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Enhancing mathematics teaching and learning in early childhood settings

In view of the ongoing government strategy within Aotearoa New Zealand to promote numeracy knowledge and skill development in the school sector, it became crucial to undertake research within an early childhood context with the intention that recommendations from the research would promote best, or wise, mathematics teaching practices for early childhood teachers.

Researchers such as Carr, Peters, and Young-Loveridge (1994), Young-Loveridge, Carr, and Peters (1995), and Wylie (2001) have for some time now highlighted the importance of how children's mathematical competencies in the early years impact on children's successes in mathematics in the school years. However, there has been little documented on mathematical learning and teaching in the early childhood sector, from the perspective of the *teacher*, and particularly within Aotearoa New Zealand. Consequently, areas that needed to be explored included:

- how mathematics teaching and learning is conceptualised in early childhood settings
- teachers' attitudes to providing learning experiences that support and extend mathematical learning
- what helps and hinders effective teaching and learning of mathematics
- what can be done to improve practices that enhance mathematical learning outcomes for children.

Aims and objectives

The overall aims of the project were to:

- act as a useful learning tool for early childhood teachers, across the wider early childhood education field, by provoking them to consider the teaching and learning of mathematics in their own contexts
- contribute to the body of knowledge within mathematics education research both within Aotearoa New Zealand and internationally
- broaden the action research field by increasing the possibilities for early childhood teachers to engage in action research.

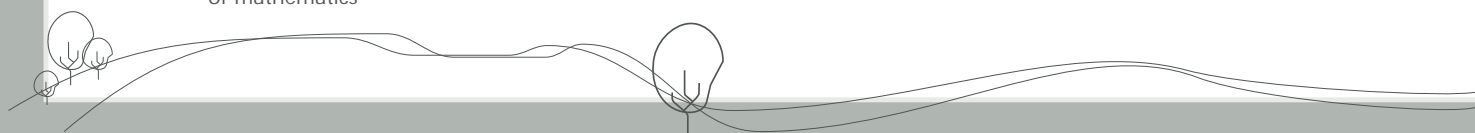
The specific objectives of the project were to:

- engage kindergarten teachers in investigating and improving their expertise in the teaching and learning of mathematics

- develop a research environment through which researchers and kindergarten teachers worked collaboratively to explore means by which mathematical outcomes for children could be maximised.

The overall objectives of the project addressed the strategic, research, and practice principles of the Teaching and Learning Research Initiative (TLRI), specifically through:

- kindergarten teachers' increased understanding of the processes of mathematics teaching and learning
- building capacity and capability as kindergarten teachers engaged in personalised and contextualised research and
- kindergarten teachers' evaluation of both the mathematical and the action research aspects of the project.





An action research approach to research does not aim for replication. However, while each individual kindergarten's mathematical journey was documented, a meta-analysis was also executed in order to:

- establish similarities and differences between the findings in the three research settings
- strengthen the transferability of new knowledge
- increase overall rigour and validity of the project.

Research questions

The overarching research question was:

What do the participant kindergarten teachers know and practise in relation to the teaching and learning of mathematics, and how can this be improved?

The specific research questions that arose at each site were:

- How can we establish a platform for making mathematics prominent?
- How can we enhance a collaborative mathematical partnership between teachers and parents?
- How can we grow teacher confidence in strategising for children's mathematical learning?

Partnerships

The project was undertaken through a research partnership between three researchers from Unitec Institute of Technology and the teaching teams at three West Auckland kindergartens. Each researcher engaged in a facilitated action-research process with one kindergarten research group, with the key researchers being the kindergarten teachers themselves.

Research design and methodology

Action research was chosen as an appropriate methodology because its fundamental principles value professional practice and collaborative research partnerships between practitioners and researchers. The project engaged the kindergarten teachers through one cycle of action research, providing them with opportunities to focus on a meaningful issue in their mathematics teaching. It was expected that changes in practice would improve mathematical outcomes for children.

Regular facilitated research meetings were used to progress through the various stages of one action research cycle. Additionally all the teachers came together for two full-day cluster meetings: one before the start of the project to introduce participants to the methodology of action research; and one on completion of the project for all participants to contribute to an evaluation of the outcomes of their research project, and to get an overview of the process they had experienced.

Summary of the findings

There were two levels of findings for the project: the findings specific to each kindergarten setting; and the overall findings from the meta-analysis of the three research journeys.

The findings for the individual kindergartens are provided as individual case studies contained in the full report of the project.

The overall findings were:

- Mathematics subject knowledge contributes to the development of a positive disposition towards mathematics for early childhood (kindergarten) teachers.
- Mathematically focused teaching strategies enable early childhood (kindergarten) teachers to maximise opportunities for children's mathematical learning.
- Pedagogical documentation enhances the teaching and learning of mathematics in early childhood.
- Distribution of children's work through documentation is an integral method for sharing children's mathematical thinking with whānau/parents.
- An action research model allows early childhood teachers (kindergarten) to build on their existing knowledge base to research their mathematical practices.

Mathematical confidence and competence

For all the teachers, by far the outstanding finding of the project was the realisation of how their own mathematical knowledge and personal disposition towards mathematics led to improved strategies for providing mathematically stimulating learning opportunities for children.

Advantages of personal subject knowledge for early childhood teachers, and in particular in mathematics, are well documented internationally (Anning & Edwards, 1999; Aubrey, 1994, cited in Pound, 1999; Baroody, 2004; Copple, 2004; Perry & Dockett, 2002). Perry and Dockett advise that to help children develop their mathematical ideas it is a benefit if an early childhood teacher has a sound understanding of their own mathematics. Similarly Copple states that for early childhood teachers "unquestionably, teachers' knowledge and skill (in mathematics) are vital to educational effectiveness" (p. 86). Baroody agrees with both, suggesting early childhood teachers need a "deep understanding" of content knowledge of mathematics. Aubrey, cited in Pound (1999), claims that adults' subject knowledge plays a crucial role in their ability to provide explanations in helping children make connections.

Meanwhile, within Aotearoa New Zealand, Hedges and Cullen (2005) recommend that "subject knowledge requires more explicit acknowledgement in early childhood education" (p. 72) and claim that "increased focus on



subject content learning is not incompatible with early childhood pedagogy and philosophy" (p. 77).

Pedagogical documentation for children, teachers and whānau/parents

In all three kindergartens, a number of strategies were employed to draw whānau/parent, and children's attention to mathematics in a highly visible way. Ways of reaching out and informing whānau/parents included a variety of forms of documentation to increase the visibility of mathematics:

- mathematics display wall
- mathematics newsletter
- "Mathematics Parent Voice" sheet
- mathematics inclusion in the weekly planning sheet
- mathematical input into learning stories
- brochure outlining the scope of mathematical experiences in the kindergarten
- inclusion of mathematical detail in daily reflections
- highlighting children's mathematical thinking and action in the project books
- parent–teacher mathematics workshop.

It has been recognised by many early years writers (Fleer & Richardson, 2004; Gould & Pohio, 2006; Katz & Chard, 1996; Rinaldi, 2006) that teachers increase their competencies and their abilities to notice, recognise, and respond to children's learning (Ministry of Education, 2004b) when they document children's work. Rinaldi explains how a teacher's familiarity with "critical facts" (p. 72) enables them to focus on what is important in a child's engagement in a particular situation, while Fleer and Richardson write of teachers "mapping children's cognitive competence" (p. 132), which again demands of teachers a certain level of specific subject knowledge.

All teachers used documentation as part of a knowledge-building process of mathematics teaching and learning. They developed strategies to document their practices in ways that would inform children, whānau/families, and the community, and would enable whānau/families to participate in the learning and teaching of mathematics in ways that were meaningful to their particular setting.

Action research for early childhood teachers

Using a collaborative action research approach enabled researchers and teachers to engage in a meaningful project that ensured the teacher's perspectives were visible. The action research model of reconnaissance, intervention, and evaluation provided a framework whereby the teachers could investigate their capabilities, current knowledge, and practices in the area of mathematics, and ways of increasing this knowledge.

The framework enabled them to identify for themselves mathematical gaps in their own subject knowledge, to

use their findings to effect action designed to enhance the mathematical learning experiences for the children, and to create forward-looking strategies in their teaching and learning of mathematics.

Overall, the teachers at all three kindergartens achieved their key objectives of making mathematics more visible in their kindergartens. In so doing, they improved their own engagement and management of mathematical learning opportunities, enhanced the enrichment of mathematical learning experiences for the children, and increased the involvement of whānau/parents in their children's mathematical learning.

Possibilities for future research

The early childhood strategic plan (Ministry of Education, 2002) wholeheartedly supports research in early childhood education, stating the "research has taught us much ... but we need to know more" (p. 19). The findings from this research project indicate that we need to know "more" about:

- effective collaborative partnerships between teacher and whānau/parents in supporting the children's mathematical learning
- the "children's voices" in the pedagogical documentation of mathematical thinking and action
- changed mathematical outcomes for children.

Building capability and capacity

The research project has contributed to building capacity and capability across the early childhood community.

For the researchers, engagement in the project built capability and capacity in facilitating action research within early childhood environments and, in particular, in the area of mathematics teaching and learning.

For the kindergarten teachers, it was evident that although the research process had been challenging, nevertheless they had benefited from the challenges and built their capacity and capability to engage in action research. While the concept of action research was familiar to many of them, their experience of it had been in more open professional development models. This research project demanded that they take a more active research role than had previously been expected of them: a challenge that they responded to within the constraints of time and resources available to them.

At the end of the project, the kindergarten teachers were asked to consider how they would continue to engage in research now that the project had concluded. They agreed that engaging in action research had enabled them to recognise their strengths and weaknesses in relation not only to their specific research focus on mathematics, but also to their ability to look beyond this focus to the broader and generic aspects of their kindergarten learning environments.



TEACHING & LEARNING RESEARCH INITIATIVE

NĀU I WHATU TE KĀKAHU, HE TĀNIKO TAKU



This project is very much at the forefront of research that contributes to our understandings of teachers' engagement in early childhood mathematics teaching and learning in Aotearoa New Zealand. Given the power of teacher-driven research to inform and challenge other teachers to develop their practices, the project has contributed to building capability and capacity within the wider early childhood community.

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The full reports of all TLRI projects are published on the TLRI website (www.tlri.org.nz).

Researchers



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Her diverse career spans early childhood, primary, secondary, and tertiary levels. Throughout her career she has integrated her passion for mathematical teaching and learning into all contexts.



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Janita Crow lectures in early childhood education at the Unitec Institute of Technology, Auckland. Her long standing

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Katrina Bone and Petra Wyrsh: Don Buck Kindergarten, Massey, Auckland. Katrina has been head teacher for many years and led the project at her kindergarten.

Kathryn Palmer and Melanie Chaplin: Birdwood Kindergarten, Ranui, Auckland. With Kathryn as head teacher, together they shared the running of the project at their kindergarten.

Marjo Whyte-van Diessen: Avondale Kindergarten, Auckland. As head teacher, Marjo successfully led the project at her kindergarten.