Exploring Issues in
Mathematics Education

# An Evaluation of the Early Numeracy Project 2003

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# Executive Summary

The Early Numeracy Project (ENP) is positioned within the context of the Ministry of Education's Literacy and Numeracy strategy. The ENP is one of four projects that formed the Numeracy Development Project in 2003. The others are the Advanced Numeracy Project (years 4 to 6), the Year 7-10 Project (encompassing the Intermediate Numeracy Project (INP) and the Secondary Numeracy Project (SNP)), and Te Poutama Tau (Māori-medium project). The focus of the project is to improve student achievement in mathematics by improving the professional capability of teachers.

The Numeracy Development Project has an evolutionary approach to implementation as it continues to be informed by the findings and experiences associated with the professional development projects that have operated since 2000. The findings from the project evaluations combined with feedback from national coordinators and facilitators inform the modification and further development of the projects.

This evaluation report is the fourth in a series that has investigated the impact of the Numeracy Development Project on year 0-3 students and their teachers. This report describes the impact of the ENP on the 31,423 year 0-3 students who participated in 2003. It also reports on the longer-term sustainability of the project as investigated in 15 schools that first participated in the project in 2000 or 2001.

**Key Findings**

<u>Student achievement</u>

- Consistent with the findings of previous years, the ENP was successful in lifting student achievement as measured by the Number Framework. This improvement in number knowledge and operating strategies was greater than that which would have been expected prior to the implementation of the project.

- The quantitative data collected on over 31 000 students provides a rich source of information on which to clarify expectations of student achievement.
  - Eighty-nine percent of year 0-1 students are able to at least count from one to solve addition and subtraction problems, including 20% who were able to count-on or count-back to solve such problems.
  - By the end of year 2, 58% of the students are able to at least use advanced counting strategies with 15% of these using early additive part-whole strategies to solve addition and subtraction problems.
  - Forty-one percent of year 3 students are able to use at least one part-whole strategy to solve problems involving addition or subtraction.

- The percentages of year 0-3 students making three key transitions was higher in 2003 than in 2002.
  - Eighty-seven percent of initially emergent students progressed to at least one-to-one counting, compared to 82% in 2002.

  - Forty-nine percent of initially counting-from-one students progressed to at least advanced counting, compared to 46% in 2002.
  - Forty-six percent of initially advanced counting students progressed to at least early additive part-whole, compared to 42% in 2002.

- The numeracy profile of students is strongly linked to their ethnicity and the decile of their school.
  - By the final assessment 59% of NZ European and 61% of Asian year 0-3 students were rated as at least advanced counting. This compares to 45% of Māori and 38% of Pasifika students. The comparison is similar at early additive part-whole, with 22% of NZ European and 26% of Asian students attaining at least this stage, compared to only 13% of Māori students and 8% of Pasifika students.
  - By the final assessment 61% of students from high decile schools are rated as at least advanced counting, with 24% at least early additive part-whole. This compares to 55% and 20% for medium decile schools, and 47% and 13% for low decile schools.

- The progress that students make on the Number Framework is linked to starting stage, year level, gender, ethnicity and the decile level of the school.
  - Students who begin at lower stages on the Number Framework progress through more stages than those who begin at higher stages.
  - Older students make greater progress than younger students from all stages on the Number Framework.
  - Students in higher decile schools make greater progress than students in lower decile schools.
  - The progress made by Pasifika students from the higher stages of the Number Framework is consistently lower than that made by Māori and NZ European students.
  - Boys tend to make greater progress from the higher stages of the Number Framework than girls who start at the same stages.

- Students who are at higher stages on the knowledge domains are more likely to progress on the strategy domains.
  - Students who know their forward number word sequence to 10 and can identify numerals to 10 are more likely to make the transition from emergent to counting from one.
  - Students who can group with 10s are more likely to make the transition from counting from one to advanced counting.
  - Students who can group with 10s in 100 are more likely to make the transition from advanced counting to early additive.

<u>TIMSS testing of students in longitudinal schools</u>

- Students in years 4 and 5 performed better on items from the Third International Maths and Science Study than norms from New Zealand students in 1995, particularly on questions targeting numeracy concepts. Year 8 students performed at least as well as norms from 1995.

- Students in year 5 in the longitudinal schools performed particularly well, averaging 59% on a test for which New Zealand scores from TIMSS 1995 would have produced an average of 50%.

Longitudinal study interviews and questionnaires

- Teachers in the longitudinal study indicated that they continue to incorporate the Numeracy Project into their classroom teaching, with many indicating that it forms the core of their mathematics programme.

- Teachers who have had numeracy practices in their mathematics programmes for two to three years believe the project has had a positive impact on students' achievement in number and in mathematics generally. This increased ability was attributed to students' increased range of operating strategies, improved attitudes, and greater enthusiasm for mathematics.

- The mean strategy stage of year 0-3 students in schools involved in the longitudinal study that first participated in 2000 or 2001 is consistently lower in 2003 than those of students involved in the ENP 2003. The mean strategy stages of year 5-8 students in schools involved in the longitudinal study are consistently higher than those of students whose teachers are participating in the Numeracy Development Project in 2003.

- Higher proportions of year 5-8 students from longitudinal schools become advanced additive part-whole than do students nationally.

- Schools in the longitudinal study have developed a number of different strategies to help ensure progress was maintained. These include contracting an external facilitator, running staff meetings on numeracy topics, and providing professional development to new teachers.

# Chapter One: Introduction

## The Development and Background to the Early Numeracy Project

The Early Numeracy Project (ENP) is one of four projects that formed the Numeracy Development Project in New Zealand in 2003. The ENP is for teachers of year 1 to 3 students, the Advanced Numeracy Project (ANP) is for teachers of year 4 to 6 students, the Year 7 to 10 Project is for teachers of those year levels, and Te Poutama Tau is for teachers in Māori-medium settings.

The Numeracy Development Project is positioned within the framework of the Ministry of Education's Literacy and Numeracy Strategy and is closely aligned to a range of policies and projects focused on improving student achievement in literacy and numeracy.

> *While the Numeracy Development project is nested within the government's Literacy and Numeracy strategy, links exist also with other strategies such as the Assessment Strategy and the development of exemplars, and the other Numeracy Assessment Tools. There are also links with Ministry initiatives such as the Curriculum Stocktake, website development, and curriculum support materials development.* (Higgins, Parsons and Hyland, 2003, p. 164)

A key feature of the Numeracy Development Project is its "dynamic and evolutionary approach to implementation" (Ministry of Education, 2003, p. i). The current project has developed from the findings and experience associated with the projects and their evaluations in 2000, 2001 and 2002. Also shaping the project is input and feedback from many groups whose membership includes teachers, teacher educators, policy analysts, researchers, mathematics educators and mathematicians (Higgins et al., 2003).

The Numeracy Development Project was first implemented in New Zealand Schools in 2002. Since then approximately 300 000 students and 11 500 teachers in approximately 1450 schools have participated. It is intended that by 2007, almost every teacher of year 1 to 6 students, and many teachers of year 7 and 8 students, will have had the opportunity to participate in the Numeracy Development Project.

The focus of the Numeracy Development Project is improving student performance in mathematics through improving the professional capability of teachers.

> *Teachers are key figures in changing the way in which mathematics is taught and learned in schools. Their subject matter and pedagogical knowledge are critical factors in the teaching of mathematics for understanding. The effective teacher of mathematics has a thorough and deep understanding of the subject matter to be taught, how students are likely to learn it, and the difficulties and misunderstandings they are likely to encounter.* (Ministry of Education, 2003, p. i)

The Numeracy Development Project helps teachers address the following three questions which have been linked to improving student achievement (McMahon, 2000):

- What can the students do now?

- Where are they heading?
- How can their next learning steps be supported?

## Previous Findings of the Early Numeracy Project Evaluations

The evaluation reports of the project to date highlight the success of the professional development approach used (Higgins, 2001, 2002, 2003; Irwin and Niederer, 2002; Irwin, 2003; Thomas and Ward, 2001, 2002; Thomas, Tagg and Ward, 2003). The Numeracy Development Projects have contributed to what we know about:

- *Children's learning and thinking strategies in early mathematics;*
- *effective identification of, and response to, children's learning needs;*
- *the characteristics of professional development programmes that change teaching practice; and*
- *effective facilitation.* (Ministry of Education, 2003, p. i)

An important component of the Numeracy Development Projects has been the collection of quantitative data on students' number strategies and knowledge. This information has been collected by teachers through the diagnostic interview at the start and end of the project and forwarded to a secure website. Results for the CMIT pilot project, the ENP 2001, and the ENP 2002 were all impressive (Thomas and Ward, 2001, 2002; Thomas et al., 2003). Student progress as measured against the Number Framework has been impressive in each of the three years of implementation irrespective of age, region, decile or ethnicity. Although all students made similar gains, there were marked differences between the subgroups when their profiles, expressed as stages on the number frameworks, were compared. In the three years since 2000 the number profiles of students were higher in higher decile schools or among students of New Zealand European or Asian descent.

A key finding of the ENP 2001 evaluation was that the number of stages gained by students was a function of their starting stage on the Number Framework (Thomas and Ward, 2002). Students starting at lower stages of the framework made greater gains, which substantiated the belief that the framework stages are not of equal size and that the higher stages represent "bigger steps for students to make" (Thomas and Ward, 2002, p. ii). The data from 2000, 2001 and 2002 also suggests that the transition from early to advanced additive strategies is challenging and one that a significant proportion of students in the ENP are unable to make, irrespective of years of participation in the project.

The professional development programme was positively received by participating teachers, principals and facilitators in 2000 and 2001. The teachers reported developments in their professional knowledge as a result of their involvement in the project and noted changes in their classroom practices to accommodate their new knowledge and understandings (Thomas and Ward, 2001, 2002). They also noted increases in confidence and enthusiasm for mathematics teaching (Thomas and Ward, 2001, 2002).

## Description of the Number Framework

At the core of the Numeracy Development Project is the Number Framework. The framework, which is identified as one of the key factors in the success in the Numeracy Development Project, "gives [teachers] direction for responding effectively to children's learning needs" (Higgins et al., 2003, p. 166).

In the two main sections of the framework, a distinction is made between strategy and knowledge. The strategy section of the framework describes the mental processes students use to estimate answers and solve operational problems with numbers. The strategy section consists of a sequence of nine global stages, which can be grouped into two broad bands: counting, and part-whole. Each stage also contains three operational domains: addition and subtraction, multiplication and division, and proportions and ratios. The knowledge section describes the key items of knowledge that students need to learn, and have been categorized under five content domains: number identification, number sequence and order, grouping and place value, basic facts, and written recording. The distinction between knowledge and strategy was made for pedagogical reasons from the "underlying assumption that new knowledge gained by students through strategising from their existing knowledge was likely to contain rich connections with other knowledge" (Thomas and Wright, 2002, p. 3). The two sections are viewed as interdependent with "strategy creating new knowledge through use, and knowledge providing the foundation upon which new strategies are built" (Young-Loveridge and Wright, 2002, p. 722). It is considered important that students make progress in both sections concurrently.

> *Strong knowledge is essential for students to broaden their strategies across a full range of numbers, and knowledge is often an essential prerequisite for the development of more advanced strategies.* (Ministry of Education, 2003, p. 1).

A description of the strategy component of the Number Framework is contained in Appendix A.

## The Diagnostic Interview

Another key factor in the success of the Numeracy Development Project is the diagnostic interview (Higgins et al., 2003). The Numeracy Project Assessment (NumPA) is a diagnostic interview designed to give teachers quality information about the knowledge and operational strategies of their students, as aligned to the Number Framework.

The NumPA tool has three interview forms of varying difficulty. The teacher determines the appropriate interview form to use for each student following their response to the "strategy window questions". The NumPA tool enables teachers to develop a number profile for each student. This profile has two main components, operational strategies and number knowledge. The operational strategies are broken down into the three domains from the Number Framework:

- addition and subtraction;
- multiplication and division; and
- proportion and ratios.

The number knowledge component is assessed on six domains:

- facility with forward number word sequences (FNWS);
- facility with backward number word sequences (BNWS);
- ability to identify numerals (NID);
- ability to use fractions (Fractions);
- ability to use decimals and percentages (Decimals); and
- understanding of the place value nature of the number system (Grouping and Place Value).

Teachers participating in ENP are required to assess their students twice using the NumPA interview, first at the completion of the professional development workshop on the use of the tool and second after the 15-20 weeks of the teaching programme that follows the initial assessments. Teachers use the results of the initial NumPA and subsequent assessments to make decisions regarding learning experiences necessary for individual students and groups of students.

A copy of the NumPA strategy window is contained in Appendix B. Complete copies of the interview are available on the nzmaths website (www.nzmaths.co.nz/Numeracy/project_material.htm).

**Structure of This Report**

This report details the progress of student participants in ENP 2003 and examines the findings of the longitudinal study of fifteen schools that first participated in the project in 2000 or 2001. Chapter Two outlines the methodology used to address the research questions. Chapters Three to Five present the analysis of student results from ENP 2003. Chapter Six examines the performance of year 4, 5 and 8 students in the longitudinal study on a selection of items taken from the Third International Mathematics and Science Study. Chapter Seven presents the performance of students in the longitudinal study on the strategy section of the Number Framework. Chapter Eight uses interview and questionnaire data from teachers in the longitudinal study to present views on the impact and sustainability of the project. Chapter Nine contains a summary of the key findings of this report.

# Chapter Two: Methodology

The 2003 ENP evaluation comprised two main components. The first focused on the progress of students whose teachers were participants in ENP during 2003. The second was the continued examination of the progress of achievement of students in a sample of schools who first participated in either 2000 or 2001.

**Aims of the ENP Evaluation**

The first aim is focused on the impact of ENP on students' understanding of number concepts as detailed on the Number Framework. The research questions linked to this part of the evaluation are:

- What progress do students make on the Number Framework?
- Is the progress of students linked to age, ethnicity, region, school decile level, or gender?
- How does progress in 2003 compare to progress in the previous years of the project?

The second aim involved a more comprehensive look at the impacts and sustainability of the project by continuing to investigate a sample of schools that first participated in 2000 or 2001. The following research questions were addressed:

- What impact has participation in the Numeracy Development Project had on student achievement in mathematics beyond the Number Framework?
- What progress do students make on the number strategy component of the Number Framework in the years following participation in the Numeracy Development Project?
- How do schools sustain numeracy practices once the professional development programme has concluded?

**Design and Methodology**

The investigation had two approaches. The first approach involved the collection of data from all year 0-3 students whose teachers participated in ENP in 2003. The second approach involved the students, teachers and principals from 15 schools that had participated in CMIT in 2000 or ENP in 2001.

Before data was collected, ethical approval was obtained from the Dunedin College of Education's Research and Ethics Committee.

<u>Approach One: Participating Students in 2003</u>

The research evaluation of ENP in 2003 involved the schools that were accepted into the ENP project through a School Support Services contract offered on behalf of the Ministry of Education. This included approximately 40 000 year 0-3 students in 478 schools.

A similar process to that used in 2001 and 2002 was followed in 2003. The teachers assessed the students twice during the project using the NumPA tool, first at the completion of the professional development workshop on the assessment tool and second after 15-20 weeks of the teaching programme. Each participating school was required to submit the results of both the initial and final NumPA to a secure website. In addition to the results of the NumPA, information was collected about each student's gender, date of birth, school year level and ethnicity. The date of birth was used to calculate the age of each student as at 1 May 2003. As the students were linked to schools, their performance could also be reported with respect to region and decile. For the purposes of this report the deciles have been grouped into three bands. Deciles one to three form the low decile band, deciles four to seven form the medium decile band and deciles eight to ten form the high decile band.

Although there were over 40 000 students in the project, this report examines the data of 31,423 students in schools that had submitted the initial and final NumPA results by December 1, 2003. This represents approximately 76% of the students participating in ENP during 2003. The remaining schools were expected to enter final results by the end of the school year and do not form part of this evaluation. Tables 2.1 and 2.2 illustrate the biographic and demographic profiles of the students that form the sample of students for this report. Fewer than 1% of schools did not return decile information. Table 2.3 reports on the spread of the students according to region. The regions are defined by the school support service that was responsible for the delivery of the ENP professional development under contract to the Ministry of Education. Due to rounding, some table columns in this report do not add to exactly 100%.

**Table 2.1: Profile of ENP students by age and year level**

| | Year level | | | |
|---|---|---|---|---|
| Age | 1 | 2 | 3 | Total |
| 5 | 31% | 0% | 0% | 10% |
| 6 | 69% | 33% | 0% | 33% |
| 7 | 1% | 66% | 34% | 34% |
| 8+ | 0% | 1% | 66% | 23% |
| Total | 10101 | 10664 | 10658 | 31423 |

**Table 2.2: Profile of ENP students by ethnicity and school decile**

| | Decile group | | | | |
|---|---|---|---|---|---|
| Ethnicity | None given | Low | Medium | High | Total |
| NZ European | 32% | 29% | 68% | 81% | 60% |
| Māori | 63% | 38% | 18% | 7% | 21% |
| Pasifika | 2% | 25% | 4% | 1% | 9% |
| Asian | 1% | 4% | 5% | 6% | 5% |
| Other | 1% | 4% | 4% | 5% | 4% |
| Total | 424 | 9349 | 11986 | 9664 | 31423 |

**Table 2.3: Profile of ENP students by region**

| Region | Frequency |
|---|---|
| Auckland | 34% |
| Christchurch | 16% |
| Massey | 15% |
| Dunedin | 7% |
| Waikato | 16% |
| Wellington | 10% |
| Total | 31423 |

**Table 2.4: Profile of ENP students by gender**

| Gender | Frequency |
|---|---|
| Female | 49% |
| Male | 51% |
| Total | 31423 |

<u>Approach Two: Wider Impacts and Sustainability</u>

The 2002 ENP evaluation included an analysis of the results of students from 19 schools that were first involved in the Numeracy Development Project either through the CMIT pilot project in 2000 or through ENP 2001. Fifteen of these schools (seven from CMIT 2000 and eight from ENP 2001) accepted the invitation to participate in the 2003 longitudinal component which aimed to further investigate the ongoing impact and sustainability of the Numeracy Development Project. These schools will be subsequently referred to as the 2003 longitudinal schools. Demographic information on the students in the 2003 longitudinal schools is provided in Chapter Seven.

Questionnaires were sent to all teachers in the 2003 longitudinal schools in September (see Appendix H) to elicit their perceptions about the wider and ongoing impacts of the project and its sustainability. Respondents were also asked to provide demographic information.

The principal and/or teacher with responsibility for mathematics in seven of the schools were interviewed for their views about any wider impacts of the project and its sustainability. One concern with relation to the sustainability of the project is whether schools will be able to maintain a sufficient level of professional development to continue to implement the project subsequent to completion of direct facilitation. The 2003 longitudinal schools were provided with access to the online workshops used in the pilot of the online facilitation of the Numeracy Development Project and were invited to provide feedback on its usefulness in helping maintain the momentum of the project. The interviews were conducted from June to October and followed the framework contained in Appendix I.

The fifteen schools were asked to submit the strategy stages of their students by the end of November. Schools were informed that a full NumPA assessment was not required, as grouping by strategy stage within the class' mathematics programme is common in these schools.

To investigate the impact of the Numeracy Development Project on students' overall performance in mathematics, tests were developed using items from the 1995 Third International Mathematics and Science Study (TIMSS). The design and implementation of the TIMSS tests is described in Chapter Seven. The results of nearly 12 000 New Zealand students and over half a million students internationally in years 4, 5, 8 and 9 were collected for TIMSS and these were used as a baseline against which to rate the performance of 1565 students in years 4, 5 and 8 of the 2003 longitudinal schools. The detailed results of students were returned to schools for their own reporting purposes.

# Chapter Three: Progress Made by Students on Strategy Domains

This is the first of three results chapters which report on the impact of the project on students in years 0-3. As data is reported on 31 423 students, there are large numbers in each sample, even when they are analysed by subgroups according to biographic and demographic variables. Sample size raises issues related to practical versus statistical significance. With such large samples, even the smallest differences can be statistically significant. Throughout the following chapters the results are reported in terms of the real or practical significance of any observed difference between groups.

The findings presented in this chapter are organised into two sections. The first section presents an overview of the findings in terms of the percentages of students reaching the various stages on the strategy section of the Number Framework. The second section focuses on the students' number strategies and looks at the progress of students with reference to their starting points on the Number Framework. The progress of students in relation to the variables of year level, gender, ethnicity, school region and school decile are examined.

**Impact of the Project on Students' Number Strategies**

Consistent with the findings of previous years (Thomas and Ward, 2001, 2002; Thomas et al., 2003) the progress of year 0-3 students was impressive. As illustrated by Table 3.1 the project had a positive impact on students' number strategies with the percentage of students at the lowest stages on the framework decreasing and the percentage of students at the higher stages correspondingly increasing.

**Table 3.1: Percentage of year 0-3 students by stage on the additive domain at the initial and final assessments**

| | Initial additive | Final additive |
|---|---|---|
| N= | 31423 | 31423 |
| 0: Emergent | 6% | 1% |
| 1: One-to-one counting | 15% | 4% |
| 2: Counting from one on materials | 39% | 24% |
| 3: Counting from one by imaging | 12% | 16% |
| 4: Advanced counting | 23% | 36% |
| 5: Early additive part-whole | 5% | 18% |
| 6: Advanced additive part-whole | 0% | 2% |

At the start of the project 21% of the year 0-3 students were assessed as either emergent or one-to-one counting on the additive domain. By the end of the project only 5% of the students were still unable to join sets to solve addition problems. The percentage of students who were able to at least count-on or count-back (Stage 4) to solve addition or subtraction problems increased from 28% to 56%.

Table 3.2 shows the same information broken down by year level. As well as showing that the trend of improvement is consistent across all three levels, this table shows that the improvement is greater than that expected over time alone. Year 0-1 students perform similarly or slightly better after six months of numeracy instruction than do year 2 students before instruction. By the end of the project only 11% of year 0-1 students were still unable to join sets to solve addition and subtraction problems. This compares to 15% of year 2 students at the start of the project. A similar comparison of year 2 final scores and year 3 initial scores shows that only 23% of year 2 students were unable to image to solve addition and subtraction problems by the end of the project, compared to 28% of year 3 students at the start of the project.

**Table 3.2: Percentage of year 0-3 students by year and stage on the additive domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | |
|---|---|---|---|---|---|---|
| Additive stage | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 |
| 0: Emergent | 16% | 3% | 3% | 1% | 1% | 1% |
| 1: One-to-one counting | 28% | 8% | 12% | 2% | 5% | 1% |
| 2: Counting from one on materials | 47% | 47% | 48% | 20% | 22% | 6% |
| 3: Counting from one by imaging | 6% | 22% | 16% | 19% | 12% | 7% |
| 4: Advanced counting | 2% | 18% | 18% | 43% | 46% | 45% |
| 5: Early additive part-whole | 0% | 2% | 2% | 14% | 13% | 36% |
| 6: Advanced additive part-whole | 0% | 0% | 0% | 1% | 1% | 5% |

Appendices C-E detail the percentages of year 0-3 students by stage at the end of the project on the various domains of the Number Framework as a function of gender, ethnicity, school decile level, and region.

Table 3.3 compares the percentages of year 0-3 students at each stage of the additive domain of the Framework in 2001, 2002 and 2003. This analysis shows that the differences between percentages of students at each stage initially compared with finally are remarkably consistent across all three years of the project.

**Table 3.3: Percentage of year 0-3 students by stage on the additive domain at the initial and final assessments in 2001 to 2003**

| | 2001 | | 2002 | | 2003 | |
|---|---|---|---|---|---|---|
| Additive stage | Initial | Final | Initial | Final | Initial | Final |
| 0: Emergent | 14% | 2% | 13% | 2% | 6% | 1% |
| 1: One-to-one counting | 21% | 7% | 18% | 7% | 15% | 4% |
| 2: Counting from one on materials | 26% | 23% | 26% | 21% | 39% | 24% |
| 3: Counting from one by imaging | 12% | 17% | 12% | 16% | 12% | 16% |
| 4: Advanced counting | 21% | 28% | 24% | 30% | 23% | 36% |
| 5: Early additive part-whole | 6% | 19% | 7% | 20% | 5% | 18% |
| 6: Advanced additive part-whole | 1% | 4% | 1% | 4% | 0% | 2% |

Tables 3.4 to 3.7 present the mean additive stage at the initial and final assessment as an indication of where differences exist between subgroups. All subgroups were found to make a gain of around a stage, with the differences explained largely by the different starting points for each subgroup. Younger students, Māori and Pasifika students, and those from lower decile schools started and finished at a lower mean stage than the other students. The largest gain was made by year 0-1 and year 2 students (1.02), and the lowest was made by the Pasifika students (0.86).

Tables 3.4 to 3.7 also allow for the comparison with 2002 results. Table 3.4 shows that the mean initial and final stages for year 0-3 students were very similar to those recorded in 2002. Year 0-1 students started at a slightly lower mean stage with the difference largely explained by the percentages of students assessed at stages 0 (26% in 2002 and 16% in 2003) and 2 (33% in 2002 and 47% in 2003). Year 2 students started at the same mean stage in both years but made slightly greater gains in 2003, with 15% reaching the additive stages, compared to 12% in 2002.

**Table 3.4: Mean additive stage at the initial and final assessments by year level for year 0-3 students in 2002 and 2003**

| Year level | N | | Initial additive | | Final additive | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| 0-1 | 5491 | 10101 | 1.3 | 1.5 | 2.3 | 2.5 |
| 2 | 6014 | 10664 | 2.4 | 2.4 | 3.3 | 3.5 |
| 3 | 6887 | 10658 | 3.3 | 3.4 | 4.1 | 4.2 |
| Total | 18392 | 31423 | 2.4 | 2.5 | 3.3 | 3.4 |

**Table 3.5: Mean additive stage at the initial and final assessments by gender for year 0-3 students**

| Gender | N | | Initial additive | | Final additive | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Female | 9048 | 15435 | 2.4 | 2.5 | 3.3 | 3.4 |
| Male | 9344 | 15988 | 2.4 | 2.5 | 3.3 | 3.4 |
| Total | 18392 | 31423 | 2.4 | 2.5 | 3.3 | 3.4 |

**Table 3.6: Mean additive stage at the initial and final assessments by decile band for year 0-3 students**

| Decile group | N | | Initial additive | | Final additive | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Low | 6207 | 9349 | 2.4 | 2.2 | 3.1 | 3.2 |
| Medium | 6757 | 11986 | 2.3 | 2.4 | 3.3 | 3.4 |
| High | 5052 | 9664 | 2.5 | 2.7 | 3.5 | 3.7 |
| None given | 376 | 424 | 2.6 | 2.2 | 3.5 | 3.2 |
| Total | 18392 | 31423 | 2.4 | 2.5 | 3.3 | 3.4 |

**Table 3.7: Mean additive stage at the initial and final assessments by ethnicity for year 0-3 students**

| Ethnicity | N | | Initial additive | | Final additive | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Asian | 859 | 1625 | 2.7 | 2.8 | 3.6 | 3.8 |
| NZ European | 11129 | 18879 | 2.5 | 2.6 | 3.4 | 3.5 |
| Māori | 3784 | 6646 | 2.2 | 2.2 | 3.0 | 3.2 |
| Pasifika | 1911 | 2942 | 2.3 | 2.2 | 2.8 | 3.0 |
| Other | 709 | 1331 | 2.5 | 2.6 | 3.4 | 3.5 |
| Total | 18392 | 31423 | 2.4 | 2.5 | 3.3 | 3.4 |

Students were not assessed in the multiplicative and proportional domains unless they were at the advanced counting stage on the additive domain. Consequently, 77% of the year 0-3 students were not rated on the other two domains at the start of the project. By the end of the project 46% of the students were rated on these domains as shown in Tables 3.8 and 3.9. Again year 0-1 students at the end of the project tend to perform as well as or better than year 2 students at the start of the project. The same is true when the year 2 final results are compared to the year 3 initial results.

**Table 3.8: Percentage of year 0-3 students by stage on the multiplicative domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| Multiplicative stage | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| Not Assessed | 99% | 88% | 86% | 54% | 47% | 20% | 77% | 53% |
| 2-3: Counting from one | 1% | 5% | 9% | 13% | 23% | 12% | 11% | 10% |
| 4: Advanced counting | 0% | 6% | 4% | 27% | 24% | 41% | 10% | 25% |
| 5: Early additive part-whole | 0% | 1% | 1% | 5% | 5% | 18% | 2% | 8% |
| 6: Advanced additive part-whole | 0% | 0% | 0% | 1% | 1% | 8% | 0% | 3% |
| 7: Advanced multiplicative part-whole | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |

**Table 3.9: Percentage of year 0-3 students by stage on the proportional domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| Proportional stage | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| Not Assessed | 99% | 88% | 86% | 53% | 48% | 19% | 77% | 53% |
| 1: Unequal sharing | 1% | 3% | 7% | 8% | 18% | 8% | 9% | 6% |
| 2-4: Equal sharing | 0% | 9% | 7% | 34% | 31% | 52% | 13% | 32% |
| 5: Early additive part-whole | 0% | 0% | 0% | 4% | 3% | 17% | 1% | 7% |
| 6: Advanced additive part-whole | 0% | 0% | 0% | 1% | 0% | 4% | 0% | 2% |
| 7: Advanced multiplicative part-whole | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |

## Patterns of Progress on the Number Framework (Additive Strategies)

The 2001 and 2002 evaluations of the ENP found that the number of stages gained by students varied as a function of their initial stage on the framework (Thomas and Ward, 2002; Thomas et al., 2003). The lower stages of the framework have been shown to be smaller, or easier to progress through. This means that it is not appropriate to compare the gains of various subgroups unless they have the same starting stage on the framework. This section examines progress on the strategy section of the Number Framework in relation to starting points.

Table 3.10 shows the percentage of students at each stage of the framework at the final assessment in relation to their starting point. The percentages in bold are the students who remained at the same stage throughout the project. The percentage of students who remain at the same stage increases the higher the initial stage on the framework. At least 87% of the students initially at Stage 0 or Stage 1 moved up at least one stage compared to the 46% who moved up from Stage 4. In italics are the small percentages of students whose final stage is lower than their initial stage. Cells for stages in which no students were rated are left blank; 0% represents percentages which round down to 0. It seems likely that the 2% (one student) of initially Stage 6 students who were rated as Stage 0 at the end of the project is the result of error in data collection or entry. Figure 3.1 provides a graphical representation of the same data.

**Table 3.10: Final additive stage by initial additive stage for year 0-3 students**

| | Initial additive stage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Final additive stage | 0 | 1 | 2 | 3 | 4 | 5 | 6 | Total |
| 0: Emergent | **13%** | *1%* | *1%* | *0%* | *0%* | *0%* | *2%* | 1% |
| 1: One-to-one counting | 26% | **11%** | *0%* | *0%* | *0%* | | | 4% |
| 2: Counting from one on materials | 49% | 53% | **32%** | *2%* | *0%* | | | 24% |
| 3: Counting from one by imaging | 7% | 19% | 26% | **22%** | *1%* | *0%* | | 16% |
| 4: Advanced counting | 4% | 15% | 36% | 62% | **53%** | *3%* | | 36% |
| 5: Early additive part-whole | 1% | 1% | 5% | 14% | 44% | **76%** | *4%* | 18% |
| 6: Advanced additive part-whole | | 0% | 0% | 0% | 2% | 21% | **95%** | 2% |
| N= | 2015 | 4642 | 12233 | 3699 | 7092 | 1685 | 57 | 31423 |

**Figure 3.1: Final additive stage by initial additive stage for year 0-3 students**

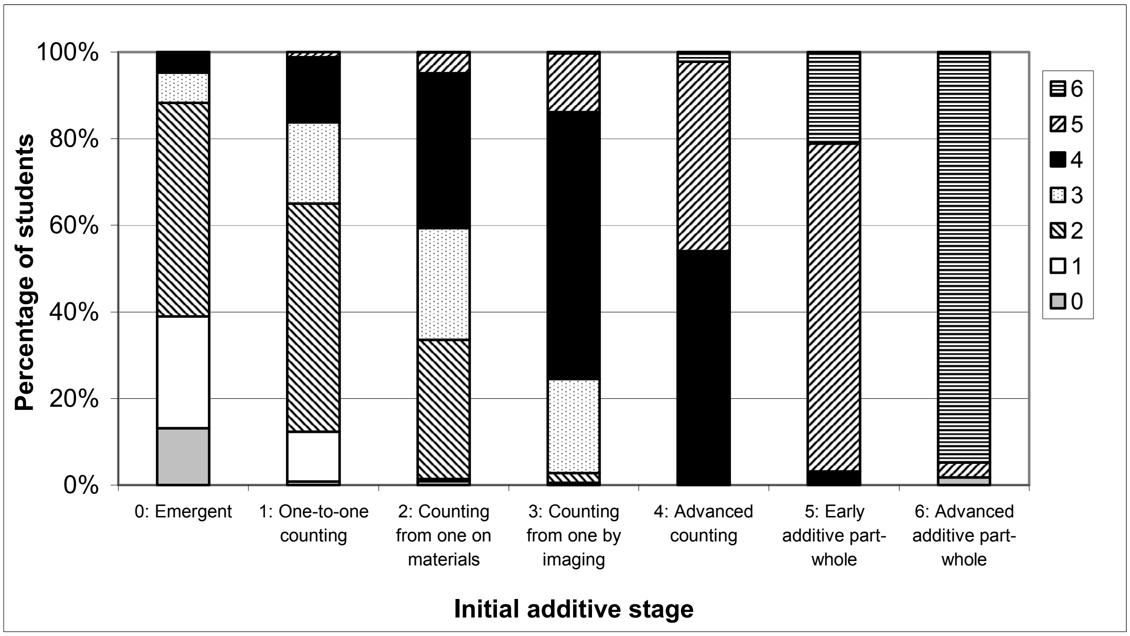



Figure 3.2 illustrates the patterns of progress when the year 0-3 students are analysed according to year level. Consistent with previous years, older students tend to make greater progress regardless of their starting stage. An exception to this is the higher percentage (23%) of initially emergent year 3 students who remain emergent, compared to 12% for year 0-1 and 15% for year 2 students. Alternatively, 37% of year 3s move from emergent to at least advanced counting compared to 11% of year 2s and 2% of year 0-1 students. This suggests that there is a small number of year 3 students (22) who have very significant learning difficulties in number.

**Figure 3.2: Final additive stage by initial additive stage and year level for year 0-3 students**

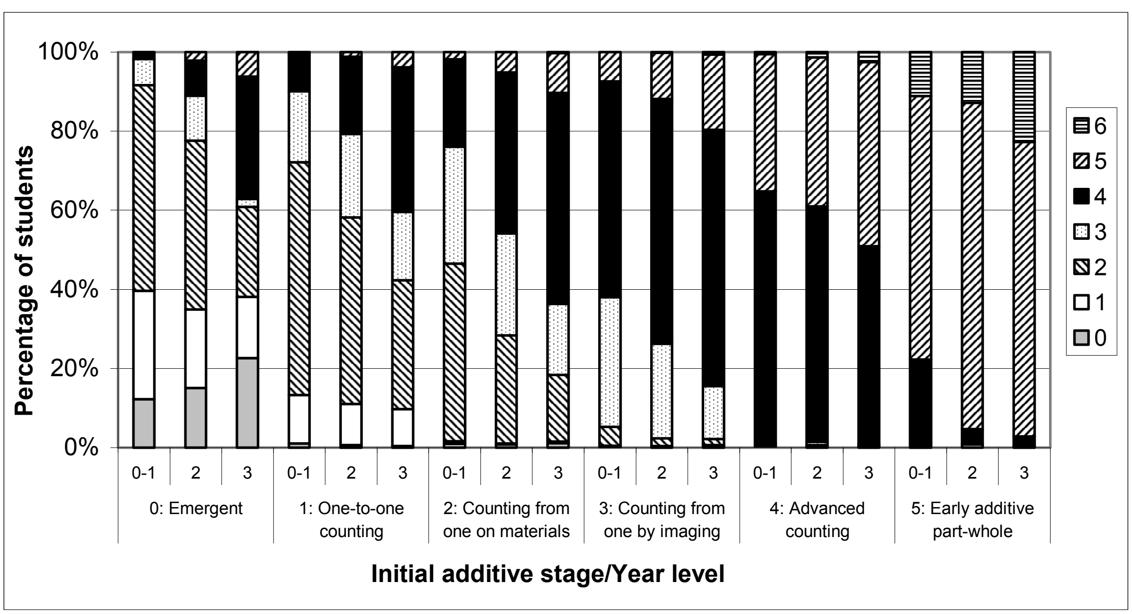


Figure 3.3 illustrates the patterns of progress when the year 0-3 students are analysed according to gender. The pattern for year 0-3 girls is very similar to year 0-3 boys for those who began the project in the lowest two stages. However, the boys make greater gains at the higher stages, with 51% of the boys making the transition from advanced counting to early additive part-whole, compared with 41% of the girls. The boys are also more likely to move from early to advanced additive part-whole (25% compared to 14%). Similarly, 3% more boys made the transition from counting from one by imaging to advanced counting.

**Figure 3.3: Final additive stage by initial additive stage and gender for year 0-3 students**

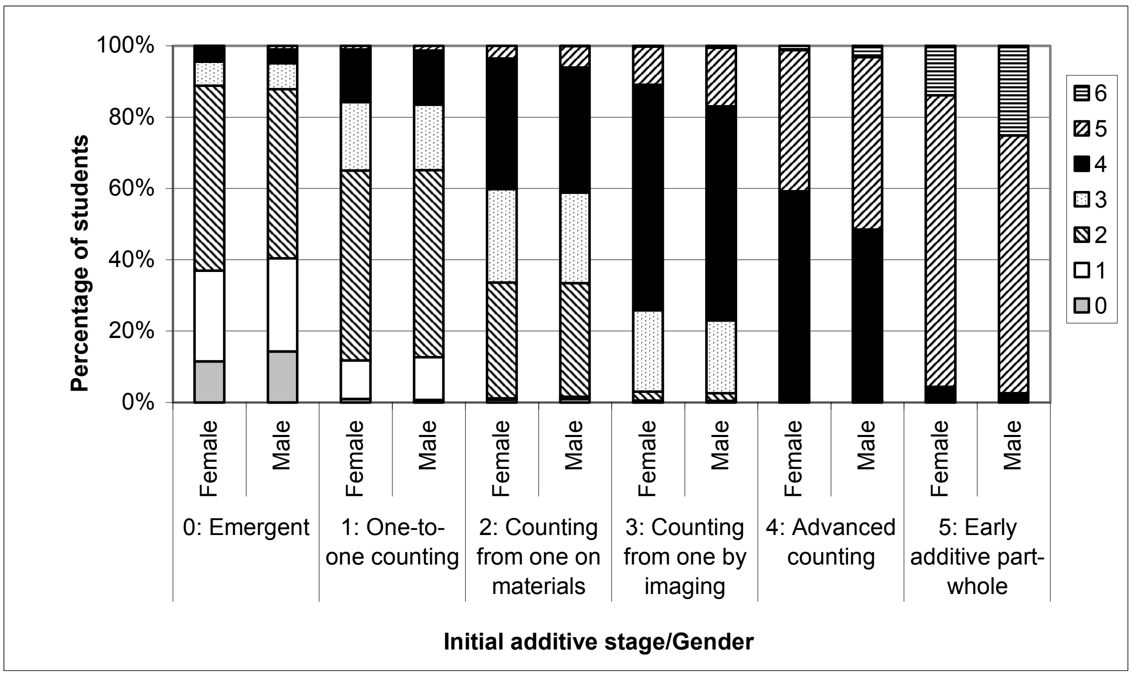



Figure 3.4 presents the final stage of year 0-3 students when the results are analysed according to ethnicity and starting stage. Consistent with the findings of the ENP 2001 and 2002 evaluations the gains made by Pasifika students were slightly but consistently lower than the gains made by the other groups (Thomas and Ward, 2002; Thomas et al., 2003). Māori students, while performing better than Pasifika students, performed consistently lower than either NZ European or Asian students. There were two exceptions to these trends. Firstly, amongst initially early additive students, NZ European, Māori, and Asian students were all equally likely to progress to advanced additive part-whole. Secondly, amongst initially emergent students, more Pasifika students progressed to Stage 2 (combining sets to solve addition and subtraction problems) than did representatives of any other ethnic group.

**Figure 3.4: Final additive stage by initial additive stage and ethnicity for year 0-3 students**

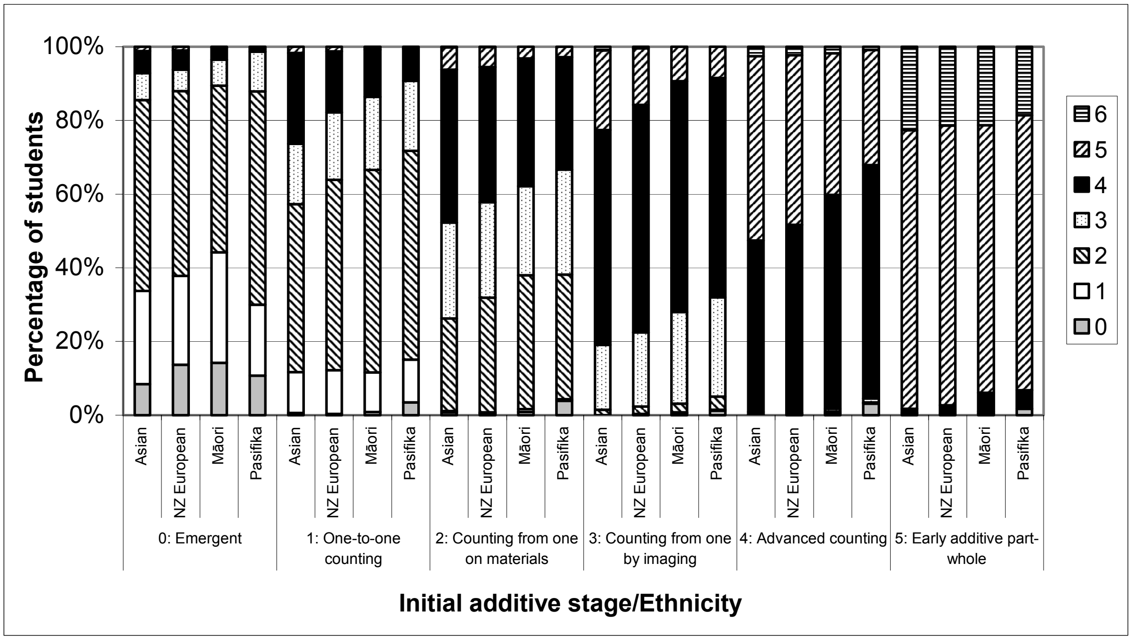



Figure 3.5 presents the final stage of year 0-3 students when their progress is analysed according to the decile level of their school and starting stage. The impact of decile is seen most noticeably in the students who were initially assessed as Stage 2, 3 or 4. Seventy percent of students from high decile schools moved from Stage 2 to Stage 3 or higher, compared with 67% for medium and 62% for low decile schools. A similar difference is seen at Stages 3 and 4.

**Figure 3.5: Final additive stage by initial additive stage and decile group for year 0-3 students**

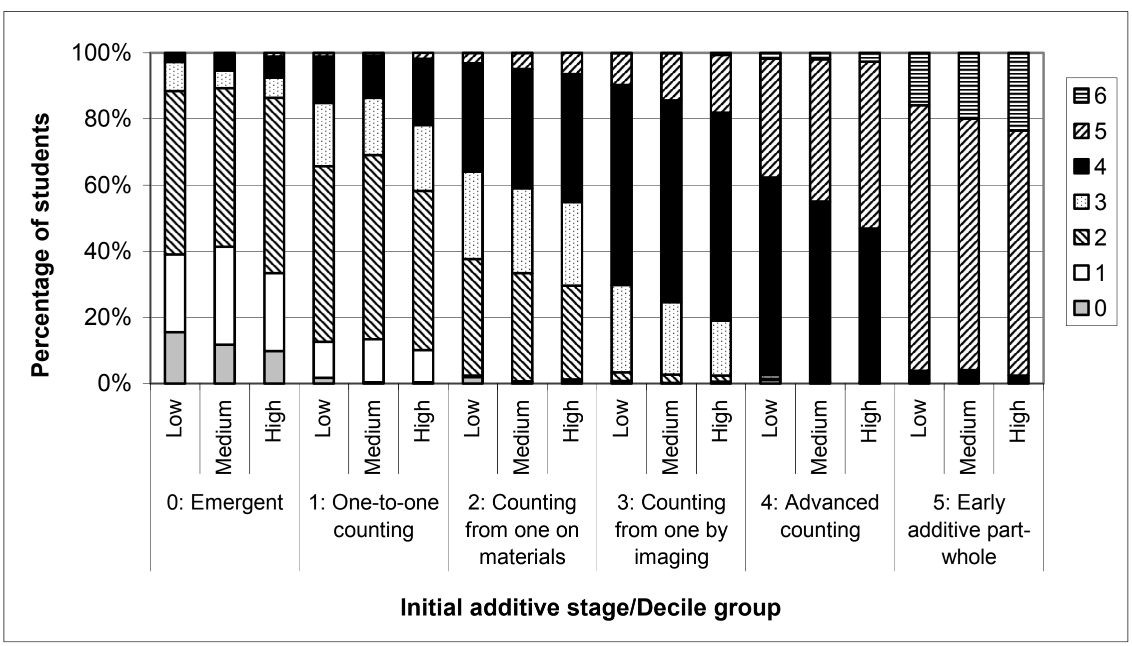
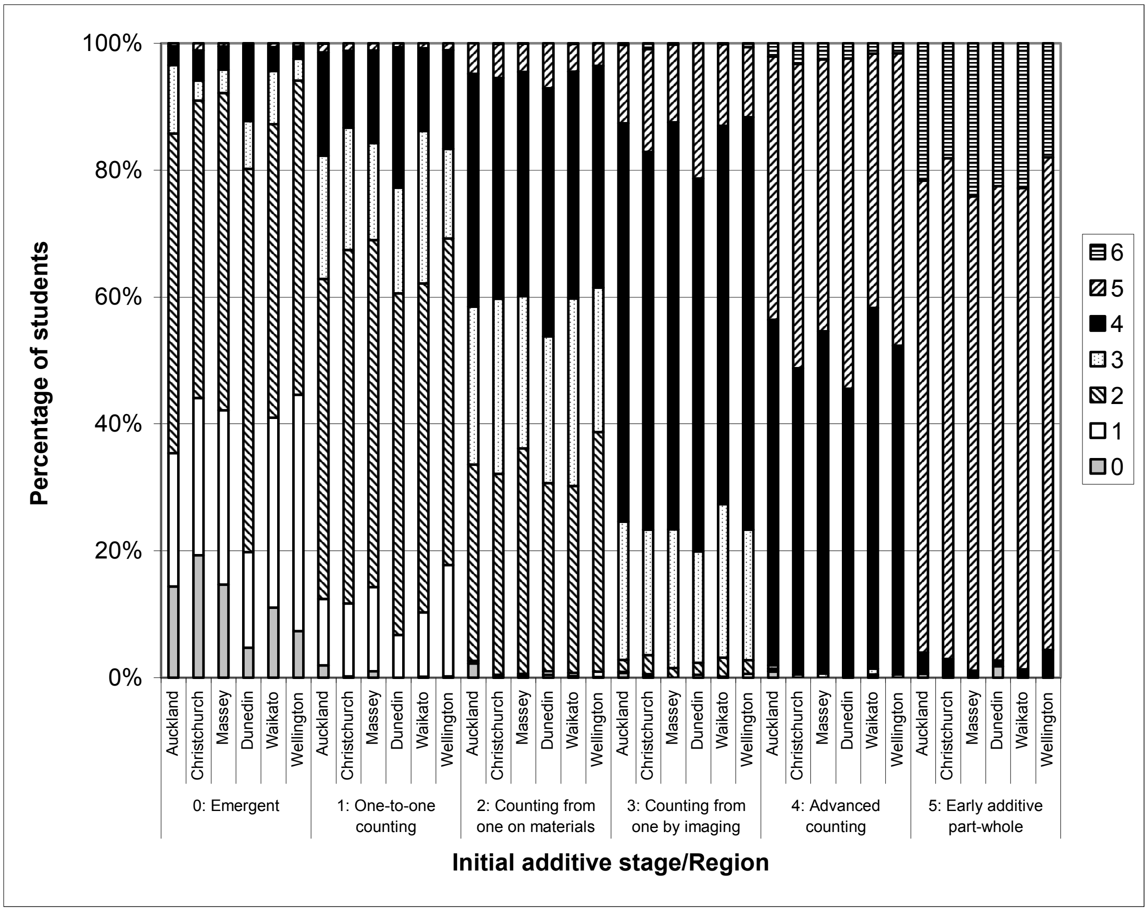


Figure 3.6 presents the pattern of progress when analysed by region. The regions are defined by the school support service that was responsible for the delivery of the ENP. The most noticeable trend is that students in the region served by the Dunedin College of Education School Support Service contract (Dunedin contract) tend to make better progress than students from other regions. This is particularly evident amongst initially emergent students. In the Dunedin contract 80% of these students move to at least Stage 2, compared to 55% to 65% of students from other regions.

**Figure 3.6: Final additive stage by initial additive stage and school support service contract for year 0-3 students**



# Chapter Four: The Impact of the Project on Students' Number Knowledge

This chapter examines the profile and progress of students on five of the six knowledge domains as assessed by the NumPA. Detailed tables of results by gender, ethnicity, school decile level, and region can be found in Appendices C to E. As fewer than 1% of the year 0-3 students were assessed on the decimal domain, these results are not discussed in this section.

Table 4.1 presents the proportion of year 0-3 students at each stage on the Forward Number Word Sequence (FNWS) domain. Nineteen percent of the year 0-3 students began the project unable to state the number after a given number in the range 0 to 10 (Stage 0 or Stage 1). By the end of the project this had fallen to 4%. Seventy-two percent of the students knew the FNWS to at least 100 by the final assessment, compared to 39% percent at the initial assessment.

**Table 4.1: Percentage of year 0-3 students by stage on the FNWS domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| 0: Emergent | 11% | 2% | 3% | 1% | 1% | 1% | 5% | 2% |
| 1: Initial to 10 | 30% | 5% | 9% | 1% | 2% | 0% | 14% | 2% |
| 2: To 10 | 35% | 16% | 24% | 4% | 6% | 1% | 21% | 7% |
| 3: To 20 | 18% | 33% | 29% | 15% | 15% | 4% | 21% | 17% |
| 4: To 100 | 6% | 37% | 31% | 50% | 50% | 32% | 29% | 40% |
| 5: To 1000 | 0% | 6% | 5% | 26% | 24% | 55% | 10% | 29% |
| 6: To 1 000 000 | 0% | 0% | 0% | 1% | 1% | 7% | 0% | 3% |

Figure 4.1 compares the progress by ethnicity of students on the forward number word sequence. In a pattern similar to that seen for number strategies, Asian students who were initially at Stages 0, 1, or 2 make the greatest progress, followed by NZ European, Māori and Pasifika students. For example, 91% of the Asian students who began the project as emergent had progressed to at least Stage 1 by the final assessment. This compares to 88% for NZ European, 81% for Māori, and 72% for Pasifika. Similar patterns of progress between the ethnic groups are also seen at the other stages. The one exception is for students with an initial assessment of Stage 4. Fifty-five percent of Pasifika students remain at or regress from Stage 4, compared to 40%, 41%, and 44% for Asian, NZ European and Māori students, respectively.

**Figure 4.1: Final FNWS stage by initial FNWS stage and ethnicity for year 0-3 students**

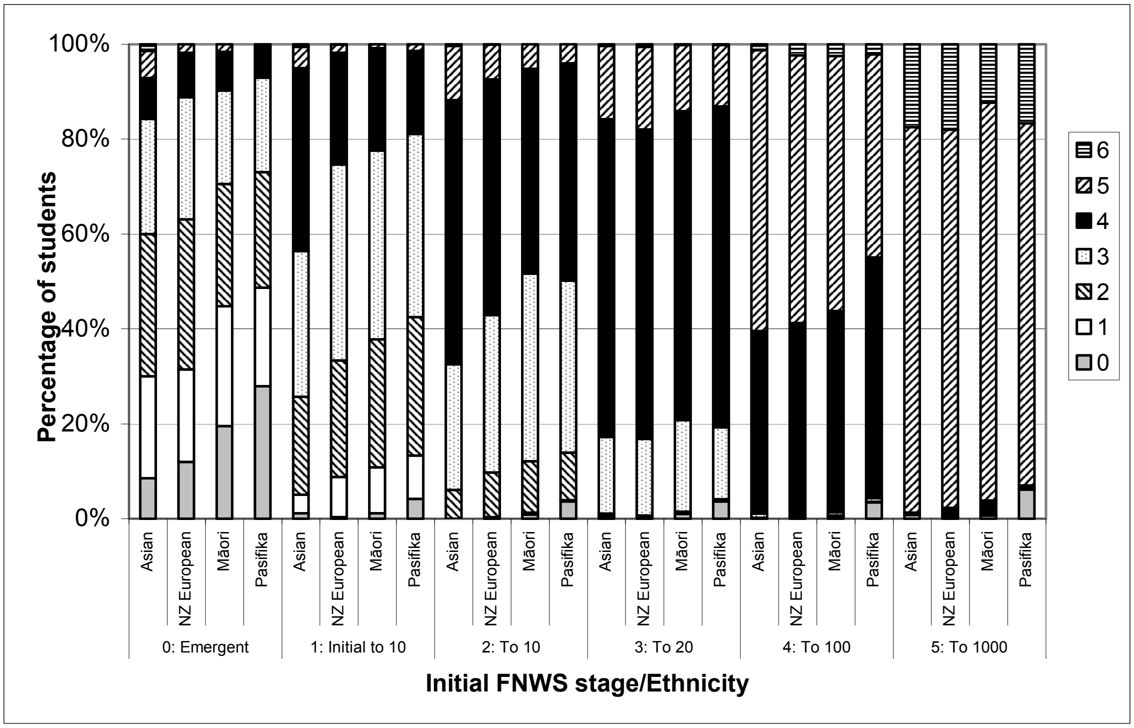



Figure 4.2 compares the progress of students on the forward number word sequence by decile group. Again the pattern is clear, students from high decile schools make more progress than those from medium decile schools, and students from low decile schools make significantly less progress than either. A closer analysis shows that the numbers of students moving forward at least one stage from Stages 0, 1, 2, or 3 are similar for all students, but that high decile students are more likely to advance multiple stages. For example, 90% of initially Stage 2 students in both high and medium decile schools, and 88% of low decile students, progressed at least one stage. Sixty percent of high decile students progressed two stages, compared to 56% of medium decile, and 49% of low decile students.

A surprising feature that emerges when initial and final forward number word stages are compared is the 156 students who were initially rated as at least able to give the number after a given number in the range 0-10 (Stage 2), but apparently regressed to being unable to produce the number sequence to 10 (Stage 0). Over half (79) of the 156 were Pasifika students and three quarters (117) were from low decile schools.

**Figure 4.2: Final FNWS stage by initial FNWS stage and decile for year 0-1 students**

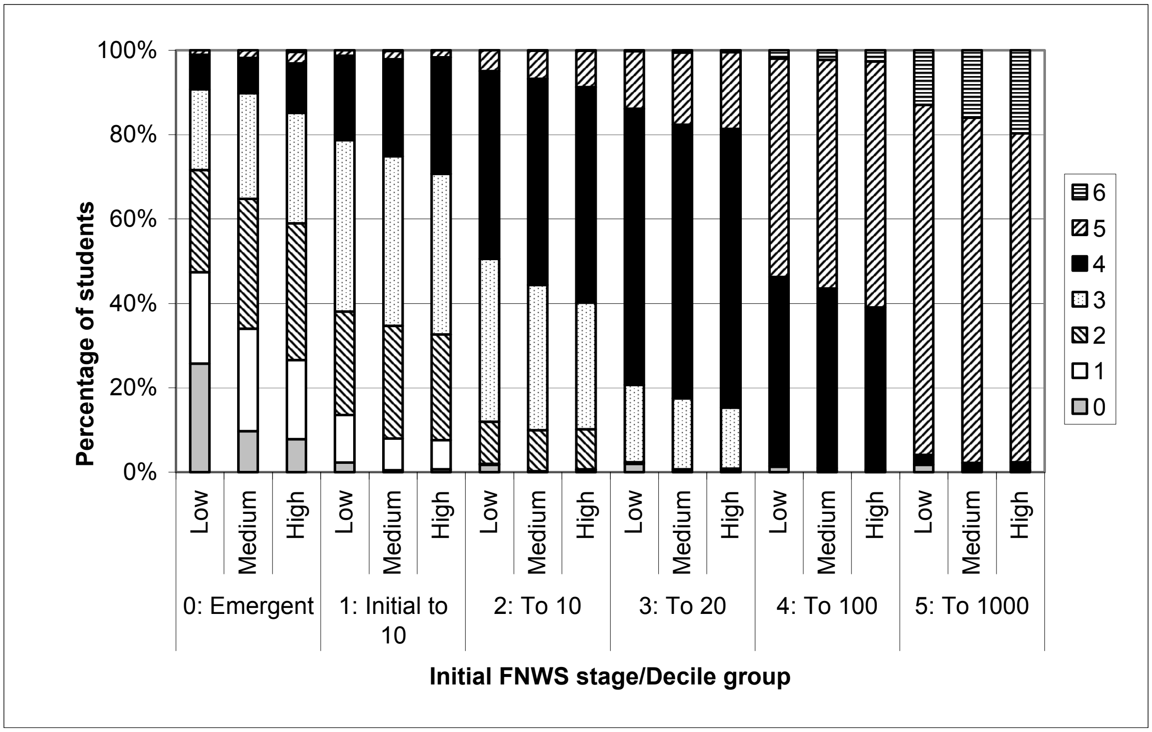



Table 4.2 shows similar patterns of improvement for the backward number word sequence (BNWS). At the start of the project, 58% of the year 0-3 students were unable to state the number before a given number in the range 0 to 10. This had dropped to 23% by the end of the project. Correspondingly, the proportion of students who knew the BNWS to at least 100 had increased from 30% to 62%.

**Table 4.2: Percentage of year 0-3 students by stage on the BNWS domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| 0: Emergent | 41% | 6% | 10% | 2% | 3% | 1% | 17% | 3% |
| 1: Initial from 10 | 23% | 11% | 14% | 3% | 5% | 1% | 14% | 5% |
| 2: From 10 | 28% | 30% | 36% | 13% | 17% | 4% | 27% | 15% |
| 3: From 20 | 5% | 23% | 16% | 16% | 14% | 6% | 12% | 15% |
| 4: From 100 | 3% | 24% | 19% | 41% | 39% | 33% | 21% | 33% |
| 5: From 1000 | 0% | 5% | 5% | 23% | 22% | 49% | 9% | 26% |
| 6: From 1 000 000 | 0% | 0% | 0% | 1% | 1% | 6% | 0% | 3% |

Only students assessed using form A of the NumPA were assessed on their numeral identification knowledge. The number of students not assessed on this domain increased from 22% to 37%. For the purposes of this discussion students not assessed on numeral identification are considered to be at least at Stage 4 on this domain. It is clear from Table 4.3 that the project had a positive impact on students' ability to identify numbers, with the percentage of students at the lower stages on the framework decreasing while those at the upper stages increased. Thirty percent of the students were unable to identify numbers in the range 0-10 at the initial assessment; this had dropped to 8% by the final assessment. Correspondingly, the proportion of students who were able to identify numbers to at least 1000 had increased from 32% to 59% by the final assessment.

**Table 4.3: Percentage of year 0-3 students by stage on the numeral identification domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| 0: Emergent | 30% | 4% | 4% | 1% | 1% | 1% | 11% | 2% |
| 1: To 10 | 37% | 14% | 18% | 3% | 3% | 1% | 19% | 6% |
| 2: To 20 | 16% | 15% | 16% | 5% | 4% | 1% | 12% | 7% |
| 3: To 100 | 14% | 43% | 38% | 29% | 23% | 8% | 25% | 26% |
| 4: To 1000 | 2% | 17% | 11% | 30% | 17% | 18% | 10% | 22% |
| Not Assessed | 2% | 6% | 13% | 32% | 52% | 72% | 22% | 37% |

Only students assessed using forms B and C were assessed on their knowledge of fractions. The percentage of students assessed on these forms increased from 24% to 47% during the project. Table 4.4 shows that the numbers of year 0-3 students assessed as able to at least assign unit fractions to regions (Stage 4 or higher) increased from 3% to 29%.

**Table 4.4: Percentage of year 0-3 students by stage on the fractions domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| Not Assessed | 99% | 88% | 86% | 54% | 46% | 19% | 77% | 53% |
| 2-3: Non-fractions | 1% | 7% | 13% | 23% | 47% | 22% | 21% | 18% |
| 4: Assigned unit fractions | 0% | 3% | 0% | 16% | 5% | 28% | 2% | 16% |
| 5: Ordered unit fractions | 0% | 1% | 0% | 8% | 2% | 28% | 1% | 12% |
| 6: Co-ordinated numer./denomin. | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 1% |
| 7: Equivalent fractions | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

As shown by Table 4.5, the proportion of year 0-3 students assessed as using groupings of numbers (Stage 2-3 or higher) increased from 27% to 70% over the project. By the final assessment 66% of year 3 students were at least able to group with tens (Stage 4).

**Table 4.5: Percentage of year 0-3 students by stage on the grouping domain at the initial and final assessments**

| | Year 0-1 | | Year 2 | | Year 3 | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | Initial | Final | Initial | Final |
| N= | 10101 | 10101 | 10664 | 10664 | 10658 | 10658 | 31423 | 31423 |
| Not Assessed | 3% | 1% | 1% | 1% | 1% | 1% | 2% | 1% |
| 0-1: Non-grouping | 93% | 51% | 77% | 26% | 45% | 11% | 71% | 29% |
| 2-3: With 5s and within 10 | 4% | 35% | 16% | 35% | 26% | 22% | 16% | 31% |
| 4: With 10s | 0% | 12% | 5% | 32% | 23% | 43% | 10% | 29% |
| 5: 10s in 100 | 0% | 1% | 0% | 6% | 4% | 19% | 1% | 9% |
| 6: 10s and 100s | 0% | 0% | 0% | 1% | 0% | 3% | 0% | 1% |
| 7: 10s 100s and 1000s | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |

Figure 4.3 shows the progress by ethnicity of year 0-3 students on the grouping domain. Pasifika students are least likely to progress regardless of which stage they start the project. The exception is at Stage 5 where 2 of the 7 (29%) Pasifika students progressed to Stage 6, compared to 20% (10), 26% (88), and 17% (8) of Asian, NZ European and Māori students respectively. Neither of the Pasifika students progressed beyond Stage 6, while between 7% and 12% of students of other ethnicities did so. The small numbers of students represented in these results needs to be noted. The performance of Asian and NZ European students was consistently better than that of Māori students. The difference between the ethnic groups is most evident amongst initially unassessed students. Eighty-nine percent of Asian students are assessed by the end of the project with 67% assessed at Stage 2-3 or higher, compared to 81% and 46% of NZ European students, 63% and 25% of Māori students, and 39% and 14% of Pasifika students.

**Figure 4.3: Final grouping stage by initial grouping stage and ethnicity for year 0-3 students**

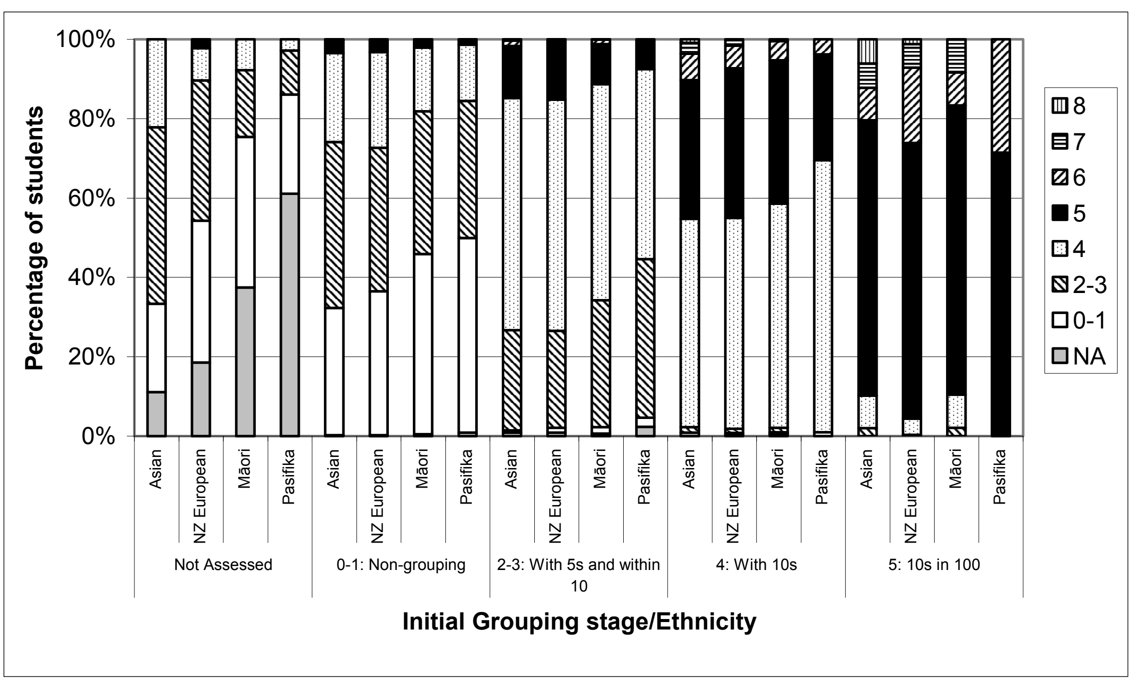
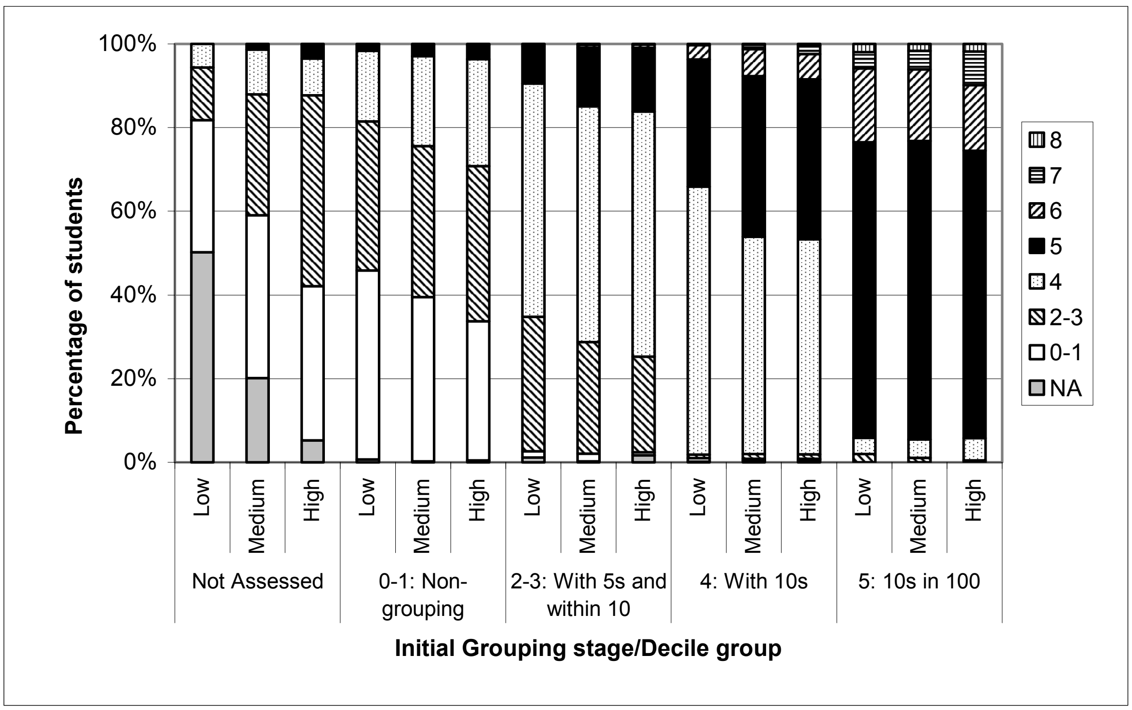


Figure 4.4 compares the progress of students on the grouping domain by decile level of their school. Again, high decile schools perform better than medium decile schools, who in turn perform better than low decile schools. Exceptions occurred at Stage 4, where medium and high decile students were equally likely to progress, and at Stage 5, where medium and low decile students were equally likely to progress. Again the differences were largest amongst initially unassessed students. Fifty percent of initially unassessed students from low decile schools were still not assessed by the end of the project, compared with 20% of medium and 5% of high decile students. Correspondingly, 18% of students who were not assessed in this domain in the initial assessment progressed to at least Stage 2-3, compared to 41% of medium and 58% of high decile school students.

**Figure 4.4: Final grouping stage by initial grouping stage and decile for year 0-3 students**



# Chapter Five: The Relationship between Strategies and Knowledge

This chapter examines the relationship between the students' use of strategies and their number knowledge. More specifically, it compares the knowledge profile of students who made three key transitions: the transition from emergent to one-to-one counting, the transition from counting from one to advanced counting, and the transition from advanced counting to the use of additive strategies. As illustrated in Tables 4.1 to 4.6 these groups differ in the five knowledge domains displayed.

Tables 5.1 and 5.2 make use of the results of the 2015 year 0-3 students who were initially rated as emergent (Stage 0) on the additive domain. Table 5.1 compares the end-of-project knowledge profile of students who made the transition to counting from one (Stage 1 or higher) with those who remained at Stage 0. Seventy-eight percent of students who progressed could give the number after a given number in the range 0-10 (Stage 2) compared to 23% those who remained at Stage 0. A similar difference is seen in the backward number word sequence with 55% of those who became counters assessed as knowing the number before a given number in the range 0-10, compared to just 11% of those who remained emergent. Taking into account the fact that students not assessed on the numeral identification domain are at the top end of the scale, 54% of students who progressed could identify numbers to at least 20, compared to 23% of those who did not progress. Students who made the transition were also stronger in their knowledge of groupings with 20% assessed as able to group at least with 5s compared to only 3% of those who did not make the transition.

Table 5.2 shows the same results, but in this case the percentages given are the percentage of students finishing the project at each knowledge stage who did or did not make the progression from emergent number strategies. This table helps to demonstrate the importance of knowledge in determining whether students make this progression. The knowledge profile of the 1750 (87%) initially emergent students who had progressed to one-to-one counting by the end of the project is considerably different from that of the 265 students who remained emergent. Seventy-nine percent of students who could count to 10 (Stage 1) and 94% of students who could state the number after a given number to 10 (Stage 2) made the transition from emergent. A similar pattern is shown for backward number word sequence. Knowledge of grouping is also shown to be a key factor in determining who will make this progression. Students rated as non-grouping were less likely to progress, while virtually all of those who could group made the transition. Ninety-two percent of students who could identify numerals to at least 10 made the progression from emergent to counting. It is interesting to note that 58% of students who were still unable to identify numerals to 10 became counters.

Two findings from Table 5.2 are confusing and need further investigation. One is the 38 students (25%) who were non-emergent by the final assessment and could therefore form a set of eight objects, but were assessed as unable to count to ten as a sequence of number words. The other concerns the 30 students (35%) who remained emergent, but were not assessed on the numeral identification domain. It is only those students who were assessed on forms B and C that were supposed to be excused from assessment on the numeral identification domain. It is possible that these emergent students were incorrectly coded as not assessed rather than emergent on the numeral identification domain.

**Table 5.1: Comparing the number knowledge profile of initially emergent students (Stage 0) who progressed to counting with those who remained emergent**

| | Remained emergent | Progressed |
|---|---|---|
| N= | 265 | 1750 |
| FNWS | | |
| 0: Emergent | 44% | 2% |
| 1: Initial to 10 | 33% | 19% |
| 2: To 10 | 14% | 34% |
| 3: To 20 | 7% | 31% |
| 4: To 100 | 2% | 11% |
| 5: To 1000 | 0% | 2% |
| 6: To 1 000 000 | 0% | 0% |
| BNWS | | |
| 0: Emergent | 73% | 18% |
| 1: Initial from 10 | 16% | 28% |
| 2: From 10 | 6% | 35% |
| 3: From 20 | 4% | 11% |
| 4: From 100 | 1% | 7% |
| 5: From 1000 | 0% | 2% |
| 6: From 1 000 000 | 0% | 0% |
| NID | | |
| 0: Emergent | 55% | 12% |
| 1: To 10 | 21% | 35% |
| 2: To 20 | 6% | 22% |
| 3: To 100 | 6% | 24% |
| 4: To 1000 | 0% | 5% |
| Not Assessed | 11% | 3% |
| Fractions | | |
| Not Assessed | 100% | 95% |
| 2-3: Non-fractions | 0% | 3% |
| 4: Assigned unit fractions | 0% | 2% |
| 5: Ordered unit fractions | 0% | 1% |
| Grouping | | |
| Not Assessed | 12% | 1% |
| 0-1: Non-Grouping | 85% | 78% |
| 2-3: With 5s and within 10 | 3% | 17% |
| 4: With 10s | 0% | 3% |
| 5: 10s in 100 | 0% | 0% |
| 6: 10s and 100s | 0% | 0% |

**Table 5.2: Comparing the proportions of initially emergent students (Stage 0) at each number knowledge stage who progressed with those who remained emergent**

| | N= | Remained emergent | Progressed |
|---|---|---|---|
| | | 265 | 1750 |
| FNWS | | | |
| 0: Emergent | 155 | 75% | 25% |
| 1: Initial to 10 | 424 | 21% | 79% |
| 2: To 10 | 635 | 6% | 94% |
| 3: To 20 | 568 | 3% | 97% |
| 4: To 100 | 196 | 3% | 97% |
| 5: To 1000 | 35 | 0% | 100% |
| 6: To 1 000 000 | 2 | 0% | 100% |
| BNWS | | | |
| 0: Emergent | 501 | 39% | 61% |
| 1: Initial from 10 | 532 | 8% | 92% |
| 2: From 10 | 634 | 3% | 97% |
| 3: From 20 | 197 | 5% | 95% |
| 4: From 100 | 116 | 2% | 98% |
| 5: From 1000 | 33 | 0% | 100% |
| 6: From 1 000 000 | 2 | 0% | 100% |
| NID | | | |
| 0: Emergent | 349 | 42% | 58% |
| 1: To 10 | 663 | 8% | 92% |
| 2: To 20 | 406 | 4% | 96% |
| 3: To 100 | 432 | 4% | 96% |
| 4: To 1000 | 79 | 0% | 100% |
| Not Assessed | 86 | 35% | 65% |
| Fractions | | | |
| Not Assessed | 1930 | 14% | 86% |
| 2-3: Non-fractions | 45 | 2% | 98% |
| 4: Assigned unit fractions | 29 | 0% | 100% |
| 5: Ordered unit fractions | 11 | 0% | 100% |
| Grouping | | | |
| Not Assessed | 57 | 54% | 46% |
| 0-1: Non-grouping | 1590 | 14% | 86% |
| 2-3: With 5s and within 10 | 302 | 3% | 97% |
| 4: With 10s | 57 | 2% | 98% |
| 5: 10s in 100 | 8 | 0% | 100% |
| 6: 10s and 100s | 1 | 0% | 100% |

Tables 5.3 and 5.4 make use of the results of the 15 932 year 0-3 students who were initially rated as counting from one (Stage 2 or 3) on the additive domain. Table 5.3 compares the end-of-project knowledge profile of the 7769 students who made the transition to advanced counting (Stage 4) with those who remained at or below Stage 3. Ninety-two percent of students who progressed knew their forward number word sequence to at least 100 compared to 55% of those who remained at Stage 3. A similar difference is seen in the BNWS; with 84% of those who became advanced counters assessed as knowing the sequence to at least 100, compared to just 37% of those who remained counting from one. Taking into account the fact that students not assessed on the numeral identification domain are at the top end of the scale, 79% of students who progressed could identify numbers to at least 1000, compared to 31% of those who did not progress. Students who made the transition were also stronger in their knowledge of groupings with 85% assessed as able to group at least with 5s compared to 55% of those who did not make the transition.

Table 5.4 shows the same results, but in this case the percentages given are the percentage of students finishing the project at each knowledge stage who did or did not make the progression. This table gives a clear picture of the knowledge that students require to make this key progression. Approximately half (53%) of the students who knew the FNWS to 100 and the large majority of students who knew the FNWS to 1000 (83%) or 1 000 000 (97%) progressed to advanced counting. A similar pattern is shown for BNWS. Numeral identification seems less closely linked than the other knowledge domains to the progression to advanced counting. Seventy-four percent of the students who could identify numerals to 100 did not become advanced counters. Fifty-five percent of students who could identify numbers to 1000 made the transition, as did 93% of the students who were not rated on this scale. Knowledge of grouping also appears to be an important factor in determining who will make this progression. Students rated as non-grouping were unlikely to progress to advanced counting, while more than three-quarters of those who could group with tens made the transition.

**Table 5.3: Comparing the number knowledge profile of initially count-from-one students (Stage 2 or 3) who became advanced counters (Stage 4 or higher) with those who remained count from one**

| | Remained count from 1 | Became advanced counting |
|---|---|---|
| N= | 8163 | 7769 |
| FNWS | | |
| 0: Emergent | 2% | 0% |
| 1: Initial to 10 | 1% | 0% |
| 2: To 10 | 9% | 1% |
| 3: To 20 | 32% | 6% |
| 4: To 100 | 48% | 57% |
| 5: To 1000 | 7% | 34% |
| 6: To 1 000 000 | 0% | 1% |
| BNWS | | |
| 0: Emergent | 3% | 0% |
| 1: Initial from 10 | 6% | 0% |
| 2: From 10 | 26% | 5% |
| 3: From 20 | 29% | 10% |
| 4: From 100 | 31% | 53% |
| 5: From 1000 | 6% | 30% |
| 6: From 1 000 000 | 0% | 1% |
| NID | | |
| 0: Emergent | 2% | 0% |
| 1: To 10 | 7% | 1% |
| 2: To 20 | 11% | 1% |
| 3: To 100 | 50% | 18% |
| 4: To 1000 | 28% | 35% |
| Not Assessed | 3% | 44% |
| Fractions | | |
| Not Assessed | 94% | 32% |
| 2-3: Non-fractions | 4% | 35% |
| 4: Assigned unit fractions | 2% | 23% |
| 5: Ordered unit fractions | 0% | 10% |
| 6: Co-ordinated numer./denomin. | 0% | 0% |
| Grouping | | |
| Not Assessed | 1% | 0% |
| 0-1: Non-grouping | 44% | 14% |
| 2-3: With 5s and within 10 | 43% | 36% |
| 4: With 10s | 12% | 43% |
| 5: 10s in 100 | 0% | 6% |
| 6: 10s and 100s | 0% | 0% |
| 7: 10s, 100s and 1000s | 0% | 0% |

**Table 5.4: Comparing the proportions of initially count-from-one students (Stage 2 or 3) at each number knowledge stage who became advanced counters (Stage 4 or higher) with those who remained count from one**

| | N= | Remained count from 1 | Became advanced counting |
|---|---|---|---|
| FNWS | | | |
| 0: Emergent | 182 | 91% | 9% |
| 1: Initial to 10 | 113 | 97% | 3% |
| 2: To 10 | 832 | 93% | 7% |
| 3: To 20 | 3114 | 85% | 15% |
| 4: To 100 | 8393 | 47% | 53% |
| 5: To 1000 | 3192 | 17% | 83% |
| 6: To 1 000 000 | 106 | 4% | 96% |
| BNWS | | | |
| 0: Emergent | 273 | 88% | 12% |
| 1: Initial from 10 | 487 | 94% | 6% |
| 2: From 10 | 2541 | 84% | 16% |
| 3: From 20 | 3142 | 75% | 25% |
| 4: From 100 | 6617 | 38% | 62% |
| 5: From 1000 | 2783 | 17% | 83% |
| 6: From 1 000 000 | 89 | 3% | 97% |
| NID | | | |
| 0: Emergent | 138 | 90% | 10% |
| 1: To 10 | 610 | 90% | 10% |
| 2: To 20 | 978 | 89% | 11% |
| 3: To 100 | 5536 | 74% | 26% |
| 4: To 1000 | 4962 | 45% | 55% |
| Not Assessed | 3708 | 7% | 93% |
| Fractions | | | |
| Not Assessed | 10138 | 76% | 24% |
| 2-3: Non-fractions | 3016 | 10% | 90% |
| 4: Assigned unit fractions | 1921 | 9% | 91% |
| 5: Ordered unit fractions | 837 | 4% | 96% |
| 6: Co-ordinated numer./denomin. | 20 | 10% | 90% |
| Grouping | | | |
| Not Assessed | 140 | 87% | 13% |
| 0-1: Non-grouping | 4694 | 77% | 23% |
| 2-3: With 5s and within 10 | 6294 | 55% | 45% |
| 4: With 10s | 4289 | 22% | 78% |
| 5: 10s in 100 | 495 | 3% | 97% |
| 6: 10s and 100s | 18 | 6% | 94% |
| 7: 10s, 100s and 1000s | 2 | 0% | 100% |

Tables 5.5 and 5.6 show the results of the 7 092 year 0-3 students who were initially rated as advanced counting (Stage 4) on the additive domain. Table 5.5 compares the end-of-project knowledge profile of students who made the transition to using additive strategies (Stages 5 or 6) with those who remained at or below Stage 4, and is similar in findings to those reported in the 2002 ENP evaluation (Thomas et al., 2003). Eighty-three percent of students who progressed knew their FNWS to at least 1000 compared to 56% of those who remained at Stage 4. A similar difference is seen in the BNWS, with 78% of those who became additive assessed as knowing the sequence to at least 1000, compared to just 48% of those who remained advanced counting. Students who made the transition were also stronger in their knowledge of groupings, with 36% assessed as able to group with 10s in 100 compared to 12% of those who did not make the transition.

Table 5.6 shows the same results, but in this case the percentages given are the percentage of students finishing the project at each knowledge stage who did or did not make the progression. This table highlights that the students who make this key progression are at the higher knowledge stages. While there are relatively few students still at the lower stages of the knowledge domains, some useful comparisons can be made. Students who could not give the number before and after a given number in the range 0-1000 were unlikely to make the transition, while 75% of those who could do so in the range 0-1 000 000 progressed to the use of additive strategies. Slightly more than half (56%) of the students who could give the numbers before and after to 1000, but not to 1 000 000, made the transition. Knowledge of grouping appears to be a key factor in determining who will make this progression. Seventy-one percent of the students who could group with 10s in 100 (Stage 5) and 86% of those who could group with 10s and 100s (Stage 6) made the transition. Correspondingly, 25% of students who could group with 5s and 12% of non-grouping students became additive by the end of the project.

**Table 5.5: Comparing the number knowledge profile of initially advanced counting students (Stage 4) who became additive part-whole (Stage 5 or higher) with those who remained count from one**

| | Remained advanced counting | Became additive |
|---|---|---|
| N= | 3834 | 3258 |
| FNWS | | |
| 0: Emergent | 2% | 0% |
| 1: Initial to 10 | 0% | 0% |
| 2: To 10 | 0% | 0% |
| 3: To 20 | 2% | 0% |
| 4: To 100 | 40% | 16% |
| 5: To 1000 | 53% | 74% |
| 6: To 1 000 000 | 3% | 9% |
| BNWS | | |
| 0: Emergent | 2% | 0% |
| 1: Initial from 10 | 0% | 0% |
| 2: From 10 | 2% | 0% |
| 3: From 20 | 4% | 1% |
| 4: From 100 | 44% | 21% |
| 5: From 1000 | 46% | 69% |
| 6: From 1 000 000 | 2% | 9% |
| NID | | |
| Not Assessed | 78% | 90% |
| 0: Emergent | 0% | 0% |
| 1: To 10 | 0% | 0% |
| 2: To 20 | 0% | 0% |
| 3: To 100 | 5% | 1% |
| 4: To 1000 | 17% | 9% |
| Fractions | | |
| Not Assessed | 11% | 2% |
| 2-3: Non-fractions | 34% | 20% |
| 4: Assigned unit fractions | 34% | 35% |
| 5: Ordered unit fractions | 21% | 41% |
| 6: Co-ordinated numer./denomin. | 0% | 2% |
| 7: Equivalent fractions | 0% | 0% |
| 8: Orders fractions | 0% | 0% |
| Grouping | | |
| Not Assessed | 1% | 0% |
| 0-1: Non-grouping | 9% | 1% |
| 2-3: With 5s and within 10 | 25% | 9% |
| 4: With 10s | 53% | 54% |
| 5: 10s in 100 | 11% | 31% |
| 6: 10s and 100s | 1% | 4% |
| 7: 10s, 100s and 1000s | 0% | 1% |
| 8: Tenths, hundredths and thousandths | 0% | 0% |

**Table 5.6: Comparing the proportions of initially advanced counting students (Stage 4) at each number knowledge stage who became additive part-whole with those who remained advanced counting**

| | N= | Remained advanced counting | Became additive |
|---|---|---|---|
| FNWS | | | |
| 0: Emergent | 67 | 88% | 12% |
| 1: Initial to 10 | 0 | na | na |
| 2: To 10 | 9 | 89% | 11% |
| 3: To 20 | 73 | 86% | 14% |
| 4: To 100 | 2081 | 74% | 26% |
| 5: To 1000 | 4459 | 46% | 54% |
| 6: To 1 000 000 | 403 | 27% | 73% |
| BNWS | | | |
| 0: Emergent | 67 | 88% | 12% |
| 1: Initial from 10 | 3 | 100% | 0% |
| 2: From 10 | 86 | 91% | 9% |
| 3: From 20 | 171 | 89% | 11% |
| 4: From 100 | 2361 | 71% | 29% |
| 5: From 1000 | 4031 | 44% | 56% |
| 6: From 1 000 000 | 373 | 25% | 75% |
| NID | | | |
| Not Assessed | 5913 | 51% | 49% |
| 0: Emergent | 15 | 80% | 20% |
| 1: To 10 | 6 | 67% | 33% |
| 2: To 20 | 10 | 70% | 30% |
| 3: To 100 | 208 | 90% | 10% |
| 4: To 1000 | 940 | 68% | 32% |
| Fractions | | | |
| Not Assessed | 483 | 87% | 13% |
| 2-3: Non-fractions | 1953 | 67% | 33% |
| 4: Assigned unit fractions | 2421 | 53% | 47% |
| 5: Ordered unit fractions | 2129 | 38% | 62% |
| 6: Co-ordinated numer./denomin. | 92 | 15% | 85% |
| 7: Equivalent fractions | 12 | 0% | 100% |
| 8: Orders fractions | 2 | 50% | 50% |
| Grouping | | | |
| Not Assessed | 61 | 85% | 15% |
| 0-1: Non-grouping | 388 | 88% | 12% |
| 2-3: With 5s and within 10 | 1262 | 76% | 24% |
| 4: With 10s | 3798 | 54% | 46% |
| 5: 10s in 100 | 1423 | 29% | 71% |
| 6: 10s and 100s | 140 | 14% | 86% |
| 7: 10s, 100s and 1000s | 18 | 0% | 100% |
| 8: Tenths, hundredths and thousandths | 2 | 0% | 100% |

## Concluding Comment

The findings presented in this chapter support the contention that "knowledge is often an essential prerequisite for the development of more advanced strategies" (Ministry of Education, 2003, p. 1). Year 0 to 3 students who make the key progressions from emergent to counting strategies, and from counting to additive strategies, are at higher stages on five of the knowledge domains of the Number Framework.

# Chapter Six: Are We Getting Better at Mathematics?

This is the first of three chapters that examine the impact of the Numeracy Development Project in the fifteen schools participating in the longitudinal component of the research. These schools will subsequently be referred to as the longitudinal schools and their students as the longitudinal students. This chapter reports on the performance of year 4, 5 and 8 students on a mathematics test comprised of items from the Third International Maths and Science Study (TIMSS) in 1995. Detailed information of TIMSS procedures and the New Zealand samples has been taken from Garden (1996, 1997, 1998). Items have been taken from the released items sets, and detail of percentages correct from the data almanacs, both available at the TIMSS 1995 website (http://timss.bc.edu/timss1995.html).

**Background to TIMSS**

The International Association for the Assessment of Educational Achievement (IEA) is a non-profit international cooperative of research institutions. The IEA undertakes comparative research projects on an international scale with the aim of providing factual information to assist in improving education systems.

New Zealand has participated in a number of IEA studies, including TIMSS 1995 and the follow-up TIMSS Repeat study in 1999. While TIMSS 1995 tested students in years 4 and 5, years 8 and 9, and in their final year of school, the TIMSS Repeat study focussed solely on the year 8 and 9 group. For this reason results from TIMSS 1995 have been used here.

Forty-five countries participated in TIMSS 1995, with results collected from a total of more than half a million students and their teachers. Results were collected on three samples of students; the definitions of the three samples are shown in Table 6.1. Data was collected on Population 1 students from 26 countries, Population 2 students from 41 countries and Population 3 students from 21 countries. New Zealand students were tested in all three cases.

**Table 6.1: Descriptions of TIMSS populations**

| Sample | Description | NZ school year |
|---|---|---|
| Population 1 | All students enrolled in the two adjacent grades that contained the highest proportion of students in the age 9 cohort (at the time of testing). | Years 4 and 5 |
| Population 2 | All students enrolled in the two adjacent grades that contained the highest proportion of students in the age 13 cohort (at the time of testing). | Years 8 and 9 |
| Population 3 | All students enrolled in their final year of secondary education. | Years 12 and 13 |

All schools with at least five students in the desired year ranges, excluding special schools and the Correspondence School, were included in the sampling frame for participation in TIMSS. A sample of schools was randomly selected with weighting given to their number of students in the target year levels. One mathematics group or class was randomly selected from each school for testing, with both the students and the teacher involved in the study.

The testing carried out for TIMSS was based on a conceptual framework that identifies three aspects of the curriculum: the intended, implemented, and attained curricula. The intended curriculum refers to nationally or regionally defined aims, content, and methods for teaching. The implemented curriculum describes the way mathematics is actually presented to students and includes teacher interpretation of content, teaching strategies and time allocation, as well as social, cultural and economic characteristics of the community, parent expectations and participation rates. The attained curriculum consists of the concepts, processes, skills and attitudes that students have acquired during their schooling.

The intended curricula of the participating countries were analysed in two ways, firstly through questionnaires, and secondly through an analysis of the current trends in mathematics, curriculum documents, guides, and textbooks of each country. The implemented curricula were explored through questionnaires completed by both teachers and school administrators. These questionnaires included information on the professional backgrounds, opinions, attitudes, and teaching practices of teachers, as well as the resources, management and internal policy-making practices of the schools. The attained curricula were investigated by way of three sets of information collected from student participants; results of pencil and paper tests, performance in a set of hands-on 'Performance Assessment' activities, and responses to a questionnaire gauging opinions and attitudes of students as well as demographic data. The results of the pencil and paper tests have been used in this research.

New Zealand students did not perform particularly well in the TIMSS test when compared with international students, consistently performing below the international means for populations 1 and 2 (Table 6.2). A positive viewpoint is that the older the sample the better New Zealand students performed; year 4 and 5 students each scored 30 points less than the international average, year 8 and 9 students were only 12 and 5 points below the international average respectively, and final year students in New Zealand scored 25 points more than the international average for final year students. A more detailed breakdown of the international performances of year 4, 5 and 8 students is given in Appendix F.

**Table 6.2: New Zealand students' performance in TIMSS**

| School Year | Number of countries | NZ rank | Countries meeting guidelines | NZ rank | International mean | NZ mean |
|---|---|---|---|---|---|---|
| 4 | 24 | 18 | 16 | 10 | 470 | 440 |
| 5 | 26 | 20 | 17 | 13 | 529 | 499 |
| 8 | 39 | 25 | 27 | 18 | 484 | 472 |
| 9 | 41 | 24 | 25 | 15 | 513 | 508 |
| 9 (1999) | 38 | 21 | 38 | 21 | 487 | 491 |
| Final | 21 | 8= | 8 | 3 | 500 | 525 |

## Using TIMSS Items in the Longitudinal Study

The TIMSS 1995 results represent performance of a random sample of New Zealand students prior to the implementation of the Numeracy Development Project. As a means of comparing the overall mathematics performance of students in the longitudinal study with this sample, three tests were generated using items from the TIMSS pencil and paper tests. The reported results of percentages of New Zealand students who answered each question correctly in the TIMSS 1995 testing were used to create tests for each of years 4, 5 and 8. The items were selected to give coverage of all areas of the mathematics curriculum.

The three tests generated from TIMSS items were used to test 1566 students at years 4, 5, and 8 from the 15 longitudinal schools. Table 6.3 compares the ethnic profiles of the TIMSS sample with the longitudinal students. The numbers are obtained from the ethnicities given for students with data in this year's numeracy database for the twelve schools who entered data, and from the most recent data entered on the numeracy database for the other three schools. The proportion of Pasifika students in the longitudinal sample is higher than in the TIMSS 1995 sample for both populations. The difference is primarily balanced by a decrease in the proportion of NZ European students. Slightly over half of the longitudinal students tested were male, with similar percentages of students from each of the decile bands at years 4 and 5. There were far fewer students at year 8, with only one year 8 student from a medium decile school tested.

**Table 6.3: Comparison of ethnicities**

| | | NZ European | Māori | Pasifika | Asian | Other |
|---|---|---|---|---|---|---|
| Population 1 | TIMSS | 63% | 26% | 6% | 3% | 2% |
| (Years 4 & 5) | Longitudinal | 54% | 24% | 12% | 6% | 4% |
| Population 2 | TIMSS | 68% | 19% | 7% | 5% | 1% |
| (Years 8 & 9) | Longitudinal | 59% | 14% | 24% | 1% | 1% |

**Table 6.4: Breakdown of students by year and gender**

| | Year 4 | Year 5 | Year 8 | Total |
|---|---|---|---|---|
| Male | 379 (50%) | 329 (54%) | 105 (55%) | 813 (52%) |
| Female | 385 (50%) | 282 (46%) | 86 (45%) | 753 (48%) |
| Total | 764 (100%) | 611 (100%) | 191 (100%) | 1566 (100%) |

**Table 6.5: Breakdown of students by year and decile band**

| | Year 4 | Year 5 | Year 8 | Total |
|---|---|---|---|---|
| Low | 242 (32%) | 207 (34%) | 77 (40%) | 526 (34%) |
| Medium | 239 (31%) | 167 (27%) | 1 (1%) | 406 (26%) |
| High | 283 (37%) | 237 (39%) | 113 (59%) | 633 (40%) |
| Total | 764 (100%) | 611 (100%) | 191 (100%) | 1566 (100%) |

**Results of TIMSS in the Longitudinal Schools**

The tests were designed so that the average total score in each test would be 50% based on the percentages of students answering each item correctly in TIMSS 1995. All reporting of results is based on the average percentage of items answered correctly by students in a given group. For each question, the 95% confidence limits for the difference in mean proportion between the longitudinal students and New Zealand students in TIMSS 1995 are given in Appendix G. For years 4, 5 and 8, differences between mean percentages of at least 4.0%, 4.5% or 7.5% respectively, are larger than that expected due to sampling variation and therefore indicate probable changes in the percentages over time. Unless results differ by at least these amounts they are referred to as the same in this chapter.

The differences between genders at years 4 and 8 were too small to be significant. However, males performed on average 5% better than females at year 5 (Table 6.6).

**Table 6.6: Average score by year and gender**

| | Year 4 | Year 5 | Year 8 |
|---|---|---|---|
| Male | 56% | 61% | 51% |
| Female | 56% | 56% | 52% |
| Total | 56% | 59% | 52% |

As shown in Table 6.7 low decile students at all year levels performed not only lower than medium and high decile students, but also lower than the 1995 TIMSS sample overall. High decile students performed between 16% and 24% better than low decile students and around 10% better than medium decile students.

**Table 6.7: Average score by year and decile band**

| | Year 4 | Year 5 | Year 8 |
|---|---|---|---|
| Low | 48% | 46% | 42% |
| Medium | 55% | 58% | 38%* |
| High | 64% | 70% | 58% |
| Total | 56% | 59% | 52% |

* Only one year 8 student was tested from a medium decile school.

Each test had 24 distinct questions, with data on the answers given by each student to each question collected to allow for detailed analysis. These results are summarised in Appendix G.

Year 4 Longitudinal Results

Of the 24 questions in the year 4 test, longitudinal students performed better on average than the TIMSS 1995 New Zealand sample on fifteen questions, and equally well on six questions.

The two questions on which longitudinal students performed more than 5% lower than New Zealand students in TIMSS 1995 were question 6 (37% compared to 47%), in which students were presented with the sum 6971+5291 in vertical form, and question 21 (57%

compared to 64%), in which students were asked to estimate the length of a picture of a pencil.

The numbers presented in question 6 are too large, and with three columns adding to greater than 10, too complicated, to be readily added using a mental strategy. As written forms are not introduced until the higher stages of the Number Framework few year 4 students would be expected to answer this question correctly.

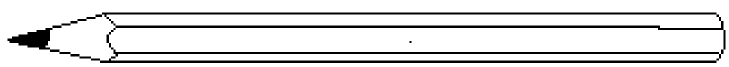
6 Add 6971
+5291

a 11 162
b 12 162
c 12 262
d 1 211 162

| | Percentage |
|---|---|
| Long. 2003 | 37% |
| NZ 1995 | 47% |
| Intnl 1995 | 67% |

Question 21 involves an understanding of units of measurement and we can only surmise that the decreased performance on this item may relate to a decrease in classroom time devoted to this aspect of the measurement strand.

21 About how long is this picture of a pencil?



a 5 cm
b 10 cm
c 20 cm
d 30 cm

| | Percentage |
|---|---|
| Long. 2003 | 57% |
| NZ 1995 | 64% |
| Intnl 1995 | 69% |

Of the fifteen questions on which the longitudinal students performed better than the New Zealand students in TIMSS 1995, there were fourteen in which the difference in percentage of correct answers was greater than 5% and 9 in which the difference was greater than 10%.

The single biggest difference was found on question 20 where students were asked to write a fraction greater than 2/7. 64% of longitudinal students answered correctly, compared to only 38% of New Zealand students in TIMSS 1995.

20 Write a fraction that is larger than $\frac{2}{7}$.

Answer ……………………………………

| | Percentage |
|---|---|
| Long. 2003 | 64% |
| NZ 1995 | 38% |
| Intnl 1995 | 41% |

The next three largest differences were for questions 2, 9 and 13, with differences in percentages of correct responses of 14%, 16% and 16% respectively.

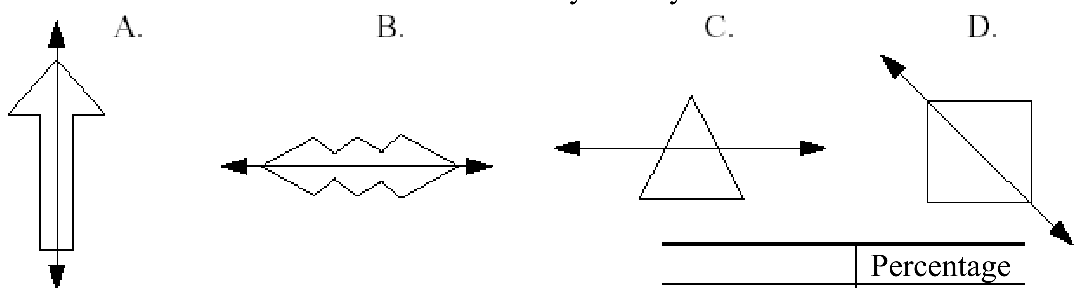
Questions 20, 2 and 13 are all based in the number strand, on which students in Numeracy Development Project schools have had a greater focus. Their strong performance on these questions, while not unexpected, is encouraging.

2 A teacher marks 10 of her pupils' tests every half hour. It takes her one and one half hours to mark all her pupils' tests. How many pupils are in her class?

Answer …………………………………

| | Percentage |
|---|---|
| Long. 2003 | 40% |
| NZ 1995 | 26% |
| Intnl 1995 | 30% |

9 Which of these does NOT show a line of symmetry?




| | Percentage |
|---|---|
| Long. 2003 | 70% |
| NZ 1995 | 54% |
| Intnl 1995 | 54% |

13 What is 5 less than 203?

Answer .....................................................................

| | Percentage |
|---|---|
| Long. 2003 | 51% |
| NZ 1995 | 35% |
| Intnl 1995 | 48% |

The results of question 7 are interesting, in that, while longitudinal students performed better than New Zealand students in TIMSS 1995, they were 10% lower than the international average for students in TIMSS 1995.

7 Tanya has read the first 78 pages of a book that is 130 pages long. Which number sentence could Tanya use to find the number of pages that she must read to finish the book?

a 130 + 78 = □
b □ – 78 = 130
c 130 ÷ 78 = □
d 130 – 78 = □

| | Percentage |
|---|---|
| Long. 2003 | 39% |
| NZ 1995 | 33% |
| Intnl 1995 | 49% |

Year 5 Longitudinal Results

Of the 24 questions in the year 5 test longitudinal students performed better on average than New Zealand students in TIMSS 1995 on 18 questions, and equally well on five question.

The only question for which the percentage correct for longitudinal students was significantly lower than that for New Zealand students in TIMSS 1995 was question 6, the same addition problem presented in vertical form that proved difficult for year 4 students.

6 Add 6971
+5291

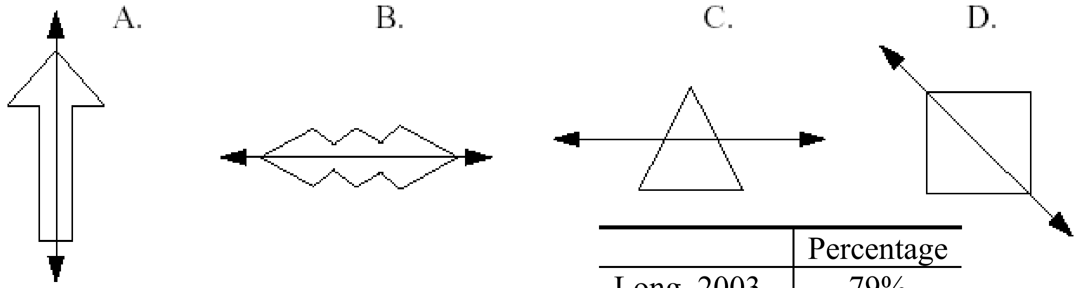
a 11 162
b 12 162
c 12 262
d 1 211 162

| | Percentage |
|---|---|
| Long. 2003 | 56% |
| NZ 1995 | 69% |
| Intnl 1995 | 84% |

Of the eighteen questions on which the longitudinal students performed significantly better than the TIMSS 1995 students, there were eleven on which the difference was greater than 10%.

The two questions in which the difference was the greatest were question 9, the same symmetry question on which year 4 students performed well, and question 17, where students were asked to write a fraction greater than 2/7 (year 4 question 20).

9 Which of these does NOT show a line of symmetry?




| | Percentage |
|---|---|
| Long. 2003 | 79% |
| NZ 1995 | 58% |
| Intnl 1995 | 64% |

17 Write a fraction that is larger than $\frac{2}{7}$.

Answer ……………………………………

| | Percentage |
|---|---|
| Long. 2003 | 70% |
| NZ 1995 | 51% |
| Intnl 1995 | 57% |

The next three greatest differences were recorded for questions 11, 19 and 20, in all of which the longitudinal students outperformed New Zealand students in TIMSS 1995 by at least 15%.

11 Here is the beginning of a pattern of tiles.

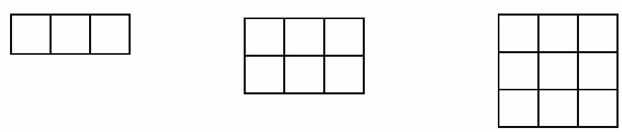


Figure 1 Figure 2 Figure 3

If the pattern continues, how many tiles will be in Figure 6?

a 12
b 15
c 18
d 21

| | Percentage |
|---|---|
| Long. 2003 | 65% |
| NZ 1995 | 49% |
| Intnl 1995 | 63% |

19 $25 \times 18$ is more than $24 \times 18$. How much more?

a. 1
b. 18
c. 24
d. 25

| | Percentage |
|---|---|
| Long. 2003 | 43% |
| NZ 1995 | 28% |
| Intnl 1995 | 45% |

20 Which of these would most likely be measured in milliliters?

a. The amount of liquid in a teaspoon
b. The weight (mass) of a pin
c. The amount of gasoline in a tank
d. The thickness of 10 sheets of paper

| | Percentage |
|---|---|
| Long. 2003 | 50% |
| NZ 1995 | 35% |
| Intnl 1995 | 38% |

It is interesting to note that, of the five questions in which year 5 longitudinal students performed best, only two (questions 17 and 19) are based in the number strand. The other three are from geometry, measurement and algebra. It is also of interest to note that for questions 11 and 19, whilst the longitudinal students performed considerably better than the New Zealand students in TIMSS 1995, they were within 2% of the international average.

Questions 7 and 22 are of interest in that while longitudinal students performed better than New Zealand students in TIMSS 1995, they were still 10% lower than the international averages for those items in TIMSS 1995.

7 Tanya has read the first 78 pages of a book that is 130 pages long. Which number sentence could Tanya use to find the number of pages that she must read to finish the book?

e $130 + 78 = \square$
f $\square - 78 = 130$
g $130 \div 78 = \square$
h $130 - 78 = \square$

| | Percentage |
|---|---|
| Long. 2003 | 52% |
| NZ 1995 | 48% |
| Intnl 1995 | 62% |

22 A team is selling raffle tickets. The table shows how many tickets they have sold so far.

| Player's Name | Number of Tickets Sold |
|---|---|
| Carlos | 4 |
| Maria | 7 |
| Bill | 3 |
| Ted | 7 |
| Faye | 6 |
| Abby | 9 |

They need to sell 60 tickets altogether.
How many more tickets must they sell?

Answer ………………………………..

| | Percentage |
|---|---|
| Long. 2003 | 44% |
| NZ 1995 | 38% |
| Intnl 1995 | 55% |

Year 8 Longitudinal Results

Of the 24 questions in the year 8 test, longitudinal students performed significantly better on average than New Zealand students in TIMSS 1995 on six questions and were significantly lower on three.

The three questions in which longitudinal students performed significantly lower than New Zealand students in TIMSS 1995 were questions 11, 21 and 22, with differences of 11%, 12% and 8% respectively.

The responses from question 11 are particularly interesting in that, while only 27% of students correctly identified that 4/5 is the largest of the four fractions given (compared to 38% for New Zealand students in TIMSS 1995), over half (52%) chose 3/4 as their answer. Student achievement in fractions is an area that warrants further investigation.

11) Which number is largest?

A. $\frac{4}{5}$

B. $\frac{3}{4}$

C. $\frac{5}{8}$

D. $\frac{7}{10}$

| | Percentage |
|---|---|
| Long. 2003 | 27% |
| NZ 1995 | 38% |
| Intnl 1995 | 34% |

21) Four children measured the width of a room by counting how many paces it took them to cross it. The chart shows their measurements.

| Name | Number of paces |
|---|---|
| Steven | 10 |
| Tama | 8 |
| Ana | 9 |
| Carlos | 7 |

Who had the longest pace?

A. Steven
B. Tama
C. Ana
D. Carlos

| | Percentage |
|---|---|
| Long. 2003 | 45% |
| NZ 1995 | 57% |
| Intnl 1995 | 69% |

22) A cake is put in the oven at 7:20. If the cake takes three quarters of an hour to bake, at what time should it be taken out of the oven?

Answer: ______________________________

| | Percentage |
|---|---|
| Long. 2003 | 64% |
| NZ 1995 | 72% |
| Intnl 1995 | 65% |

Of the six questions on which the longitudinal students performed significantly better than the TIMSS 1995 students there were three in which the difference was greater than 10%.

The three questions in which the difference was the greatest were question 1a, question 16 and question 23, with differences of 13%, 11% and 12% respectively.

1) Here is a sequence of three similar triangles. All of the small triangles are congruent.

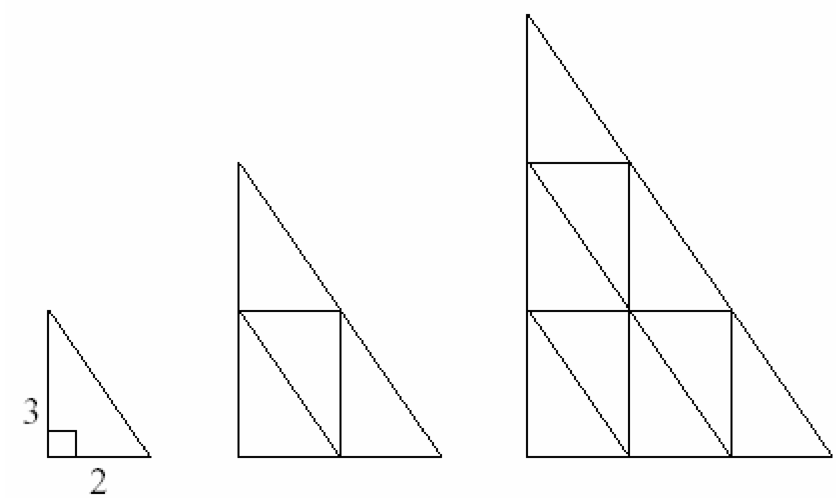



Figure 1 Figure 2 Figure 3

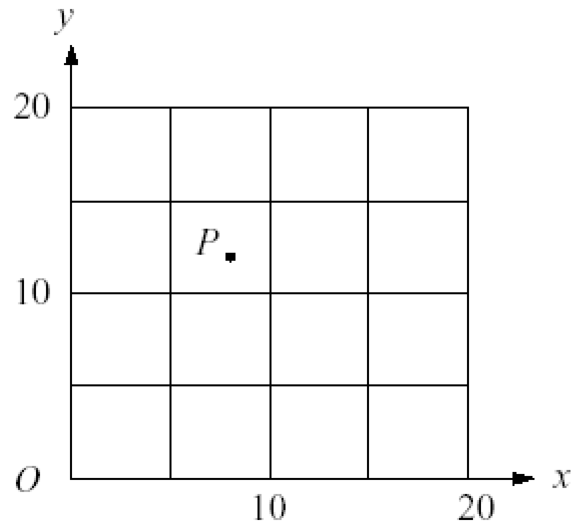
a. Complete the chart by finding how many small triangles make up each figure.

| Figure | Number of small triangles |
|---|---|
| 1 | 1 |
| 2 | |
| 3 | |

| | Percentage |
|---|---|
| Long. 2003 | 85% |
| NZ 1995 | 72% |
| Intnl 1995 | 72% |

16) Which of the following are most likely to be the coordinates of point *P*?

A. (8, 12)
B. (8, 8)
C. (12, 8)
D. (12, 12)




| | Percentage |
|---|---|
| Long. 2003 | 53% |
| NZ 1995 | 42% |
| Intnl 1995 | 47% |

23) A class has 28 students. The ratio of girls to boys is 4 : 3. How many girls are in the class?

Answer ________________________

| | Percentage |
|---|---|
| Long. 2003 | 42% |
| NZ 1995 | 30% |
| Intnl 1995 | 30% |

There are four questions for which, despite the difference between longitudinal students and New Zealand students in TIMSS 1995 being relatively small, the difference between longitudinal students and the international averages for TIMSS 1995 are greater than 10%.

For question 5, while the longitudinal students were only 3% better than the New Zealand students in TIMSS 1995, they were 16% better than the average for TIMSS 1995.

5) In a bag of cards $\frac{1}{6}$ are green, $\frac{1}{12}$ are yellow, $\frac{1}{2}$ are white, and $\frac{1}{4}$ are blue.
If someone takes a card from the bag without looking, which color is it most likely to be?

A. White
B. Blue
C. Green
D. Yellow

| | Percentage |
|---|---|
| Long. 2003 | 76% |
| NZ 1995 | 73% |
| Intnl 1995 | 60% |

Of concern are the three questions on which they continue to perform significantly worse than the international average. Longitudinal students scored within 4% of the same percentages as New Zealand students in TIMSS 1995 for questions 12, 13, and 19, but were at least 11% below international averages for all three. This is even more concerning given that all three questions are based on concepts from the Number strand.

12) A person's heart is beating 72 times a minute. At this rate, about how many times does it beat in one hour?

A. 420 000
B. 42 000
C. 4 200
D. 420

| | Percentage |
|---|---|
| Long. 2003 | 50% |
| NZ 1995 | 54% |
| Intnl 1995 | 61% |

Question 13, the single item on which year 8 students performed worst compared to international averages, is again a problem which is most easily solved using an algorithm. It is of concern that, by year 8, students do not appear to have a method which allows them to solve problems too complex to be solved mentally.

13) Subtract: 2.201 – 0.753 =

A. 1.448
B. 1.458
C. 1.548
D. 1.558

| | Percentage |
|---|---|
| Long. 2003 | 54% |
| NZ 1995 | 56% |
| Intnl 1995 | 74% |

19) Peter bought 70 items and Sue bought 90 items. Each item cost the same and the items cost $800 altogether. How much did Sue pay?

Answer: Sue paid ___________________

| | Percentage |
|---|---|
| Long. 2003 | 20% |
| NZ 1995 | 19% |
| Intnl 1995 | 32% |

**Concluding Comment**

The performance of students in the longitudinal schools on the TIMSS items is encouraging. The year 5 longitudinal students performed on average 9% better than the 1995 New Zealand cohort. Similarly, the year 4 longitudinal students performed 6% higher than the 1995 New Zealand cohort. The year 8 longitudinal students' average overall test score was not significantly higher than that of the 1995 New Zealand students although they outperformed them on seven questions and were lower on only three.
The comparatively low performance of year 8 students may be partly explained by fewer years of involvement in the project by both the students and their teachers but requires further research.

# Chapter Seven: Longitudinal Numeracy Results

This is the second of three chapters examining the ongoing impact of the Numeracy Development Project in the longitudinal schools. This chapter presents the performance of students in twelve of the fifteen longitudinal schools as measured against the Number Framework. The remaining three schools, while participating in the other aspects of the longitudinal component, did not submit number strategy data on their students. The demographic profile of students in the longitudinal schools is contained in Tables 7.1 and 7.2. As illustrated in Table 7.2 the demographic profile of students in the longitudinal sample is similar to that of the ENP 2003 students.

**Table 7.1: Profile of longitudinal students by age and year level**

| | Year group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | 0-1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| 5 | 50% | 0% | | | | | | | 7% |
| 6 | 50% | 34% | | | | | | | 12% |
| 7 | | 65% | 33% | 0% | | | | | 14% |
| 8 | | 1% | 66% | 29% | | | | | 15% |
| 9 | | | 1% | 71% | 32% | | | | 17% |
| 10 | | | | | 66% | 34% | | | 14% |
| 11 | | | | | 2% | 66% | 26% | | 11% |
| 12 | | | | | | 1% | 62% | 40% | 5% |
| 13 | | | | | | | 12% | 60% | 3% |
| Total | 505 | 488 | 513 | 598 | 474 | 494 | 200 | 144 | 3416 |

**Table 7.2: Profile of longitudinal students and students nationally by ethnicity and school decile**

| | Decile group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ethnicity | Low | | Medium | | High | | Total | |
| | Long. | NZ | Long. | NZ | Long. | NZ | Long. | NZ |
| NZ European | 21% | 32% | 58% | 69% | 81% | 82% | 51% | 60% |
| Māori | 45% | 40% | 22% | 19% | 7% | 7% | 26% | 22% |
| Pasifika | 28% | 21% | 6% | 4% | 2% | 1% | 13% | 8% |
| Asian | 3% | 4% | 9% | 5% | 6% | 6% | 6% | 5% |
| Other | 2% | 4% | 5% | 4% | 4% | 4% | 4% | 4% |
| Total | 1343 | 19443 | 1051 | 23470 | 1022 | 17128 | 3416 | 61121 |

Table 7.3 shows the mean final additive stage of longitudinal students by year compared to the national data. Year 1, 2, and 3 longitudinal students in all decile groups have means lower than those nationally, as do year 4 and 5 low decile students and year 4 high decile students. This finding is similar to that reported in the 2002 ENP evaluation (Thomas et al., 2003). By year 6 students in longitudinal schools have mean final additive scores higher than those of students nationally. Year 7 and 8 longitudinal students have mean scores 0.6 and 0.7 of a stage higher respectively than students nationally. This pattern of performance is most likely due to the fact that, while

numeracy is not as high a priority in these schools as it is in those still involved in the numeracy professional development, students in the higher year levels in longitudinal schools have had the benefit of several years of exposure to numeracy practices.

**Table 7.3: Mean final additive stage by year for longitudinal students compared to national data**

| Year | Low | | Medium | | High | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Long. | NZ | Long. | NZ | Long. | NZ | Long. | NZ |
| 0-1 | 2.1 | 2.3 | 2.0 | 2.5 | 2.1 | 2.8 | 2.1 | 2.5 |
| 2 | 3.4 | 3.2 | 3.0 | 3.5 | 3.6 | 3.7 | 3.3 | 3.5 |
| 3 | 3.8 | 3.9 | 3.9 | 4.3 | 4.5 | 4.5 | 4.0 | 4.2 |
| 4 | 4.6 | 4.4 | 4.3 | 4.7 | 4.7 | 4.9 | 4.5 | 4.7 |
| 5 | 5.0 | 4.7 | 4.7 | 4.9 | 5.4 | 5.1 | 5.0 | 4.9 |
| 6 | 5.3 | 4.9 | 5.2 | 5.1 | 5.7 | 5.4 | 5.4 | 5.1 |
| 7 | 5.4 | 4.6 | | 5.2 | 5.8 | 5.3 | 5.6 | 5.0 |
| 8 | 5.7 | 4.8 | | 5.4 | 5.8 | 5.4 | 5.8 | 5.1 |

Table 7.4 shows the numeracy profile both of longitudinal students and of students nationally. While the longitudinal students have higher proportions at the lower levels in years 1 to 5, the most significant feature to note is the high proportions of longitudinal students reaching Stage 6 (advanced additive part-whole). By year 8, 82% (118) of the 144 students were able to use a variety of part-whole strategies to solve addition and subtraction problem. Less than half (48%) of year 8 students from schools in their first year of involvement with the Numeracy Development Project reached this stage. Significantly higher proportions of year 5, 6 and 7 students from longitudinal schools also reached Stage 6 by the end of the year than did students nationally.

**Table 7.4: Final additive stage by year for longitudinal students compared to national data**

| | | | Final additive stage | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | | N | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0-1 | Long. | 505 | 7% | 21% | 44% | 19% | 9% | 1% | |
| | NZ | 10101 | 3% | 8% | 47% | 22% | 18% | 2% | 0% |
| 2 | Long. | 488 | 1% | 5% | 22% | 24% | 38% | 10% | 1% |
| | NZ | 10664 | 1% | 2% | 20% | 19% | 43% | 14% | 1% |
| 3 | Long. | 513 | 1% | 1% | 10% | 10% | 46% | 28% | 4% |
| | NZ | 10658 | 1% | 1% | 6% | 7% | 45% | 36% | 5% |
| 4 | Long. | 598 | | 0% | 5% | 6% | 32% | 46% | 11% |
| | NZ | 7349 | 0% | 0% | 2% | 3% | 32% | 50% | 12% |
| 5 | Long. | 474 | 0% | | 1% | 2% | 24% | 38% | 35% |
| | NZ | 6338 | 0% | 0% | 1% | 1% | 22% | 54% | 21% |
| 6 | Long. | 494 | | 0% | 0% | 1% | 13% | 33% | 53% |
| | NZ | 6482 | 1% | 0% | 1% | 1% | 14% | 48% | 35% |
| 7 | Long. | 200 | | | | | 11% | 24% | 66% |
| | NZ | 4753 | 5% | 0% | 1% | 1% | 15% | 42% | 37% |
| 8 | Long. | 144 | | | 1% | 0% | 1% | 16% | 82% |
| | NZ | 4254 | 5% | 0% | 0% | 0% | 10% | 36% | 48% |

## Concluding Comment

The end of year strategy results of longitudinal students provide positive signs for the long term impact of the Numeracy Development Project. While students in the lower year levels tend to perform slightly lower in schools that are no longer directly engaged in the professional development associated with the project, greater proportions of students in higher year levels attain the top stage of the additive domain.

# Chapter Eight: Sustained Development of Numeracy Practices

This is the third of three chapters examining the impact and sustainability of the Numeracy Development Project in the fifteen schools participating in the longitudinal component of the research. This chapter reports on the outcomes of interviews and questionnaires designed to identify school and teacher-related factors that appear to facilitate or inhibit the sustained development of numeracy practices.

The teachers in the longitudinal schools completed a questionnaire focused on their perceptions of the extent to which they had sustained Numeracy Development Project practices in their classroom. A copy of the questionnaire is included in Appendix H. In addition, the researchers conducted telephone or in-person interviews with the lead teachers in seven of the fifteen schools during October to discuss their perceptions of the factors associated with the sustainability of numeracy practices over time.

Questionnaire responses were received from all fifteen schools, with a total of 163, or 71% of questionnaires returned from the 230 sent to schools. The questionnaire forms were sealed in individual envelopes for confidentiality, with the school responses collected for postage in one larger envelope.

The questionnaire asked teachers to respond using a five-point Likert scale, with written comments for further elaboration. Responses are reported as percentages, using the scale results, with the nature of the comments received being used to illustrate the responses further. Percentages for the first two tables are given as percentage of total respondents (163), while later tables analyse only the responses of the 135 numeracy trained teachers. Not all teachers answered all questions, so some percentages do not sum to 100%. The quotes used are typical of the comments given and are taken directly from the questionnaires. Where applicable, comparisons are drawn between responses made by teachers in the 2002 ENP evaluation (Thomas et al., 2003).

Table 8.1 shows the year levels taught by respondent teachers.

**Table 8.1: Year level taught by respondent teachers**

| Year level currently taught | N | % |
|---|---|---|
| 0 – 3 | 77 | 47 |
| 3 – 6 | 77 | 47 |
| 6 – 8 | 14 | 9 |

Table 8.2 outlines the type of numeracy professional development that teachers in the longitudinal schools received. The majority of teachers (77%) completed the Numeracy Development Project in their current school. This is a 7% percentage decrease from 2002, reflecting the movement of teachers between schools. Correspondingly the percentage of teachers who received their training in a different school increased from 2% in 2002 to 5% in 2003. Sixteen percent of teachers have incomplete training

experiences and are either receiving professional development during the 2003 school year from within their school or with another local cluster of schools.

**Table 8.2: Completion of the Numeracy Project professional development programme**

| | N | % |
|---|---|---|
| Programme completed in current school | 125 | 77 |
| Programme completed in different school | 8 | 5 |
| Not Numeracy trained | 26 | 16 |

**Perspectives on Student Achievement**

Two of the items in the questionnaire asked the teachers to reflect on the impact of the Numeracy Development Project on their students' ability in number and in mathematics more generally.

**Table 8.3: Perceptions of the impact of the Numeracy Project on students' mathematics**

| | Negative or no impact | Slightly positive | Very or highly positive |
|---|---|---|---|
| Impact on number | 1% (1) | 12% (16) | 84% (113) |
| Impact on maths in general | 0% (0) | 13% (18) | 85% (115) |

In general, the respondents believed the project has had a positive impact on students' ability in number, with 84% describing this impact as very positive or highly positive. This is the same percentage as in 2002. The reasons identified for this increased ability indicate that teachers see an increased range of strategies, greater enjoyment and improved attitudes, and more focused teaching as key contributors.

> *Children are more confident and willing to take risks trying new ways. They love "playing" with numbers and count all the time.*
>
> *The students talk confidently about what they can do and how they do it. They are very positive about maths.*
>
> *Children's attitude to maths has improved and this has had an impact on results. Teachers are more focused in their teaching – knowledge and strategies.*
>
> *Able to solve more complex problems at an early age.*
>
> *The project has given students a better understanding of concepts in maths, where they can image to solve problems using a variety of quick and accessible strategies to use, aiding the problem-solving process.*
>
> *Children are more efficient problem solvers, more flexible and more able to articulate their thinking.*
>
> *I feel teaching is more focused, which has benefited students' learning.*

*Because of the diagnostic testing the children and myself know exactly where they are at.*

The majority (85%) of teachers also believed that the project has had a very positive or highly positive impact on their students' mathematics achievement. A smaller percentage (72%) of teachers had the same positive belief in 2002. Teachers ascribed the improved achievement in mathematics to an improved attitude towards mathematics generally, and to an increase in number understanding, explaining that this understanding underpins the other strands of mathematics. Although the year 4, 5 and 8 students had completed the TIMSS tests by the time the teachers completed the questionnaire, the results had not been returned to the schools.

*Students look forward to maths – feel disappointed when their idea of maths (action packed) is not done in a given day.*

*Attitude improvement. Children enjoy maths no matter what the strand. Positive attitude and number "sense" carries on into measurement. Generally positive attitude encourages better attempts at success.*

*The increase in their number knowledge has been translated into the other strands.*

*They now show understanding of strategies and can apply them to varying maths situations. Find they can work out answers in their heads.*

Interviews with lead teachers and principals supported the views expressed in the questionnaires, with lead teachers generally believing that students are achieving at a higher level since the implementation of the Numeracy Development Project.

School A

| | |
|---|---|
| *Researcher* | *Have you noticed any difference in the children's achievement in the other strands?* |
| *Teacher* | *Yes they are getting better and it's obvious really. Number is part of the other strands so it figures if they are stronger in number they will do better on the other strands.* |
| *Researcher* | *Can you elaborate on what you have noticed?* |
| *Teacher* | *You know you can't make much progress in say statistics if you haven't got good number. This is really obvious with our juniors who are now working with much bigger numbers in statistics. The charts and graphs are bigger and the children understand. So yes, we think we are doing better work in statistics and all the other strands.* |
| *Researcher* | *Do you have any evidence to support your feelings that the students are performing better in the other strands?* |
| *Teacher* | *Nothing formal but all the teachers at meetings have commented on how much better their children seem to be doing. They [the children] are also a lot keener on maths and to be honest we all have better attitudes to it [maths].* |

One principal e-mailed a further comment about the maths performance of their students:

School B
*We got some really good results in the Australasian Maths Competition this year. We entered 25 children, and we got 5 Distinctions and 6 Credits. Three of the Distinctions were for year 6 children but none of these same children had got Distinctions last year.*

Two of the lead teachers referred to improved results in the Progressive Achievement Tests (PAT) as evidence for the increased achievement of their students.

School C

| | |
|---|---|
| *Teacher* | *Our PAT results have allowed us to track achievement and this is what they are looking like [shows table and bar graph of PAT data using stanines].* |
| *Researcher* | *These are your year 5s in 2003?* |
| *Teacher* | *That's right. They are the first lot [of students] that we can track as a cohort using PATs. This column is their PAT results at the start of 2002 when they were year 4s. This one is them in 2003.* |
| *Researcher* | *At the start of 2003 they would have had 2 years on the Numeracy Project compared to one year in 2002.* |
| *Teacher* | *Let me think. Yes they did ENP in 2001 as year 3s and ANP in 2002.* |
| *Researcher* | *Good.* |
| *Teacher* | *So you can see the shift over the two years. Their mean last year was 3.87 and this year it's 4.64.* |
| *Researcher* | *You can see the shift clearly in the movement from the bottom two deciles.* |
| *Teacher* | *Yes and we are excited about that. Last year 22% were in the bottom two stanines and this year there's just 6%.* |
| *Researcher* | *You also have an increase in the higher stanines.* |
| *Teacher* | *Not as much as we would like but it is better I suppose [25% are above stanine 5 in 2003 compared to 13% in 2002].* |
| *Researcher* | *How much of the improvement do you attribute to the Numeracy Project?* |
| *Teacher* | *All of it really but we think a lot of it is to do with attitude. We wonder if they just didn't bother with the tests before. They actually love maths now and when we gave them the PATs this year they went "yah". I even had some say "Can we do it again?"* |
| *Researcher* | *Another test?* |
| *Teacher* | *Yes. Can you believe it? The attitude had changed markedly and that's making a difference.* |

School D

| | |
|---|---|
| *Teacher* | *We are pleased with the progress of our year 6s and they have only had one year on the project.* |

| | |
|---|---|
| *Researcher* | *How are they going?* |
| *Teacher* | *Last year there were ten children here in the bottom quartile and this year there are four. We've still got the same amount in the middle [pointing to quartiles two and three] but at least we've moved six off the bottom. So we're pleased with progress.* |
| *Researcher* | *Yes. That's a strong movement from the lowest quartile.* |
| *Teacher* | *The bulge is moving up which is great.* |
| *Researcher* | *So you use achievement data extensively?* |
| *Teacher* | *Yes we do. They are an integral part of our discussions as a staff. Not just PATs but also the NumPA. In fact on a day-to-day basis we use the Number Framework but the PATs have been wonderful for verifying progress. The results are so encouraging. It's what makes you want to keep going. You know that it [your teaching] is working.* |
| *Researcher* | *Absolutely.* |
| *Teacher* | *When you get great results like that, I mean wow, you just want to keep going.* |

When discussing student achievement, on-site interviews also covered students who were failing to progress as expected. One lead teacher identified a reluctance to take risks as one factor for a group of students who had not made the transition to part-whole additive strategies.

School E

| | |
|---|---|
| *Researcher* | *You mentioned that you still have some students who are not making the progress that you would like. Why do you think that is?* |
| *Teacher* | *I had a group of year 5s and three of them stayed stuck at counting on. They seemed to be OK when they were working with me in a group, but as soon as I gave them a question I could see that they were still counting on even if they were saying something else.* |
| *Researcher* | *What were they saying?* |
| *Teacher* | *They might have used a ten fact and then added on but I could see that they were first doing it by counting.* |
| *Researcher* | *They weren't sure?* |
| *Teacher* | *I think so. They didn't want to take the risk and use something new without checking with the counting.* |
| *Researcher* | *What did you do?* |
| *Teacher* | *I went back and spent a lot of time with them making sure they were happy about the ten facts. You know eight plus two, five plus five, six plus four and so on.* |
| *Researcher* | *Did that work?* |
| *Teacher* | *One of them has definitely moved on but the others are still wanting to count.* |
| *Researcher* | *What next for them?* |
| *Teacher* | *I'm not sure. I will keep making sure that they have the number knowledge in place. Even though I tell them its OK to get something wrong, they just don't want to take the risk it seems.* |

Another lead teacher identified negative attitudes to learning within the students' homes as one reason why a group of their students were failing to make progress.

School C

| | |
|---|---|
| *Teacher* | *Our ERO reports are good, there is strong professional development but we're still not moving all of our children. Our results show that some are staying put. So we've gone beyond the school into the homes trying to change attitudes to learning.* |
| *Researcher* | *What does this involve?* |
| *Teacher* | *We have a home-school liaison person. That's a teacher who is flexible and so that teacher can work with children who classroom teachers identify as not making progress. She can then go into the home.* |
| *Researcher* | *Is this just about the Numeracy Project?* |
| *Teacher* | *No. It's about progress in literacy too – you know those who aren't making progress in reading and for some we notice it first in their oral language.* |
| *Researcher* | *How is this working?* |
| *Teacher* | *This initiative is tied in with a computer at home project. So the focus is on the computer but with lots of positive messages about learning and education. We are pleased with the links that have been established but it's going to take time as changing attitudes to education isn't something that will happen overnight. So we're also not expecting any immediate change in the children's achievement. Ask me again next year.* |

One of the schools has run a mathematics recovery programme since 2002 targeted at groups of at risk students. Students are identified as being at risk if they fail to meet certain milestones set by the school.

School B

| | |
|---|---|
| *Researcher* | *How is your maths recovery programme operating this year?* |
| *Teacher* | *It has changed a bit and now this year I have got an advanced group and a couple of groups who are just a bit below average. Not way behind like the kids in the remedial groups from last year.* |
| *Researcher* | *What happened to last year's groups?* |
| *Teacher* | *I basically stopped them at end of term two.* |
| *Researcher* | *Why is that?* |
| *Teacher* | *Stopped them because they had had a pretty good go and mostly they had caught up. They weren't too far behind where they ought to be.* |
| *Researcher* | *What level did they get to?* |
| *Teacher* | *Only two of the twenty or so in the remedial groups didn't get to early additive and some got further.* |
| *Researcher* | *What year level?* |
| *Teacher* | *Years 4 to 6.* |
| *Researcher* | *So you don't consider them at risk anymore?* |
| *Teacher* | *No, and their attitude changed as well. They didn't think they were dumb for a start. I focussed all the time on what they could do* |

| | |
|---|---|
| | *rather than what they couldn't and so they got a real sense of achievement. I am convinced that had a lot to do with the progress they made.* |
| *Researcher* | *What about the two who didn't get to early additive?* |
| *Teacher* | *They are at advanced counting and that was a big move for them as they were almost emergent. Those two have a lot of learning problems so I was very pleased with their progress.* |
| *Researcher* | *After term two you picked a couple of average groups. What was the reasoning behind an average group?* |
| *Teacher* | *Because an average group seemed to be dropping down to about the level of the remedial group. They weren't making the progress that their teachers thought they could have made so they got an extra little boost.* |
| *Researcher* | *How many children did you have in that group?* |
| *Teacher* | *I had a group of ten year 5 and 4 and I had a group of year 3s. There were nine in that group. The year 3s came for three half-hours and the years 4s and 5s for four half-hours.* |
| *Researcher* | *What has happened to them?* |
| *Teacher* | *Mostly they have come up to scratch, which is good. Most of them have moved to early additive part-whole.* |
| *Researcher* | *All of the groups?* |
| *Teacher* | *Not all of the Year 3s but the 4s and 5s mostly have.* |
| *Researcher* | *You must be pleased with that progress.* |
| *Teacher* | *Absolutely.* |

Several of the lead teachers described how their schools shared the achievement outcomes from the Numeracy Development Project with their students. One lead teacher firmly attributed improved student attitudes to mathematics to the success the students were seeing themselves having in number.

> School F
> *The other thing we did do at the end of last year was show the children doing ANP the progress they had made. We showed them where they were at the start and end using the NumPA results. And honestly we had children who were so proud of themselves. They could see their own gains by using the results and so could their teachers. And it affected their attitude to doing maths. They said 'hey I can do this. I am good at this.'*

**Perspectives on the Numeracy Development Project**

Teachers were asked to rate the usefulness of several of the resources designed to support the Numeracy Development Project; their responses are shown in Table 8.4. Both the Teaching Booklets and the Diagnostic Interview were rated as very useful by an overwhelming majority (92%) of teachers. The Numeracy component of the nzmaths site, a non-compulsory resource, was rated as very useful by 59% of respondents, with only 14% rating it as not, or only slightly useful.

Teachers involved in the longitudinal study were offered the opportunity to use the online facilitation workshops if they wished. While only 18% did, the majority of those found them very useful, with only one teacher describing them as only slightly useful.

**Table 8.4: Usefulness of elements of the Numeracy Project professional development programme**

| | Have not used | Not or Slightly Useful | Moderately Useful | Very Useful |
|---|---|---|---|---|
| Teaching booklets | | 1% (1) | 8% (11) | 91% (124) |
| Diagnostic interview | | 1% (2) | 6% (8) | 93% (124) |
| nzmaths Numeracy component | | 14% (19) | 22% (30) | 59% (89) |
| Online facilitation workshops | 82% (111) | 1% (1) | 8% (11) | 9% (13) |

While the diagnostic interview was rated as very or moderately useful by 98% of the teachers many commented on the time taken to conduct the NumPA.

> *The diagnostic interview is time consuming but very useful to decide on where to go next with teaching of groups and class.*
>
> *Diagnostic interview initially confusing but easier with increased use.*
>
> *Diagnostic interview is useful but because it's so time consuming it becomes difficult to use more than once a term, which would be really useful. Refer to all the booklets often. "Getting started" in particular.*
>
> *The diagnostic interview is invaluable in assessing the children at the start of the year.*

The respondents commented on the usefulness of the Numeracy Development Project booklets.

> *Teaching booklets (latest edition) are easy to follow and use. Activities are clearly defined.*
>
> *Booklets are easy to follow and provide an excellent resource. The diagnostic interview although time-taking to complete provides excellent data.*
>
> *The teaching booklets are my "bibles".*

Reasons why the nzmaths website and online facilitation workshops were rated as less useful tended to be related to access to, or familiarity with technology, rather than to the site itself.

> *Numeracy nzmaths on line excellent resource – use it all the time for planning and activities.*
>
> *Breakdown of computers etc. a problem. Time to roam website often difficult to find.*

*Website – as classroom teacher, have limited access to using website.*

*I am beginning to use the website. I've browsed and last week took some worksheets from it – also some assessment. Intend to use it a lot more.*

*Website is great!! It is great to be able to access resources this way.*

*I have found the numeracy site has ideas not always covered by the booklets.*

*Couldn't get CD to run, I'm not computer literate enough to enable me to work a website.*

*I have looked at them [online facilitation workshops] and thought they would be handy for new teachers, untrained teachers and teachers having difficulty.*

Two questions on the questionnaire asked teachers to rate the extent to which they have thus far, and will continue to, incorporate Numeracy Development Project ideas and materials into their classroom mathematics programme. Their responses are shown in Table 8.5.

**Table 8.5: Extent of incorporation of Numeracy Development Project ideas and materials into classroom mathematics programme**

| | Not at all or slightly | Moderately | Considerably or fully |
|---|---|---|---|
| Currently | 1% (2) | 10% (13) | 86% (116) |
| In the future | 1% (1) | 8% (11) | 90% (122) |

Eighty-six percent of respondents said that they have considerably or fully incorporated the ideas and materials from the Numeracy Development Project into their classroom mathematics programme. Comments indicated that many teachers see the Numeracy Development Project as the core of their mathematics programme with other resources and activities being brought in to support it.

*I do number for 5 weeks of the term then integrate it into maintenance and other relevant topics.*

*Numeracy Project ideas are incorporated into programme as much as possible – independent work, if not teaching sessions.*

*I really enjoy the numeracy material. I have developed other games and activities to supplement independent activities.*

*NUMP is a major component in our current maths programme.*

*I teach 3 days number and 2 days other strands.*

*Our whole school has redeveloped how we look at/operate our maths programme. Numeracy is at least 60% of our maths programme.*

*NUMP is the core of our numeracy programme. The strategies learned are applied beyond numeracy throughout measurement and general problem solving.*

*There's no other way. Without numeracy, other strands cannot be achieved as all rely on some aspects of number.*

*As I was a year one teacher in 2001 I have considerably integrated ENP into my programme, although I have still used other activities to complement and add variety.*

Ninety percent of respondents indicated that they will considerably or fully incorporate ideas and materials from the Numeracy Development Project in the future. Teachers indicated in their comments that they feel that they will continue to use the project material because they have found it successful, and that they may use it more as they become more familiar with it.

*Because I can see the potential in the project and the benefit to the children.*

*As I become more familiar with strategies and processes I will probably use the material more.*

*I use ANP starters/games all the time through the year.*

*Will use ideas, resources now and am finding my knowledge still growing even this far down the track.*

*Will continue to use as I do and would like to teach more number (ANP) than I do.*

*Have found it successful so will continue to use it.*

**Sustaining Numeracy Development Project Practices**

The principals and lead teachers interviewed were invited to comment on the ways they sustained Numeracy Project practices within their schools. Their responses fell into three main categories: ongoing external facilitation; internal facilitation; support for new teachers.

<u>Ongoing External Facilitation</u>

Three of the nine schools interviewed had contracted additional support from a numeracy facilitator.

School B

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|---|---|
| *Teacher* | *We got facilitator X in from advisory and she took demonstration lessons and staff meetings and observed teachers in their class and gave them immediate feedback.* |
| *Researcher* | *Did she visit all the teachers?* |

| | |
|---|---|
| *Teacher* | *Everybody. She went through the whole school doing it. She took two demonstration lessons in each classroom before she observed any teacher's. Making sure everybody's on the ball and making sure that they carried on doing it [numeracy practices].* |
| *Researcher* | *How did this work out?* |
| *Teacher* | *Oh it was brilliant. I was talking to some of the senior teachers and some of the other teachers just generally and they really appreciate all that we've done this year.* |
| *Researcher* | *Will you continue this in the future?* |
| *Teacher* | *Not sure if we can afford it but it's important. If they [the teachers] know that somebody's coming in from outside, they know they have to get the work done. If it was just internal, I don't know that it would have the same effect.* |
| *Researcher* | *So you believe external observations are most important?* |
| *Teacher* | *Well observations are important and feedback. Even if we can't afford someone like X to come in, then we will have classroom teachers going and observing in the next classroom. I think as long as someone's observing you all the time. This year we used these [observed] lessons for our appraisals as well.* |

Another school employed a numeracy facilitator for one day a term to help maintain the momentum of numeracy practices.

School B

| | |
|---|---|
| *Teacher* | *So what we have done this year is pay for X [facilitator] to come once each term because we think it's important for teachers to know we are still part of it [the Numeracy Project]. It is great because X does demonstration lessons and we release all our teachers to watch and then she talks to them about it. It gives them new things to try, especially for fractions and multiplication. X gives a workshop after school so it keeps us focussed.* |

<u>Internal Facilitation</u>

All seven schools interviewed commented on the role of the lead teacher in supporting numeracy within their school. The extent and nature of this support varied between the schools. Four of the schools commented on the use of teachers within the school to observe and give feedback on one another's numeracy teaching.

School F

| | |
|---|---|
| *Teacher* | *I've used some of my non-teaching time to go into each classroom and observe numeracy teaching. Gives me a good idea of what is going on in each classroom and who maybe needs some more help and encouragement. Like one of the teachers in the junior syndicate still sometimes wonders if she's doing it right and that sort of thing.* |
| *Researcher* | *How do you give feedback to the teacher?* |
| *Teacher* | *Pretty informally. I just suggest things that I think may be good to try but I try to make sure they feel good about what they are* |

*doing too.*

Another school had used the NumPA results to target classes with students who did not appear to be making progress. The lead teacher worked with the teachers in these classes although she also commented that she had also been able to observe maths in every class in the school.

School A

| | |
|---|---|
| *Teacher* | *When I looked at the results by class I could see the teachers who had made huge gains. I don't have a class so my job has been to work with those who need more in-class support to get the children moving. Although I focus on some I have just been round all the classes to make observations and give them feedback.* |
| *Researcher* | *How is that working?* |
| *Teacher* | *Now that it's established it's fine. It was making sure that there was trust and that I am there to support and not assess. But still I do see big differences in [teacher] attitudes to maths and that affects how teachers work with their children. The results are so encouraging. It's what makes you want to keep going. You know that it [your teaching] is working.* |

All of the schools said that they had run staff meetings on aspects of the Numeracy Development Project with two of the schools commenting on the use of the online workshops at these meetings.

School F

| | |
|---|---|
| *Teacher* | *We have run staff sessions using the on-line workshops. Just recapping what the staff had already been through. We put them through the data projector and showed the staff snippets of them [online workshops].* |
| *Researcher* | *How did it go?* |
| *Teacher* | *It was really neat because two days after that the beginning teachers sat down together in their release afternoon and went through the workshops and found them really helpful.* |
| *Researcher* | *Good.* |
| *Teacher* | *And they came back and gave me really good feedback on the session that we ran so it was quite timely. So we have got to use them [online workshops] again, which we will do.* |

School B

| | |
|---|---|
| *Teacher* | *We've used the workshops you sent on the CD-ROM too. Some teachers have used them to go over things, especially the fractions one. We did that at a syndicate meeting.* |
| *Researcher* | *How did your teachers respond?* |
| *Teacher* | *They were happy and those that aren't as confident can do it [again] in their own time.* |

Supporting New and Beginning Teachers

The number of new or beginning teachers to come to one school since the Numeracy Development Project's implementation had posed a significant challenge. The principal commented that only 50 percent of staff had completed the numeracy professional development at the school.

School D

| | |
|---|---|
| *Principal* | *Teacher change has been the most significant challenge, hasn't it? Because a lot of the good basic dialogue has gone by the board because a couple of the teachers have drawn ahead of the others. The others sort of play catch-up, don't they?* |
| *Teachers* | *That is right.* |
| *Principal* | *And they may play catch up as individuals and they miss out on that dialogue.* |
| *Teacher* | *The dialogue is going well in the junior syndicate. It's the middle syndicate which I am really concerned about. That is why I am interested in the year 4 results, not the year 3s but the year 4s because none of them have had the solid training. We have given them as much as we can.* |
| *Researcher* | *How have you worked with the new teachers?* |
| *Teacher* | *We have used the online workshops this year, which has helped lots. Last year we just struggled along trying to give information and then visit in class but there is only so much time. It has been a big issue for us, the number of new teachers without training.* |

Many schools commented that their new teachers had been able to participate in the Numeracy Development Project with neighbouring schools.

School B

| | |
|---|---|
| *Researcher* | *How many new teachers do you have?* |
| *Teacher* | *Only one and she is able to join in with another school. She goes off to workshops but we do observations here in school.* |

One school had decided to only employ teachers who had already participated in the Numeracy Development Project.

School F

| | |
|---|---|
| *Principal* | *We state it [the requirement to have participated in the Numeracy Project] in our advertisement for new teachers.* |

## Concluding Comment

The teachers, lead teachers and principals in the longitudinal schools generally perceive that the Numeracy Development Project is continuing to have a positive impact on student achievement in number and in mathematics more generally. Most of the teachers indicated that they fully incorporated numeracy practices into their mathematics programme and would continue to do so into the future. The schools had implemented a number of practices to ensure the sustainability of numeracy practices including school-funded visits from numeracy facilitators, lead-teacher-managed classroom observations, and staff meetings for reviewing numeracy practices and evaluating student progress.

# Chapter Nine: Conclusion

Consistent with the findings of previous years, the ENP was successful in raising the achievement of students as measured against the Number Framework.

The improvement in number strategies was greater than that which would have been expected prior to the implementation of the project and, in the case of three key transitions, greater than that identified in 2002. Eighty-seven percent of initially emergent students progressed to at least one-to-one counting, compared to 82% in 2002. Forty-nine percent of initially counting-from-one students progressed to at least advanced counting, compared to 46% in 2002. Forty-six percent of initially advanced counting students progressed to at least early additive part-whole, compared to 42% in 2002.

The data reported previously in Table 3.2 provides a rich source of information on which to clarify expectations of student achievement following the first year of implementation of the ENP. Eighty-nine percent of year 0-1 students were able to at least count from one to solve addition and subtraction problems, including 20% who were able to count-on or count-back to solve such problems. By the end of year 2, 58% of the students were able to at least use advanced counting strategies with 15% of these using early additive part-whole strategies to solve addition and subtraction problems. Forty-one percent of year 3 students were able to use at least one part-whole strategy to solve problems involving addition or subtraction.

Both the numeracy profile of students and the progress they make on the various domains of the Number Framework is linked to their year level, gender, ethnicity and the decile level of the school. In general, older students and students from high decile schools start at higher stages of the Number Framework. They also make greater progress than do younger students and those from lower decile schools. Pasifika students start at lower stages and make less progress than Māori students with NZ European and Asian students performing better than either.

The findings support the contention that progress on the strategy domains is linked to students' knowledge profiles. Students at higher stages on the knowledge domain made greater progress on the additive domain. Students who know their FNWS to 10 and can identify numerals to 10 are more likely to make the transition from emergent to counting from one. Students who can group with 10s are more likely to make the transition from counting from one to advanced counting. Students at the next level, who can group with 10s in 100, are more likely to make the transition from advanced counting to early additive.

The longitudinal study provided positive results to support the ongoing impact of the project. Although year 0-3 students in the longitudinal schools had lower profiles and lower mean scores on the additive domain than did students in ENP 2003 schools, students in years 5-8 had significantly higher mean scores and were more likely to become advanced additive part-whole thinkers than students participating for the first time in 2003.

Testing of year 4, 5, and 8 longitudinal students using tests constructed from TIMSS 1995 items also provided positive feedback on the wider impact of the project. Students in years 4 and 5 performed better than norms from TIMSS 1995, particularly on questions targeting numeracy concepts. Students in year 5 in the longitudinal schools performed particularly well, averaging 59% on a test for which NZ scores from TIMSS 1995 would have produced an average of 50%. Students in year 8 performed at least as well as norms from TIMSS 1995.

Teachers in the longitudinal study indicated that they continue to incorporate practices from the Numeracy Project into their classroom, with many indicating that it forms the core of their mathematics programme. Some of the approaches adopted by schools to sustaining numeracy practices included contracting an external facilitator, running staff meetings on numeracy topics, and providing professional development to new teachers.

Teachers who have implemented numeracy practices in their mathematics programmes for two to three years believe the project has had a positive impact on students' achievement in number and in mathematics generally. This increased ability was attributed to students' increased range of operating strategies, improved attitudes, and greater enthusiasm for mathematics.

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