Chapter 1: Introduction

This report evaluates changes in the professional knowledge of twelve teachers while they were undertaking the Year 4–6 Numeracy Exploratory Study professional development programme. The report identifies the experiences and factors that the teachers reported as influencing the changes in their professional knowledge. It also discusses whether, and in what ways, the teachers perceive the changes in their professional knowledge as having impacted on their classroom practice.

Background factors are also likely to affect the nature and extent of change. For example, most of the teachers involved had a positive orientation towards mathematics, irrespective of whether they considered themselves competent. In addition, there was a culture of professional development and support from senior management in many of the participating schools.

To provide a context for the evaluation, this report first backgrounds recent developments in mathematics education in New Zealand.

Recent developments in mathematics education in New Zealand

Over the last few years, there have been a number of developments in primary mathematics education. As with other countries in the English-speaking western world, these developments have arisen from the results of the Third International Mathematics and Science Study (TIMSS). The New Zealand results prompted commentary on the teaching of mathematics at the primary level, and questions were raised about student achievement and teachers' personal knowledge of mathematics (Garden, 1997). In response to the TIMSS results, the New Zealand Government set up the Mathematics and Science Taskforce, which first met in 1997.

The taskforce identified a number of overriding issues including: the need to raise expectations; underachievement amongst Māori and Pacific Islands students; the professional skills and knowledge of teachers; material resources for teachers; and professional development for teachers. The taskforce established both immediate and long-term priorities. The priorities for long-term action were identified as research into mathematics education; improving the expectations, recruitment, and training of teachers; and parent and community education. The immediate priorities were identified as developing teacher (activity) guides accompanied by professional development, a journal-style publication for classrooms, a video package, assessment/evaluation materials, and classroom resource materials.

To date, a number of these priorities have been actioned, including: a mathematics education research seminar; teacher professional development with an emphasis on year 3 mathematics programmes; a series of journals for schools with a mathematics, science, and technology focus (the Connected series); and a website for teachers devoted to supporting the mathematics curriculum (the New Zealand Maths site). The Mathematics Support for Year Three Students (Year Three Mathematics Contract) professional development programme assisted junior syndicates and teachers to review their current practice and examine resources (such as Cycles 9

to 12, Beginning School Mathematics) in the delivery of *Mathematics in the New Zealand Curriculum.*

Initial interest in the Count Me In Too (CMIT) programme arose from the approach taken to the Year Three Mathematics Contract in Auckland and Waikato, where Vince Wright and Peter Hughes introduced the ideas from CMIT to teachers. This project is based on the work of the Australian researcher, Dr Bob Wright (1997), and incorporates previous work by such US researchers as Les Steffe and others at the University of Georgia (Steffe & Cobb, 1988). Visits by officials from the New South Wales Department of Education and Training in April 1999 led to facilitator training programmes being set in place for the end of 1999 and nationwide pilot projects being implemented in 2000. (See Thomas and Ward, 2001 for an evaluation of the CMIT pilot.) At the same time, a small exploratory study focusing on numeracy in years 4 to 6 was carried out in terms 2, 3, and 4 2000. This report evaluates the pilot exploratory study.

The Numeracy Think Tank was first convened in December 1999 and met in early February 2000, with a final meeting in October 2000. This group developed the New Zealand Learning Framework for Number for the Ministry of Education. The Learning Framework for Number underpins the Early and Advanced Numeracy projects being trialled in New Zealand schools in 2001.

The acquisition of number concepts

Number is an important part of primary mathematics, especially in the first six years of school. The last ten to fifteen years in particular have been a period of concentrated development of theoretical models explaining how children's understanding of number develops. In the last two or three years, several frameworks have been proposed, including those of Jones et al (1996), Fuson et al (1997), Wright (1998), and Young-Loveridge (1999).

These frameworks have identified different conceptual structures or key constructs in their attempts to capture the complexities of place value and multi-digit understanding for instructional purposes. Most of the models address the complexities arising from the interrelationships between the key constructs of counting, number knowledge, and grouping and partitioning. While there is debate about the finer details of the specific relationships between the key constructs that are part of understanding place value and multi-digit numbers, it is generally accepted that there are two broad areas of understanding. One is based on counting, including number relationships, and the other is based on collections or groups.

Wright's (1998) framework forms the basis of the CMIT project (the Department of Education and Training, New South Wales, 1998), and early forms of this framework provided the theoretical basis for a mathematics recovery programme developed by Wright. This framework is organised into the Learning Framework in Number (LFIN) which consists of three parts, incorporating eleven aspects of early number learning, which are set out in stages or levels.

The LFIN stages are emergent counting, perceptual counting, figurative counting, the initial number sequence (counting-on stage), the intermediate number sequence, and the facile number sequence (part/whole). The LFIN stages encapsulate how a child tackles a simple problem-solving task at different stages of his or her number development. The aspects a child might use include base ten strategies, number recognition, and combining and partitioning. (See Wright,

1998 for a full list and discussion of the LFIN aspects.) These aspects are overlapping rather than discrete and are described in terms of strategies or knowledge. Counting is key to the changing cognitive demands as a child develops number understanding, that is, the type of counting at each level varies in terms of the cognitive demand. At the early stages, counting is typified by counting-by-ones. It then changes to counting-on, which develops from advanced counting-by-ones strategies. The facile stage (part/whole) involves a range of strategies and procedures that might include counting-by-ones.

Issues identified as problematic in early number instruction

Several issues have recently been identified as problematic in early number instruction. These include teaching place value, student strategies, mental arithmetic, and formal algorithms (Wright 2000). An increasing number of commentators (for example, Kamii, 1985; Treffers, 1991; Wright, 2000) have warned of the pitfalls in the early introduction of the algorithm of column arithmetic. A number of writers have recently advocated greater use of mental strategies in the teaching of place value. The work of Dutch mathematics educators has been influential in promoting the use of mental strategies with numbers greater than 10 (Beishuizen, 1993). Wright (2000) suggested that specific content topics in early number that include, for example, addition or mental strategies for two-digit addition or subtraction, should not be tightly coupled across broad instructional strands of counting, grouping, and knowledge of number words and numerals. In particular, he warned against the traditional approach of combining the learning topics of number words, numerals, and quantity, arguing that this was not helpful to children who were developing place value understanding. It would seem that what is in question is the overall traditional approach to teaching children place value.

The professional knowledge of teachers

There is little disagreement amongst commentators that teachers' knowledge of subject matter and pedagogical content is a critical factor in the teaching of mathematics. It is seen as an important issue both for policy makers and from an educational point of view (McNamara, 1991). From both perspectives, the adequacy of this knowledge continues to be raised as a matter of concern. This concern has existed over the last few decades and is not peculiar to New Zealand. The recently reported results from New Zealand's participation in TIMSS (Garden, 1997) have prompted renewed concern (Begg, 1997; Biddulph et al, 1997; Ministry of Education, 1997a; Ministry of Education, 1997b; Young-Loveridge, 1997).

The arguments presented in recent policy documents and the accompanying commentary are consistent in their identification of teachers' subject knowledge as one of the critical factors in the effective teaching of mathematics. It appears, however, that the definition of subject knowledge is less consistent amongst commentators, some regarding it as the level of attainment in the subject, while others appear to include elements of pedagogical content knowledge as part of their interpretation. Shulman's (1986) argument for a different perspective on teacher knowledge set the research agenda of developing a more coherent theoretical framework which could encompass transformations of content knowledge through the process of teaching. A number of current educational arguments have developed from Shulman's position. These appear to be characterised by a focus on the relationship between subject knowledge and teaching (Ball & McDiarmid, 1990; Grossman et al, 1989; McNamara, 1991). More recently, Wilson & Ball (1996) suggested that teachers' subject knowledge has become more critical with such curriculum

reforms as the NCTM Standards (1989), in which teachers are required to "teach more complex content to deeper levels of understanding" (p. 122).

The question remains: what kinds of knowledge do teachers need to teach mathematics in the first six years at school? The nature of the subject knowledge which teachers need to implement primary mathematics programmes is not simply an understanding of mathematical concepts, but also includes an understanding of the interconnectedness of aspects of mathematical knowledge and an appreciation of the interrelationship between teaching and learning mathematics (Aubrey, 1997).

In evaluating the impact of CMIT on the professional knowledge of teachers in New South Wales, Bobis (1999) reported an increase in teachers' pedagogical content knowledge and their knowledge of how children learn mathematics. Teachers identified the consultant or facilitator as having the most influence over changes in their knowledge. The length of time that the programme had been in operation was also a factor. There was evidence of greater "connectedness" between different types of teacher knowledge.

Effective teacher development

Ideas about "effective" teacher development and the role of the facilitator have changed over the last thirty years. In the 1970s, the notion of teacher development was based on stage theory, that is, the issues common to teachers at particular stages of their professional lives. In this model, the facilitation of teacher development was based on the categorisation of participating teachers into their stage, as defined by their years of experience. The problem with this approach was the generic treatment of all teachers at a particular stage, with little regard for the context within which each of them was working and other factors impinging on each of them as teachers.

The models of teacher development in the 1980s took a more interpretive approach that situated the teacher at the centre of the development, with the facilitator working with the teacher to identify dilemmas arising from the resulting changes to practice. This teacher-centred trend developed further in the 1990s. Fullan and Hargreaves (1992), key commentators on teacher development, suggested that:

> Teacher development, then, must actively listen to and sponsor the teachers' voice; establish opportunities for teachers to confront the assumptions and beliefs underlying their practices; avoid faddism and blanket implementation of favoured new instructional strategies; and create a community of teachers who discuss and develop their purposes together over time. (p. 5)

Most recently, the view of knowledge in teacher development has changed again. Wideen et al (1996) suggested that an interpretive perspective defines knowledge as "being actively constructed within the unstable, uncertain, conflict-filled world of practice. The resulting knowledge is an idiosyncratic, situated knowledge, made powerful by the contexts in which it is acquired and used" (p. 191). Such a view of teachers' professional knowledge has implications for what might constitute "effective" teacher development.

The structure of this report

Chapter 2 discusses the methodology used. Chapter 3 presents the concept-maps that provided the basis for the teacher interviews and highlights any changes that teachers made in their second map. Chapter 4 provides evidence from the interviews on the impact of the Year 4–6 Numeracy Exploratory Study. It discusses the increased emphasis on number and changes in the ways these teachers taught number. It examines specifically the emphasis on strategies and the related changes to pedagogy. These changes include greater emphasis on questioning and on eliciting students' explanations, different ways of using equipment, changes to the ways of assessing students, and changes in the way students are grouped for instruction. Chapter 5 suggests that the key reasons for these changes are the impact of the diagnostic interview, improved teacher knowledge, provision of a framework, support by school management, and in-class support and advice provided by the facilitator.