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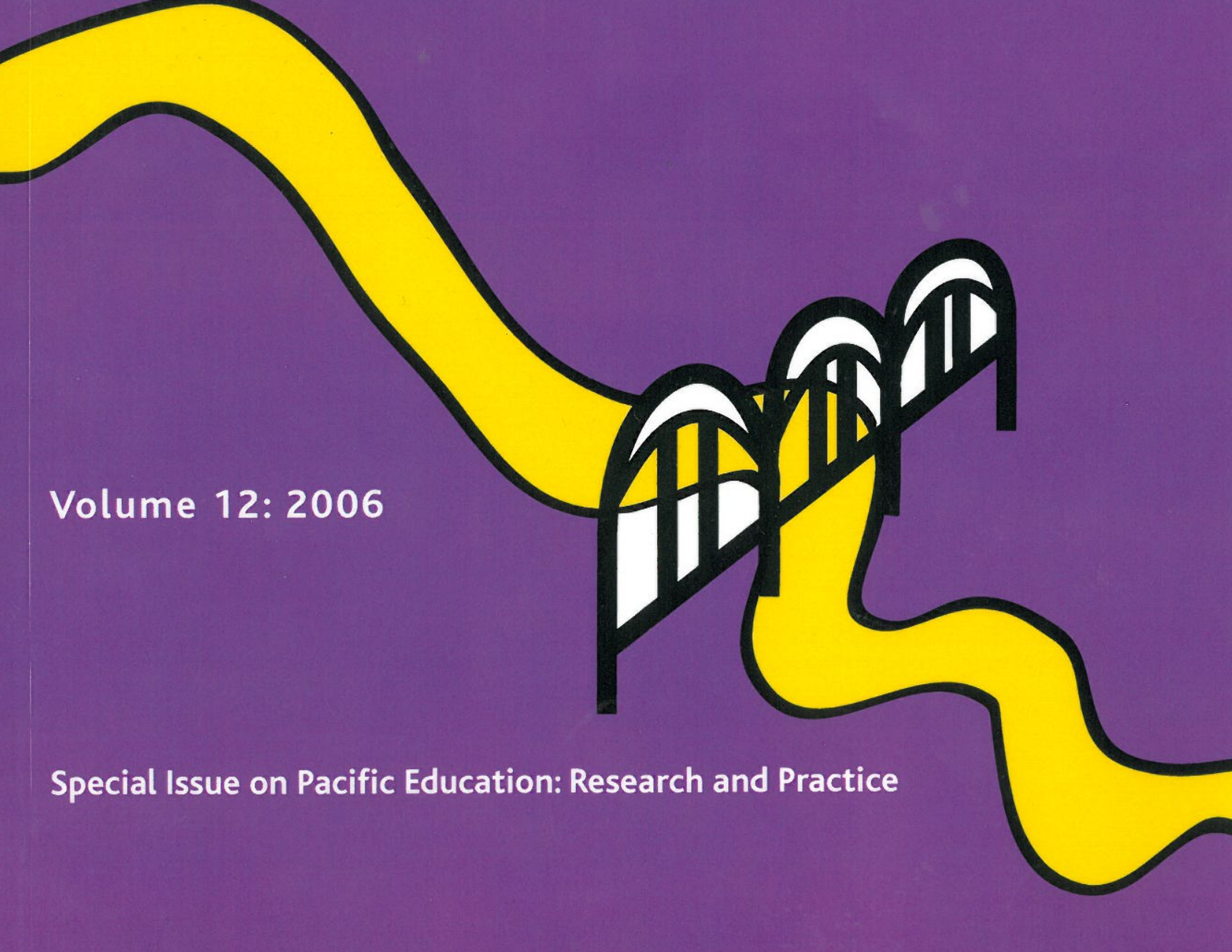

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ENHANCING THE MATHEMATICS ACHIEVEMENT OF PASIFIKA STUDENTS: PERFORMANCE AND PROGRESS ON THE NUMERACY DEVELOPMENT PROJECT

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ABSTRACT *This paper reports on the analysis of data from approximately 30,000 Pasifika students whose teachers participated in the Numeracy Development Project (NDP) between 2002 and 2005. Most students' performance improved from the beginning of the year to the end, and performance and progress seemed to improve from 2002 to 2005. As a result, the gap between European and Pasifika students appeared to reduce fairly steadily over time. These improvements coincided with changes in the composition of the cohort over time, most notably a reduction in the percentage of students from low-decile schools and an increase in the percentage of students from medium- and high-decile schools. Hence, it is difficult to conclude with any confidence that it is the NDP that is primarily responsible for the improvements. Although the gaps in achievement between European and Pasifika students were not completely eliminated, when these differences were put beside those found in other large-scale studies, it was evident that NDP differences were much smaller (a quarter of a standard deviation compared to a whole standard deviation). The use of an individual, orally presented assessment tool with an emphasis on explaining the strategies used to get answers, rather than a written test on which the number of correct answers is simply totalled, may help to explain the positive outcomes for NDP students.*

KEYWORDS

Mathematics, Numeracy, Achievement gap, Pasifika, Educational reform

INTRODUCTION

According to the most recent Census figures available, Pasifika people comprise approximately 6% of the New Zealand population (Statistics New Zealand, 2002). However, with almost 2 in every 5 Pasifika people under the age of 15, the proportion of school-aged Pasifika students is closer to 10%. While Pasifika students contribute to the enormous cultural diversity of New Zealand schools, the challenge for teachers is to find ways of meeting the learning needs of Pasifika students in ways that are culturally appropriate.

There has been considerable concern about the mathematics achievement of Pasifika students for some years. For example, international comparisons such as the Third International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) found that, of the four main ethnic groups in New Zealand (European, Māori, Pasifika, Asian), Pasifika students scored the lowest on a written test of mathematics (Chamberlain, 2001; Chamberlain & Walker, 2001; Garden, 1996, 1997;

Sturrock & May, 2002). Data from national studies shows a pattern that is consistent with those of the international comparisons. For example, Gilmore (1998) found five-year-old Pasifika students arrived at school with the lowest scores on numeracy. New Zealand's Education Monitoring Project found that Year 4 Pasifika students scored significantly lower than other students on 45% of the mathematics tasks, while Year 8 students scored significantly lower on 27% of tasks (Crooks & Flockton, 2001).

According to many writers, the need to improve the educational experiences of Pasifika students in New Zealand schools is imperative (e.g., Barton, 1995; Clark, 1999). Mathematics education in New Zealand has developed out of the British tradition and tends to reflect European values such as questioning, doubting and justifying one's thinking (Barton, 1995; Umaki, 2004). The emphasis at school tends to be on individual success, as well as independence and personal responsibility, rather than on the benefit to the collective group. This can make mathematics learning difficult for students who have been raised in a cultural context where different values are given priority. Issues that have been identified as crucial for Pasifika learners include teacher expectations, comfort in the classroom situation and cultural mores (Clark, 1999). For example, the reluctance of Pasifika students to ask questions of the teacher or speak in class can substantially disadvantage them in the classroom, not only because they may not be able to ask for the help they need but also because their reluctance to speak up may be interpreted by teachers as a lack of interest in learning. Several writers have written about a tendency on the part of Pasifika students to separate their worlds of home and school in order to cope with the conflict in values and expectations (Hill & Hawk, 1998; Umaki, 2004). The critical importance for Pasifika students of teacher/student relationships has been the focus of several studies (e.g., Hawk, Tumama Cowley, Hill & Sutherland, 2002). Building strong partnerships between school and home is another way of helping Pasifika students with their school learning (Ministry of Education, 2005; Umaki, 2004). Teacher education (both pre-service and in-service) has a responsibility to help teachers find ways of meeting the learning needs of Pasifika students more effectively (Clark, 1999). The Ministry of Education's Best Evidence Synthesis highlights the importance for academic learning of social factors, both within the classroom and in other cultural contexts in which students are being socialised (Alton-Lee, 2003).

The New Zealand Numeracy Development Project (NDP), like other reforms in mathematics education world worldwide, came about as a result of concern about the quality of mathematics teaching (see Bobis, Clarke, Clarke, Thomas, Wright, Young-Loveridge & Gould, 2005; British Columbia Ministry of Education, 2003; Commonwealth of Australia, 2000; Department for Education and Employment, 1999; National Council of Teachers of Mathematics, 2000). This concern was sparked by the results from the TIMSS study showing that the mathematics achievement of students in many western nations was below international averages (Garden, 1996, 1997).

The NDP has been underway for approximately six years. It sits within the context of the Ministry of Education's Literacy and Numeracy Strategy, and reflects the key themes of that strategy: clarifying expectations (for student learning), improving professional capability, and involving the community (Ministry of Education, 2001). The focus of the NDP has been on improving student achievement in mathematics by improving the professional capability of teachers. Key aspects of the NDP include a research-based framework to describe progressions in mathematics learning (see Figure 1), individual task-based interviews to assess children's mathematical thinking and ongoing reflective professional development for teachers (for more information, see Ministry of Education, n.d.).

Figure 1. New Zealand's Number Framework

Stage	Description
0.	**Emergent (EM)** Cannot count
1.	**One-to-One Counting (OT)** Can count a small collection up to 10 but cannot use counting to add or subtract collections
2.	**Counting from One on Materials (CM)** Can add two collections by counting but counts all the objects in both collections
3.	**Counting from One by Imaging (CI)** Adds two collections by counting all but counts mentally by imaging objects
4.	**Advanced Counting (AC)** Recognises that the last number in a counting sequence stands for all the objects in the collection, so counts on for the second collection
5.	**Early Additive Part-Whole Strategies (EA)** Recognises that numbers are abstract units that can be partitioned (broken up) & recombined (part-whole thinking). Uses known number facts to derive answers
6.	**Advanced Additive Part-Whole Strategies (AA)** Chooses from a range of different part-whole strategies to find answers to addition and subtraction problems
7.	**Advanced Multiplicative Part-Whole Strategies** Chooses from a range of different part-whole strategies to find answers to multiplication and division problems
8.	**Advanced Proportional Part-Whole Strategies** Chooses from a range of different part-whole strategies to find answers to problems involving fractions, proportions and ratios

The teaching model used in the NDP draws on the work of several key mathematics education researchers (Fraivillig, Murphy & Fuson, 1999; Pirie & Kieran, 1994).

Data on students' mathematics achievement, from individual assessments by their teachers using the diagnostic interview, consist of judgements about the framework stages reached on various operational (strategy) and knowledge domains at the start and end of the project. Analysis involved comparing the percentages of students at particular framework stages initially and finally, as well as examining the patterns of progress on the number framework as a function of initial framework stage. This paper focuses on the results for Pasifika students who participated in the NDP over the period 2002 to 2005.

METHOD

Participants

Data from approximately 30,000 Year 0 to 8 Pasifika students who participated in the Numeracy Development Project between 2002 and 2005 were included in this analysis (see Table 1). By far the majority of Pasifika students were from low decile schools (close to three-quarters of the cohort in the first 3 years of the project and just over half in 2005). The next largest group were from medium decile schools (approximately one sixth were from medium decile schools in the first 3 years of the project and almost a third in 2005). Only a tiny proportion of the Pasifika students were from high decile schools, although this went up to about one eighth in 2005. Over the four years, the proportion of Year 0-3 students was between a quarter and just under a half, while the proportion of Year 4-6 students ranged from a third to a half. The proportion of Year 7-8 students was approximately one fifth of the Pasifika cohort in each of the four years.

Table 1. Composition of the Cohort as a Function of Decile Band and Year Group (2002-2005)

	2002	**2003**	**2004**	**2005**
No. of children	*6065*	*13171*	*6998*	*3780*
Decile Band	%	%	%	%
Low Decile (1-3)	77.9	80.8	74.1	55.4
Mid Decile (4-7)	18.4	15.4	19.9	31.3
High Decile (8-10)	3.7	3.8	6.0	13.2
Year Group	%	%	%	%
Yr 0-3	33.8	44.5	31.2	26.2
Yr 4-6	49.0	35.4	47.1	51.9
Yr 7-8	17.2	20.1	21.6	22.0

Procedure

Students were interviewed individually by their teachers at the beginning and end of the year, using the diagnostic interview (Numeracy Project Assessment: NumPA), and the data sent to a secure website (www.nzmaths.co.nz). Only students with both initial and final data were included in the analysis for this report.

RESULTS AND DISCUSSION

Patterns of Performance

The first part of this paper examines students' performance at the beginning and end of the year (see Table 2). At the end of the year, many students were at a higher framework stage than they had been at the start of the year. For example, in 2005, the proportion of Pasifika students at stage 6 (Advanced Additive Part-Whole) or higher, increased from 5% to almost 15%. Whereas about one third (33.9%) of Pasifika students were at a part-whole stage initially (stage 5 or above), by the end of the year the proportion of part-whole students was more than half (53.7%). At the same time, the proportion of students at stage 2 (Counting from One on Materials) or below dropped from almost one fifth (19.3%) to about one tenth (9.9%). The overall pattern over the four years was one of improvement, with more students at stage 5 or above and slightly fewer students at stage 2 or below.

However, this pattern coincided with the drop in the proportion of low SES students and the rise in the proportion of high SES students, indicating that SES is an important factor to take into account. The increases in the proportion of students at stage 5 or higher may also be the result of the growth of knowledge and experience on the part of numeracy facilitators (Young-Loveridge, 2006b). It is important to interpret cautiously the data that uses average framework stage because of the problems already identified with the stages on the framework not constituting an interval scale (because the steps at the lower end of the framework are smaller than those at the upper end). The next section of this paper, which looks at patterns of progress with respect to identical starting points, provides a more reliable measure of students' performance and progress.

Table 2. Percentage of Year 0-8 Pasifika Students at Each Framework Stage on Addition/Subtraction (2002-2005)

	2002		**2003**		**2004**		**2005**	
	Initial	*Final*	*Initial*	*Final*	*Initial*	*Final*	*Initial*	*Final*
No.	*6374*	*6374*	*13523*	*13523*	*7120*	*7120*	*3785*	*3785*
Framework Stage								
	%	%	%	%	%	%	%	%
0-EM	5.4	1.1	6.5	3.3	4.1	0.7	2.7	0.4
1-OT	6.4	2.7	8.5	2.8	6.7	2.2	6.3	1.7
2-CM	11.0	10.4	20.2	14.8	13.5	8.9	10.3	7.8
3-CI	13.2	11.2	7.6	10.1	8.0	7.8	8.2	6.1
4-AC	41.9	33.7	36.1	32.3	39.4	33.9	38.6	30.3
5-EA	17.6	31.8	17.3	27.7	23.6	34.3	28.9	39.1
6-AA	4.4	9.1	3.8	8.9	4.7	12.1	5.0	14.6
	%	%	%	%	%	%	%	%
Stages 5+	22.0	40.9	21.1	36.6	28.3	46.4	33.9	53.7
Stages 2-	22.8	14.2	35.2	20.9	24.3	11.8	19.3	9.9

Table 3. Percentages of Students Who Progressed to a Higher Framework Stage on Addition/Subtraction at Each Initial Stage (2002-2005)

Initial Stage	**2002**	**2003**	**2004**	**2005**
Stage 0 EM No. of Children	*346*	*874*	*292*	*102*
	%	%	%	%
Up 1	28.6	22.8	25.0	30.3
Up 2	40.2	44.1	42.1	49.0
Up 3	9.8	10.1	8.9	1.0
Up 4	4.6	8.1	7.9	3.9
Up 5	-	3.1	5.8	-
Total	**83.2**	**88.2**	**89.7**	**84.2**
Stage 1 OT No. of Children	*411*	*1153*	*478*	*238*
	%	%	%	%
Up 1	55.0	53.3	42.5	40.3
Up 2	15.3	17.3	22.0	20.2
Up 3	12.9	12.7	18.6	22.3
Up 4	0.7	1.2	1.3	2.9
Total	**83.9**	**84.5**	**84.4**	**85.7**
Stage 2 CM No. of Children	*700*	*2728*	*963*	*389*
	%	%	%	%
Up 1	27.0	27.4	30.7	27.2
Up 2	29.0	32.2	33.0	35.0
Up 3	1.9	3.5	4.2	4.1
Total	**57.9**	**63.1**	**67.9**	**66.3**
Stage 3 CI No. of Children	*844*	*1030*	*567*	*312*
	%	%	%	%
Up 1	44.4	55.7	63.8	61.9
Up 2	8.1	11.2	11.8	12.5
Up 3	0.9	0.2		0.3
Total	**53.4**	**67.1**	**75.6**	**74.7**
Stage 4 AC No. of Children	*2668*	*4876*	*2806*	*1460*
	%	%	%	%
Up 1	41.1	39.1	40.5	45.1
Up 2	2.5	3.2	3.3	5.1
Total	**43.6**	**42.3**	**43.8**	**50.2**
Stage 5 EA No. of Children	*1123*	*2346*	*1682*	*1094*
	%	%	%	%
Up 1	**21.3**	**24.1**	**27.3**	**27.3**

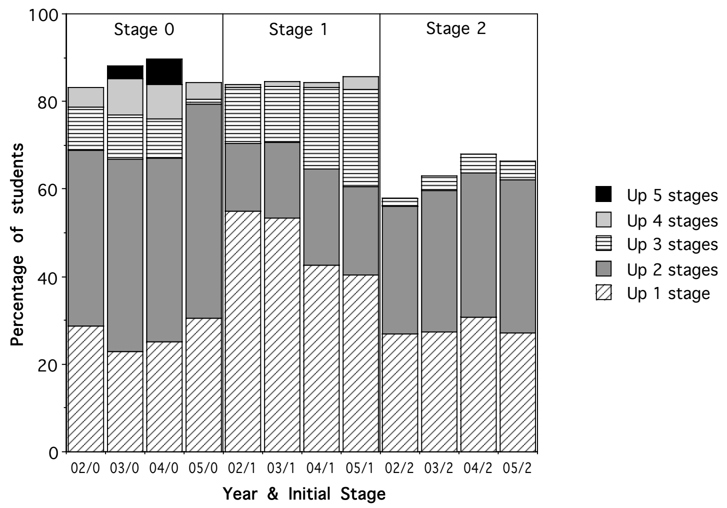
Patterns of Progress

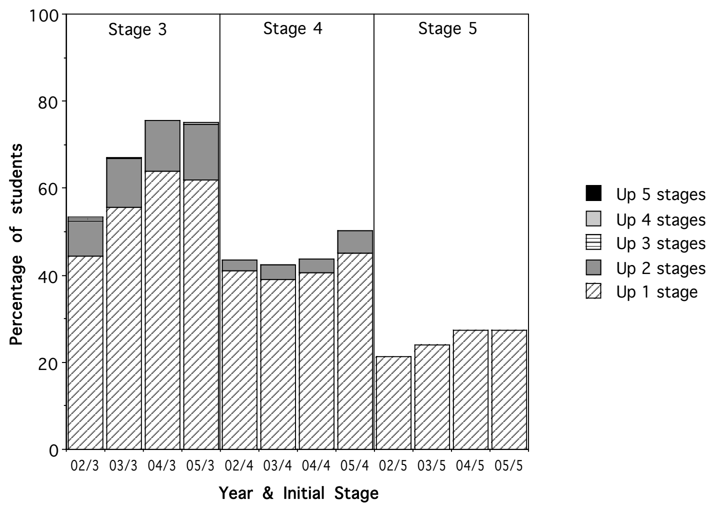
Patterns of progress were examined by looking at the proportions of students who moved to a higher framework stage relative to particular starting points. Table 3 shows the percentages of students at each initial stage who moved to a higher framework stage between 2002 and 2005. Figure 2 shows these patterns of progress for Pasifika students over 2002 to 2005. Students who started at stage 0 (Emergent) or stage 1 (One-to-One Counting) showed the greatest progress, with more than 80% of students moving to a higher framework stage. For example, in 2005, almost a third of the students who began the project at stage 0 (Emergent) learned how to count (30.3% went up a stage to stage 1, One-to-One Counting), and half of the students learned how to use counting to work out how many objects in two collections (49.0% went up 2 stages to stage 2, Counting from One on Materials). A very small proportion learned to use counting to work out the total of two collections that were screened (1.0% went up 3 stages to stage 3, Counting from One using Imaging), or to count on (3.9% went up 4 stages to stage 4, Advanced Counting).

Between half and three-quarters of the students who started at stages 2 (Counting from One on Materials) or 3 (Counting from One with Imaging) moved to a higher framework stage. In general, progress was better for those who started at stage 3 than for those who started at stage 2, despite the fact that stage 3 students could progress only three stages at the most, whereas those at stage 2 could potentially improve by four stages. This suggests that once students understand how to use counting to work out the total when two collections are joined, they make rapid progress through at least stages 2 (Counting from One on Materials) and 3 (Counting from One using Imaging). Close to half (or more) of the students who were able to use imaging progressed to counting on (stage 4), and about one tenth went on to acquire part-whole strategies. Dependence on concrete materials to work out the total of two collections (stage 2) seemed to limit the proportion of students who could learn to count on (to about one third) or progress to using part-whole strategies (4% or fewer). About 40 percent of students who were able to count on (stage 4) at the beginning of the project went on to acquire part-whole strategies, but just a tiny proportion reached stage 6 (5% or fewer). Approximately one quarter of the students who began the project at stage 5 (Early Additive Part-whole) progressed to stage 6, the highest possible stage. Interestingly, the proportion increased between 2002 and 2003, even though there were virtually identical percentages of high-decile students, fewer middle-decile students and more low-decile students. Surprisingly, in 2005, when the proportion of high-decile students more than doubled from the previous year, middle-decile students increased substantially and low-decile students decreased, the proportion of students progressing from stage 5 to stage 6 was identical.

Figure 2 presents the patterns of progress as cumulative histograms, with students who started at stages 0-2 in the upper histogram, and those starting at stages 3-5 in the lower histogram. The increasing improvement over time is clearly evident. Even when the total percentage of students who progressed did not change much (as was the case for students who started at stage 1), the size of the bands at the upper levels of the histogram (i.e., those who moved up either 3 or 4 stages) became greater over time. This may reflect the impact of additional initiatives such as the Manurewa Enhancement Initiative (MEI), one of the School Improvement initiatives put in place to provide extra support for schools in certain low-income areas that caters for schools with high proportions of Pasifika students. The MEI had as one of

Figure 2. Percentages of Year 0-8 Pasifika Students at Each Initial Stage (0-2 above, 3-5 below) Who Progressed to a Higher Framework Stage on Addition/Subtraction in 2002-2005





its goals 'added value' because, in addition to implementing the Numeracy project, it has provided several extra support systems for schools (e.g., a programme to address truancy, special training for teacher aides, specialised postgraduate mathematics education credentials for teachers). In an earlier analysis, the patterns of progress for the students at eight low-decile primary schools involved in the MEI (n=942) were compared with the corresponding patterns of progress for students at other low-decile schools (n=17,329). MEI students who began the project at stage 1 (One-to-One Counting) made significantly greater progress than that made by other low-decile students who began the project at the same framework stage. Significantly greater progress was also made by MEI students who began the project at stage 3 (Counting from One), and stage 4 (Advanced Counting), in relation to comparable students who started at the same framework stages (see Young-Loveridge, 2005).

The patterns of progress for Pasifika students who started at lower framework stages were very encouraging, with more than three quarters progressing to a higher framework stage. It was interesting to note in another analysis of this data that Pasifika students who started at stage 0 or stage 1 made greater progress than either Māori or European students who started at one of these two stages (see Young-Loveridge, 2006a). One possible reason for this is that many Pasifika students start school as second-language learners of English, and this leads to their initial numeracy assessments being lower. Evidence has shown that with good literacy teaching, Pasifika students can make rapid progress (Phillips, McNaughton & MacDonald, 2001). Something similar may also occur with their mathematics learning, particularly in relation to acquiring knowledge of counting sequences and the pairing of that knowledge of forward number word sequence with objects to determine how many objects in two collections. Another possibility is that the experiences of Pasifika students with the recitation of texts at church and at home helps in the development of memory skills (Fletcher, Parkhill & Fa'afoi, 2005; McNaughton, 2002), and this may assist in the early development of counting skills. It is also possible that teachers initially underestimated the understanding of Pasifika students (perhaps because of low expectations for their achievement) but, after a year of professional development on ways to advance children's mathematics learning, their later assessments became more accurate. This would be consistent with two of the key themes underpinning the Literacy and Numeracy Strategy that are addressed by the NDP; that is, clarifying expectations for students' achievement and enhancing the professional capability of teachers (Ministry of Education, 2002). The idea that teachers initially underestimated what Pasifika students could do is also thought to be consistent with the idea that Pasifika students are kinaesthetic learners, a common assumption according to Umaki (2004). If teachers believe that Pasifika students need to manipulate concrete materials in order to do mathematics, then the students' learning opportunities will be restricted because their teachers do not expect them to be able to deal with abstract ideas such as part-whole relationships.

Students who started in the middle or upper stages on the framework also made considerable progress, although fewer of them progressed to a higher framework stage compared to those who started lower. However, this was typical of the pattern for all students, regardless of ethnicity. Earlier analyses had shown that the steps on the framework seem to get increasingly larger and it becomes more difficult (or takes longer) to progress, the higher the starting point on the framework (Young-Loveridge, 2004). Over the period between 2002 and 2005, there was a tendency for more students at the middle and high levels to progress to a higher stage, a pattern that was particularly marked for students who began the project at either stage 2 or stage 3.

Narrowing the Achievement Gap

In order to investigate the extent to which the NDP narrowed the gap in mathematics achievement between Pasifika students and those from the dominant majority (European), effect sizes were calculated for the differences between European and Pasifika students for 2002 to 2005. Because of the problems with the framework stages not constituting an interval scale, separate effect sizes were calculated for students who began the project at each initial stage. Effect sizes were calculated by dividing the average difference between two groups by the standard deviation for the two groups combined. The median effect size for different initial stages was then used as an indicator of the pattern overall. Table 4 presents the median effect sizes for each comparison between 2002 and 2005. Analysis shows that the median effect size for differences between European and Pasifika students reduced from 0.26 in 2002 to 0.17 in 2005.

According to Cohen's classification (see Fan, 2001), an effect size of 0.2 is considered 'small' (a difference of less than a quarter of a standard deviation), those of 0.5 are thought to be 'medium' (a difference of half a standard deviation), and those of 0.8 are considered 'large' (a difference of more than three-quarters of a standard deviation). Hence, the effect sizes for the ethnicity comparisons are quite modest.

Table 4. Median Effect Sizes for Comparison of Progress (European vs. Pasifika) on Addition/Subtraction for Students Who Started at Identical Framework Stages 2002–2005

Year	European – Pasifika
2002	0.26
2003	0.21
2004	0.16
2005	0.17

Putting Effect Sizes into Perspective

The NDP was initially designed to raise mathematics achievement for all students. The projects seem to have been fairly successful at doing this. Analyses have shown that, although all students made progress, the achievement gaps between European and Pasifika students have not been completely eliminated. However, it is important to see these differences in the wider perspective. When the effect sizes for these differences are compared with corresponding differences found on other large-scale studies of mathematics achievement, it becomes clear that the effect sizes for the differences on NDP were substantially smaller than those found in the other studies. For example, on the TIMSS study, effect sizes were about one standard deviation for the European–Pasifika comparison (see Table 5).

Based on Cohen's classification (see Fan, 2001), these are 'large' effect sizes (that is, about 0.8 or more), whereas those on NDP are mostly about 0.2, which is considered 'small' on Cohen's classification. The effect sizes for the PISA study (0.53) are smaller than those on TIMSS but this study differs in an important way from the others. The PISA study looked at students aged 15 years 3 months to 16 years 2 months. Evidence from educational statistics shows that some Pasifika students have left school by the age of 15 years. Hence, the comparison does not include a full cohort of students. It is often those students who are not succeeding at secondary school who decide to leave early. Hence, the PISA results do not include the full range of mathematics achievement levels and this will inevitably have somewhat reduced the magnitude of effect sizes.

It seems likely that the nature of the assessment may be a crucial factor in determining the patterns showing smaller ethnicity differences on NDP than on TIMSS or PISA. The diagnostic interview used in the NDP to assess students' mathematical proficiency (NumPA) involves the assessment of students individually by their own teachers, with tasks presented orally. Moreover, the emphasis is on the nature of the strategies used rather than simply whether or not the answer given was correct. By presenting tasks orally and expecting students to respond orally and to explain their thinking and reasoning, NDP assessment effectively minimises the literacy requirements and allows students to access the mathematics and demonstrate their mathematical proficiency unimpeded by literacy barriers. Although it is also possible that teachers unwittingly help certain students in the individual interview situation, and this might help to explain the different patterns found for TIMSS and NDP, evidence against this possibility comes from a study of teacher judgements using the NDP assessment (Thomas, Tagg & Ward, 2006). Thomas et al. found a high level of agreement between the judgements of classroom teachers and those of independent researchers, supporting the validity and reliability of the individual interview data gathered with NDP.

Table 5. Effect Sizes for the Comparison of Pasifika vs. European on TIMSS, PISA, and NDP

Study	Age/Year Level	Year/Level	Effect Size
TIMSS	Yr 5	1994	0.95
TIMSS	Yr 5	1998	0.97
TIMSS	Yr 9	1994	1.15
TIMSS	Yr 9	1998	0.96
PISA	15 years	2000	0.53
NDP	Yr 0-8	2002 Initial	0.37
NDP	Yr 0-8	2003 Initial	0.35
NDP	Yr 0-8	2004 Initial	0.21
NDP	Yr 0-8	2005 Initial	0.23

GENERAL DISCUSSION

The findings presented show that Pasifika students have improved substantially as a result of their participation in the NDP. However, there is more to mathematics learning than simply making progress on the number framework. Other kinds of data have the potential to further inform the picture about how Pasifika students are doing in their mathematics learning. For example, one evaluation study of the NDP has included a focus on the language used by Pasifika students during classroom mathematics sessions (Irwin & Woodward, 2005, 2006). The researchers found that although the teacher used the kind of language advocated by Fraivillig and colleagues (1999) to advance students' mathematics learning, when students worked in small groups without the teacher, they did not appear to work co-operatively or engage in exploratory talk to solve problems. Instead, they sometimes role-played being the teacher or the students. The researchers described the students' behaviour as having the feel of 'playing school' rather than being genuine co-operative learning.

The importance of establishing classroom norms, both social and sociomathematical, has been discussed extensively by Yackel and Cobb (1996). However, shifting classroom discourse away from a traditional teaching approach towards a greater focus on students communicating their mathematical reasoning, justification and argumentation is no easy matter. Anecdotal evidence suggests that only a small minority of teachers have been able to make such a shift towards establishing a community of mathematical learners who participate in collective problem-solving. Hunter (2005, 2006) has documented the experiences of one New Zealand teacher in a low SES school with a high proportion of Pasifika students who managed to shift her classroom discourse away from teacher questioning and student explaining, towards building a community of learners who were able to challenge one another and justify their mathematical reasoning. It was a lengthy process for the teacher to change children's expectations about appropriate ways of engaging with mathematical reasoning and debate within the classroom. She had to teach her students how to disagree with one another honestly but respectfully. Hunter's findings are consistent with those of other researchers who have explored argumentation in classrooms (e.g., Hufferd-Ackles et al., 2004; White, 2003; Wood, 1999).

CONCLUSIONS

The findings show that Pasifika students have responded well to the NDP. The majority of students who began the year at lower framework stages made good progress. The individual interview seems to have provided teachers with a powerful tool with which to identify the strengths and weaknesses of individual students and plan their instructional programme for the classroom. Because the diagnostic purpose of the assessment tool has been given a high priority, it seems likely that teachers' expectations of Pasifika students have become more accurate than they were previously. It may be that one of the reasons for the substantial improvements of Pasifika students is that teachers have underestimated their knowledge and understanding initially and after working with the NDP for a year, they are able to make more accurate judgements about where students are positioned on the number framework. The comparison of NDP findings (gathered using individual interviews) with those of the international comparisons (using written tests) indicate that ethnicity differences in the past may have been exaggerated and that there may be less need for concern about the mathematics achievement levels of Pasifika students than previously thought.

REFERENCES

Alton-Lee, A. (2003). *Quality teaching for diverse students in school: Best evidence synthesis.* Wellington: Ministry of Education.

Barton, B. (1995). Cultural issues in NZ mathematics education. In J. Neyland (Ed.), *Mathematics education: A handbook for teachers, Vol. 2* (pp. 150-164). Wellington: Wellington College of Education.

Bobis, J., Clarke, B., Clarke, D., Thomas, G., Wright, R., Young-Loveridge, J., & Gould, P. (2005). Supporting teachers in the development of young children's mathematical thinking: Three large scale cases. *Mathematics Education Research Journal, 16*(3), 27–57.

British Columbia Ministry of Education (2003). *Supporting early numeracy: BC Early Numeracy Project (K-1)*. Province of British Columbia: British Columbia Ministry of Education.

Chamberlain, G. (2001). *Trends in Year 5 students' mathematics and science achievement: Results from a New Zealand study based on the Third International Mathematics and Science Study*. Wellington: Ministry of Education.

Chamberlain, M., & Walker, M. (2001). *Trends in Year 9 students' mathematics and science achievement: Results from New Zealand's participation in the repeat of the Third International Mathematics and Science Study*. Wellington: Ministry of Education.

Clark, M. (1999). Māori and Pacific Islands student performance in mathematics. In A. Else (Ed.), *Proceedings of Research Seminar on Mathematics Education (Year 0-6 students) held at the Ministry of Education on 12 June 1998* (pp. 31-37). Wellington: Ministry of Education.

Commonwealth of Australia (2000). *Numeracy, a priority for all: Challenges for Australian schools: Commonwealth numeracy policies for Australian schools*. Canberra: Commonwealth of Australia.

Crooks, T., & Flockton, L. (2002). *Mathematics assessment results 2001: National Education Monitoring Report 32*. Dunedin: Educational Assessment Research Unit.

Department for Education and Employment (1999). *The National Numeracy Strategy: Framework for teaching mathematics from reception to year 6*. London: Department for Education and Employment.

Fan, X. (2001). Statistical significance and effect size in educational research: Two sides of a coin. *Journal of Educational Research, 94,* 275–282.

Fletcher, J., Parkhill, F., & Fa'afoi, A. (2005). What factors promote and support Pasifika students in reading and writing? *Set: Research Information for Teachers, 2,* 2-8.

Fraivillig, J. L., Murphy, L. A., & Fuson, K. C. (1999). Advancing children's mathematical thinking in everyday mathematics classrooms. *Journal for Research in Mathematics Education, 30,* 148-170.

Garden, R. A. (1996). *Mathematics performance of New Zealand Form 2 and Form 3 students: National results from New Zealand's participation in the Third International Mathematics and Science Study*. Wellington: Ministry of Education.

Garden, R. A. (1997). *Mathematics and science performance in middle primary school: Results from New Zealand's participation in the Third International Mathematics and Science Study*. Wellington: Ministry of Education.

Gilmore, A. (1998). *School entry assessment: The first national picture*. Wellington: Ministry of Education.

Hawk, K., Tumama Cowley, E., Hill, J., & Sutherland, S. (2002). The importance of the teacher/student relationship for Māori and Pasifika students. *Set: Research Information for Teachers, 2*, 44-49.

Hill, J., & Hawk, K. (1998). Aiming for student achievement: How teachers can understand and better meet the needs of Pacific Island and Māori students. *Set: Research Information for Teachers, 2*, 1-4.

Hufferd-Ackles, K., Fuson, K., & Sherin, M. G. (2004). Describing levels and components of a math-talk learning community. *Journal for Research in Mathematics Education, 35*, 81-116.

Hunter, R. (2005). Reforming communication in the classroom: One teacher's journey of change. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce & A. Roche (Eds.), *Building connections: Research, theory and practice. Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia* (pp. 451-458). Sydney: MERGA.

Hunter, R. (2006). Structuring the talk towards mathematical inquiry. In P. Grootenboer, R. Zevenbergen & M. Chinnappan (Eds.), *Identities, cultures and learning spaces. Proceedings of the 29th annual conference of the Mathematics Education Research Group of Australasia* (pp. 309-317). Adelaide, SA: MERGA.

Irwin, K. C., & Woodward, J. (2005). A snapshot of the discourse used in mathematics where students are mostly Pasifika: A case study of two classrooms. In J Higgins, K. C. Irwin, G. Thomas, T. Trinick & J. Young-Loveridge, *Findings from the New Zealand Numeracy Development Project 2004* (pp. 66-78). Wellington: Ministry of Education.

Irwin, K. C., & Woodward, J. (2006). Advancing Pasifika students' mathematical thinking. In F. Ell, J. Higgins, K. C. Irwin, G. Thomas, T. Trinick, & J. Young-Loveridge, *Findings from the New Zealand Numeracy Development Project 2005* (pp. 80-90). Wellington: Ministry of Education.

MacNaughton, S. (2002). *Meeting of minds*. Wellington: Learning Media.

Ministry of Education (2001). *Curriculum Update No. 45: The Numeracy Story*. Wellington: Learning Media.

Ministry of Education (2002). *Curriculum Update No. 50: Literacy*. Wellington: Learning Media.

Ministry of Education (2005). Pasifika education overview. Retrieved 24 July, 2005, from http://minedu.govt.nz/index.cfm?layout=document&documentid=4712&indexid=5746 &indexparentid=4329

Ministry of Education (n.d.). *New Zealand Numeracy Project material*. Retrieved April 18, 2005, from http://www.nzmaths.co.nz/Numeracy/project_material.htm

National Council of Teachers of Mathematics (NCTM) (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Phillips, G., McNaughton, S., & MacDonald, S. (2001). *Picking up the pace: Effective literacy interventions for accelerated progress over the transition into decile 1 schools*. Wellington: Ministry of Education.

Pirie, S. E. B., & Kieran, T. E. (1994). Beyond metaphor: Formalising in mathematical understanding within constructivist environments. *For the Learning of Mathematics, 14*(1), 39-43.

Statistics New Zealand (2002). *Census Snapshot: Pacific Peoples*. Retrieved July 24, 2005, from http://www.stats.govt.nz/products-and-services/Articles/census-snpsht-pac-ppls-Jun02.htm

Sturrock, F., & May, S. (2002). *PISA 2000: The New Zealand context: The reading, mathematical and scientific literacy of 15-year-olds: Results from the Programme for International Student Assessment*. Wellington: Ministry of Education.

Thomas, G., Tagg, A., & Ward, J. (2006). Numeracy assessment: How reliable are teachers' judgements? In F. Ell, J. Higgins, K. C. Irwin, G. Thomas, T. Trinick & J. Young-Loveridge, *Findings from the New Zealand Numeracy Development Projects 2005* (pp. 91-102). Wellington: Ministry of Education.

Umaki, S. M. (2004). *Raising Pacific achievement in mathematics*. Unpublished Directed Study. University of Waikato, Hamilton.

White, D. Y. (2003). Promoting productive mathematical classroom discourse with diverse students. *Journal of Mathematical Behavior*, 22, 37-53.

Wood, T. (1999). Creating a context for argument in mathematics class. *Journal for Research in Mathematics Education, 30,* 171-191.

Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27,* 458-477.

Young-Loveridge, J. (2005). Patterns of performance and progress: Analysis of 2004 data. In J Higgins, K. C. Irwin, G. Thomas, T. Trinick & J. Young-Loveridge, *Findings from the New Zealand Numeracy Development Project 2004* (pp. 5–20, 115–127). Wellington: Ministry of Education.

Young-Loveridge, J. (2006a). Patterns of performance and progress on the Numeracy Development Project: Looking back from 2005. In F. Ell, J. Higgins, K. C. Irwin, G. Thomas, T. Trinick & J. Young-Loveridge, *Findings from the New Zealand Numeracy Development Project 2005* (pp. 6-21, 137-155). Wellington: Ministry of Education.

Young-Loveridge, J. (2006b). *The development of children's mathematical thinking in the early school years*. Unpublished manuscript. University of Waikato, Hamilton.