Findings from the New Zealand Numeracy Development Projects 2006

Foreword

The Numeracy Development Projects (NDP) began with a pilot in 2000 and since then have expanded to involve almost all of the primary schools in New Zealand. This is the third compendium of papers detailing research into a range of aspects of the NDP. The twelve papers here have been written by academics, independent consultants, and Ministry of Education personnel who are in some way involved in the local mathematics education scene, if not in the NDP itself. The papers in this compendium are arranged under the headings of Student Achievement, Lead Teachers and Sustaining Numeracy in Schools, and Professional Practice.

Student Achievement

"Do They Continue to Improve? Tracking the Progress of a Cohort of Longitudinal Students" (p. 8) by Tagg and Thomas continues a series of papers and reports that go back to 2002. In their research, the performance of students from schools that have completed the professional development stage of the NDP has been considered on two measures. The first of these is the data collected nationally on the strategy domains of the Number Framework and the second is on items for which there are normed scores available. In almost all instances, students in longitudinal schools outperformed those in the comparison groups.

The current paper considers results from 26 schools that have completed the professional development stage of the NDP. The results of previous years are sustained with the present group. Further, students in these schools continue to build on the gains they have achieved. So, for example, year 6 students at schools that have been involved with the NDP over a period of years have a lower proportion of students still using counting strategies and a higher proportion able to use partitioning strategies. In addition, the findings here support anecdotal data that suggests that students' increase in number ability has carried across to other strands, with year 6 longitudinal students scoring 5% higher on non-numeracy test items than the average for New Zealand students as a whole.

"Patterns of Performance and Progress on the Numeracy Development Projects: Findings from 2006 for Years 5–9 Students" by Young-Loveridge (p. 16) follows others of a similar nature by the same author in 2005 and 2006. The current well-researched work looks at the results of over 37,000 students from years 5 to 9 who had been assessed by their teachers at the beginning and end of 2006. Extensive results have been presented graphically.

Young-Loveridge produces a number of important findings. In no special order, these are: first, the gains made by European, Māori, and Pasifika students were comparable, so the differences between their respective performances are not increasing. Indeed, Pasifika and low-decile students appear to be making small gains on their peers. Secondly, it seems that when teachers concentrate on basic facts, there is an improvement in the strategy domains of the Framework. Thirdly, those students who are persistent counters also have weaknesses in place value, basic facts, and number sequences. Finally, year 6 students in this study do not as yet seem to have reached stages that are comparable with the new draft curriculum (2006). This suggests that further professional development may be required in order to bring students up to the desired level.

Irwin and Britt (p. 33) report on a longitudinal study of algebraic thinking in "The Development of Algebraic Thinking: Results of a Three-year Study". The results for the first two years of the study can be found in the 2005 and 2006 compendia.

Four secondary schools were paired with one of their contributing intermediate schools. Year 8, 9, and 10 students from these schools were given an Algebraic Thinking Test consisting of five compensation questions in each of the four arithmetic operations. Within each of the operations, the items developed from purely arithmetic to purely algebraic.

Analyses of the data for the three years of the study showed:

i. high correlations for individuals' scores on the NDP assessments at the end of year 9 and their scores on the Algebraic Thinking Test

ii. a steady increase in Algebraic Thinking Test scores for all year 9 and 10 students in the one school pair for which sufficient data was available

iii. a significant increase in algebraic thinking ability as determined by a comparison of the means of Algebraic Thinking Test scores of all students who had participated in the study over the three years.

The results for the school pair highlighted under (ii) above are of particular interest. In that pair, only the intermediate school had participated in the NDP. Nevertheless, there are features common to both schools that seem to have been crucial to the ongoing development of algebraic thinking. These are discussed in the paper, which draws attention to the role of working flexibly with numerical operational strategies as a basis for developing skills in algebraic thinking and introductory algebra.

New Zealand is a bicultural society, so it is no surprise that the NDP have both an English and a Māori perspective. The Māori-medium version of the NDP is called Te Poutama Tau. Since 2004, research and evaluation in that part of the NDP has been undertaken by Trinick and Stevenson. Their paper this year, "Te Poutama Tau 2006: Trends and Patterns" (p. 44), looks at the overall progress that students made on the Number Framework, in which areas the students performed well and in which not so well, and how progress in 2006 compared with that in 2004 and 2005.

Analyses over the years have shown that there have been positive gains in most areas of the Framework in Te Poutama Tau schools. Further, where there have been areas of concern and teachers have concentrated on these areas, improved performances have resulted.

As a result of the analysis of the data, Trinick and Stevenson make several recommendations for areas on which to focus in 2007. These are:

i. concentrate on older students who have made minimal gains

ii. concentrate on the teaching of addition and proportion, especially in year 4

iii. determine what influence Te Poutama Tau is having on other strands of the curriculum

iv. continue to investigate the relationship between te reo Māori and mathematics

v. determine how younger students can best be prepared for senior mathematics, especially in algebra.

In "'Who helps me learn mathematics and how?': Māori Children's Perspectives" by Hāwera, Taylor, Young-Loveridge, and Sharma (p. 54), 40 children in kura kaupapa Māori schools were interviewed in te reo Māori to find out their views on their learning of mathematics. Among other questions, they were asked "How do you think your teacher helps you to learn mathematics?", "Are there people at home who help you to learn mathematics?", and "How do you prefer to work most of the time – by yourself or with your friends?"

Most students thought that their teacher helped them by showing them strategies, but their responses indicated that the students felt that very little input was required of them in their own learning. The

students did not seem to be involved in significant classroom discussions about central mathematical concepts.

Although most students said that they got help from their friends, many students preferred to work by themselves. Reasons for this included fear of being distracted and having their own progress hampered. There was also a feeling that, somehow, collaboration was cheating.

Of the 40 students, 39 cited a range of people at home who helped them on various aspects of their mathematics learning.

Fractions is the focus of Young-Loveridge, Taylor, Hāwera, and Sharma's paper, "Year 7–8 Students' Solution Strategies for a Task Involving Addition of Unlike Fractions" (p. 67). The task used was the addition of $\frac{3}{4}$ and $\frac{7}{8}$, which had to be extracted from a word problem. This task was undertaken in the presence of an interviewer who wanted to know the students' thoughts about learning mathematics as well as how they achieved their answer in the addition task.

As well as providing an interesting, and perhaps worrying, discussion of the results of the interviews, the paper provides a thorough review of the literature on fractions. In this review, the following key points are raised:

i. fractions are an important areas of mathematics

ii. learning about fractions is difficult for most students

iii. these difficulties impinge on students' learning of other areas of mathematics

iv. teaching understanding of fractions can aid students' learning of algebra

v. fractions involve five sub-constructs: part–whole, ratio, quotient, operator, and measure

vi. there is debate in the literature over whether the teaching of algorithms is a good idea

vii. "adding across" denominators as well as numerators is a common error.

The literature motivates the research of this paper in that it looks into an important area of the curriculum and aims to find out students' understanding of simple addition of fractions.

Young-Loveridge et al. found that just over 13% of the 238 students in their study were able to add the two fractions correctly and explain their method. Roughly half as many students again used a correct method but made an error. On the other hand, just under 30% used the "add across" approach.

As a consequence of this piece of research, and in conjunction with the work of Ward, Thomas, and Tagg (p. 87), Young-Loveridge et al. suggest that it should be a high priority to strengthen teachers' knowledge of fractions both at the pre-service and in-service levels.

Lead Teachers and Sustaining Numeracy in Schools

Over the last two years, with the initial phase of the NDP almost complete and nearly every primary and intermediate school in New Zealand having had the opportunity to take part, the focus is moving onto sustaining and improving the gains already achieved.

Papers on sustainability first appeared in *Findings from the New Zealand Numeracy Development Projects 2005* (Ell and Irwin, and Thomas and Ward); in this 2006 compendium, there are papers by Ward, Thomas, and Tagg (p. 87), Higgins, Sherley, and Tait-McCutcheon (p. 99), and Ell (p. 109).

The paper by Ward, Thomas, and Tagg ("Numeracy Sustainability: Current Initiatives and Future Professional Development Needs" p. 87) reports on data received from lead teachers and facilitators

in schools that have been involved in the NDP prior to 2006. An on-line survey was developed that focused on two key research questions. These were:

i. To what extent are the sustainability initiatives meeting the professional learning needs of individual teachers?

ii. What elements of numeracy support are needed to sustain or further develop effective numeracy teaching and learning needs in schools?

All schools involved in the NDP in the years since its inception in 2000 were invited to participate. Approximately 26% of lead teachers and 38% of facilitators responded to the surveys. As the result of lead teacher professional development initiatives in 2006, approximately one-third of lead teachers believed that numeracy practices in their school had strengthened. Further, more than half of the lead teachers felt that their learning needs both as a lead teacher and classroom teacher were either "met" or "fully met". Only 10% described their learning needs as "not addressed".

Both lead teachers and facilitators agreed on a number of aspects, including the need to develop teacher content knowledge, especially in the upper stages of the Framework. But they also had different emphases in other areas. For example, lead teachers supported the provision of quality resources as their top priority for successful sustainability, while facilitators thought that the provision of release time for lead teachers would be a more useful course of action.

The paper by Higgins, Sherley, and Tait-McCutcheon ("Leading a Curriculum Reform from Inside a School", p. 99) asks the question "What domains of knowledge inform leadership actions that shift teacher practice and enhance student outcomes?" The paper uses questionnaires and interviews to seek the views of lead teachers, principals, and teachers in an investigation of the knowledge required of lead teachers in the NDP.

Higgins et al. build on Stein and Nelson's 2003 construct of leadership content knowledge, with four categories emerging from their investigation. These are:

i. knowledge of, and attitudes towards, mathematics

ii. knowledge of students as learners

iii. knowledge of teacher as learners

iv. knowledge of communities as learners.

Surprisingly, the relative importance for lead teachers of three of the four categories varies over the three participant groups. Overall, teachers and principals regarded the first and second categories more highly than did the lead teachers, while lead teachers thought that the fourth category was the most important.

Ell's paper "Keeping Going at Country School: Sustaining Numeracy Project Practices" (p. 109) continues her research on sustainability by concentrating this year on Country School (as opposed to the comparison of City School and Country School that Ell and Irwin undertook for the previous compendium). Interviews and videos were used to provide data from an enthusiastic six-teacher rural school.

Patterns and structures appear to have developed in this school that will enable them to continue to use NDP practices. The school continues to embrace, use, and reflect on NDP approaches and on their students' achievement data. The teachers have progressed in their discourse and practice since last year.

Three key points have arisen from this study. These are:

i. Teachers are beginning to use the principles of the NDP in strands other than number. This suggests that the principles of the NDP have been internalised and may support effective practice across the curriculum.

ii. The recognition of children's needs is leading to more carefully planned instruction. Teachers are eager to choose the right activities, ensure the use of appropriate material, and targeting instruction for "where to next".

iii. The role of the NDP resource books seems to be changing from reliance on them (2005) to their use as a guide (2006).

Overall, the gains accomplished in the NDP by Country School are not just on the achievement tests but also in other measures such as the Progressive Achievement Test.

Professional Practice

Annan's paper, "The Numeracy Development Projects: A Successful Policy–Research–Practice Collaboration" (p. 116), brings a new perspective in that he looks at the NDP from a school improvement perspective. In his paper, he clearly enunciates four improvement principles that underlie the NDP. These are:

i. determining students' number knowledge and strategies

ii. designing lessons appropriate to students' abilities

iii. teaching that makes teachers' and students' thinking explicit

iv. checking lesson outcomes using diagnostic and formative assessments.

Annan summarises these as "developing evidence-informed collaborative inquiry" and notes that they are present in other initiatives outside mathematics. He sees this inquiry as enabling the development of relationships among the range of participants – policy developers, resource developers, publishers, facilitators, teachers, and researchers – that evolved out of the task in which they were engaged. He notes two tiers of collaboration that have developed in the NDP. These are strategic and operational. Those in the former tier led the design and evaluation of the NDP, while those in the latter tier were responsible for implementing the NDP in the classroom. These collaborations are moving towards nationwide involvement.

Although the aim of the NDP is to produce better mathematical achievement by New Zealand students generally, Annan is specifically concerned about solving the underachievement problem of disadvantaged children.

The paper by Ward and Thomas, "What do Teachers Know about Fractions?" (p. 128), discusses a tool that they developed to assess teachers' knowledge of the teaching of fractions. In addition, the paper discusses the trial of that tool with a small group of teachers. The tool, developed collaboratively with teachers and facilitators, was focused on the pedagogical content knowledge that teachers require in order to be effective teachers of fractions. This tool comprised a pen-and-paper task based on teaching and learning scenarios involving fractions and proportional reasoning. A typical question asked the teacher if the student's work in a given scenario was correct, and, after showing the student's explanation of that work, asked what, if any, was the key understanding that needed to be developed by that student.

Ward and Thomas found that the tool was both efficient and effective in differentiating between teachers on the basis of their responses. They also found that teachers were more able to answer content questions about fractions than to describe the key concepts involved in the questions. The teachers had difficulty describing the actions they would take next with students in response to the scenarios. Of most concern is the fact that between 30% and 40% of the teacher respondents were unable to solve problems involving operations with fractions and proportional reasoning.

The authors note that "Further work in this area is required to establish a link between teachers' scores in the assessment and student achievement data." Given the responses by teachers here and the corresponding student results from the paper by Young-Loveridge et al. (p. 67), it would seem that the call for such "further work" is justified.

Home–School Partnership: Numeracy (HSPN) began in 2006 as a pilot programme. It follows a similar programme in literacy and is founded on the two notions of the importance of all people and the value of partnership. The aim of the HSPN is to raise the mathematical achievement of Pasifika and other bilingual students by enhancing family and community involvement in their children's learning and is based on the idea that children's learning is increased when school and home act in partnership.

The HSPN programme involved about six community sessions. The families of all children in the schools involved were invited to attend these sessions, which included principles and pedagogy from the NDP. The sessions were led by lead teachers and selected parents (lead parents), who had attended a number of training workshops to prepare them for leading the community sessions. The paper "Exploratory Study of Home–School Partnership: Numeracy" (p. 139), by Fisher and Neill summarises the findings of a study into that pilot.

A number of factors were identified by Fisher and Neill that were important for the success of the HSPN. Among these were careful selection of the lead parents, ensuring that the community sessions were engaging to parents, and providing mathematical exploration that relates to real life. On the other hand, Fisher and Neill also noted areas in which the programme might be improved, such as providing more opportunities for the community sessions to be in parents' first language, having a succession plan to ensure continuity, and developing more ways to reach the community and get parents to attend.

Conclusion

A number of common themes appear through the papers of this compendium. For instance, the large body of statistics that is being added to each year shows continual progress being made in students' results across the board. This progress can be seen from almost all of the papers in the Student Achievement section. Although some groups still have progress to make, one of the pleasing aspects is that the groups that are behind are not getting further behind each year. Indeed, there are signs that some gaps are decreasing, albeit in a small way. Evidence for this can be seen in Trinick and Stevenson (p. 44) and Young-Loveridge (p. 16).

It is also pleasing to note that teachers are beginning to apply the pedagogy promoted in the NDP to other strands of the curriculum. Ell (p. 109) and Tagg and Thomas (p. 8) both mention this aspect of teachers' work.

Also on the positive side is the fact that students are managing to do well on a variety of standard tests outside of the NDP (PAT, asTTle, TIMSS, and NEMP). Evidence is found for this both in this compendium (Tagg and Thomas, p. 8, and Ell, p. 109) and in the previous compendium (Thomas and Tagg p. 22).

However, there are clearly areas where effort is going to be required in the immediate future. This is especially true for fractions and proportional reasoning, which are acknowledged as matters of general concern in the community as a whole. The work of Young-Loveridge (p. 16), Ward and Thomas (p. 128), and Trinick and Stevenson (p. 44) also exposes them as a problem for both English-medium and Māori-medium schools. It is clear that an emphasis will have to be put on fractions and proportional reasoning in professional development for some time yet.

Nevertheless, despite the areas of concern, there is no doubt that the NDP, supported by a stack of data and a wealth of research, is one of the leading teacher professional development programmes in mathematics in the world.

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