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Numeracy Practices and Change

This project was a two-year study that looked at issues to do with equity, proficiency, and sustainable practice as a result of recent numeracy reforms in the primary school sector. It was a collaborative venture between researchers, teachers, and students in 16 schools previously involved in the Numeracy Development Project. It offered schools and classroom teachers the opportunity to undertake a serious deliberation of the effects of their work following the reforms. We formed four projects to explore teacher knowledge, mathematical practices, the perspectives of the learner, and teacher change. We looked at the personal, school-wide and community capacities needed for changing teaching and learning—including a look at how students themselves viewed mathematics learning.

PROJECT AIMS

The project had two central aims:

- to investigate equity issues surrounding numeracy teaching and learning
- to identify those factors associated with sustained changed practice.

The four projects nested under these aims explored different aspects of the effects of a new large-scale initiative in classrooms—the Numeracy Development Project.

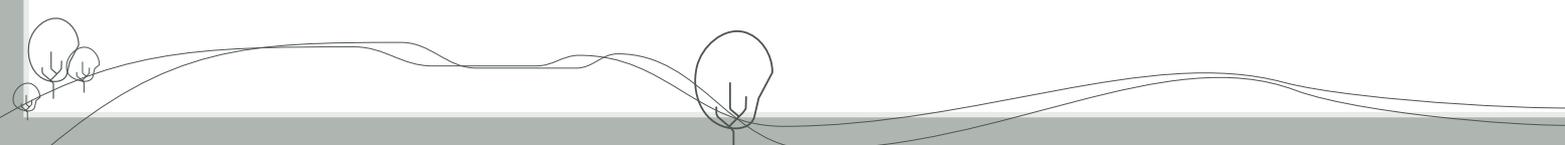
Project 1: Teacher knowledge

Aim: To investigate teachers' numeracy knowledge and explore how teachers enact that knowledge in their classrooms.

This project focused on teacher knowledge and explored how teachers become learners in their own classrooms. Specifically, we probed teacher knowledge by looking closely at what teachers actually do in their classrooms. This included analysing the sorts of challenges which numeracy teachers respond to in the course of their everyday practice. We investigated teachers' understanding of the subject matter and how they used it in the classroom, and investigated their knowledge about their students' mathematical development.

We asked:

- What content knowledges are demanded of numeracy teaching?
- How is such knowledge "held" and used in teachers' practice?





Project 2: Mathematical practices

Aim: To investigate the development of mathematical practices through a teaching experiment designed to foster a classroom environment of inquiry.

Project 2 focused on understanding mathematical practices and how those practices are developed by teachers and learned by students. Competent mathematical practice refers to what successful mathematical learners and users actually do; for example, modelling, justifying claims, using symbolic notations efficiently, defining terms precisely, and making generalisations.

We asked:

- How are teachers' mathematical practices developed through a collaborative team effort, that involves initiation of an issue by a teacher or by teachers, and the facilitation and resolution of the issue by the researcher and the other group members?

Project 3: Numeracy practices from the learner's perspective

Aim: To investigate what numeracy means for the learner.

Project 3 focused on students' interpretations of numeracy in the classroom. Nationwide mathematics reforms have been the subject of extensive investigation and although many of those investigations have included students, almost all of the studies have assumed an outsider's perspective.

We asked:

- How are students' identities and knowledges being reconceptualised and reformed through new classroom practice?

Project 4: Teacher change

Aim: To identify whole-school and teacher-related factors that appear to facilitate or inhibit the development of teaching practices as described through the Numeracy Development Project.

Project 4 focused on factors that relate to individual teachers themselves, to the community of teachers with whom they work closely, and to their wider school community. It looked at the interplay between teachers' personal resources and "external" support and incentives in the numeracy reforms, and at how these factors merged to contribute to implementing and sustaining the Numeracy Development Project.

We asked:

- What changes to practice, beliefs, knowledge, values, and ideas about teaching and learning are evident in the short term and in the long term?
- What programme and personal factors initiated those changes?

- What teacher and school community factors contribute to the classroom teacher's ability to sustain those changes?

Research design

The four projects formed an interactive "research ecology", to explore the teaching and learning effects resulting from the implementation of the Numeracy Development Project. The four projects employed a range of research methods to generate national data and a multifocused analysis of the engagement and sustainability of numeracy classroom practices.

Project 1: Teacher knowledge

This project focused on a cluster of eight teachers from three different schools. The researcher initiated discussion with the cluster group by focusing on content knowledge, tasks, investigations and assessment activities. Later, teachers shared videotaped case studies from their own teaching to explore mathematics content related to their students' learning.

Project 2: Mathematical practices

This project began with seven teachers and was successively refined to develop case studies of four teachers from the same school working with the researcher to investigate communication practices and patterns of interactions in the numeracy classroom. Teachers engaged in regular study group meetings in which research literature and material from the Numeracy Professional Development Project books were examined and discussed. Video clips of their classroom teaching were critiqued collaboratively.

Project 3: The learners' perspective

The principal research method in this study was in-depth interview. Sixty students from 12 primary schools participated and formed a representative spread of Years 4–6 students. Cluster groups formed in six schools arrived at a collective experience of a fictional student in the numeracy classroom. In another six schools, four students were interviewed individually. Their responses provided a complementary element to the collective voice and offered rich detail about experience as a student in a numeracy classroom.

Project 4: Teacher change

This study involved case studies of 12 schools, and identified changes in mathematics teaching practices. Principals, lead mathematics teachers, numeracy teachers and new teachers within each of the schools were interviewed individually. Their interview data allowed us to investigate the links between teachers' and schools' personal resources and the "external" incentives that enabled them to engage



with the Numeracy Development Project. The data analysis explored: teacher beliefs and knowledge; clarity and valuing of the programme's vision; coherence, consistency and immediacy of support within the school; and priority of resourcing of the programme.

Summary of findings

Project 1: Teacher knowledge

- The Numeracy Development Project brought a new language. Getting to grips with the vocabulary was not easy for some teachers.
- Teachers benefited significantly from their participation within a small community of learners that provided the support and mentoring necessary to allow them to develop new pedagogical knowledge.
- During the change process, teachers transformed, adapted, or negotiated content knowledge in their teaching practice (Sherin, 2002).

Project 2: Mathematical practices

- It took months, rather than weeks, to build up student participation, as students gradually learnt what it means to question an explanation, to expect an explanation to be justified, and to learn how to prove an explanation and to argue mathematically. Student engagement in quality mathematical practices was a result of the teacher steadily expecting increased levels of participation.
- Over time, positioning of authority in the classroom shifted as the teacher increasingly facilitated discussion, and the students increasingly expected mathematical explanations to be justified.
- Students in the study needed explicit scaffolding to support ways of working together when problem solving.
- Students in the study needed time and space to think within inquiry classrooms.

Project 3: Numeracy practices from the learner's perspective

- A new sense of student ownership resulted from the increased levels of classroom communication.
- Students were positive about hearing alternative solutions to problems, although many expressed concerns about talking in public if their answers were incorrect.
- Students spend more time working with groups than with the whole class. Groups mean changes in the ways students interact with teachers.
- Group work appeared to be mostly a way of differentiating instructional provision. There were few

reported examples of students working collaboratively on extended problems.

- Students reported an increased use of games and enjoyable activities.
- Students frequently reported that basic facts recall and knowledge was the keystone to being a "good" mathematics student, but when pressed to explain their strategies for calculation problems, many students used inappropriate strategies that resulted in incorrect answers.

Project 4: Teacher change

- For many schools the lack of hard written evidence of students' learning is an issue that needs to be reconciled with parents' expectations.
- Some principals have raised a concern about bringing new teachers on board with the project.
- Schools have had to make changes to the way they plan their mathematics programme.
- Many schools have found that the strategy stages of the Numeracy Development Project Number Framework have been a useful indicator of students' progress.
- Some teachers have found that their use and purposes of the diagnostic interviews have changed over time.

Over and above the findings of the separate projects, a number of common threads were identified that ran across all four projects. We learned how the Numeracy Development Project has created teaching and learning experiences which are radically different from those experiences traditionally offered in mathematics classrooms. In addition we found that:

- The Numeracy Development Project in schools has had a positive impact. In particular, teachers believe that their own skills and knowledge base have been enhanced and students' love of mathematics has increased, and that student outcomes have been enhanced.
- Effective classroom numeracy teachers develop caring relationships that involve reciprocity and an intention to move students towards independence.
- Sound teacher content pedagogical knowledge is fundamental to enacting the numeracy reforms.
- Changing practice is a slow process. There is a general feeling that the changed expectations as to what counts as effective teaching and learning have brought with them periods of uncertainty as teachers and their students negotiate their way towards expected levels of engagement and new ways of doing things.
- Teachers and principals are clear that to sustain the Numeracy Development Project and make a difference to long-term teaching and learning in mathematics, it is essential to have ongoing professional development and assistance with self-reflection.



Limitations of the project

Nested projects 1 and 2 addressed the classroom practices of a small number of teachers. While they were designed to address specific research questions, and while their findings are directly relevant to the participants, the extent to which they might be generalised to others is unclear. Nested projects 3 and 4 drew on larger more representative samples of school decile rating and character and, in that sense, has more application to schools generally in New Zealand.

Guidelines for practice

- Different classroom cultures provided different opportunities for students to engage in mathematical practices that were intended by the Numeracy Development Project. Practices associated with public sharing of mathematical strategies are much more effective if they take place within a classroom principled by an ethic of care and respect.
- Sound content knowledge allows teachers to act on students' strategy sharing by nudging learning in mathematically enriching ways.
- Changing practice is a slow process and involves periods of uncertainty as teachers and their students negotiate their way towards expected levels of engagement and new ways of doing things.
- To enact numeracy reforms in classrooms effectively teachers need the material, systems, human and emotional support, and resourcing from school leaders, as well as the collaborative efforts of teacher colleagues.
- To sustain the Numeracy Development Project in schools, teachers need to engage in ongoing professional learning that involves exploration of students' mathematical thinking.

Dissemination of findings

This project has already generated conference papers, overviews, and articles. The following list represents published refereed papers resulting from the project:

- Hunter, R. (2005). Reforming communication in the classroom: One teacher's journey of change. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *Building connections: Theory, research and practice. Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia* (pp. 451–458). Sydney: MERGA.
- Davies, N., & Walker, K. (2005). Learning to notice: One aspect of teachers' content knowledge in the numeracy classroom. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *Building connections: Theory, research and practice. Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia* (pp. 274–281). Sydney: MERGA.
- Hunter, R. (2006). Structuring the talk towards mathematical inquiry. In P. Grootenboer, & R. Zevenbergen (Eds.), *Identities, cultures and learning spaces. Proceedings of the 29th annual conference of the Mathematics Education Research Group of Australasia*. Sydney: MERGA.
- Walshaw, M., & Anthony, G. (2006). Numeracy reform in New Zealand: The crucial role of the school. In J. Novotna, H. Moraova, M. Kratka, & N. Stehlikova (Eds.), *Mathematics in the centre, Proceedings of the 30th conference of the International Group for the Psychology of Mathematics Education* (pp. 361–368). Prague: PME.

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

Project directors



Associate Professor Glenda Anthony is a researcher and teacher in the School of Curriculum and Pedagogy at Massey University. Her research focuses on both mathematics education and on initial teacher education and effective teaching practices for the classroom.



Dr Margaret Walshaw has had a lifelong interest in mathematics education. She teaches in the pre-service and post-graduate programmes in the College of Education at Massey University. Her research interests are broad and include gender issues, teaching and learning, and curriculum.

These two researchers have recently completed the Ministry of Education report *Effective Pedagogy in Mathematics/Pāngarau: Best Evidence Synthesis Iteration [BES]*. The findings of the Numeracy Practices and Change Project are incorporated in the Best Evidence report.