Evidence for Expectations: Findings from the Numeracy Project Longitudinal Study

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Recent research in New Zealand and internationally suggests that a school-wide focus on using achievement information contributes to improved student achievement. Knowing acceptable rates of progress and appropriate levels of achievement enables school communities to critically reflect on achievement information. This paper reports on the numeracy achievement of students in 31 schools in the years following their participation in the Numeracy Development Project. The findings provide evidence for expected levels of numeracy achievement over time. The schools who reported extensive use of numeracy achievement data appeared to raise the achievement of their students more than schools with a lower reported use of achievement information.

Background

The Numeracy Development Project

The Numeracy Development Project (NDP) focuses on improving students' achievement in mathematics through strengthening the professional capability of their teachers (Ministry of Education, 2004). Several key components are considered central to the effective implementation of the project (Higgins, Parsons, & Hyland, 2003). At the core of the NDP is the Number Framework, which has been informed by research showing that there are identifiable progressions in how children develop number concepts (see Cobb, Gravemeijer, Yackel, McClain, & Whitenack, 1997; Jones, Thornton, Putt, Hill, Mogill, Rich, & Van Zoest, 1996; Steffe, 1992; Wright, 1998; Young-Loveridge & Wright, 2002).

The framework, which has evolved over the duration of the project in response to student achievement information and feedback from teachers and numeracy facilitators, has a strategy and a knowledge section. The strategy section consists of a sequence of nine stages that describe the strategies students use to solve number problems. The first five stages (0 to 4) involve increasingly sophisticated counting strategies, while stages 5 to 8 involve the use of increasingly complex partitioning strategies. The partitioning strategies are based on using knowledge of number properties to break numbers apart and recombine them in ways that make the problem easier to solve. The knowledge section describes the key items of number knowledge that students need to learn, including number sequence and order, numeral identification, grouping and place value, basic facts, and written recording. The two components are viewed as interdependent, with strategies creating new knowledge, and knowledge providing the foundation for new strategies (Young-Loveridge & Wright, 2002). The Number Framework can be described as a pedagogical tool in that it provides teachers with "direction for responding effectively to children's learning needs" (Higgins et al., 2003, p. 166).

Another key component of the NDP is the Numeracy Project Assessment tool (NumPA), an individual, task-based interview designed to provide teachers with information about their students' number knowledge and strategy use. This number profile is aligned to the Number Framework.

A third component of the NDP is the professional development programme, which involves the participation of the whole school, usually over a two-year period. The programme involves a series of workshops and in-class visits by a facilitator, who provides feedback and support to the teacher in their implementation of numeracy practices. Teachers participating in the NDP are required to assess their students using the NumPA early in the professional development programme and again at its completion. The results of these assessments are submitted to a secure website for use by the project's evaluators.

The NDP was first implemented in New Zealand schools in 2001, following two pilot projects in 2000 (the Count Me In Too pilot for students in years 1–3, and the Numeracy Exploratory Study for students in years 4–6). Since then more than 300 000 students and 14 000 teachers have participated in the project. The project has been informed by annual evaluation reports that have examined the impact of the NDP on students' learning, as well as exploring the experiences and perceptions of the numeracy facilitators, teachers, and principals. Findings from the evaluations indicate that the project has had a positive impact on the quality of teaching and learning in mathematics (Christensen, 2003, 2004; Higgins, 2003, 2004; Irwin, 2003, 2004; Thomas, Tagg, & Ward, 2003; Thomas & Tagg, 2004; Young-Loveridge, 2004).

Positioned within the evaluations commissioned by the Ministry of Education is the NDP Longitudinal Study. The overarching aim of the Longitudinal Study is to investigate the impact over time of the NDP on students' mathematics achievement. This paper reports on aspects of the findings from the 2004 Longitudinal Study.

Using achievement information to raise achievement

Recent research in New Zealand has linked the use of student achievement information to quality teaching practices that facilitate higher achievement (Alton-Lee, 2003; Timperley & Parr, 2004). Alton-Lee, in her evidential synthesis of quality teaching, states that:

> The gathering and analysis of high-quality student achievement data and the use of externally referenced benchmarks have been found to be powerful tools in bringing about changes in teacher practice that facilitates higher achievement for students. (p. 19)

Evidence from New Zealand and overseas suggests that a school-wide focus on using achievement information effectively helps to raise student performance (see Goddard, Hoy, & Woddfolk Hoy, 2004; Timperley & Parr, 2004).

> New Zealand research has shown that teachers and their curriculum leaders who worked together to examine the implications of evidence of student achievement for their teaching had higher achieving students. (Timperley & Parr, 2004, p. 11)

Further to this, Alton-Lee (2003) and Timperley (2003) contend that effective professional development initiatives are those that make explicit the kinds of teaching practices that support learning and link these approaches to student achievement information. Alton-Lee cites the NDP as an example of such a professional development initiative.

> The study [NDP] is particularly significant in our best evidence synthesis because it is one of the few New Zealand studies to trace increases in student achievement linked to professional development and teaching practice across a broad national sample of students. (Alton-Lee, 2003, p. 45)

NDP Longitudinal Study: Overview and Methodology

One of the aims of the NDP Longitudinal Study is to collect numeracy data from students in the years following their school's participation in NDP to help establish benchmarks or expectations for achievement. In addition to tracking the numeracy achievement in schools over time, the Longitudinal Study in 2004 sought to link achievement levels to the extent that schools reported they made use of achievement information.

Sample

The NDP Longitudinal Study began in 2002 and has focused on tracking the achievement of students on the Number Framework over time. Each year since 2002, further schools have been added to the study. In 2004, a total of 31 schools were invited to participate in the study. Eight of these schools first participated in 2000, seven first participated in 2001, and 16 began in 2002. Nineteen of these 31 schools submitted data on their students' strategy stages to the project website during November 2004. Table 1 shows the breakdown of these longitudinal students by ethnicity compared to the NDP 2004 figures. The longitudinal sample had a higher proportion of Māori students and a correspondingly lower proportion of New Zealand European students.

Table 1
Analysis of Students by Gender and Ethnicity

Ethnicity	Female		Male		Total	
	Longitudinal	NDP 2004	Longitudinal	NDP 2004	Longitudinal	NDP 2004
NZ European	52%	61%	51%	60%	51%	60%
Māori	27%	19%	27%	20%	27%	20%
Pasifika	11%	10%	11%	10%	11%	10%
Asian	7%	5%	6%	5%	6%	5%
Other	5%	4%	5%	4%	5%	4%
Total	3012	34423	3087	35875	6099	70298

Table 2 compares the longitudinal and NDP 2004 samples by year level and school decile.[2] There is a greater proportion of students from low-decile schools and a correspondingly lower proportion from medium-decile schools in the longitudinal sample that returned data than in the national sample from NDP 2004. There are similar proportions of high-decile schools. The analyses undertaken for the NDP evaluations since its implementation have consistently shown that students from low-decile schools are lower performing than students from medium- and high-decile schools (Young-Loveridge, 2004). In addition, the trend has been for Māori and Pasifika students to perform lower than New Zealand European and Asian students

[2] The Ministry of Education uses a decile rating system for school funding purposes. Each decile contains approximately 10% of schools. Schools in decile 1 have the highest proportion of students from low socio-economic backgrounds. Schools in decile 10 have the lowest proportions of these students. The low-decile band includes decile 1 to 3 schools, the medium band includes decile 4 to 7 schools, and the high-decile band includes decile 8 to 10 schools. A small number of schools in NDP 2004 did not return decile information and were excluded from Table 2.

(Young-Loveridge, 2004). Consequently, the impact of these two factors needs to be considered when the longitudinal results are compared to the national sample from NDP 2004.

Table 2
Analysis of Students by Year and School-decile Band

	Low Decile		Medium Decile		High Decile		Total	
Year	Longitudinal	NDP 2004	Longitudinal	NDP 2004	Longitudinal	NDP 2004	Longitudinal	NDP 2004
1	38%	20%	31%	37%	31%	40%	1119	7793
2	37%	21%	28%	35%	35%	40%	819	8196
3	37%	25%	26%	35%	37%	38%	912	8515
4	32%	26%	29%	37%	39%	34%	878	10012
5	41%	29%	33%	38%	26%	31%	925	9868
6	43%	29%	33%	36%	24%	32%	838	9959
7	44%	27%	28%	47%	28%	21%	326	8372
8	48%	29%	30%	45%	22%	19%	282	7306
Total	39%	26%	30%	39%	31%	32%	6099	70298

Methodology

The longitudinal schools were asked to submit the additive, multiplicative, and proportional strategy stages of their students on the Number Framework to a secure website during November 2004. In addition to the strategy stages, information was collected about each student's gender, date of birth, school year level, and ethnicity. The students were linked to schools, so their achievement can also be reported by decile. As previously mentioned, 19 of the 31 schools submitted this information; the remaining 12 schools failed to do so.

Questionnaires were sent to all teachers in the 2004 longitudinal schools in August to gain their perceptions on student numeracy achievement, details on the data they collect on student mathematics achievement, and their use of student achievement information. In addition, the researchers held a day-long meeting with the numeracy lead teachers in six of the schools that reported extensive use of student achievement information.

Results and Discussion

How do the longitudinal students compare?

This section details the levels of achievement, as measured by stages on the Number Framework, of students in the 19 longitudinal schools that submitted numeracy data. Figures 1–4 compare the achievement of the longitudinal students on the Number Framework with the before-project and after-project results of students in schools participating in NDP 2004. The bars show the percentage of students at each framework stage on the given strategy domain. The NDP 2004 students are labelled as "NZ", while the longitudinal are referred to as "Long". "Initial" and "Final" refer to the result of the NumPA interviews conducted at the start and conclusion of the NDP 2004. A description of the numbered stages is included in the appendices (Appendix D).

Figure 1 shows the performance of year 1 to 3 students on the additive domain. The additive domain examines the strategies that students use to solve addition and subtraction problems. These strategies can be categorised as counting strategies (stages 1 to 4) or partitioning strategies (stages 5 to 6). A student at stage 0 is classified as pre-counting or emergent. A comparison of the second and third bars within each year level shows that the year 2 and 3 longitudinal students have similar patterns of achievement to the NDP 2004 students. This suggests that, over time, the gains made during the project are sustained. The year 1 students in the NDP 2004 outperform the longitudinal year 1 students, with 12% of the NDP 2004 students at stage 0 or 1 compared to 29% of the longitudinal students. This is consistent with the findings of the 2003 Longitudinal Study (Thomas & Tagg, 2004) and is most likely the result of the almost exclusive focus on numeracy in the mathematics programme of teachers during the professional development phase of the project. It may also reflect the impact of the different demographics of the two samples as students in low-decile schools are more likely to start school at the emergent stage (24%) than students in high-decile schools (11%).

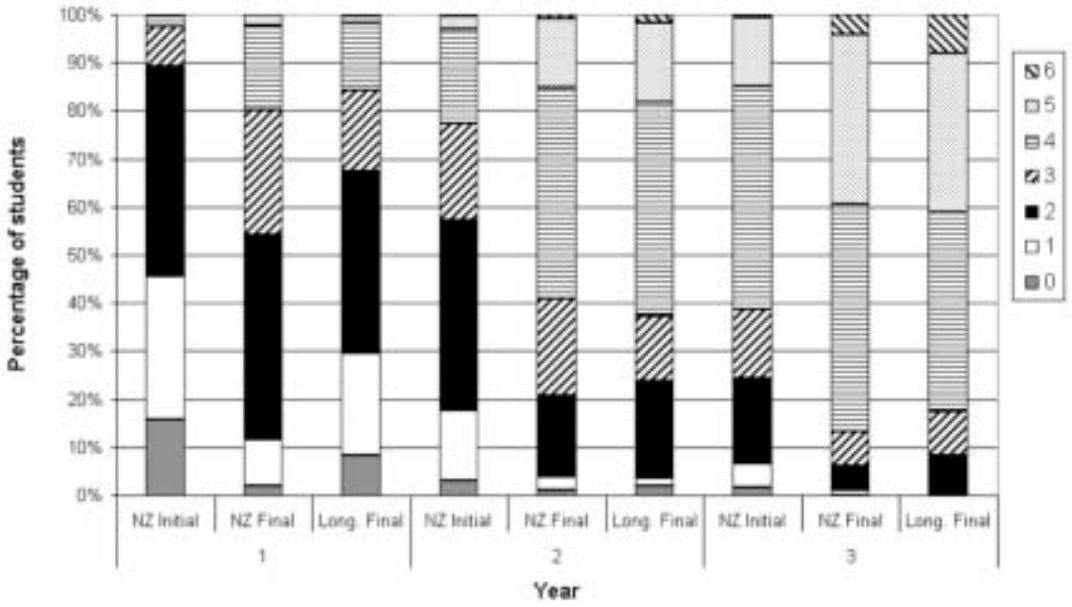

Figure 1. Additive strategy levels of year 1–3 longitudinal and NDP 2004 students

Figure 2 shows the percentage of year 4 to 8 students at each framework stage on the additive domain. The first two bars in each year level show the gains made during the project for the NDP 2004. These gains appear similar to those found in previous years of the project (see Young-Loveridge, 2004). A comparison of the second and third bars in each year level suggests that the gains made during the project have been extended over time. For example, 50% of the year 6 longitudinal students are at the highest stage on the additive domain (stage 6) compared to 37% of the NDP 2004 students. A comparison of the third bar at each year level with the first bar of the next year level provides an indication of the raised levels of numeracy achievement as a result of the project. At years 4 to 7, the longitudinal students have significantly higher levels of achievement than the before-project results of students at the next year level. For example, 78% of year 5 longitudinal students are using partitioning strategies (stage 5 or 6) compared to 62% of the NDP year 6 students prior to the project.

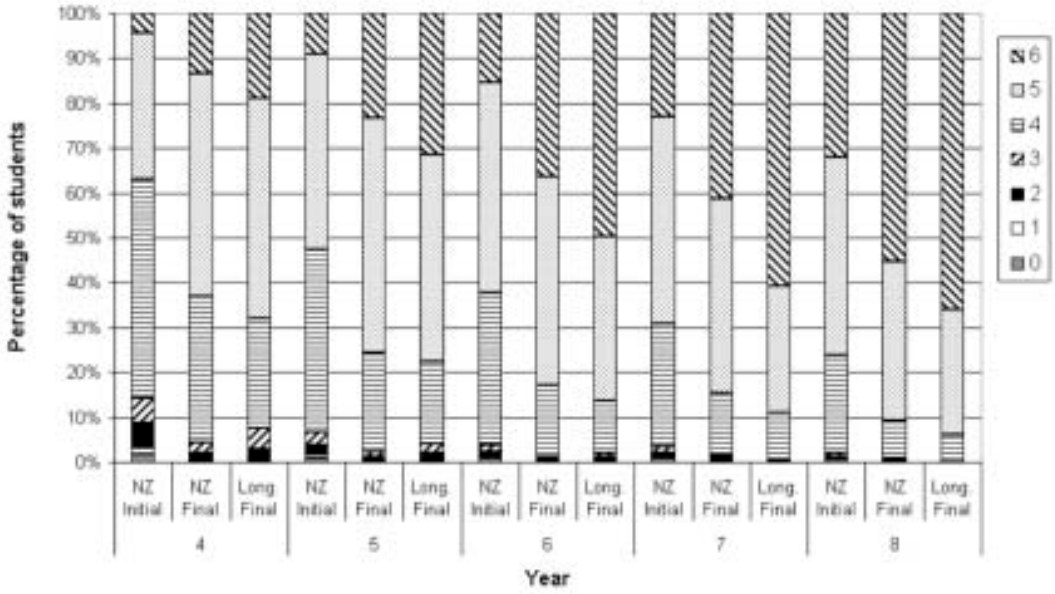

Figure 2. Additive strategy levels of year 4–8 longitudinal and NDP 2004 students

Figure 3 shows the percentage of year 4 to 8 students at each framework stage on the multiplicative domain. The multiplicative domain examines the strategies that students use to solve multiplication and division problems. The first two bars in each level show the gains made during the project for the NDP 2004. These gains appear similar to those made in previous years of the project (see Young-Loveridge, 2004). A comparison of the second and third bars in each year level indicates whether gains made during the project have been sustained over time. This comparison suggests that the gains made on the multiplicative domain develop further at years 7 and 8. For example, 47% of the year 8 longitudinal students are at stage 7 (advanced multiplicative) compared to 33% of NDP 2004 students. Similarly, 68% of the year 7 longitudinal students are at stages 6 or 7 compared to 61% of the NDP 2004 students. This improved performance over time is not apparent for the year 4 to 6 students on the multiplicative domain. For example, 32% of year 5 longitudinal students are at stages 6 or 7 compared to 38% of the NDP 2004 students.

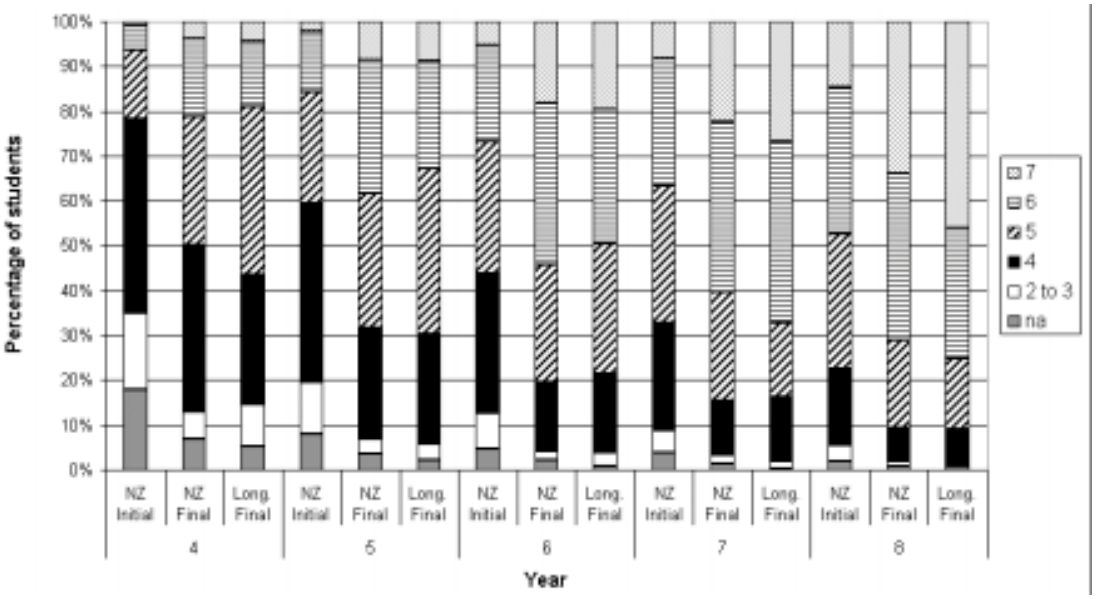

Figure 3. Multiplicative strategy levels of year 4–8 longitudinal and NDP 2004 students

Figure 4 shows the percentage of year 4 to 8 students at each framework stage on the proportional domain. The proportional domain examines the strategies that students use to solve problems involving rates and proportions. The gains illustrated by a comparison of the first two bars in each level are similar to those made in previous years of the project (see Young-Loveridge, 2004). A comparison of the second and third bars illustrates similar patterns of achievement at years 4–6. The longitudinal students appear to outperform the NDP 2004 students at years 7 and 8. As illustrated by Figure 4, a very small proportion of students are rated at stage 8. However, it is encouraging to note that there is a greater percentage of longitudinal year 8 students (19%) at stage 8, compared with NDP 2004 students (9%).

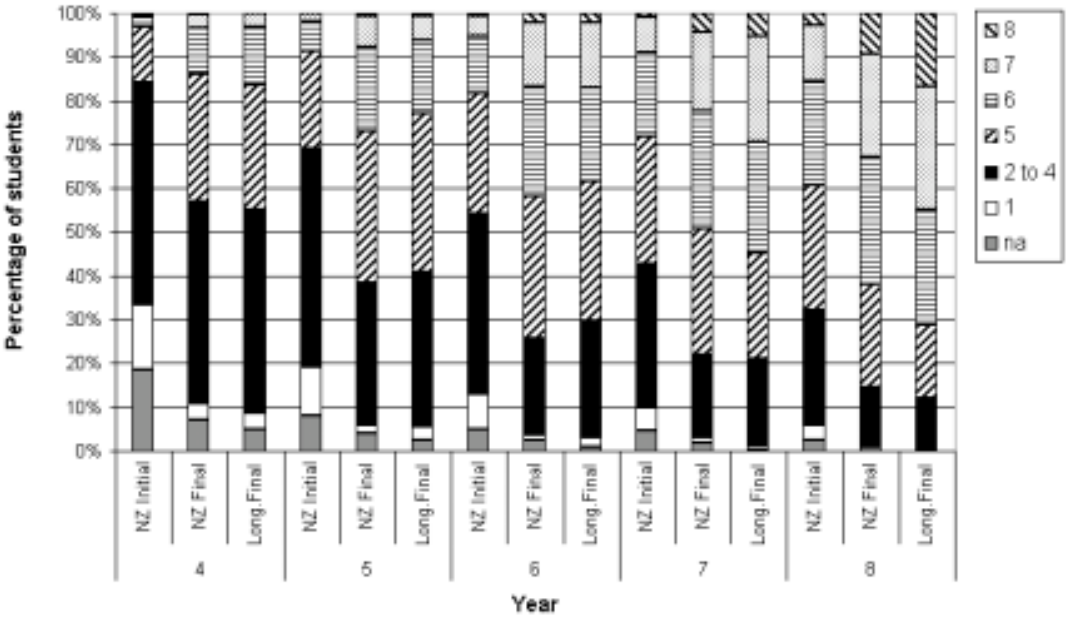

Figure 4. Proportional strategy levels of year 4–8 longitudinal and NDP 2004 students

Patterns of progress in the longitudinal schools: evidence for expectations

This section examines patterns of performance in the longitudinal schools since 2002. In 2002 and 2003, the schools were only asked to return information on the additive domain, so this is the only domain reported on in this section. There were also few year 7 and 8 students in the 2002 data return, so only year 1 to 6 students are discussed. The bars in Figures 5 to 6 show the percentage of students at each framework stage on the additive domain in the given year.

Figure 5 presents the percentages of year 1 to 3 students at each stage on the additive domain since 2002. The three bars at each year level illustrate a consistency in performance over time. The slightly higher levels in 2004 are surprising, given the skewed demographics of the longitudinal sample in 2004. It is pleasing to note how few year 2 and 3 students in the longitudinal sample are at the lowest stages of the Number Framework and how this percentage has continued to fall over time. For example, the percentage of year 2 students at stage 0 or 1 has dropped from 7% in 2002 to 3% in 2004. The consistent pattern of results illustrated in Figure 5 provides evidence for expected levels of achievement for year 1 to 3 students. For example, it seems reasonable to expect almost all year 3 students to be at least at stage 4 (advanced counting), with 40% at stage 5 (early additive) or higher.

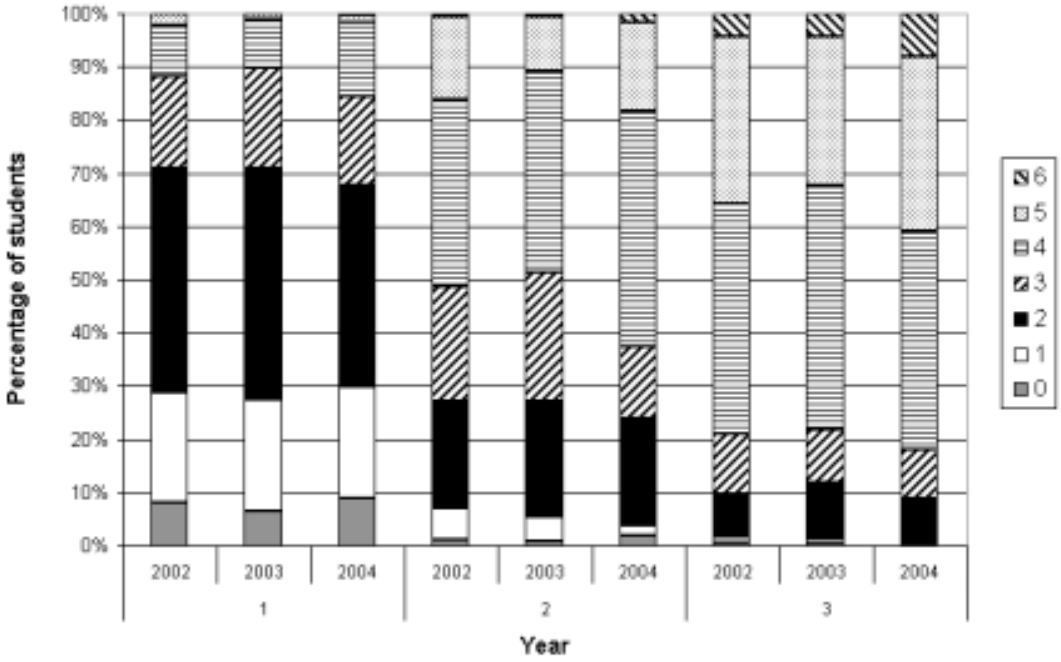

Figure 5. Additive strategy levels of year 1–3 longitudinal students

Figure 6 shows the proportions of year 4 to 6 students at each stage on the additive domain since 2002. There has been a decrease over time in the percentage of students using counting strategies (stages 1–4) at all three year levels. In 2002, 45% of the year 4 students used counting strategies compared with 32% in 2004. Fourteen percent of the year 6 students were assessed at the counting stages in 2004 compared with 22% in 2002. The percentage of students reaching stage 6 in 2004 is slightly lower than in 2003. This may be the result of the different demographic profiles of the two samples. Figure 6 provides evidence for expected levels of achievement for year 4 to 6 students who have been taught for at least two years by numeracy-trained teachers. It will be interesting to see if these levels continue to increase as students experience numeracy practices from school entry. Figure 6 suggests that it is reasonable to expect almost all year 6 students to be using additive strategies (stage 5 or 6), with 50% at the highest level of the additive domain (stage 6).

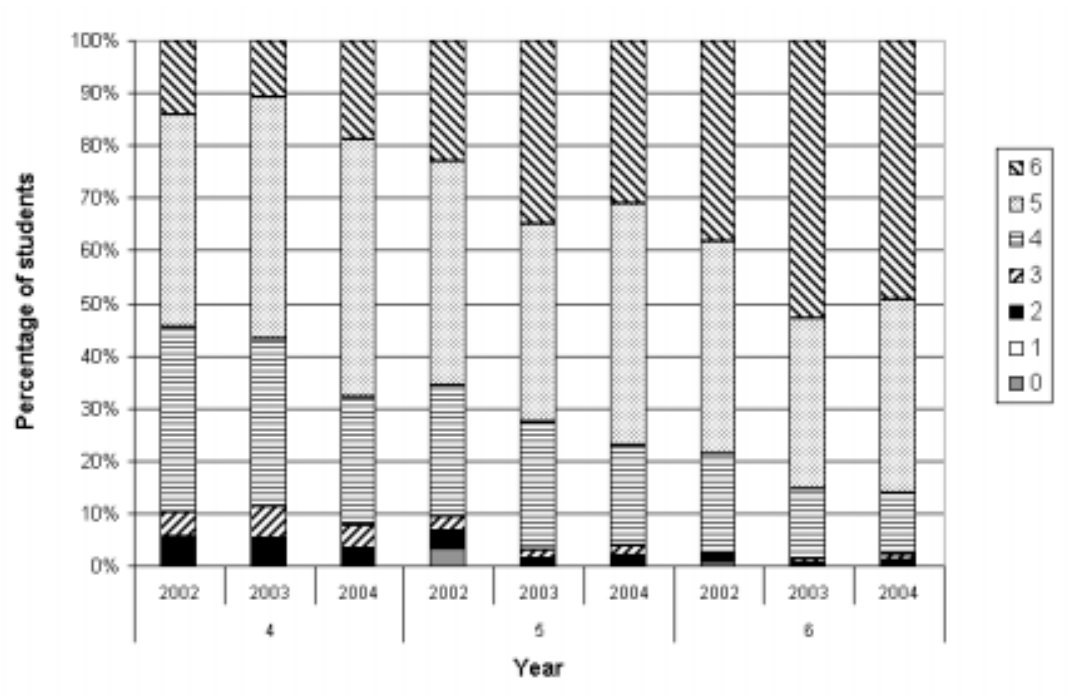

Figure 6: Additive strategy levels of year 4–6 longitudinal students

Perspectives of the teachers in the Longitudinal Study

This section summarises the key findings from the questionnaires returned by a total of 283 teachers from 30 of the 31 longitudinal schools. The questionnaire items asked teachers to respond using a five-point Likert scale. Each item included a space for teachers to provide written elaboration. Seventy-eight percent of the teachers had completed the NDP, with 89% of these undertaking training in their current school. The majority of those who had not completed the NDP reported receiving some level of numeracy professional development in 2004.

Two of the items asked the teachers to reflect on the impact of the NDP on their students' ability in number and in mathematics more generally. In general, the respondents believed that the project had an ongoing positive impact on students' ability in number, with 74% describing this impact as very positive or highly positive. One respondent who indicated a very positive impact explained that this impact would change to highly positive as her teaching strategies improved.

> I'm very impressed with how quickly the children are able to use numbers in their heads. I will circle highly positive impact when improvement in my teaching generates that. (Teacher, high-decile school)

The majority (66%) of teachers also believed that the project has had a very positive or highly positive impact on their students' mathematics achievement. Teachers ascribe the improved achievement to an improved attitude and enthusiasm for mathematics and an increase in number understanding, explaining that this understanding underpins the other strands of mathematics.

> Noticing an application of sound number sense in other areas of maths – stats, measurement. Greater enjoyment in maths, therefore progress is quicker. (Teacher, low-decile school)

Several questions were designed to gather information on the use of mathematical achievement information, including the establishment and use of achievement targets. Fifty-seven percent of the teachers indicated that their school had developed targets for achievement. While many of the teachers indicated that the targets were used for reporting progress to parents and the Board of Trustees, the focus in other schools was on the use of targets to identify students requiring additional support on or aspects of teaching practice that needed attention.

> Use targets to show strengths at certain year levels and any points of issue. To identify problem areas that are stopping us from reaching targets and develop these through professional development and targeted teaching. (Teacher, low-decile school)

> To measure teacher and whole-school and student effectiveness. Identify gaps/areas for improvement. Data collected yearly and children compared to targets. Those not reaching targets are identified for additional support. We raise teacher awareness of children not reaching targets. (Teacher, low-decile school)

Seventy-five percent of the teachers reported that they were happy with the achievement levels in their class. A similar proportion of teachers indicated that the majority of students in their class were on track to meet expected levels of achievement. Of those who were unhappy, the majority were able to suggest plans for addressing the problem. The plans ranged from a greater focus on the lower achieving students to more professional development for the teacher. A number of respondents also suggested a greater emphasis is needed on numeracy in early childhood education.

> My own professional development. As a beginning teacher, the professional development I received in 2003 didn't meet my needs. I would like to have seen more hands-on teaching and to have had more feedback on my practices. (Teacher, medium-decile school)

> Early childhood experiences/education should have a greater emphasis on early mathematics acquisition. Several children entering school have very limited experiences of number or language concepts such as above/below, more/less, big/small, etc. (Teacher, medium-decile school)

The impact of using achievement information

The data collected in the Longitudinal Study in 2004 allowed us to examine the assertion that a school-wide focus on using achievement information effectively helps to raise student performance. In order to examine this, we categorised the 19 schools that returned student numeracy results into two groups on the basis of their reported *use* of student achievement information. A school was categorised as having a focus on achievement data if more than 75% of the teachers reported that their school had established and used targets for student achievement in numeracy. Consequently, 13 of the 19 schools were classified as having a school-wide focus on numeracy. In all but one of the remaining six schools, fewer than 25% of the teachers said the school had established and used numeracy targets. In the remaining school, there was an almost even split between those teachers who said targets were used and those who said they weren't. It needs to be noted, however, that the six schools that were classified as not having a focus did at least collect achievement information for the longitudinal study. It was, of course, not possible to compare the achievement of students in schools where no achievement data was collected as the longitudinal achievement information is reliant on returns from schools.

Figure 7 shows the percentage of students at each strategy stage on the additive domain for the longitudinal schools, categorised by their reported use of student achievement information. The first bar in each year level shows the performance of students in schools whose teachers report a focus on the use of achievement information. The second bar shows the performance of students in schools where the teachers reported a lower or inconsistent focus on student achievement data. Table 3 shows the proportion of students in each decile group in the two groups of students. It is interesting to examine the figure for trends in the proportions of students who are at the lower levels of the Number Framework. There are fewer of these students in the schools that focus on student achievement information. For example, at year 3, 13% of the students in the focus schools are at stages 0 to 3 compared to 30% in the non-focus schools. Nineteen percent of the year 5 students in the focus schools are at stages 0 to 4 compared to 33% in the non-focus schools. There appears to be little difference in the achievement of students in year 4 and year 7 between the two classifications of schools. Another finding in support of a school-wide focus on achievement is the substantially higher proportion of year 6 students in the focus schools (54%) who are at the highest stage, compared to the non-focus schools (28%).

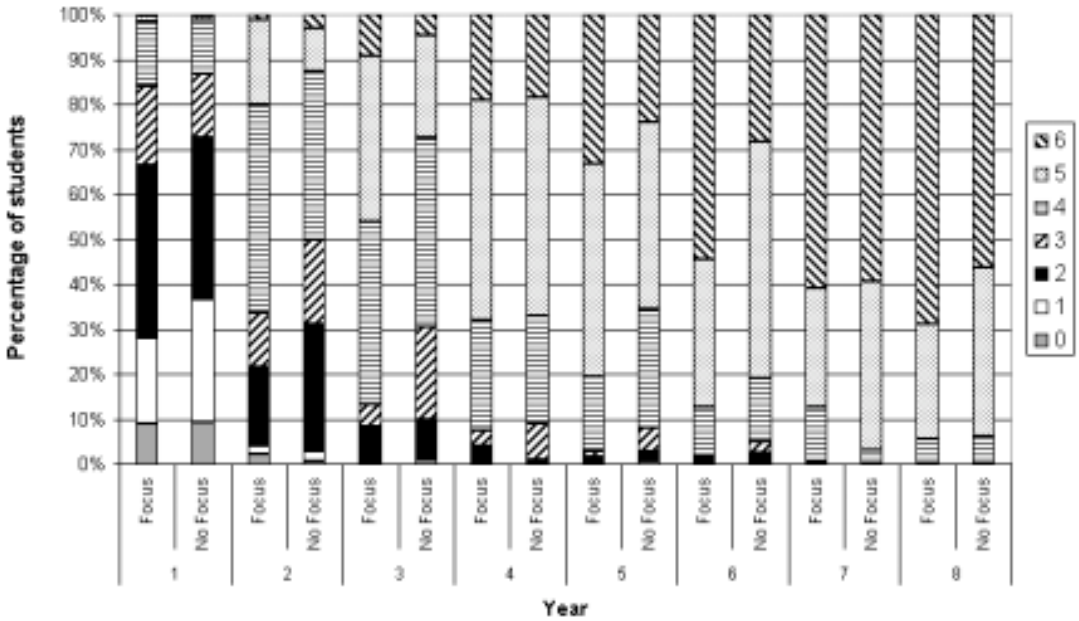

Figure 7. Additive strategy levels of longitudinal students by school focus on achievement information

Table 3
Number of Students by Decile Group and School Focus on Achievement Information

Decile Group	Focus	No Focus
Low	43%	22%
Medium	22%	60%
High	35%	18%
Total	4762	1337

Concluding Comment

The performance of students in the longitudinal schools on the Number Framework provides evidence for describing the levels of performance that can reasonably be expected from students in schools that have participated in the NDP. While there are slight fluctuations in performance over the three years of the longitudinal study, overall there is a consistent pattern. Students in schools that have implemented numeracy practices over several years consistently perform better than students of the same age did prior to the implementation of the NDP, and, at the higher year levels, also perform better than schools after their first year of involvement in the NDP. While demographic factors have been shown to influence the performance of cohorts of students, the representative sample of students involved in the longitudinal study means that the results obtained can reasonably be used as a starting point for goal setting.

The findings of the current research also provide further evidence in support of the importance of focusing on student achievement data as a means of raising achievement. The 13 longitudinal schools that set school-wide targets for numeracy and collected student achievement information outperformed the six longitudinal schools that did not set school-wide numeracy targets.

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