing the cultural knowledge each whānau and ākonga bring to their education, including supporting early numeracy and literacy skills” (Ministry of Education, 2022c). It could be argued that each early childhood service across Aotearoa New Zealand should be automatically offered and encouraged to access this professional learning as a more targeted response to concerns about children’s current mathematical learning opportunities, rather than ECE leaders choosing whether to opt-in or not.

So what could an effective professional development model look like?

Current knowledge suggests that it is important to match professional development content and style of delivery with the desired outcomes (Elek & Page, 2018). For example, if the outcome is for teachers to gain content knowledge or information, a workshop or online resource may be effective. If the outcome is to challenge teacher beliefs or to support the transfer of knowledge to practice, more intense and sustained PLD opportunities, such as coaching, are required (Elek & Page, 2018). Systematic literature reviews have identified that coaching is an effective strategy for facilitating changes in teacher practice over time (Kraft et al, 2018; Elek & Page, 2018). An example of a coaching approach to mathematics is workshops (to gain information and knowledge) followed by goal setting and coaching cycles of observation, feedback, and reflection time (to help teachers put their knowledge into practice in ways that are appropriate and effective for their context and setting). However, coaching is typically resource intensive. In Aotearoa, a key to success is likely to be implementing a strategy of coaching strong pedagogical leaders within each early childhood setting, so that leaders are able to facilitate ongoing PLD and coaching within their local contexts (Education Review Office, 2016).

The role of pedagogical leadership

High-quality learning and teaching environments are derived from leaders having in-depth content and pedagogical knowledge (Carrol-Lind et al., 2016). The term is referred to as pedagogical leadership. The Education Review Office (ERO) unpacks this and further describes how “Strong pedagogical leaders understand how to integrate mathematics throughout their service’s curriculum to best support children’s learning” (ERO, 2016, p.10). Pedagogical leadership is best defined as a leader who places emphasis on curriculum as opposed to focusing purely on administrative tasks and includes teachers who don’t have official leadership roles as pedagogical leaders (Carrol-Lind et al., n.d.). As described in Te Ara Poutama, it is essential that leaders have the skills and knowledge to support teachers to reflect and refine their teaching practice and this should occur through the process of internal evaluation (Education Review Office, 2020).

Effective internal evaluation enables the learning community of an early childhood setting to come together to ensure quality outcomes for children (Education Review Office, 2020). A learning community encompasses leaders, teachers, families and children and involves developing a shared understanding of what quality looks like from the perspective of each member of the learning community (Education Review Office, 2020) as well as research-informed quality indicators (Education Review Office, 2020). Interestingly, from a maths perspective, the only two quality indicators that are specific to mathematics in Te Ara Poutama are evident through the intentional teaching indicator and reference to ‘subject content knowledge’ within the professional development quality indicator. Potentially the thinking behind this is to create space for teachers to engage in in-depth research focused on what quality teaching and learning of mathematics looks like. However, given the current positioning that the teaching of mathematics needs to be more robust, the indicators specific to mathematics within Te

Ara Poutama are a potential area for further consideration.

How can we make children's mathematical learning more visible?

Gathering evidence of outcomes for learning is a critical component of internal evaluation (Education Review Office, 2021). Children's progression of learning documented through assessments is an effective and tangible form of evidence of outcomes for children (Education Review Office, 2021). However, historically teachers in New Zealand have struggled with assessment approaches and authentic ways to show the progression of learning through assessment (Anthony et al., 2015). Anthony et al.'s findings suggest that teachers more often assessed learning that was evident through specific mathematics experiences rather than through everyday play experiences. ECE services that demonstrate in-depth mathematical content knowledge and engage in effective assessment and planning practices that make maths learning visible, foster quality mathematical learning for children (Education Review Office, 2016). ERO report that in services where such practices are visible a balance between deliberate and spontaneous mathematical learning opportunities is evident. Anecdotally one of the roadblocks for teachers is often the lack of specific reference to children's mathematical understanding through assessment which then leads to challenges in articulating progression across subsequent assessments and iterations of planning. Take the following two hypothetical examples:

"Patrick today you spent a lot of time exploring and experimenting with the shapes and magnets. As you explored we talked about the names of the shapes and counted them which will extend your mathematical knowledge and support you as you transition to school."

"Patrick, you confidently named the shapes you picked up including the triangle, square and circle then showed me there were more shapes that were the same. "Look two triangles". Patrick this tells me that you can "subitize" which in maths means that you can instantly recognise the total number of a small group. As you found more triangles you started to point to each one as you counted showing you also understand that each object has a number name (one-to-one principle). You confidently counted to eight then we worked together to count the rest of the triangles"

Through the first assessment, we see Patrick's interest and engagement in a mathematical experience however it would be difficult to assess the progression of his learning through further assessments. The second assessment describes Patrick's mathematical learning more specifically which would support teachers to plan possible avenues for extending learning and articulate progression. This assessment also highlights the depth of the teacher's mathematical content knowledge.

Supporting teachers' knowledge of children's progression in their mathematical learning is part of the strategy outlined in the Literacy & Communication and Maths Strategy (Ministry of Education, 2022a). This focus area of the strategy is aimed at strengthening mathematical learning opportunities for children through early childhood. More specifically practice and progress tools are introduced as part of this focus area which if used effectively by teachers alongside current assessment practices such as learning stories would make children's mathematical learning and the progression of that learning more visible. Kōwhiri Whakapae is a practice and

progress resource that has been developed to help teachers to strengthen their practice and foster their understanding of the progression of children's learning over time (Ministry of Education, webinar, November 14, 2022). Kōwhiri Whakapae is focused on three curriculum areas including social-emotional learning, oral language, maths and literacy within the context of the strands and goals of Te Whāriki (Ministry of Education, webinar, November 14, 2022). One of its many purposes is to support the implementation of the focus areas within the Literacy & Communication and Maths Strategy (Ministry of Education, 2022a). With the focus on practice evident through Kowhiti Whakapae, effective engagement with the practice and progress tools referred to within the Literacy & Communication and Maths Strategy would lead to teachers' enhanced mathematical content knowledge alongside fostering an understanding of what progression might look like. These tools are intended to support teachers to focus on what children are exploring through their play and then to utilise the practice and progress tools to extend their content knowledge alongside growing their understanding of mathematical learning. When teachers have in-depth mathematical content knowledge, progression in children's learning becomes more evident through assessment, leading to more complex planning and learning opportunities for children (Education Review Office, 2016). A hypothetical example of a teacher's knowledge of patterning and how this is recognised through a child's play is outlined through the following assessments:

Exploring patterns

Patrick, I have noticed recently that you are a mathematical thinker. Today this was highlighted while you were climbing. You were creating a pattern as you climbed on the rope bridge by stepping on every third and then every second rope. To support your thinking we talked about the pattern that you were creating and the order of it "3,2,3,2". You decided to repeat your climb across the bridge and after a few more repeats you started to tell me what would come next in your climbing pattern. Great work Patrick, recognising patterns in everyday life is part of Algebra which you will continue to explore as you move into school. To support you with your understanding of patterns and your interest in the confidence course we could set different patterns up using the equipment and discuss these with you.

Understanding patterns

What a learning journey you have been on Patrick. Our plan to support your mathematical thinking was put into action with you and each day we set the confidence course up in a different pattern. For example up, down, up, down or up, across, down, up, across, down. You were engaged each day and had many conversations with the teachers about the patterns. Yesterday, while I was inside, you came running to celebrate with me that you had created a pattern by yourself and it was "up, up, down, up, up, down". You took me to have a look and I could see you had used a range of planks and tyres to create your patterned obstacle course. Patrick this shows a huge growth in your understanding of Algebra as you are now not only creating your own patterns but you are naming them and communicating them to others.

What is evident through these assessments is that the teacher has knowledge about mathematics which has led to recognising an opportunity to introduce the concept of

patterning through Patrick's play, specifically his interest in the confidence course. The other significant element is the teacher's recognition and description of the progression of Patrick's understanding of patterns and the way the teacher has made this visible for Patrick and his whānau. Assessments are an effective way of connecting with families about their child's mathematical learning, as well as a means for children to revisit and evaluate their own learning (Haynes et al., 2007).

A maths-rich environment

The role of the environment is also significant, particularly in how teachers intentionally set up the environment to promote mathematical thinking. Introducing 'loose parts' to both the indoor and outdoor environment is a way of encouraging children to explore resources in an imaginative way and promotes mathematical thinking across the strands. Loose parts are recyclable products that have been introduced into early childhood environments by teachers for children to use creatively to extend their play (Stephenson, 2003). McLennan (2020) encourages teachers that when setting the environment from a mathematical perspective "open-ended invitations empower children to choose the direction of their play and can spark deeper inquiries along the way" (p. 104). Introducing mathematical tools alongside loose parts adds another dimension to promoting mathematical thinking. Scales, rulers, number lines, tape measures, number cards, sorting bowls, clipboards, paper and pens, images of groups of toys, copies of maps, house plans, repeated patterns, and cultural patterns are all potential provocations that offer opportunities to foster children's mathematical thinking. McDonald (2018, cited in McLennan, 2020) emphasises the importance of the teacher's role in affirming that teachers' use of questioning that promotes and reinforces children's mathematical thinking is essential alongside a rich mathematical environment.

The role of kaiako

Te Whāriki describes teachers as a key resource within early childhood environments and that teachers must have a good understanding of effective, intentional teaching practices (Ministry of Education, 2017). This includes being able to integrate domain knowledge such as mathematics through play-based experiences (Ministry of Education, 2017). The key to being an intentional teacher is engaging in observation to gain a deeper understanding of children's strengths and interests alongside recognising further possibilities (Clarke & McLaughlin, 2018). Recognising and responding to further possibilities through a mathematical lens involves thinking about and planning ways of extending a child's mathematical learning through their interest. Clarke and McLaughlin (2018) remind teachers that planning is essential and that an intentional and responsive teacher has a plan but adapts and responds to spontaneous play and the teachable moment. From a mathematical perspective, an intentional teacher creates engaging invitations to play with a mathematical lens based on children's interests. They then engage with children by listening to their questions or wonderings, encouraging prediction, and problem-solving along with supporting children to communicate their thinking (McLennan, 2020).

Summary

Children's confidence and competence in mathematics in the early years have a long-standing positive impact on their success through schooling and into adulthood (Duncan et al., 2007). Specifically, a positive disposition towards mathematics during early childhood contributes to enjoyment and engagement in later schooling (MacDonald & Murphy, 2021). Current limitations and areas for focus have been explored with reference to the release of the Literacy & Communication and Maths Strategy in Aotearoa New Zealand (Ministry of Education, 2022a). These include strengthening

teachers' content knowledge through more effective, consistent professional development, and exploring quality assessment practices. Practical examples of assessment alongside ideas for extending children's mathematical experiences within the environment have also been introduced for teacher reflection. Combined, the thinking outlined in this article is intended to support teachers' self-efficacy in their teaching of mathematics, offer some insights for enhancing practice, and ultimately encourage children's enjoyment and positive engagement with mathematics as life-long learners (Duncan et al., 2007).

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