

The Numeracy Development Projects' Longitudinal Study: How Did the Students Perform in Year 7?

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The Numeracy Development Projects (NDP) have been implemented in schools in New Zealand since the Count Me In Too pilot project in 2000. This paper reports on the year 7 performance of 83 students whose progress in mathematics has been tracked since school entry in 2002. The findings indicate that the proportion of these 83 students achieving at curriculum level expectations over the last seven years has been consistently high. The students' strategy stages correlated positively with their results on a standardised test. Their responses to attitude questions showed a positive correlation between perceived and actual ability in mathematics.

Background

In 2002, as the first schools completed two years of participation in the Numeracy Development Projects (NDP), the Ministry of Education identified the need to address issues of sustainability so that the changes observed in the short term would translate to long-term changes in mathematics teaching and learning. One component of the ongoing research into the effectiveness and sustainability of the NDP has been the collection of information from a sample of schools in the years following their two years of participation in the NDP (Thomas, Tagg, & Ward, 2003; Thomas & Tagg, 2004, 2005, 2006, 2007). While there were a number of replacements of schools participating in this research, every effort was made to keep the demographic profile of the sample consistent. Where new schools were added, they were randomly selected from a list stratified by decile in an effort to keep the sample as representative of the national population as possible.

From 2002 to 2007, the participating schools provided results for their students on the three strategy domains of the Number Framework. These results have been used to inform the Ministry of Education's expectations for student achievement (Ministry of Education, n.d. 2). In 2002 and 2003, qualitative information was collected from teachers and principals in longitudinal study schools to provide insight into the challenges and rewards involved in ongoing implementation of the NDP (Thomas, Tagg, & Ward, 2003; Thomas & Tagg, 2004). Between 2003 and 2006, the study investigated the performance of students from a wider group of schools (Thomas & Tagg, 2004, 2005, 2006, 2007). The focus of the Longitudinal Study in 2007 was on a group of 151 students from the original group who were in year 6 in 2007 and for whom NDP results were available for every year of their schooling (Thomas & Tagg, 2008). The Longitudinal Study in 2008 follows 83 of these 151 students as they move into year 7.

Research has consistently shown that the NDP continue to impact positively on the number strategies of students in NDP-focused schools in the years following their initial implementation (Thomas & Tagg, 2004, 2005, 2006, 2007, 2008). The results of tests relating to mathematics more generally have shown that students in schools that continue to implement NDP practices tend to perform similarly or slightly better on items relating to all areas of mathematics, not just those related to number knowledge and strategies (Thomas & Tagg, 2004, 2005, 2006). The findings from the 2007 study suggested that students who are able to perform at expected levels at any year level have an 80% likelihood of continuing to achieve at expected levels in subsequent years (Thomas & Tagg, 2008).

Method

Materials

A written assessment was developed for the 2008 Longitudinal Study. This assessment included the 41 items from Progressive Achievement Test (PAT): Mathematics Test 4 (NZCER, 2006), five attitude items, and four items designed to assess students' use of number strategies. The four items used to assess number strategy were taken from the NDP Global Strategy Stage (GloSS) forms (Ministry of Education, n.d. 1). These items required the students first to write an answer to a word problem and then to explain their thinking. The problem in Figure 1 was included in the assessment as an example of how to complete the strategy items.



Mani knows that there are 9 teams in the rugby tournament.
Each team has 18 players.
What is the total number of players at the tournament?

Write a number sentence for this problem and then work out the answer.

$$9 \times 18 = 162$$

Show or explain in a couple of sentences how you worked out the answer to the problem.

I know that 10×18 is 180.
I took one lot of 18 away from 180, which gave me 162.

Figure 1. Sample strategy item from longitudinal study assessment

Procedure

The move to year 7 often involves a transition to an intermediate school, so the researchers decided to track the longitudinal study students in consultation with their families rather than through their schools. The schools that the 151 students from the 2007 Longitudinal Study had attended were asked in April 2008 to forward a letter of invitation to the students' families that outlined the purpose and ongoing nature of the study. Informed consent was requested from both the students and their parents for their participation in this research. Eighty-eight students and their parents returned consent forms.

These 88 students were sent the test early in term 4, with a book voucher included as an incentive for them to complete and return the test. One student's tests was returned unopened. 83 of the remaining 87 students returned completed tests. These are the 83 students reported on throughout this paper. An attempt was made to contact the other four families. Two were unable to be contacted, one chose to withdraw from the study, and one returned the assessment several weeks after the analysis had been completed.

Participants

This section compares the demographic characteristics of the full sample of 151 students from 2007 with the 83 students who elected to continue to participate in the study. More of the 83 students are female (61%) than male (39%), and nearly three-quarters (72%) of the students identified as New Zealand European, with 17% identifying as Māori. As illustrated by Table 1, there were larger proportions of Māori and Pasifika students in the 151 students from 2007 than in the 83 students who continued to participate in 2008.

Table 1
Ethnicity and Gender of the 2007 and 2008 Longitudinal Study Students

	2007			2008		
	Male	Female	Total	Male	Female	Total
NZ European	28	53	54%	20	40	72%
Māori	18	19	25%	7	7	17%
Pasifika	9	9	12%	2	2	5%
Asian	8	2	7%	2		2%
Other	2	3	3%	1	2	4%
Total ¹	65	86	151	32	51	83

The 83 students were contacted and tracked through their families rather than through their schools, so no data is available on the schools they attended in 2008. Consequently, the decile data reported in Table 2 for these students is based on the schools they attended in years 1–6. As shown by Table 2, there was a shift in the decile composition of the 2008 participating students, with a smaller proportion having attended decile 1–3 schools in years 1–6 than those who participated in 2007.

Table 2
Decile of the Schools Attended by the 2007 and 2008 Longitudinal Study Students in Years 1–6

	2007	2008
Decile 1–3	18%	11%
Decile 4–7	59%	57%
Decile 8–10	22%	33%
Total	151	83

The self-selecting nature of the 83 students in the 2008 Longitudinal Study has resulted in assessment of a group who had a higher mean strategy stage (6.4) in 2007 than the full 2007 group (6.0).

Analysis

This section describes the analysis of the 83 students' responses to the 2008 assessment. The responses to the 41 items from PAT: Mathematics Test 4 were analysed by NZCER, with comparisons made with national norms for year 8 students. A comparison with year 8 norms rather than with year 7 norms was considered to be more appropriate because the norm data was collected in term 1, whereas the longitudinal study data was collected in term 4. Consequently, the longitudinal study students were generally about 6 months younger than the national reference group.

Each student's GloSS was estimated from their responses to the four strategy items posed within word problems. The minimum evidence required for a rating at each stage is listed in Table 3. Each student was rated at the highest stage for which they met the criteria. Examples of responses at each stage are included in Table 3. Fifty of the students provided sufficiently detailed explanations of their thinking for a strategy stage to be readily assigned. Two researchers independently examined

¹ Percentages in tables may not total to 100 due to rounding.

the remaining 33 students' responses and rated them as either stage 6 (advanced additive), stage 7 (advanced multiplicative), or stage 8 (advanced proportional). Nine students who provided no evidence of strategies at stage 6 or higher were rated as stage 5 or below and were treated as stage 5 for the purpose of calculating means. The two researchers then worked together to agree on the stage ratings for the five students for whom they had initially estimated different stages.

Table 3
Minimum Criteria for Rating Students' GloSS Stage

Stage	Minimum Criteria	Example of Response
Stage 5 or below	No evidence of strategies at stage 6 or higher	$143 - 89 =$ I know $140 - 80 = 60$ so if I add $9 + 3 = 12$ I will add 60 & 12 together to make 72
Stage 6: Advanced Additive	Uses a partitioning strategy to solve either 143 minus 89 or 28 plus 42	$89 + 11$ equals 100 so plus 43 equals 143 so in the end $11 + 43 = 54$
Stage 7: Advanced Multiplicative	Uses a partitioning strategy to solve either 5.33 minus 2.9 or 154 divided by 7	$5.33 - 3.0 + 0.10 = 2.43$ Round 2.9 to 3.0 then subtract 3.0 from 5.33 then add the 0.10 on again.
Stage 8: Advanced Proportional	Finds 28 out of 70 as a percentage	there are seventy students. 10% is 7 students. I divided the 28 students by 7 which gave me 4. Then I times that by 10 so that gave me 40%

Findings

The key research questions addressed in this section include:

- What were the patterns of performance on the Number Framework of the students since school entry?
- How did the students perform on the standardised PAT: Mathematics assessment?
- What is the relationship between the students' strategy stages and their performance on the standardised assessment?
- What were the attitudes of the students to mathematics, and did this relate to their performance?

Patterns of Performance of the Students since School Entry

Curriculum level expectations provide an important set of targets or goalposts for New Zealand schools and teachers (Ministry of Education, n.d. 2). The expectations consist of the stage or stages of the Number Framework that students are expected to be achieving at by the end of each year level of schooling. Also included in the expectations are the categories of "cause for concern" (just below expected levels) and "at risk" (well below expected levels).

While the achievement of students at the end of a single year level provides useful information, more important is the trajectory of their performance over time. Figure 2 shows the performance of the 83 longitudinal study students on the Number Framework over the seven years since school entry in 2002. The students' performance was tracked using an estimated GloSS. A student's GloSS is usually determined by using the GloSS assessment forms, but for the purposes of this study, the year 1–6 GloSS results for each of the 83 students were generated by taking the highest stage reported for that student in that year across the three strategy domains (Thomas & Tagg, 2008). The year 7 GloSS results were determined from the written assessments, as described earlier in this paper.

The shading in Figure 2 indicates the three categories of achievement in relation to curriculum level expectations (Ministry of Education, n.d. 2). Figure 2 shows that a high proportion of the 83 students have achieved at or above expected strategy levels since school entry. Figure 2 also highlights the very low percentage of students who have been considered to be “at risk” in terms of their future achievement in mathematics.

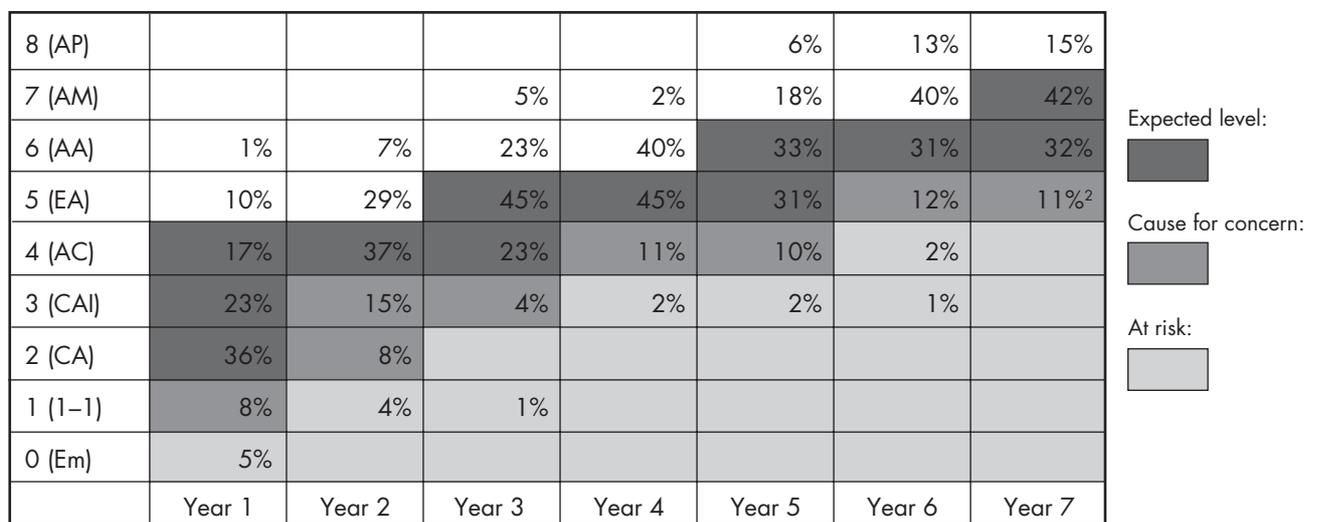


Figure 2. Percentage of the 83 students in the longitudinal study sample at each strategy stage in years 1–7

Table 4 compares the performance of the 83 longitudinal study students with the overall performance of students as reported in the curriculum level expectations on the nzmaths website (Ministry of Education, n.d. 2). As illustrated in Table 4, at least 85% of the 83 students were rated as achieving at or above expectations in every year except year 2. In years 1–3 and year 5, these percentages were very similar to those provided in the expectations. The proportion of year 6 and 7 students achieving at or above expectations was significantly higher for the 2008 longitudinal study students than for the expectations sample.

Table 4

Comparison of Percentages of the 83 Students Performing At or Above Expectations since School Entry in Relation to National Curriculum Level Expectations

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
2008 Longitudinal Study	87%	73%	95%	87%	88%	85%	89%
Curriculum Level Expectations	84%	74%	94%	73%	90%	73%	68%

² Includes all students who showed no evidence of strategies at stage 6 or higher

Performance of the Students on a Standardised Mathematics Assessment

Since 2003, the study has investigated the impact of the NDP on student achievement by collecting both numeracy results and information on students' performance in mathematics generally. The items used to assess students' ability in mathematics have come from a variety of sources for which national data is available for New Zealand students. These include the Trends in International Mathematics and Science Study (TIMSS), Achievement Resource Banks (ARBs) and PATs, the National Education Monitoring Project (NEMP), and the Assessment Tools for Teaching and Learning (asTTle). In 2008, the test completed by the 83 longitudinal study students included all 41 items from PAT: Mathematics Test 4.

Figure 3 compares the longitudinal study students' results on PAT: Mathematics Test 4 with those of the PAT year 8 national reference group. The longitudinal study students had a mean PAT scale score of 61.2 (SD = 11.3), compared with a mean of 55.5 (SD = 12.3) for the national reference group, representing a difference in average performance of nearly a stanine. The upper quartile of the longitudinal study results (65.2) was similar to that for the reference group (63.8), while the lower quartile was nearly 10 points higher (56.0 compared with 47.2). This indicates that, while the higher-scoring students in the two groups were performing at similar levels, a smaller proportion of the longitudinal study students received low scores on the test.

While it is important to note that the 2008 longitudinal study students did not represent a randomly selected sample, this favourable comparison with students half a year older indicates that these students were performing well in mathematics.

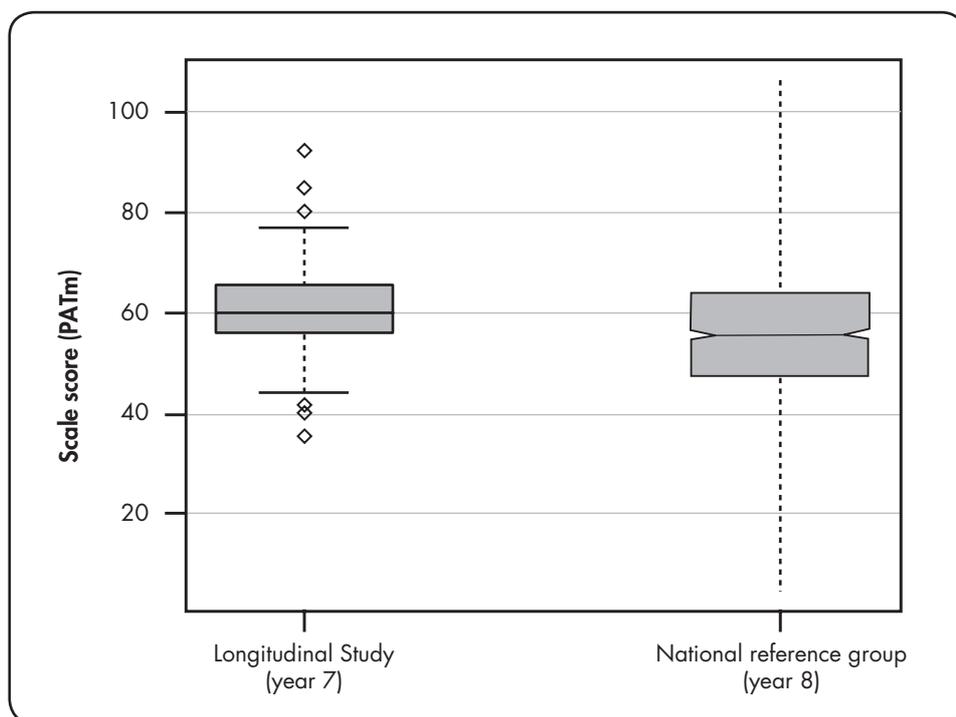


Figure 3. Comparison performance of students on PAT: Mathematics Test 4

The Relationship between the Students' Strategy Stages and their PAT Scores

The NDP focuses on developing students' understanding of numbers and their ability to use numbers to solve mathematical problems. Although the NDP focuses on the Number and Algebra strand of the mathematics and statistics learning area of the curriculum, this is at least partly because

an understanding of number also underpins the other strands. The information gathered in the Longitudinal Study in 2008 allows investigation of the relationship between strategy stages and performance on mathematics more generally, as measured by PAT scores.

Table 5 shows the mean scale scores and stanines of the longitudinal study students based on their GloSS stage. Comparing the students' PAT scale scores and GloSS stages yielded a Pearson's correlation coefficient of 0.56 ($p < 0.01$). The strong correlation between strategy stages and PAT scale scores suggests that it is reasonable to use numeracy stages to predict students' overall mathematics ability.

Table 5
The Relationship between the Students' Strategy Stages and their PAT Scores

GloSS	N =	Mean PAT Scale Score	Standard Deviation of PAT Scale Score	Mean PAT Stanine	Standard Deviation of PAT Stanine
≤ 5	9	49.1	9.9	3.8	1.6
6	27	57.2	7.9	5.3	1.4
7	35	62.5	9.0	6.1	1.3
8	12	75.8	9.6	7.8	1.5
All students	83	61.2	11.3	5.9	1.8

The Relationship between Attitudes and Performance in Mathematics

The five attitude questions completed by students took the form of statements for which the students were asked to indicate their level of agreement. Table 6 compares the mean GloSS stage and mean PAT scale score of students based on their responses to the five questions.

Table 6
The Relationship between the Students' Performance and their Responses to Attitude Questions

Statement		Agree a lot	Agree a little	Disagree a little	Disagree a lot
1. I usually do well in mathematics	Mean GloSS	7.0	6.6	6.1	5.0
	Mean scale score	70.4	59.0	56.0	40.0
	N =	22	48	9	1
2. I enjoy learning mathematics	Mean GloSS	6.8	6.6	6.1	6.5
	Mean scale score	62.7	62.4	54.7	59.1
	N =	29	41	10	2
3. I learn things quickly in mathematics	Mean GloSS	7.1	6.6	6.3	6.3
	Mean scale score	69.7	61.5	53.7	56.1
	N =	20	39	19	3
4. I think learning mathematics will help me in my daily life	Mean GloSS	6.5	6.9	6.7	
	Mean scale score	60.4	65.0	53.0	
	N =	54	24	3	
5. I need mathematics to learn other school subjects	Mean GloSS	6.9	6.4	6.7	
	Mean scale score	60.7	61.7	62.9	
	N =	28	41	12	

Two of the statements relate to students' perception of their own ability in mathematics: "I usually do well in mathematics" and "I learn things quickly in mathematics". The students who agreed a lot with these statements had higher mean strategy stages than those who agreed a little, and both groups had higher stages than those who disagreed. An ANOVA (analysis of variance) test indicated that these differences were statistically significant at the 0.01 level for statement 1 and at the 0.05 level for statement 3. The same pattern was true for scale scores, with the differences in means for both statements being statistically significant at the 0.01 level. The differences between means for the other three statements were not statistically significant. This finding is consistent with findings from the 2007 Longitudinal Study, in which the only attitude question for which the differences between mean GloSS stages of responses was significant was "How good do you think you are at maths?"

Concluding Comment

In previous years, this study has examined the impact of the NDP on students' ability to use number strategies in the years following their schools' participation in the NDP professional development programmes. It has also collected information to compare the mathematics performance of students in these schools with the performance of national reference groups. The findings have consistently shown that the NDP continue to impact positively on the strategy performance of students in the years following their initial implementation, and that students in schools that continue to implement NDP practices perform similarly or better on items relating to mathematics more generally.

The findings of the current study support the previous findings, with the 83 students performing better than comparative samples of students nationally on both the strategy stages and on PAT: Mathematics Test 4. It should be noted that, although this sample was not randomly selected, the strategy profile of the group in their first three years of school was very similar to the profile described in the curriculum expectations (Ministry of Education, n.d. 2). The high proportion of students reaching expected strategy stages in year 7 and the strong performance on the PAT indicate the benefits these students gained by remaining until at least year 6 in schools that implement NDP practices.

The responses of students to questions relating to their attitudes to mathematics support previous findings showing that there is a positive correlation between students' perceived ability and their actual performance. This is true of performance on both PAT items and strategy stages.

In tracking the performance of this group of 83 students, the Longitudinal Study continues to find evidence supporting the positive impact of the NDP on students' long-term development of mathematical ability.

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