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## Chapter Three: Student Progress

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The impetus for the CMIT project was a desire to improve students' number learning, therefore a significant aspect of the project evaluation was to quantify any such improvement. As outlined in Chapter One (p. 7), the students were assessed on five aspects of number: SEAL, FNWS, BNWS, NID, and Base 10. In this chapter, the results of this assessment are discussed under three main sections. The first section presents an overview of the findings in terms of mean gains in order to help orient the reader for a more detailed analysis of results in the following sections. The second section examines the findings related to the students' number strategies and, in particular, reports on the SEAL and Base 10 strategies. The other aspects of students' number knowledge, namely, NID, FNWS and BNWS are discussed together in the final section. Each section also investigates any impacts that the decile of the school or the ethnicity of the students have had on the results.

Because data was collected on close to 10,000 students, there are large numbers in each sample even when samples are categorised according to the variables of students' age and ethnicity and school region and decile. Sample size raises issues related to practical versus statistical significance in the analysis and reporting of the results. With such large samples, even the smallest differences can be statistically significant. For example, a difference of 0.11 in the mean gain of two subgroups is significant at the 0.001 level. While the 0.11 difference is statistically significant, a difference of one tenth of a stage is not meaningful in any practical sense. The results are therefore reported in terms of the practical meaning of any observed differences in groups.

### Overview of the Findings

In short, the results for the CMIT pilot project have been impressive. There was clear and positive growth in the five aspects of number learning assessed, irrespective of students' age and ethnicity and school region and decile. It also appears that this growth is the result of involvement in the project, since the improvements are greater than those expected with time alone.

The results reported in this section are focused on the gains made by the students over the duration of the project. Overall, the trend was for students in the CMIT pilot project to advance one stage on each of the aspects. The students' progress in each of the five number aspects is shown in Table 3.1. With the exception of Base 10 strategies, the mean gains for the total sample are clustered around 1.00, which represents progress of one stage on the framework over the duration of the project. The five-year-olds made the greatest gains over the project in all aspects followed by the six-year-olds. This is at least partly explained by the number of seven and eight-year-olds who were already at the highest stages at the start of the project and could not therefore make any measurable gain. For example, 2063 (74%) of the seven-year-olds were at the highest stage on the FNWS, 1672 (60%) were at the highest stage on the BNWS, and 1570 (57%) were at the highest stage of NID.

Table 3.1: Mean Gains by Age

Age		SEAL	NID	FNWS	BNWS	Base 10
5	n=3182	1.00	1.30	1.50	1.78	0.38
6	n=3202	0.93	0.92	0.79	1.16	0.79
7	n=2774	0.68	0.42	0.31	0.57	0.71
8	n=151	0.59	0.34	0.27	0.60	0.54
Total	n=9309	0.87	0.89	0.88	1.18	0.60

Although there was no assigned reference or control group, the profile of students at the start of the project provides a degree of control when compared with the profile of students of the same age at the end of the project. Figure 3.1 compares the growth in each aspect of number learning that occurred over the duration of the project with the growth that would have been expected with age alone. The first bar shows the mean gains made over the project. The second bar represents the reference group and illustrates the gains that would have been expected by students over a six-month period prior to the implementation of CMIT. As is clearly shown, the gains made on each aspect of number learning during the project exceeded the gains that would have been expected in the students' previous classroom programmes by between 0.4 and 0.6 of a stage.

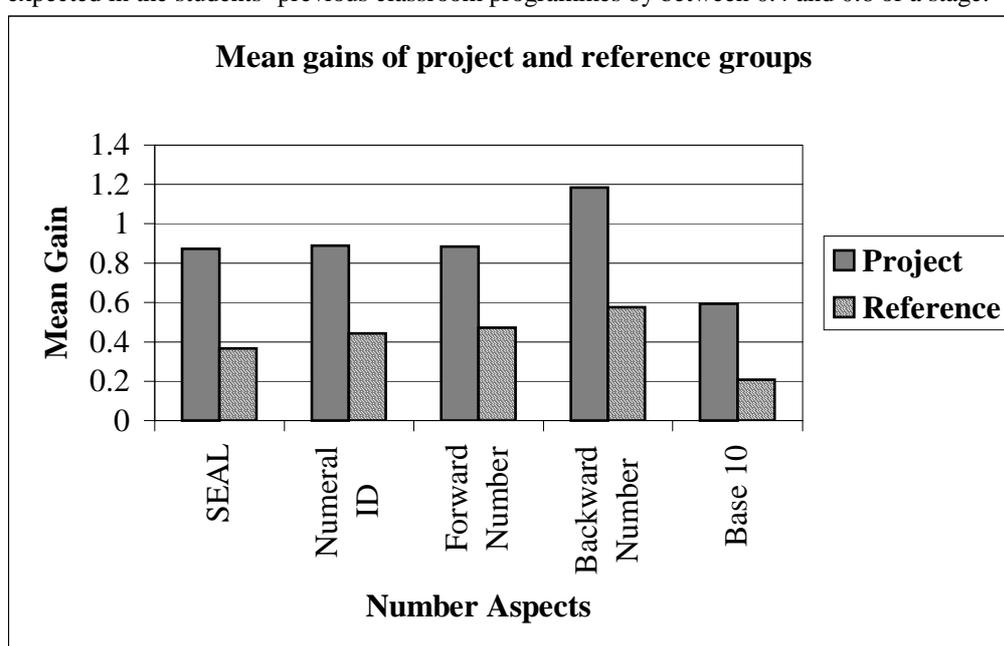


Figure 3.1: Mean Gains by Project and Reference Groups

Of particular interest throughout the evaluation was the impact that the project would have on the achievement of Māori and Pacific Islands students. As illustrated in Table 3.2, there was a high degree of similarity in the mean gains that were made in each of the five aspects of number learning, when the results are presented according to ethnicity. These results support the notion that the CMIT project is effective in raising the achievement of all students.

Table 3.2: Mean Gains by Ethnicity

Ethnicity		SEAL	NID	FNWS	BNWS	Base 10
Asian	n=448	0.84	0.74	0.77	1.04	0.58
European	n=5983	0.88	0.87	0.83	1.16	0.64
Māori	n=1736	0.84	0.92	0.94	1.26	0.54
Pacific Islands	n=766	0.87	1.03	1.17	1.27	0.46
Other	n=376	0.91	0.93	0.93	1.16	0.50
Total	n=9309	0.87	0.89	0.88	1.18	0.60

The decile rating of the school also appeared to have little impact on the success of the project. Table 3.3 provides a summary of the mean gains made in each of the five aspects of number learning by decile, with the deciles grouped into three bands. For the purposes of this report, deciles 1–3 form the low-decile band, the middle four deciles form the medium-decile band and deciles 8–10 form the high-decile band. As Table 3.3

illustrates, there was a high degree of similarity in the mean gains made by students in each of the decile bands across the five aspects of number learning that were surveyed.

*Table 3.3: Mean Gains by Decile*

<b>Decile Band</b>		<b>SEAL</b>	<b>NID</b>	<b>FNWS</b>	<b>BNWS</b>	<b>Base 10</b>
Low (1–3)	n=3033	0.86	0.92	0.99	1.24	0.55
Medium (4–7)	n=4312	0.88	0.88	0.84	1.15	0.60
High (8–10)	n=1964	0.88	0.86	0.81	1.16	0.66
Total	n=9309	0.87	0.89	0.88	1.18	0.60

The CMIT project was implemented throughout New Zealand by curriculum facilitators who each worked with clusters of approximately 30 teachers in six regional areas. With the exception of the Auckland (200) and Waikato (80) areas, approximately 60 teachers in each region implemented CMIT. As illustrated in Table 3.4, there was considerable consistency in the mean gains made, when these are analysed by region. With one exception, the gains are separated by less than 0.2 of a stage, which represents very little difference in practical terms. The single difference that exceeded 0.2 occurred between Waikato and Central North Island on NID.

*Table 3.4: Mean Gains by Region*

<b>Region</b>		<b>SEAL</b>	<b>NID</b>	<b>FNWS</b>	<b>BNWS</b>	<b>Base 10</b>
Auckland	n=3790	0.87	0.88	0.86	1.15	0.57
Waikato	n=1525	0.79	0.77	0.86	1.13	0.49
Central North Island	n=931	0.82	1.07	0.94	1.33	0.75
Wellington	n=1140	0.89	0.93	0.96	1.17	0.61
Nelson / Canterbury	n=1044	0.99	0.94	0.92	1.25	0.72
Otago / Southland	n=879	0.91	0.81	0.83	1.21	0.57
Total	n=9309	0.87	0.89	0.88	1.18	0.60

The gender of the student also had no impact on the effectiveness of the project. Table 3.5 shows that the gains made by both boys and girls were practically identical, with less than 0.03 of a stage separating the gains made on each of the five aspects of number monitored.

*Table 3.5: Mean Gains by Gender*

<b>Gender</b>		<b>SEAL</b>	<b>NID</b>	<b>FNWS</b>	<b>BNWS</b>	<b>Base 10</b>
Female	n=4455	0.87	0.90	0.87	1.19	0.58
Male	n=4854	0.88	0.88	0.90	1.17	0.61
Total	n=9309	0.87	0.89	0.88	1.18	0.60

## **Number Strategies**

Central to the CMIT pilot project was the development of students' number strategies. The SEAL and, to a lesser extent, the Base 10 strategies both explore how students solve number problems and, in particular, the mental processes that they use. The three other aspects of number learning contain key items of knowledge that students need to acquire and are discussed in the following section. It is important that students make progress in both number strategies and number knowledge, as these are clearly dependent on each other.

On the SEAL, the mean gain for the total population of students was 0.87. The range was from 1.00 for the five-year-olds to 0.59 for the eight-year-olds. Figure 3.2 compares the growth that occurred in the SEAL over the duration of the project with the growth that would have been expected with age alone. The first two bars in each cluster illustrate the growth in students' understanding over the duration of the project. The third bar represents the reference group and illustrates the growth that would have been expected by students over a six-month period prior to the implementation of the CMIT pilot project.

As illustrated by Figure 3.2, the growth that occurred in the project was significantly greater than the growth expected prior to implementation.

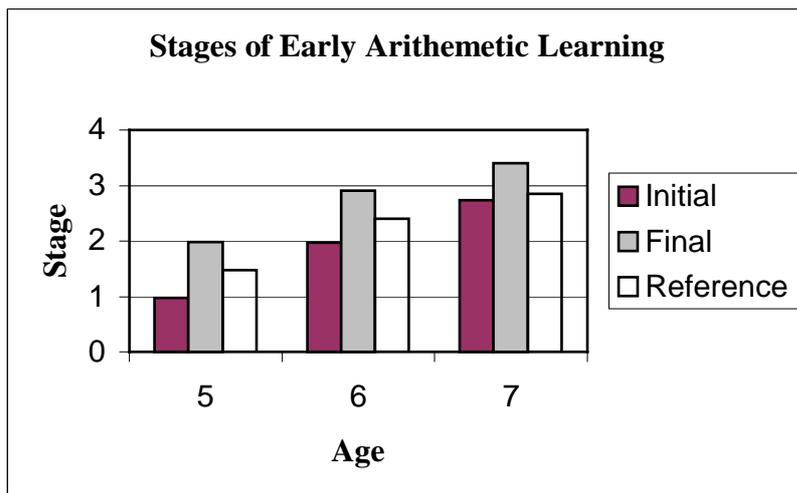


Figure 3.2: Stages of Early Arithmetic Learning

While mean gain suggests that the project was effective in raising the achievement of all students, it does not illustrate the actual profile of the students in terms of the stages attained. The changing profile of students on the SEAL over the CMIT pilot project is shown in Table 3.6. By the time of the final assessment, 49% had advanced one stage, 20% had advanced two stages, 3 % had advanced three stages, and 1% of students were recorded at a lower stage on the SEAL.

Wright (1998) suggests that a critical stage in the child’s development of arithmetical strategies is the facile stage, in which the child moves from using a range of count-by-one strategies to the use of part/whole strategies that do not use counting at all. Students who are classified as part/whole in their thinking recognise that a number is an abstract unit that can be treated as a whole or partitioned and recombined with other numbers to solve addition and subtraction problems.

Young-Loveridge (1999) highlights the importance of part/whole reasoning in developing an understanding of place value. At the time of the initial interview, 10% of the students were assessed as facile. This percentage had grown to 30% by the end of the project, with the majority of these students aged seven and eight. Although the number of seven-year-olds who were facile by the end of the project had increased from 24% to 56%, it is of concern that more than 40% were still not displaying part/whole strategies.

Table 3.6: Initial and Final SEAL Results – Percentage within Ages

AGE	SEAL	Emergent	Perceptual	Figurative	Counting-on	Facile
5 n=3182	Initial	27%	55%	12%	5%	1%
	Final	6%	33%	25%	30%	7%
6 n=3202	Initial	7%	32%	25%	29%	7%
	Final	2%	10%	16%	42%	31%
7 n=2774	Initial	3%	13%	18%	43%	24%
	Final	1%	3%	7%	34%	56%
8 n=151	Initial	4%	13%	14%	43%	26%
	Final	1%	7%	8%	27%	58%
Total n=9309	Initial	12%	34%	19%	25%	10%
	Final	3%	15%	17%	35%	30%

The first section of this chapter illustrated that the gains made by students during the project were similar, regardless of students' age and ethnicity and school region and decile. Although the gains made were similar, this does not imply that there were no differences between the profiles of students in the subgroups. In fact, there are marked differences between the subgroups when their profiles are considered as percentages on the SEAL. Given the importance of the facile stage, the remainder of this section focuses on the achievement of the seven-year-olds<sup>1</sup>. Table 3.7 shows the percentages of seven-year-old students at each of the stages of the SEAL. The percentages of Māori (42%) and Pacific Islands (38%) students who have reached the facile stage by the end of the project remains significantly less than the percentages of Asian (64%) and European (60%) students.

Table 3.7: Initial and Final SEAL Results  
Percentage of Seven-year-olds within Ethnic Subgroups.

Ethnicity	SEAL	Emergent	Perceptual	Figurative	Counting on	Facile
Asian n=159	Initial	3%	12%	11%	38%	36%
	Final	1%	3%	4%	28%	64%
European n=1792	Initial	2%	10%	16%	45%	27%
	Final	1%	2%	6%	31%	60%
Māori n=509	Initial	3%	18%	26%	38%	15%
	Final	1%	6%	11%	40%	42%
Pacific Islands n=203	Initial	3%	19%	28%	37%	13%
	Final	1%	3%	10%	48%	38%
Other n=111	Initial	2%	13%	13%	58%	14%
	Final	2%	1%	10%	38%	49%
Total n=2774	Initial	2%	13%	18%	43%	24%
	Final	1%	3%	7%	34%	55%

When the results of the seven-year-olds are analysed according to decile bands, a similar pattern is found. As shown in Table 3.8, students in the low-decile band started and finished the project at lower stages in the SEAL than the students in the medium and high-decile bands. Forty-eight percent of students in the low-decile band reached the facile stage by the end of the project, compared to 57% of students in the medium band, and 64% in the high band.

Table 3.8: Initial and Final SEAL Results  
Percentage of Seven-year-olds within Decile Subgroups.

Decile Band	SEAL	Emergent	Perceptual	Figurative	Counting on	Facile
Low (1–3) n=872	Initial	5%	15%	23%	39%	18%
	Final	1%	4%	11%	36%	48%
Medium (4–7) n=1336	Initial	2%	13%	15%	45%	25%
	Final	1%	3%	5%	34%	57%

<sup>1</sup> Similar tables of results for the five and six-year-olds are contained in Appendix E

High (8–10) n=566	Initial	1%	8%	15%	46%	30%
	Final	0%	1%	4%	31%	64%
Total n=2774	Initial	2%	13%	18%	43%	24%
	Final	1%	3%	7%	34%	55%

The link between ethnicity and decile across all students is illustrated in further detail in Table E.5 in Appendix E. While there is a greater similarity in the profiles of the different ethnic groups when these are analysed by decile band, the profiles of Pacific Islands and Māori students were lower at the start and end of the project in all decile bands. The most noticeable differences are seen in the medium decile band where 5% of all Māori and Pacific Islands students were facile at the start of the project, compared to 13% of European and 20% of Asian students. At the end of the project, the percentages of students who were facile were: Asian (45%), European (36%), Māori (22%), and Pacific Islands (18%).

The stages on the place value framework (Base Ten Strategies) are linked closely to the stages of the SEAL ( $r=0.754$ ,  $p=0.01$ ). For example, students at the perceptual or figurative stages on the SEAL were most likely to be at the initial concept of ten stage (stage 1) on the place value framework, that is, they do not see ten as a unit that they can use to count by. Students who were at the counting-on stage in the SEAL were more likely to have an intermediate concept of ten (stage 2); that is, they could count-on in groups of ten. They were aware of ten as a single entity but were also aware that the ten is made up of ten ones. Finally, students needed to be at least facile in the SEAL to be at stage 3 (facile concept of ten) on the place value framework. Students at this level can use part/whole reasoning to solve addition and subtraction tasks involving tens and ones.

For the purposes of the CMIT pilot, students were recorded as 0 on the place value framework if they were emergent on the SEAL. Table 3.9 shows the changing profile of the students over the project on the place value framework. By the end of the project, 19% of the students were assessed as having a facile concept of ten, compared to 5% of students at the start of the project. This compares to 30% who were assessed at the facile stage on the SEAL.

Table 3.9: Initial and Final Base 10 Strategies by Age

Age		0	1	2	3
5 n=3182	Initial	58%	40%	2%	0%
	Final	40%	40%	19%	2%
6 n=3202	Initial	31%	51%	16%	2%
	Final	13%	30%	41%	16%
7 n=2774	Initial	14%	41%	33%	12%
	Final	4%	17%	39%	40%
8 n=151	Initial	14%	34%	37%	15%
	Final	11%	16%	28%	45%
Total n=9309	Initial	35%	44%	17%	5%
	Final	20%	29%	33%	19%

Table 3.10 illustrates the profile of the students on the place value framework when analysed by ethnic grouping. Once more, the performance of Māori and Pacific Islands students is of concern. Most notable is the low percentage (8%) of Pacific Islands students who have a facile concept of ten by the end of the project when compared the percentage for the total sample of students (19%). Appendix F contains further result tables for Base 10 strategies.

Table 3.10: Initial and Final Base 10 Strategies – Percentage by Ethnicity

Ethnicity	Base 10	0	1	2	3
Asian n=448	Initial	26%	43%	21%	10%
	Final	14%	27%	31%	28%
European n=5983	Initial	35%	42%	18%	5%
	Final	18%	26%	34%	21%
Māori n=1736	Initial	38%	45%	14%	3%
	Final	23%	34%	29%	14%
Pacific Islands	Initial	39%	51%	9%	1%

n=776	Final	26%	39%	27%	8%
Other	Initial	27%	54%	16%	3%
n=376	Final	21%	30%	33%	16%
Total	Initial	35%	44%	17%	5%
n=9309	Final	20%	29%	33%	19%

## Number Knowledge

Students' knowledge of numerals, number sequence, and order is intertwined with their ability to apply number strategies. For example, it is unlikely that students could apply part/whole thinking to a problem if their knowledge of numbers is limited to those less than 20. As illustrated in Figures 3.3, 3.4, and 3.5, the students participating in the project made significantly greater gains than what would have been expected prior to the implementation of CMIT. The first and second columns are, respectively, the average performance of the students at the initial and final SENA assessment. The third column depicts the improvement of the reference group over a six-month period prior to the implementation of CMIT.

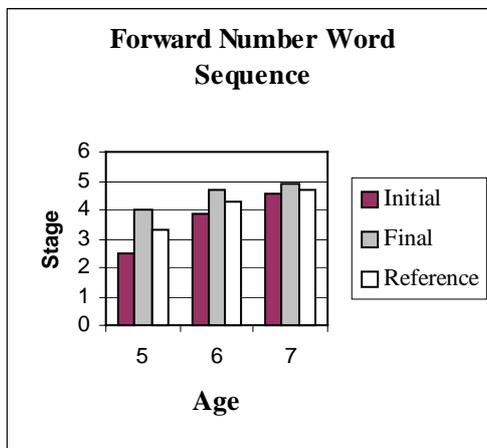


Figure 3.3: FNWS by Age

Figure 3.4: BNWS by Age

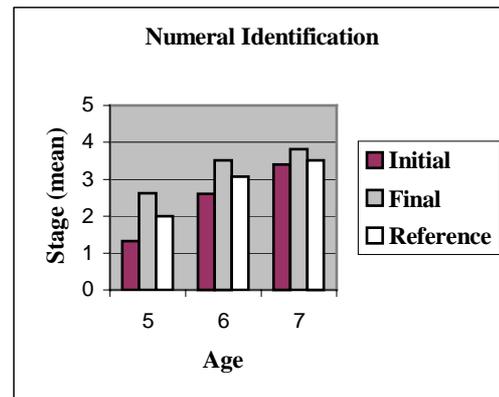
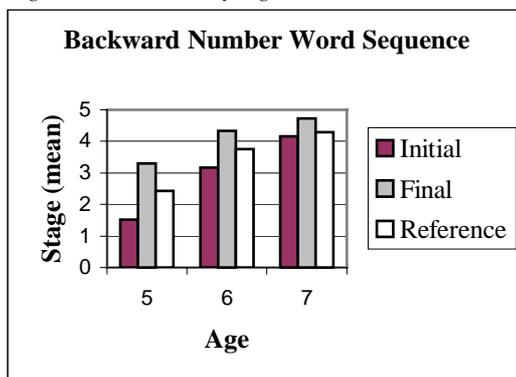


Figure 3.5: Numeral Identification by Age

The results of the initial assessment indicate that beginning school students bring with them a diverse range of mathematical knowledge. The remainder of this section focuses on the performance of the five-year-olds<sup>2</sup>.

Table 3.11 shows the spread of five-year-olds on each of the stages of the FNWS and BNWS. At the time of the initial assessment, they were spread between the six stages of the FNWS. Forty-five percent of the five-year-olds were below stage 3 (facile with FNWS up to 10) at the initial assessment, compared to 11% at the final assessment. There was also a large improvement in the BNWS with 66% of the five-year-olds below stage 3 on the first assessment, compared to 25% by the final assessment.

<sup>2</sup> Similar tables of results for the six and seven-year-olds are contained in Appendices G and H

Table 3.11: Forward and Backward Number Word Sequence (five-year-olds)

	0	1	2	3	4	5
Initial FNWS	10%	24%	11%	28%	16%	11%
Final FNWS	1%	5%	6%	15%	26%	47%
Initial BNWS	39%	19%	8%	23%	5%	6%
Final BNWS	6%	11%	8%	29%	14%	32%

There are differences in the FNWS profiles of five-year-olds when these are analysed by ethnicity. As shown in Table 3.12, 27% of the Pacific Islands students were classified as emergent at the start of the project, compared to Asian (4%), European (7%), and Māori (15%) students. All five-year-olds made significant improvements over the project. Eighty-six percent of the students improved at least one stage, with 23% improving by at least three stages. By the end of the project, 73% of the five-year-olds were facile with forward numbers to at least 100 (stages 4 and 5).

The profile of Māori and Pacific Islands students changed dramatically over the duration of the project. At the final assessment, 62% of the Māori and 60% of the Pacific Islands students were assessed at stages 4 and 5, compared to 22% and 15%, respectively, at the initial assessment.

Table 3.12: Initial and Final FNWS by Ethnicity (five-year-olds)

Ethnicity		0	1	2	3	4	5
Asian n=142	Initial	4%	20%	9%	32%	15%	20%
	Final	0%	1%	4%	11%	31%	53%
European n=2033	Initial	7%	21%	12%	30%	18%	12%
	Final	0%	4%	5%	14%	26%	51%
Māori n=595	Initial	15%	31%	8%	24%	14%	8%
	Final	3%	9%	9%	17%	24%	38%
Pacific Islands n=288	Initial	27%	27%	10%	20%	10%	5%
	Final	4%	10%	9%	17%	26%	34%
Other n=124	Initial	9%	31%	8%	28%	15%	9%
	Final	2%	4%	6%	14%	28%	46%
Total n=3182	Initial	10%	24%	11%	28%	16%	11%
	Final	1%	5%	6%	15%	26%	47%

Table 3.13 illustrates the changing ability of five-year-olds to identify numerals<sup>3</sup>. At the initial assessment, 22% of the students could identify numerals to at least 100, compared to 66% by the end of the project.

Table 3.13: Initial and Final Numeral Identification (five-year-olds)

Numeral ID	0	1	2	3	4	Total
Initial	24%	46%	9%	19%	3%	100%
Final	4%	19%	10%	42%	24%	100%

Tables 3.14 and 3.15 illustrate the profiles of all students when they are sorted by decile band and ethnicity. In a pattern similar to that found with the SEAL results, there were slightly more students in the higher decile band who were able to identify numerals to 1000 (stage 4) by the end of the project. Fewer Māori (52%) and Pacific Islands students (47%) were able to identify numerals to 1000, when compared to the Asian (67%) and European (61%) students.

Table 3.14: Numeral Identification by Decile Band (All Students)

Decile Band	Numeral	0	1	2	3	4	Total
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<sup>3</sup> Similar tables of results for the six and seven-year-olds are contained in Appendix I

	<b>ID</b>						
Low n=3033	Initial	13%	25%	7%	32%	23%	100%
	Final	3%	10%	6%	27%	54%	100%
Medium n=4312	Initial	9%	25%	6%	32%	28%	100%
	Final	1%	8%	4%	27%	60%	100%
High n=1964	Initial	6%	25%	7%	30%	32%	100%
	Final	1%	7%	4%	25%	63%	100%
Total n=9309	Initial	10%	25%	7%	31%	27%	100%
	Final	2%	9%	5%	26%	58%	100%

Table 3.15: Numeral Identification by Ethnicity (All Students)

<b>Ethnicity</b>	<b>Numeral ID</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>Total</b>
Asian n=448	Initial	4%	18%	5%	37%	36%	100
	Final	0%	4%	2%	27%	67%	100
European n=5983	Initial	8%	25%	7%	30%	30%	100
	Final	1%	8%	4%	26%	61%	100
Māori n=1736	Initial	14%	24%	7%	34%	21%	100
	Final	4%	10%	6%	28%	52%	100
Pacific Islands n=766	Initial	17%	28%	8%	32%	15%	100
	Final	4%	12%	7%	30%	47%	100
Other n=376	Initial	8%	26%	6%	37%	23%	100
	Final	2%	7%	4%	30%	57%	100
Total n=9309	Initial	10%	25%	7%	31%	27%	100
	Final	2%	9%	5%	26%	58%	100