Do They Continue to Improve? Tracking the Progress of a Cohort of Longitudinal Students

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Findings from the Numeracy Development Projects (NDP) have consistently shown that students in participating schools make significant gains on the Number Framework. Since 2002, the NDP Longitudinal Study has shown that students continue to perform well in the years following their school's completion of the professional development, with a greater proportion of students in longitudinal schools reaching higher stages of the strategy domains of the Framework than those in first year NDP schools. This paper reports on an analysis of the performance of a cohort of longitudinal students over the last five years. The findings indicate that these students continue to build on their progress, with year 6 students in longitudinal schools outperforming those in first year NDP schools by an average of almost half a stage across the strategy domains.

Background

The Numeracy Development Project (NDP)

In each year since the implementation of the pilot project in 2000, research reports have been written describing the progress made by students in schools participating in the professional development phase of the NDP (for example, Thomas, Tagg, & Ward, 2003; Thomas & Tagg, 2003, 2004, 2005, 2006; Young-Loveridge, 2004, 2005, 2006). The size of the gains made has been analysed by comparing mean stages, comparing changes to the proportions of students at each stage of each domain, and examining proportions of students making gains. Comparisons have also been made between the performance of students at the end of their school's professional development year and that of pre-professional-development students from the next year level (Thomas & Tagg, 2003, 2004; Young-Loveridge, 2005). These research reports have consistently shown that students in the professional development phase of the NDP make gains in their ability to operate with numbers as measured by the Number Framework, and that these gains are larger than those expected in a non-NDP context (Bobis, Clarke, Clarke, Thomas, Wright, Young-Loveridge, & Gould, 2005).

The Longitudinal Study

Since 2002, the NDP Longitudinal Study has tracked the progress of students in schools in the years following their professional development year (Thomas, Tagg, & Ward, 2003; Thomas & Tagg, 2004, 2005, 2006). The Longitudinal Study has tracked the performance of students in two ways: comparing the performance of students in these schools on the strategy domains of the Framework with that of students nationally, and testing students from longitudinal schools using items on which normed scores for New Zealand students are available for comparison. Findings from the Longitudinal Study have consistently shown that a greater proportion of students from longitudinal schools achieve higher stages on the Framework than students from schools in their professional development year. Additionally, with the exception of year 6 students in 2005, longitudinal students in years 4 to 6 have achieved 4–9% higher on tests comprising items from all areas of mathematics when compared to the New Zealand students on the assessments from which the items were sourced.

This paper analyses the performance over time of the cohort of students from the longitudinal schools who were in year 6 in 2006. It also compares the performance of year 6 students in longitudinal schools in each of the five years of the study.

Method

Participants / Procedure

The Longitudinal Study began in 2002 with the participation of 20 schools that first implemented the NDP in either 2000 or 2001. While there have been a number of changes to the schools participating each year since the start of the study, every effort has been made to keep the demographic profile of the sample consistent. Each year, new schools to replace those that have withdrawn are randomly selected from a list of schools that completed NDP training in the previous years. The list is stratified by decile to ensure that those selected and invited to participate in the Longitudinal Study closely approximate the national sample and that there are similar numbers of students in years 1–8. Of the 26 schools involved in 2006, 11 schools have participated in the Longitudinal Study since its inception, three were added in 2004, seven in 2005, and five in 2006. The five schools new to the study in 2006 were two high-decile schools, one medium-decile school, and two low-decile schools. The decile profile for 2006 was skewed by one of the new low-decile schools not returning numeracy results and by changes to decile ratings that caused two of the existing low-decile schools to be re-categorised as medium-decile schools. Table 1 gives the percentages of students in each decile band for which numeracy data was received for each year of the Longitudinal Study.

Table 1
Decile Band of Longitudinal Students

	Low decile (1–3)	Medium decile (4–7)	High decile (8–10)	Total
2002	33%	37%	30%	2 362
2003	39%	31%	30%	3 416
2004	39%	30%	31%	6 099
2005	30%	43%	27%	6 826
2006	15%	40%	46%	7 386

Schools participating in the 2006 Longitudinal Study were asked to provide the stages of all their students on each of the additive, multiplicative, and proportional strategy domains of the Framework in the final term of the year. Schools were instructed to collect their students' strategy stages in whatever way was most convenient for them; they were also told that full diagnostic interviews were not required. This data was entered on the online Numeracy Database for analysis.

Year 6 students in longitudinal schools were also asked to complete a written test, made up of a combination of items from the Assessment Resource Banks (NZCER, n.d.) and the Progressive Achievement Test of Mathematics (NZCER, 1993, 1994) and including items from all strands of the mathematics curriculum. These students had completed similar tests in year 4 and year 5 made up of items from the Trends in International Mathematics and Science Study (TIMSS) 1995 and TIMSS 2003 assessments respectively (Thomas and Tagg, 2005, 2006).

This paper focuses on the results of students in year 6 in 2006, who will be referred to as the target cohort. The performance of the target cohort is compared with the performance of the same cohort in previous years as well as with that of students in year 6 in longitudinal schools in previous years.

Findings

Performance of the Target Cohort on the Number Framework

Figure 1 shows the mean additive stages of students from the target cohort compared with students in the same year level from schools participating in the NDP professional development nationally from 2002 to 2006. The recently released draft mathematics curriculum (Ministry of Education, 2006) includes achievement objectives in the number strand that relate very closely to the stages of the Framework. The curriculum describes the counting stages (1–4) as being at level 1, early additive (stage 5) at level 2, and advanced additive (stage 6) at level 3. Because the levels of the curriculum are seen as roughly equivalent to two years of schooling, it is possible to identify the stages of the Framework at which the curriculum indicates students should be achieving. These stages are indicated by crosses on the graph to show the expected achievement of year 2, year 4, and year 6 students. The third line on the graph indicates the performance of students who have not been in NDP classes. Data for this line has been obtained by using the start-of-year data for the next year level from the NDP, so that, for example, year 3 initial data for 2002 is compared with year 2 final data. This means that the students represented by this line are, on average, six months older than those represented by the other two lines. The number of students for whom results were available for the longitudinal cohort ranged from 677 in 2002 to 1 050 in 2006, while there were over 6 500 students included in each year for each of the two national groups.

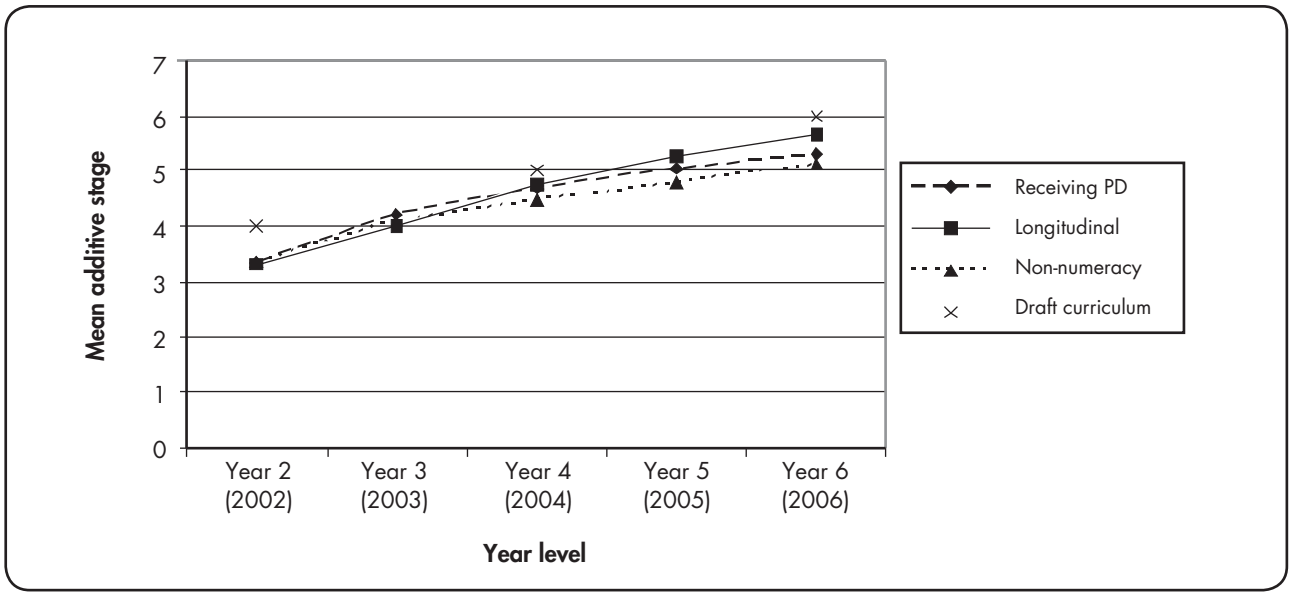


Figure 1: Mean additive stages

The performance of the target cohort as year 2 students in 2002 was very similar to that of year 2 students nationally (mean stage of 3.3 for both groups). This is as expected, considering that the schools had only recently completed the NDP professional development. In 2003, the performance of the target cohort in year 3 was poorer than that of year 3 students nationally (mean stage of 4.0 compared to 4.2). This may be explained by the increased coverage of other strands of the mathematics curriculum in the year following the first implementation of the NDP. By year 4, the two groups performed similarly, and in year 5 (5.3 compared to 5.0) and year 6 (5.7 compared to 5.3), students from the target cohort outperformed year 6 students from schools in their first year in the NDP. The mean stage of year 2, 4, and 6 students on the additive domain is close to that indicated by the draft curriculum. The students from the target cohort and students from schools in their first year in the NDP consistently have higher mean stages than students without exposure to numeracy practices, despite the six-month age deficit.

Figures 2 and 3 show the mean multiplicative and proportional stages of the target cohort from 2002 to 2006. The pattern of performance illustrated is similar to that shown on the additive domain, with the mean stage of the longitudinal students nearly half a stage higher than that of students from schools in their professional development year by the end of year 6. The performance of year 3 students in the target cohort is consistently lower than that of year 3 students in schools undertaking NDP training. This may reflect the almost exclusive focus on numeracy in the classroom mathematics programme during NDP training. The mean multiplicative and proportional stages of year 4 and 6 students are again close to those indicated by the draft mathematics curriculum and higher than for students whose schools have not yet participated in the NDP. The fact that the year 2 mean stages on these domains are lower than that indicated by the curriculum is largely due to the fact that students rated below stage 4 on the additive domain are not tested on the multiplicative or proportional domains. These students are rated as a zero for the purposes of calculating mean stages.

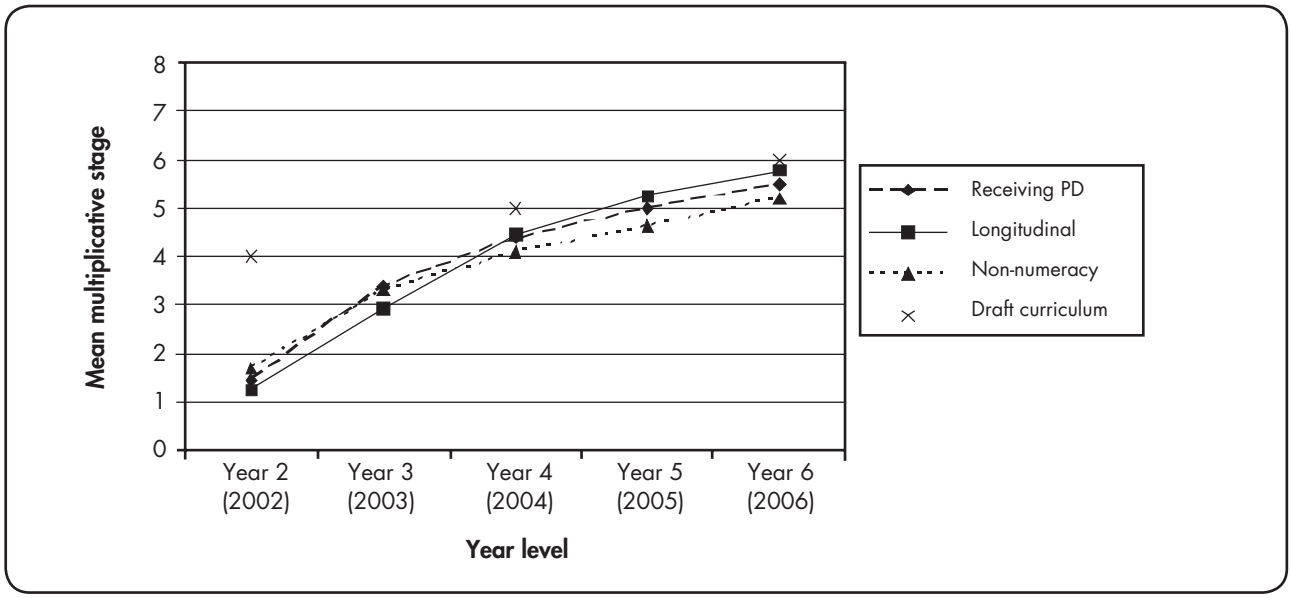


Figure 2: Mean multiplicative stages

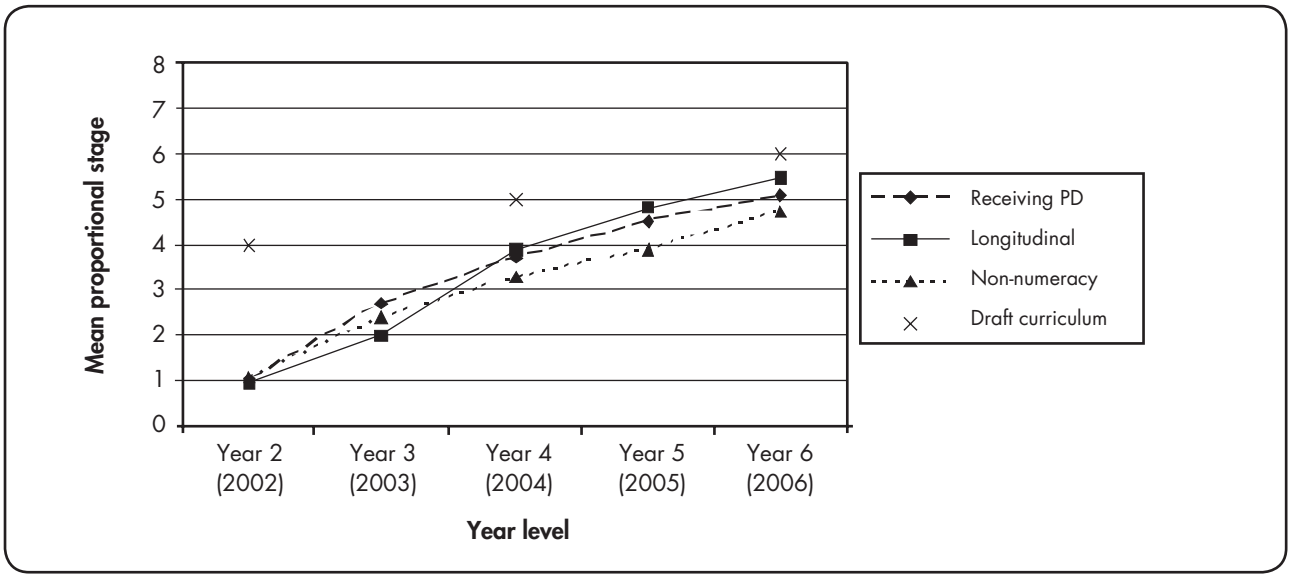


Figure 3: Mean proportional stages

Performance on the Number Framework of Year 6 Students in Longitudinal Schools 2002–2006

Figure 4 shows the proportion of year 6 longitudinal students rated as at least advanced additive (stage 6) on each of the three strategy domains for the five years of the Longitudinal Study. A clear trend can be seen, with at least 20% more students reaching the top stages of each domain in 2006 than in 2002. This graph indicates that, as schools continue to implement numeracy practices over time, an increasing proportion of their students finish year 6 at the advanced additive stage of the Framework.

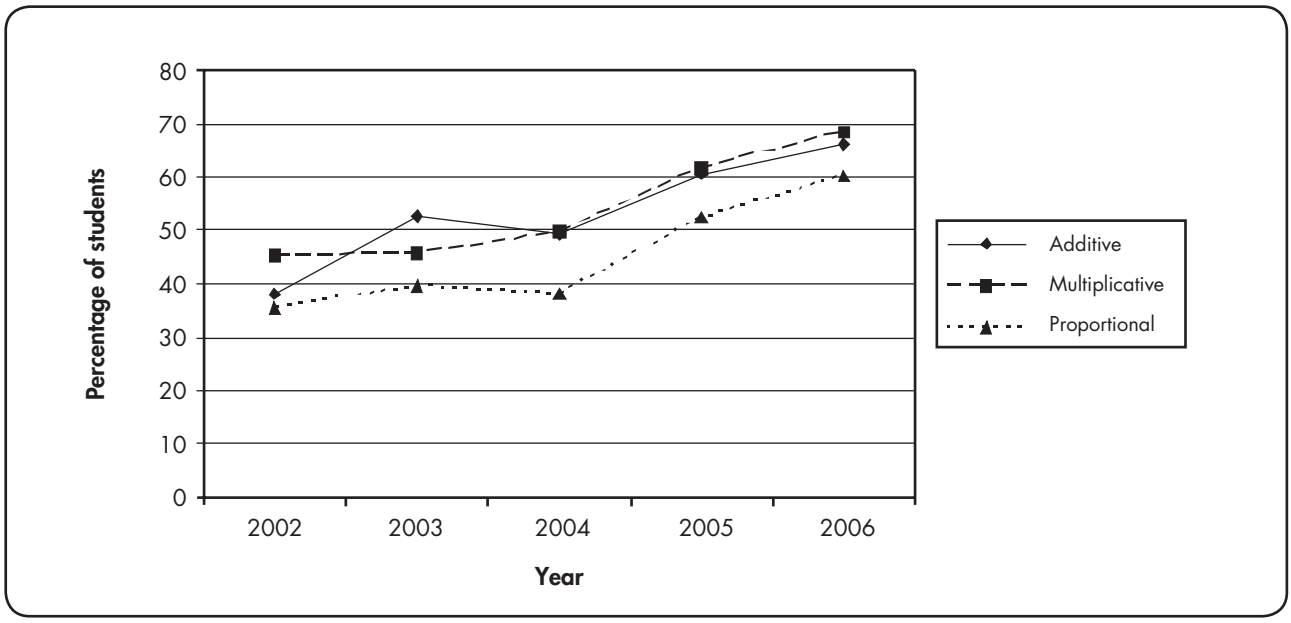
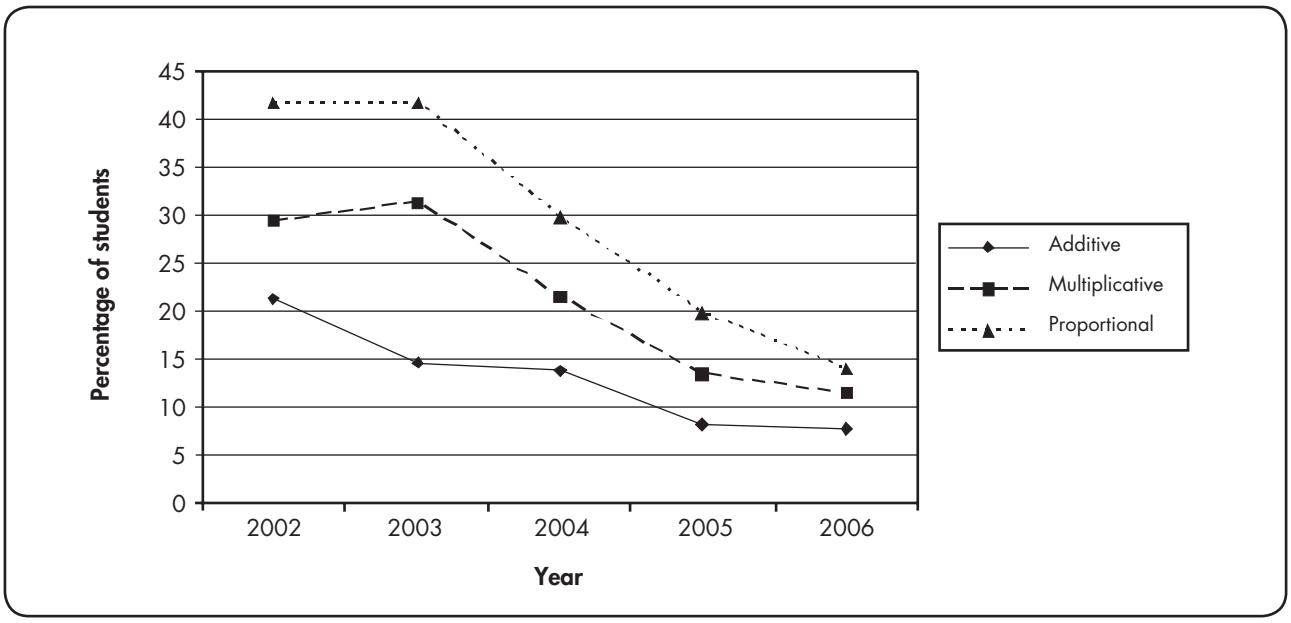


Figure 4: Percentage of year 6 longitudinal students rated as at least advanced additive on the strategy domains

Between 2002 and 2006, the percentage of year 6 students in longitudinal schools reaching at least stage 6 increased from 38% to 65% on the additive domain, from 45% to 67% on the multiplicative domain, and from 36% to 59% on the proportional domain. As a point of comparison, in 2005, 41% of year 6 students from schools in their professional development year reached stage 6 or higher on the additive domain, 56% on the multiplicative domain, and 45% on the proportional domain (Young-Loveridge, 2006). This indicates that a greater percentage of year 6 students in longitudinal schools attain at least stage 6 (level 3 of the draft mathematics curriculum) on each domain than do students in schools who are in the professional development year.

"Expectations" in the "Principal Support, Guidelines for the use and reporting of student achievement data" section of the nzmaths website describe year 6 students who are still rated as only able to use counting strategies (stage 4 or below) as "at risk" (Maths Technology Ltd, n.d.). Figure 5 shows the proportions of year 6 students in longitudinal schools rated as stage 4 or below in their end-of-year assessment. By 2006, the percentage of students still at risk on the additive domain had decreased from 21% to 8%, the percentage on the multiplicative domain had decreased from 29% to 12%, and the percentage on the proportional domain had decreased from 42% to 14%. In comparison, the national results for schools in their professional development year in 2005 showed 14% of year 6 students rated as stage 4 or below at the end of the year on the additive domain, 19% on the multiplicative domain, and 25% on the proportional domain (Ell, Higgins, Irwin, Thomas, Trinick, & Young-Loveridge,



2006).

Figure 5: Percentage of year 6 longitudinal students rated below early additive on the strategy domains

Figure 6 shows the mean stages of year 6 students on each of the three strategy domains. The trend is again positive for students in longitudinal schools, with the mean end-of-year stage on the multiplicative and proportional domains increasing by approximately one stage over the five years of the Longitudinal Study. For example, the mean proportional stage for year 6 students has increased from 4.3 in 2002 to 5.6 in 2006. Improvement on the additive domain is more modest, though a "ceiling" effect may apply in this instance because there is no stage 8 on this domain and several of the longitudinal schools continue to use older versions of the NumPA that only extend to stage 6 on the additive domain.

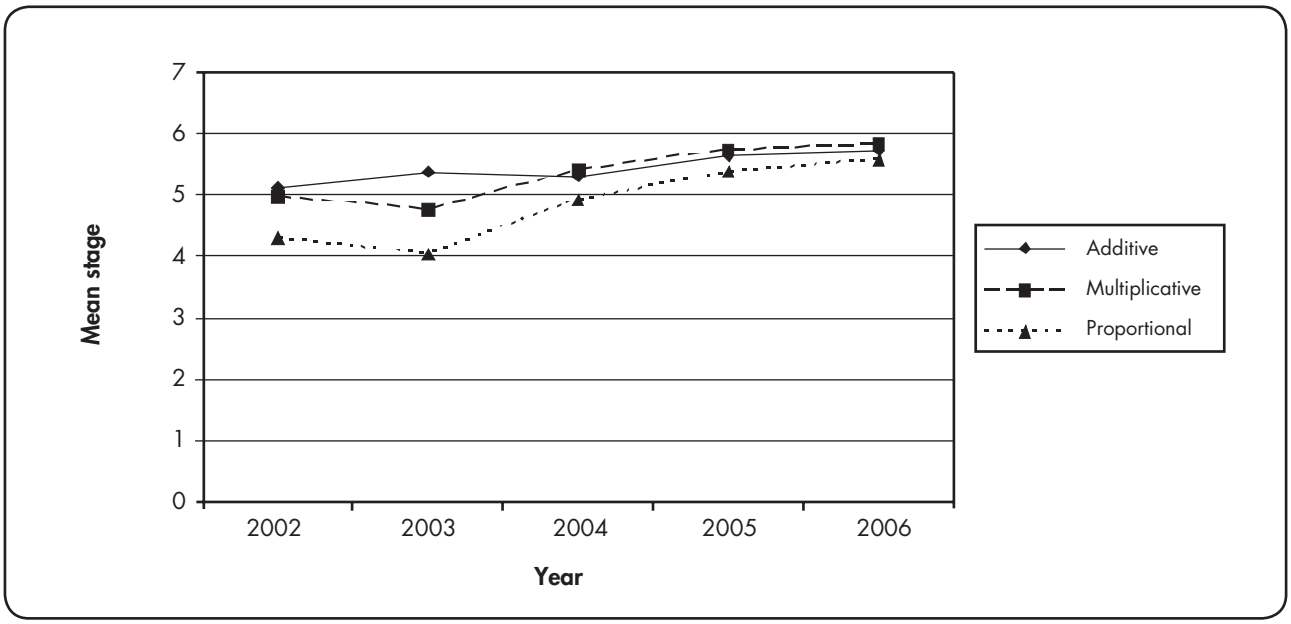


Figure 6: Mean stage of year 6 longitudinal students on the strategy domains

Performance of the Target Cohort on Written Tests

Since 2003, the Longitudinal Study has also measured the performance of students in selected year groups on pen-and-paper tests containing items whose content encompassed all strands of the mathematics curriculum. These tests aimed to determine the impact of the NDP on students' overall performance on mathematics. The items from these tests were sourced from assessments that included a significant sample of New Zealand students prior to the implementation of the NDP. The norms used for all but one of these items were found prior to the implementation of the NDP. Students in the sample cohort completed longitudinal tests in years 4, 5, and 6. Table 2 shows the source of the items in each of the three tests.

Table 2
Source of Items in Longitudinal Tests

	Year 4 (2004)	Year 5 (2005)	Year 6 (2006)
TIMSS 1995	24		
TIMSS 2003		24	
Assessment Resource Banks (ARBs)			13
Progressive Achievement Tests (PATs)			15

Table 3 compares the percentages of items answered correctly by the target cohort with those of students in the original assessments. Items in the tests were related to all strands of the curriculum. The table shows the performance of students on items specifically relating to the NDP practices as well as the performance on items with content not directly related to the NDP. In all cases, the performance of longitudinal students was better than that of students from the source assessments. On the items identified as not being related to the NDP, students from the target cohort consistently gave between 3–5% more correct answers than students in the source assessments. In 2004 and 2006, the longitudinal students performed particularly well on the NDP items, giving approximately 10% more correct answers than the students in the source assessments.

Table 3
Percentages of Items Correct for Longitudinal Students Compared with New Zealand Norms

	NDP		Other		Total	
	Long.	NZ	Long.	NZ	Long.	NZ
Year 4 (2004)	55	45	57	54	56	50
Year 5 (2005)	51	48	57	53	54	50
Year 6 (2006)	58	47	60	55	59	50

These findings support anecdotal comments from teachers in longitudinal schools who have suggested that students' increase in number knowledge has been translated to other strands and that students have also shown an increased enthusiasm for mathematics, which has led to improved performance (Thomas and Tagg, 2004).

Concluding Comment

The findings of the Longitudinal Study indicate that the NDP continue to impact positively on students in the years following their initial implementation. Further to this, it appears that students in longitudinal schools continue to build upon gains, with the end-of-year performance of year 6 longitudinal students improving over the course of the study. Schools that have implemented numeracy practices for an extended period have lower proportions of students by the end year 6 still restricted to counting strategies and higher proportions of students able to use a range of partitioning strategies.

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