MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

New Zealand
Aotearoa

A Repeat of the Third International Mathematics and Science Study, 1998-1999
Final Results for Year 9 Students

Research Division **December 2000**

This report presents an overview of findings from TIMSS-98/99 (also known as TIMSS-R), a partial replication of the Third International Mathematics and Science Study (TIMSS-94/95). The study was administered in New Zealand and other Southern Hemisphere countries in late 1998 and in Northern Hemisphere countries in early 1999. The study involved students equivalent to New Zealand's Year 9 (form 3) students from 38 countries. This report presents a brief recap of the background to the study, followed by some of the main results for New Zealand in an international context.

Key Points

- TIMSS-98/99 was an international study of mathematics and science achievement involving Year 9 students (or their equivalent) in 38 countries[1].
- Twenty-six countries participated at this Year 9 equivalent level in both TIMSS-94/95 and TIMSS-98/99[2]. Seventeen out of the 26 countries also participated in TIMSS-94/95 at the middle primary level.

Mathematics achievement

- New Zealand Year 9 students, on average, achieved at about the international mean in mathematics for the 38 countries participating in TIMSS-98/99.
- The New Zealand mean was similar to that for students in England and the United States, but was significantly[3] lower than the means for students in Canada and Australia.
- Although it was not a statistically significant result, New Zealand, along with several other countries, including Italy and Bulgaria, recorded a decrease in mean mathematics achievement between 1994/95 and 1998/99.
- New Zealand's relative performance in mathematics essentially did not change from middle primary to lower secondary levels over the four year period.

Science achievement

- New Zealand Year 9 students, on average, achieved significantly above the international mean in science for all 38 TIMSS-98/99 countries.

The remaining key points for science continue on the next page…

[1] *New Zealand has also administered a national version of the study at the middle primary level, involving mostly Year 5 students; the results will be the subject of a separate report.*

[2] *These countries are hereafter referred to as the 'trend countries'.*

[3] *The use of 'significant' means in terms of 'statistical' significance, adjusted for multiple comparisons.*

- The New Zealand student mean was similar to those for students in Malaysia and the United States, but significantly lower than the means for students in Canada, Australia, and England.

- New Zealand, as well as the United States, Belgium (Flemish), Italy and Romania, observed virtually no change in mean science achievement at the lower secondary level over the four years.

- New Zealand's relative performance in science decreased slightly from the middle primary level to the lower secondary level over the four years.

What was TIMSS-98/99?

TIMSS-98/99 is a repeat of TIMSS-94/95, an international study on mathematics and science achievement. TIMSS-98/99 was designed to measure trends in student achievement; it also examined the contexts for learning mathematics and science.

TIMSS-98/99, also known as TIMSS-R, was a partial replication of TIMSS[4], a major international study on mathematics and science administered in about 40 countries, including New Zealand, during 1994 and 1995. TIMSS-98/99, administered in New Zealand in late 1998, was not as extensive as TIMSS-94/95. At the international level, TIMSS-98/99 investigated the mathematics and science achievement of students only at the class level equivalent to form 3 (Year 9 students). New Zealand also chose to examine the mathematics and science achievement of students at the class level equivalent to standard 3 (mostly Year 5 students).[5] The results from this aspect of the study will be the subject of a separate report.

TIMSS-1998/99 examines trends in achievement by:

- comparing Year 9 students' achievement with their national counterparts in TIMSS-94/95 (*historical* trend); and
- comparing Year 9 students with their overseas counterparts in TIMSS-1998/99 (*international* comparison).

Who carried out TIMSS-98/99?

Researchers in the Ministry of Education responsible for administering TIMSS-98/99 in New Zealand worked with a number of research organisations during different phases of the study.

The Comparative Education Research Unit was responsible for carrying out the TIMSS-98/99 activities in New Zealand. This unit is located within the Research Division of the Ministry of Education.

The International Study Centre at Boston College's Lynch School of Education in the United States managed the international coordination of the project. The other organisations involved with the TIMSS-98/99 activities were:

- Statistics Canada in Ottawa;
- the IEA Data Processing Centre in Hamburg (Germany); and
- the Educational Testing Service in Princeton, New Jersey (United States).

Who took part in TIMSS-98/99 in New Zealand?

In New Zealand, approximately 4500 Years 9 students took part in various aspects of TIMSS-98/99.

In New Zealand, TIMSS-98/99 involved schools with Year 9 (form 3) students. There were:

- 27 schools in the field trial;

- 152 schools in the main survey.

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[4] *From now on, TIMSS carried out in 1994-1995 is referred to as TIMSS-94/95 to distinguish it from TIMSS-98/99, the subsequent partial replication study.*

[5] *For schools that had moved to the new nomenclature the level defined was the class in which students had three further years of primary education before entering secondary school in 2002.*

Approximately 4500 Year 9 students in New Zealand participated in the study. The mathematics and science teachers of these students, as well as their principals, also provided information on the context in which mathematics and science learning was taking place in their schools.

The countries or education systems that took part in the international study

Thirty-eight countries or education systems participated in TIMSS-98/99. They were:

Australia*#	Hong Kong, SAR*#	Lithuania*	Singapore*#
Belgium (Flemish) *	Hungary*#	Macedonia	Slovak Republic*
Bulgaria*	Indonesia	Malaysia	Slovenia*#
Canada*#	Iran, Islamic Rep. of*#	Moldova	South Africa*
Chile	Israel*	Morocco	Thailand*
Chinese Taipei	Italy*#	The Netherlands*#	Tunisia
Cyprus*#	Japan*#	New Zealand*#	Turkey
Czech Republic*#	Jordan	Philippines	United States*#
England*#	Korea, Rep. of*#	Romania*	
Finland	Latvia (LSS)*#	Russian Federation*	

* Countries that participated in TIMSS-94/95 at the lower secondary level.

Countries that participated in TIMSS-94/95 at the middle primary level.

The achievement results are summarised as Item Response Theory (IRT) scale scores.

How student achievement results in TIMSS-98/99 are being reported?

Three approaches have been taken to report student achievement results:

1. Reporting Item Response Theory (IRT) scale scores. The method summarises the achievement results on a scale with a mean of 500 and a standard deviation of 100 and uses information on the characteristics of both the test items and students taking the test. This approach was used to describe student performance in both the TIMSS-94/95 and TIMSS-98/99 international reports and is also used in this report.
2. Reporting on how students have responded to individual mathematics or science items – for example, the percentage of students who answered each individual item correctly.
3. Reporting a mean score for sets of items, commonly referred to as the mean percent correct score. This approach was adopted for reporting some of the international results and most of New Zealand's national level results on TIMSS-94/95. This approach was used to report New Zealand's preliminary results for TIMSS-98/99.

International student achievement

Mathematics

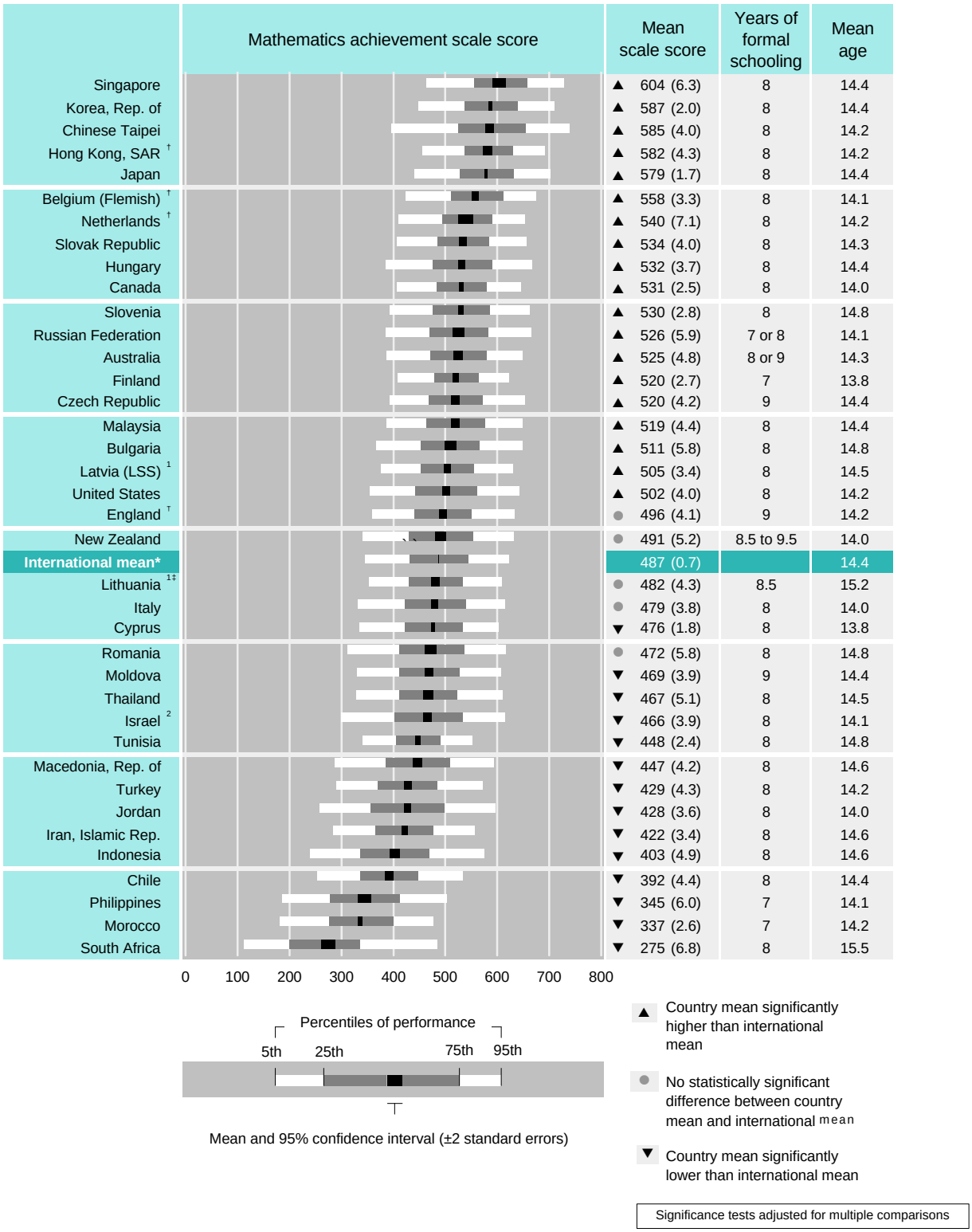
In mathematics, New Zealand Year 9 students, on average, achieved at a level similar to the international mean for 38 countries.

As shown in Figure 1, the mean for New Zealand Year 9 students was close to the international country mean for mathematics[6]. They scored a mean of 491 scale score points, which was not significantly different from the international mean of 487. Of the 38 countries that took part in TIMSS-98/99, the means for 19 countries, including Singapore, the Netherlands, Canada, Australia, Malaysia and the United States, were significantly higher than the international mean. Like New Zealand, the means for students in England and three other countries were not significantly different from the international mean. By way of contrast, the means for 14 countries, including Thailand, Chile, and the Philippines, were significantly below the international mean.

When comparisons are made across individual countries, the New Zealand mean was not statistically different from the means for the United States and England,

[6] *The international country mean (hereafter referred to as the 'international mean') was obtained by averaging the mean scale scores for each of the 38 countries.*

Figure 1: *Distribution of mathematics achievement*



* Obtained by averaging across the mean scale scores for each of the the 38 countries.

† Met guidelines for sample participation rates only after replacement schools were included.

1 National desired population does not cover all of international desired population. Because coverage falls below 65%, Latvia is annotated LSS for Latvian-speaking schools only.

2 National defined population covers less than 90 percent of national desired population.

‡ Lithuania tested the same cohort of students as other countries, did so later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Source: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999 – with minor adaptations, from Mullis et al, 2000.

but it was significantly lower than those of, for example, Singapore, the Netherlands, Canada, Australia, and Malaysia.

Science

In science, New Zealand Year 9 students, on average, achieved significantly above the international mean for 38 countries.

New Zealand Year 9 students achieved, on average, statistically significantly above the international mean for science (510 compared with the international mean of 488). Students in 19 other countries, including Singapore, Hungary, the Netherlands, Australia, England, Canada, and the United States, on average, also achieved scores significantly higher than the international mean. The means for six countries including Malaysia were not significantly different from the international mean. Mean achievement scores for 13 countries were significantly below the international mean. Figure 2 shows the distribution of science achievement scores for the 38 countries.

When comparisons are made across individual countries, the New Zealand mean was not statistically different from the means for the United States and Malaysia, but was significantly lower than those of, for example, Singapore, the Netherlands, Australia, England, and Canada.

Trends in mathematics and science achievement[7]

In mathematics, there was, however, a small, non-statistically significant decrease in New Zealand Year 9 students' mean achievement from 1994 to 1998.

The following summary examines trends in mathematics and science achievement for 23 (out of the 26) countries that took part in, and met the sampling guidelines for both TIMSS-94/95 and TIMSS-98/99 in the lower secondary level assessments[8].

Only three trend countries were found to have significantly large increases in their mean mathematics achievement – Latvia (LSS) (with an increase of 17 scale score points), Canada (10 scale score points), and Cyprus (9 scale scores points). Hong Kong, the Netherlands, and Lithuania also recorded moderate increases in mean achievement; however, due to quite large measurement errors, they were found not be of statistical significance. New Zealand, along with Italy, Bulgaria, and the Czech Republic, recorded decreases in mean mathematics achievement, although only the decrease for the Czech Republic was found to be of statistical significance.

New Zealand's mean science achievement at the lower secondary level did not change from 1994 to 1998.

In science, most countries had small to moderate non-significant increases or decreases in their mean achievement over the four years. The mean for New Zealand Year 9 students was virtually the same in TIMSS-98/99 as in TIMSS-94/95 (510 and 511 scale score points respectively). Four countries did however record significant increases in their mean science performance. The largest increase was observed for Latvia (LSS) (with an increase of 27 scale score points), followed by Lithuania (25 scale score points), Canada (19 scale score points), and Hungary (16 scale score points). Other countries which had moderate but non-significant increases in mean achievement included Hong Kong and Australia.

Decreases in mean achievement (of more than 10 scale score points) were observed in Singapore, Iran, the Czech Republic, and Bulgaria; however only the decrease for the last was statistically significant.

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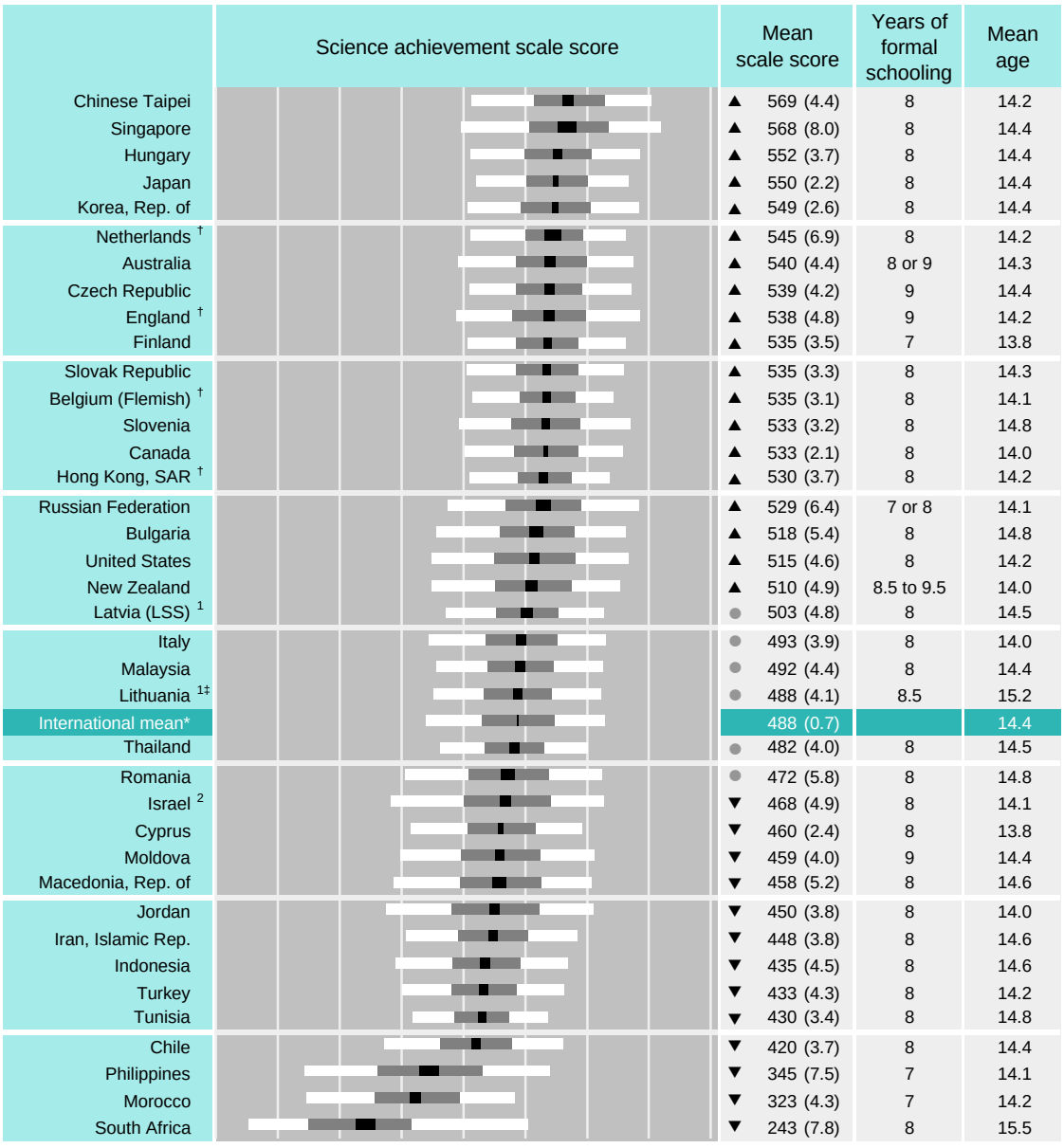
[7] *In order to be able to make comparisons between TIMSS-94/95 and TIMSS-98/99, the IRT scaling methods employed enabled the achievement results to be placed on the same scale.*

[8] *Israel, South Africa, and Thailand did not meet the requirements for classroom-level sampling in TIMSS-94/95.*

Figure 2: *Distribution of science achievement*



* Obtained by averaging across the mean scale scores for each of the the 38 countries.

† Met guidelines for sample participation rates only after replacement schools were included.

[1] National desired population does not cover all of international desired population. Because coverage falls below 65%, Latvia is annotated LSS for Latvian-speaking schools only.

[2] National defined population covers less than 90 percent of national desired population.

‡ Lithuania tested the same cohort of students as other countries, but did so later in 1999, at the beginning of the next school year.

( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Source: IEA Third International Mathematics and Science Study (TIMSS), 1998-1999 –- with minor adaptations, from Martin et al, 2000.

New Zealand's relative performance in mathematics essentially remained unchanged from middle primary in 1994 to lower secondary level in 1998.

New Zealand's relative performance in science decreased slightly from middle primary in 1994 to lower secondary in 1998.

Trends in cohort achievement

In New Zealand, both Year 5 students (in standard 3) and Year 9 students (internationally, grades 4 and 8 students, respectively) were involved in TIMSS-94/95. There were 16 other trend countries that participated in the middle primary level study in 1994/95 and at the lower secondary level in 1998/99. Although the achievement scales for the two educational levels are not directly comparable, it is possible to look at the performance of each group of students in the 17 countries in order to gauge the extent of the relative progress made by the younger (1994/95) cohort in four years[9].

The mean score in mathematics for New Zealand Year 5 students in TIMSS-94/95 was significantly below the mean for the 17 trend countries. In 1998/99, the mean for Year 9 students was still significantly below the mean for the 17 trend countries, although the differential from the mean was smaller than it had been four years earlier. However, this slight change accounted for only minimal movement in New Zealand's mathematics standing relative to the 16 other trend countries.

The mean score in science for New Zealand Year 5 students in TIMSS-94/95 was just below but not statistically different from the mean for the 17 trend countries. Four years on, the margin between the mean for Year 9 students and the international mean for the 17 countries increased slightly; thus, New Zealand's standing, decreased slightly to a level now statistically significantly below the international mean. However, this change in New Zealand's relative standing may in part be due to the improvement in the relative performance of Singapore and Hungary between educational levels rather than any decline in New Zealand's performance.

International benchmarks[10]

The TIMSS-98/99 mathematics and science achievement scales summarise (Year 9) student performance on test items designed to measure a wide range of student knowledge and understanding. Four points on each scale were identified for use as international benchmarks. The performance of all students in all countries which participated in TIMSS-98/99 were taken into account when defining these benchmarks, which are described as follows:

- The *Top 10%* benchmark was defined as the 90th percentile on the TIMSS-98/99 scale. This is the point on the scale above which the top 10 percent of the students scored.

- The *Upper Quarter* benchmark corresponds to the 75th percentile on the TIMSS-98/99 scale and is the point above which the top 25 percent of students scored.

- The *Median* benchmark corresponds to the 50th percentile or the median on the TIMSS-98/99 scale. This is the point above which the top half of the students scored.

- The *Lower Quarter* benchmark is the 25th percentile on the TIMSS-98/99 scale, reached by 75 percent of students.

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[9] *It is important to note that they are not necessarily the same students.*

[10] *A scale anchoring exercise was undertaken by the international researchers in order to describe performance at these benchmarks. Descriptions of the knowledge, skills, and understanding students scoring at these benchmarks would be expected to demonstrate are described in Mullis et al, 2000 and Martin et al, 2000, referenced at the end of this report.*

Performance against international benchmarks: mathematics

The proportions of New Zealand Year 9 students reaching the international benchmarks for mathematics in TIMSS-98/99 are presented in Table 1. As a comparison, the proportions of Year 9 students in TIMSS-94/95 reaching these same benchmarks are also shown. Although there were some decreases from 1994 to 1998 in the proportions of New Zealand students reaching the international *Median* and *Lower Quarter* benchmarks, they were found not to be of statistical significance.

Table 1: *Trends in the proportions of New Zealand Year 9 students reaching the TIMSS-98/99 international mathematics achievement benchmarks*

International Benchmark	TIMSS-94/95		TIMSS-98/99	
	Proportion of NZ students (%)	International mean* (%)	Proportion of NZ students (%)	International mean* (%)
Top 10%	8	14	8	15
Upper Quarter	26	37	25	37
Median	62	69	56	69
Lower Quarter	90	90	85	91

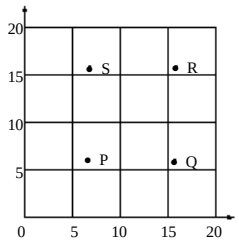
* The international mean is for the 23 trend countries that participated in and met sampling guidelines in TIMSS-94/95 and TIMSS-98/99.

Figure 3: *Two examples of mathematics assessment items that students reaching the international Median benchmark were likely to have answered correctly*

These two mathematics questions are examples of items presented to Year 9 students in TIMSS-98/99.

Example a: Geometry

J16. Which point on the graph could have coordinates (7,16)?



A. Point P

B. Point Q

C. Point R

D. Point S

NZ Year 9 students % correct	International % correct
72	58

Example b: Algebra

B12. *n* is a number. When *n* is multiplied by 7, and 6 is then added, the result is 41. Which of these equations represents this relation?

A. $7n + 6 = 41$

B. $7n - 6 = 41$

C. $7n \times 6 = 41$

D. $7(n + 6) = 41$

NZ Year 9 students % correct	International % correct
58	65

Performance against international benchmarks: science

The proportions of New Zealand Year 9 students reaching the international benchmarks for science in TIMSS-98/99 are shown in Table 2, along with the proportions of Year 9 students reaching these benchmarks in 1994/95. There was virtually no change between 1994 and 1998 in the proportions of New Zealand students reaching each benchmark.

Table 2: *Trends in the proportions of New Zealand Year 9 students reaching the TIMSS-98/99 international science achievement benchmarks*

International Benchmark	TIMSS-95/95		TIMSS-98/99	
	Proportion of NZ students (%)	International mean* (%)	Proportion of NZ students (%)	International mean* (%)
Top 10%	11	13	12	14
Upper Quarter	30	34	32	35
Median	62	65	61	66
Lower Quarter	87	88	86	89

* The international mean is for the 23 trend countries that participated in and met sampling guidelines in TIMSS-94/95 and TIMSS-98/99.

These two science questions are examples of assessment items presented to Year 9 students in TIMSS-98/99.

Figure 4: *Two examples of science assessment items that students reaching the international Median benchmark were likely to have answered correctly.*

Example a: Earth Science

J9. Diana and Mario were discussing what it might be like on other planets. Their science teacher gave them data about Earth and an imaginary planet Proto. The table shows these data.

	Earth	**Proto**
Distance from a star like the Sun	148 640 000 km	902 546 000 km
Atmospheric pressure at surface of planet	101 325 Pa	100 Pa
Atmospheric conditions		
• gas components	21% oxygen 0.03% carbon dioxide 78% nitrogen	5% oxygen 5% carbon dioxide 90% nitrogen
• ozone layer	yes	no
• cloud cover	yes	no

Write down one important reason why it would be difficult for humans to live on Proto if it existed. Explain your answer.

NZ Year 9 students % correct	International % correct
80	66

Example b: Chemistry

F6. Paint applied to an iron surface prevents the iron rusting. Which ONE of the following provides the best reason?

A. It prevents nitrogen from coming in contact with the iron.

B. It reacts chemically with the iron.

C. It prevents carbon dioxide from coming in contact with the iron.

D. It makes the surface of the iron smoother.

E. It prevents oxygen and moisture from coming in contact with the iron.

NZ Year 9 students % correct	International % correct
66	67

There were no significant differences between New Zealand Year 9 boys' and girls' mean achievement in both mathematics and science.

Gender differences

In mathematics, on average internationally, there was a modest, but statistically significant difference favouring boys. Whereas in most countries the direction of the difference between boys' and girls' mean mathematics achievement favoured boys, in New Zealand, Belgium (Flemish), Malaysia and six other countries, the direction of the difference favoured girls. However, the differences for these nine countries were not of statistical significance.

Across the 23 trend countries, the Czech Republic and New Zealand boys recorded the largest decreases in mean achievement over the four years (24 and 18 scale scores points respectively). Only the decrease for the Czech Republic boys was of statistical significance. Korea was the only country to show a statistically significant reduction in the gap between boys' and girls' mean achievement over the four year period from 1994/95 to 1998/99.

Table 3: *Trends in Year 9 students' mean mathematics achievement, by gender*

	TIMSS-94/95		TIMSS-98/99	
	New Zealand mean scale score	International mean scale score*	New Zealand mean scale score	International mean scale score*
Girls	497	516	495	520
Boys	505	522	487	524

* The international mean is for the 23 trend countries that participated in and met sampling guidelines in TIMSS-94/95 and TIMSS-98/99.

In science there was a significant difference, internationally, between boys' and girls' mean science achievement; on average, the difference was 15 scale score points in favour of boys. In 17 countries, including Canada, the Netherlands, the United States and England, the differences were large enough to be statistically significant. England had one of the largest differences at 32 scale score points, whereas New Zealand had one of the smallest non-significant differences – just seven scale score points – between boys' and girls' mean achievement. Only two countries – the Philippines and Jordan – showed differences favouring girls.

Across the 23 trend countries, there was, on average, a small significant increase in girls' mean science achievement over the four year period. There was no change in boys' mean achievement during this time. Furthermore, the difference between boys' and girls' mean achievement which internationally, on average, favoured boys reduced from 21 to 18 scale score points, a significant decrease. This trend was particularly apparent in New Zealand. New Zealand had had a relatively large statistically significant differential between boys' and girls' mean achievement favouring boys in 1994; four years later that difference had all but disappeared.

Table 4: *Trends in Year 9 students' mean science achievement, by gender*

	TIMSS-94/95		TIMSS-98/99	
	New Zealand mean scale score	International mean scale score*	New Zealand mean scale score	International mean scale score*
Girls	497	506	506	512
Boys	524	527	513	531

* The international mean is for the 23 trend countries that participated in and met sampling guidelines in TIMSS-94/95 and TIMSS-98/99.

New Zealand Year 9 students, on average, achieved around the international means for each of the five mathematics content areas.

New Zealand Year 9 students, on average, achieved significantly above the international mean for *Scientific Inquiry and the Nature of Science*. In other science areas the New Zealand means were about the same as the international means.

Achievement in the mathematics and science content areas

The TIMSS-98/99 mathematics test consisted of five content areas:

- Fractions and Number Sense
- Measurement
- Data Representation, Analysis, and Probability
- Geometry
- Algebra

With the exception of *Geometry*, New Zealand students achieved above the international means in all content areas. Although Year 9 students, on average, achieved below the international mean in *Geometry*, there were no statistically significant differences between the New Zealand and the international means for the five content areas. The performance of Year 9 students in each of the five content areas was similar to that of grade 8 students in the United States and England. New Zealand students, on average, achieved significantly below their Australian counterparts in three content areas (*Fractions and Number Sense*, *Measurement*, and *Algebra*) and significantly below their Canadian counterparts in all content areas.

The science test was designed to enable reporting in six content areas:

- Earth Science
- Life Science
- Physics
- Chemistry
- Environmental and Resource Issues
- Scientific Inquiry and the Nature of Science

New Zealand students performed above the international means in all content areas, although only in the area of *Scientific Inquiry and the Nature of Science* was the difference of statistical significance. In all content areas, New Zealand students' performance was similar to that of students in the United States and Malaysia. New Zealand students achieved, on average, significantly below their Australian counterparts in *Life Science*, *Physics*, and *Environmental Resource Issues*.

In New Zealand there were no statistically significant gender differences across either the mathematics or science content areas. In science, 15 countries, including Australia, Canada, England, the Netherlands and the United States, showed statistically significant gender differences, all in favour of boys, in one or more of the content areas.

Information on students' backgrounds and on their attitudes towards mathematics and science

To provide a context for interpreting the achievement results, detailed information on students' home backgrounds, how they spent their time out of school, and their attitudes towards mathematics and science was gathered from the students taking part in the study. To summarise this information concisely, the international researchers often combined information from students' responses to sets of questions to form indices. According to their responses, students were placed in a 'high', 'medium', or 'low' category for each index. Cut-off points were established so that the high level of an index generally corresponded to conditions or activities generally associated with good educational practice and high academic achievement. Some of the findings are presented in this following section.

New Zealand had the sixth highest proportion of students to report they were from homes with more than 100 books, three educational aids in the home including a computer, and at least one parent who had completed a university education.

Home Educational Resources

An index of Home Educational Resources (HER) was constructed based on students' responses to questions about resources in their homes (number of books, educational aids in the home, and parents' education). Eighteen percent of New Zealand students were in the high category of the index (ie, they had more than 100 books, three educational aids in the home including a computer, and at least one parent had completed a university education). More than one-fifth of the students in Canada, Australia, Israel, and the United States were also at this level of the index. On average, internationally, the mean proportion was nine percent of students in this category. Six percent of New Zealand students were in the low category of the index (ie, in homes with 25 or fewer books, not all three educational aids and both parents' highest education was some secondary education or less) compared with 19 percent internationally.

There were substantial differences in the mean mathematics and science achievement of students at the three levels (ie high, medium, and low) of HER Index in every country[11] for which data were available, including New Zealand. While there was a relationship within countries, the relationship did not necessarily translate across countries. For example, high-performing Singapore had just five percent of students at the high level of the HER Index but, overall, performed at a level significantly higher than New Zealand. In fact, the mean mathematics achievement for the eight percent of Singaporean students at the low level of the index was higher than the mean mathematics achievement of New Zealand students at the high level on the HER Index.

About 20 percent of Year 9 students in New Zealand spent less than one hour on their homework per day.

Out-of-school study time

An index of Out-of-school Study Time (OST) that assigned students to a high, medium, or low category on the basis of the amount of time they reported studying mathematics, science, and other subjects was also developed. On average, across all countries, 38 percent of students were at the high level of the index (ie they reported spending more than three hours each day out of school studying all subjects combined). Countries whose students reported that spent a lot of time studying included Malaysia (65%) and Singapore (59%). The proportion of New Zealand students was 17 percent. Fourteen percent of students on average internationally were at the low level (ie, they spent less than one hour per day on homework). There were nine countries where one-fifth or more of students were at the low level including Australia, New Zealand, and the United States.

In most countries including New Zealand, students in the low category of the OST Index had on average lower mathematics and science achievement, than their classmates who reported spending more time on their homework. However, the relationship between the OST Index in some countries including New Zealand, Canada, Australia, and the United States was not necessarily linear. That is, those students who were in the medium category achieved, on average, scores higher than their counterparts in the high and low level categories.

New Zealand students generally had high self-concept of their abilities in mathematics and science compared with their international counterparts.

Self-concept in mathematics and science

The Self-Concept in Mathematics (SCM) Index was developed to investigate students' perceptions of their abilities in mathematics, using their responses to five questions. On average internationally, 18 percent of students had a high self-concept in mathematics. Twenty-seven percent of New Zealand students were in this category. The proportions of Canadian (35%), Australian (30%), and English (30%) students, were slightly higher than for New Zealand.

[11] *Complete data for Japan, Finland, and England was not available.*

A similar index was created for students' self-concept in science (SSC). On average in those countries that taught science as a general integrated subject, 26 percent of students, had a high self-concept in science; this compared with 32 percent of New Zealand students, 45 percent of students in the United States, 42 percent in England, 38 percent in Canada, and 37 percent in Australia.

Both indices were associated with achievement. That is, within countries including New Zealand, students that had a high self-concept usually, on average, achieved higher scores than those students in the low category of the index. However, across countries this pattern was a little more complex. For example, some of the Asian Pacific countries with high mean achievement had relatively small proportions (less than 15%) of students in the high self-concept category.

Attitudes towards mathematics and science

New Zealand Year 9 students generally had positive attitudes towards mathematics and science.

Two further indices – Positive Attitudes Towards Mathematics (PATM) Index and Positive Attitudes Towards Science (PATS) Index – were developed on the basis of students' responses to questions that gauged how positive their attitudes were towards mathematics and science. New Zealand students in general held positive views on the utility of mathematics and science and their enjoyment of them as areas of learning.

New Zealand students did, however, tend to hold more moderate views than some of their international counterparts. The proportion of New Zealand that had very positive attitudes towards mathematics (ie, at the high level of the PATM Index) was 34 percent. This compared with, for example, the considerably higher proportions of Malaysian (74%), Chilean (45%), and Singaporean (45%) students in this category. Ten percent of New Zealand students held very negative attitudes towards mathematics (ie, at the low level of the PATM Index) which was comparable to the international mean proportion of 11 percent.

At 28 percent, the proportion of New Zealand students with very positive attitudes towards science (ie, they were at the high level of the PATS Index) was slightly less than for mathematics (34%). Sixteen percent of New Zealand students held very negative attitudes toward science (ie, they were at the low level of the PATS Index). By comparison, the international mean proportions were 40 percent and 10 percent respectively. In addition, it was also found that the proportions of Malaysian (72%), Chilean (49%), English (39%), and Canadian (30%) students in the high category were greater than the proportion for New Zealand.

Within most countries, including New Zealand, attitudes towards mathematics and science were related to achievement.

The mathematics and science curricula

Major emphases of the New Zealand *intended* mathematics and science curricula were similar to those in many other countries.

TIMSS-98/99 collected information about the intended and implemented curricula in mathematics and science. The following section looks at just some of the information on the intended curricula only. In most countries (35), including New Zealand, curricular intentions were developed as national curricula. There were just three exceptions – Australia, Canada, and the United States – where curricula were determined at the state or provincial level. In terms of the approaches taken to support or monitor curriculum implementation, New Zealand like most countries, uses pre- and in-service teacher education, as well as a system of school inspection/auditing. But then unlike the majority of TIMSS-98/99 countries, neither New Zealand nor England uses mandated or recommended textbooks, instructional or pedagogical guides, or Ministry directives for this educational level.

The relative emphasis given to various aspects of the intended curricula was also studied. For mathematics, New Zealand, like many other countries, places major emphasis on students understanding mathematical concepts, real-life applications of mathematics, and assessing student learning. New Zealand, along with six other countries, including Singapore and the United States also places major emphasis on solving non-routine problems and communicating mathematically. While most countries placed major emphasis on mastering basic skills at this level, New Zealand was one of nine countries, including Canada and the Netherlands, that placed moderate (or as in the case of Italy, minor) emphasis on this approach.

In science, New Zealand was one of only four countries (including the Netherlands) where the intended curriculum placed at least a moderate or major emphasis on all 13 aspects of science instruction focussed on in TIMSS-98/99. All other countries' intended curriculum placed minor or no emphasis on at least one instructional approach; usually this was that of taking a multicultural approach to science instruction. New Zealand was one of just eight countries, including Singapore, Malaysia, and the Netherlands to place a moderate (or as in the case of Israel, major) emphasis on a multicultural approach to science[12]. A major emphasis for most countries was placed on knowing basic facts and understanding science concepts. New Zealand was one of nine countries, including the Netherlands and Australia, that placed moderate emphasis on knowing basic scientific facts.

Classroom context

The following section provides a brief overview of some of the information collected from teachers and school principals. The information provides detail on the classroom environment, aspects of the implemented curricula, as well as the school context for learning in which the students were to be found at the time the study was undertaken.

Characteristics of teachers[13]

On average internationally, the majority of students (about 60 percent) were being taught by mathematics and science teachers in their 30s and 40s, and by female teachers. In New Zealand, most students were being taught mathematics by teachers in their 40s and 50s, and science by teachers in their 30s and 40s. In New Zealand, about 45 percent of students were taught mathematics and science by female teachers.

Preparation to teach mathematics and science

Fifty-one percent of New Zealand Year 9 students were taught mathematics by teachers with mathematics as their major area of tertiary study compared with 84 percent internationally.

Fifty-one percent of students in New Zealand were taught mathematics by teachers having mathematics and/or mathematics education as a major area of study in their degree course or teacher training programme, compared with an average of 84 percent internationally. In Australia, England, Malaysia, the Netherlands, and Singapore, more than 70 percent of students were taught by a teacher having mathematics and/or mathematics education as a major area of study, while the proportion of Canadian students was 28 percent.

To gauge teachers' confidence to teach mathematics, TIMSS constructed the Teachers' Confidence in Preparation to Teach Mathematics (CPTM) Index. The index was based on teachers' responses to questions on how well prepared they felt to teach each of 12 mathematics topics. In seven countries, including New Zealand

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[12] *Note that New Zealand, England, the Netherlands, and three other countries also placed a moderate emphasis on a multicultural approach to mathematics education. Two countries – Jordan and Italy – reported that they placed a major emphasis on multicultural approach.*

[13] *Responses were from the teachers of a representative sample of students and are therefore not necessarily representative of all teachers at this level.*

and the United States, more than 85 percent of students were taught by teachers who had a high level of confidence in their preparation to teach mathematics (ie, they were *'very well prepared'*). Across all countries, 63 percent of students were taught by teachers who had a high level of confidence in their preparedness to teach mathematics.

Seventy-four percent of New Zealand Year 9 students were being taught science by teachers with science(s) or science education as their major area of tertiary study compared with 82 percent internationally.

Compared to the 21 countries that offered a general science programme at the lower secondary level, New Zealand, as well as Canada, Chile, Italy, Malaysia, and the United States, were the only countries where less than 75 percent of students had teachers with a degree (or teacher training programme) major in one of the sciences or in science education. In the case of New Zealand, the proportion was 74 percent. Eighty-two percent of students, on average internationally, were taught by teachers that had a major in the science(s) or science education.

The Teachers' Confidence in Preparation to Teach Science (CPTS) Index gauged teachers' confidence to teach science, based on their responses to how well prepared they felt to teach each of 10 science topics. Of the 21 countries offering general science programmes, more than 25 percent of students in 11 countries, including New Zealand and the United States, were being taught science by teachers who had a high level of confidence in their preparedness to teach science. Internationally, 20 percent of students were taught by teachers who were in the high category on the CPTS Index.

Mathematics and science instruction time

The international data show no clear pattern between the number of in-class instructional hours in mathematics or in science and achievement in these learning areas.

The mean yearly instruction time for mathematics in New Zealand as reported by schools was 134 hours, or 14 percent of total instruction time. The international mean indicated that students received an average of 129 hours per year for mathematics, or 13 percent of total instructional time. The data reveal no clear pattern between the number of in-class instructional hours and mathematics achievement either across or within countries.

The mean yearly instructional time for science in New Zealand was 131 hours of science instruction, or 14 percent of total instruction time. Across all countries with general/integrated science classes students received an average of 122 hours, or 12 percent of total instructional time. Although in some countries the number of in-class instructional hours was related to science achievement, the data generally revealed no clear pattern either across or within countries.

Classroom activities

Forty-seven percent of New Zealand Year 9 students were being taught mathematics by teachers that placed a low emphasis on mathematics reasoning and problem solving compared with 24 percent internationally.

An index of teachers' emphasis on mathematics reasoning and problem solving (EMPRS Index) and an index of teachers' emphasis on scientific reasoning and problem solving (ESRPS Index) were developed to summarise responses to questions on the emphases given to different classroom instructional practices during lessons.

There was a wide variation across countries in the proportions of students taught by teachers who were at the high level of the EMPRS Index (ie, who gave high level of emphasis to mathematical reasoning and problem solving). For example, 49 percent of Japanese students were taught mathematics by teachers in the high category. This compared with seven percent of Australian and Singaporean students, five percent of New Zealand and Finnish students, and just three percent of English students. The majority of New Zealand students were either being taught by teachers that placed either a moderate emphasis (48%) or minor emphasis (47%) on reasoning and problem solving. The equivalent international mean proportions were 61 percent and 24 percent respectively. An emphasis on

mathematics reasoning and problem solving was associated with higher achievement, internationally; this held true across most countries including, New Zealand.

Four percent of New Zealand Year 9 students were being taught science by teachers who placed a high emphasis on scientific reasoning and problem solving compared with 16 percent internationally.

Across countries, 16 percent of students were taught science by teachers in the high category of the ESRPS Index (ie, emphasis on scientific reasoning and problem). The proportions of New Zealand and Belgium (Flemish) students taught by teachers that gave a high level of emphasis were the smallest at just four percent, in each case. On average internationally, 44 percent of students were taught science by teachers that placed a moderate level of emphasis on scientific reasoning and problem solving, compared with 46 percent of New Zealand students. While the level of emphasis on scientific reasoning and problem solving was associated with achievement in some countries, there was no strong or consistent relationship internationally or across countries.

Trend data does show small (non-significant) increases in the proportions of New Zealand students being taught by teachers that placed a high emphasis on these approaches from 1994 and 1998.

Scientific investigation

Fifty-two percent of Zealand Year 9 students were in classes with a high emphasis given to scientific investigation compared with 38 percent internationally.

In order to measure the emphasis placed on an important aspect of science education – scientific investigation – the Emphasis on Conducting Experiments in Science Classes (ECES) Index was developed. It was based on responses from both teachers and students to questions on conducting experiments in science lessons. Fifty-two percent of New Zealand students were being taught science where there was high level of emphasis given to conducting experiments in science classes, compared with 38 percent internationally.

Use of calculators

In 14 countries, including New Zealand, Australia, Canada, England, the Netherlands, Singapore and the United States, nearly all students (more than 90 percent in each case) had **access** to calculators in class compared to 73 percent of students internationally. There was however, considerable variation in terms of the emphasis given to their use – that is, how they were being used and the frequency with which they were being used. Eighty percent or more of students in the Netherlands, Singapore, Australia, and England were in mathematics classes where there was a high degree of emphasis on their use; 77 percent of New Zealand students were in mathematics classes with a high level of emphasis. The international mean proportion was 32 percent.

Use of computers

On average internationally, just five percent of students reported very frequent use of computers during their mathematics lessons; the proportion of New Zealand students was six percent. Twenty-one percent of New Zealand students reported that they use them ‘once in a while’, while 73 percent reported ‘never’ using them during their mathematics lessons. These proportions compared to the international means of 14 percent and 80 percent respectively.

In science, about 20 percent of students in Israel and the United States reported using computers during their science lessons. In New Zealand the proportion was 10 percent.

Assessment

Teachers’ reports about the weight given to various types of assessment varied greatly from country to country. TIMSS-98/99 asked mathematics and science teachers to report on which categories of assessment (eg, student responses in class,

external standardised tests) they placed 'quite a lot' or a 'great deal' of weight. New Zealand students were more likely to be taught mathematics and science by teachers that reported they placed 'quite a lot' or a 'great deal' of weight on 'teacher-made tests requiring explanations', and 'observations of students'. Also, in the case of science, 'projects or practical exercises' were also given a great deal of weight. The proportions in each category with one or two exceptions were not markedly different from the proportions for Canada and Australia.

School contexts for learning and instruction

The following section provides a brief overview of just some of the information collected from school principals in order to provide a school-level context for learning mathematics and science.

Availability of school resources

Relatively high proportions of New Zealand Year 9 students were in schools where general resource shortages as well as those related specifically to mathematics and science instruction had little or no effect on schools' capacity to deliver instruction in the two learning areas.

To measure the extent to which shortages of school resources affected schools' capacity to provide instruction, TIMSS-98/99 created an index of availability of resources for each of mathematics (ASRMI Index) and for science (ASRSI Index). There were two types of school resources: those of a general nature (eg, lighting/heating, and instructional materials and space) and those related specifically to mathematics (eg, calculators) and to science (eg, laboratory equipment and materials).

Students attending schools where principals reported that both types of shortages had 'little' or 'no' effect on instructional capacity were in the high category of the index. Students at the medium level were in schools where *one* type of shortage affected instruction 'some' or 'a lot' and the other type had 'little' or 'no' effect. Students in the low category were in schools where *both* types of shortages impinged on schools' capacity to provide instruction 'some' or 'a lot'.

On average, 34 percent of New Zealand Year 9 students attended schools in the high category of the ASRMI Index, compared with 19 percent internationally. That is, about one-third of New Zealand Year 9 students were in schools where resource shortages had either no or minimal impact on their capacity to provide mathematics instruction. A further 62 percent of Year 9 students were in schools where only shortages of one type affected mathematics instructional capacity, and four percent of students were in the low category. The proportions of New Zealand students at each level of the index was very similar to those reported for Australia and Canada.

Thirty-seven percent of New Zealand students were in schools in the high category of the ASRSI Index, the fourth largest proportion to be observed internationally. That is, New Zealand schools typically reported that shortages both of a general nature and for science had either no or just a minimal effect on science instructional capacity. In many countries, students in schools in the high category had higher mean science achievement than students in the low category on the ASRSI Index. However, the relationship between a country's mean science achievement and availability of resources for instruction is complex.

Role of school principal

New Zealand principals reported the second highest mean time (83 hours) spent on administrative duties per month compared to the international mean of 51 hours.

Principals in Australia, Canada, Chinese Taipei, New Zealand, Singapore, and the United States reported similar use of their time. For example, unlike in many European countries, principals spent relatively little time teaching and most of it on administration, communicating with the school community and education officials, and engaging in instructional leadership. New Zealand principals, after those from Chinese Taipei, reported spending the second highest number of hours on administrative duties at an average of 83 hours per month. Internationally, the

mean was 51 hours per month. New Zealand school principals also spent slightly more time on communicating with students and parents and education officials (an average of 45 hours per month) than on instructional leadership activities (an average of 39 hours per month). The average time spent on these activities per month internationally were 35 hours per month and 33 hours per month respectively.

Student behaviour

An index based on schools' responses to the seriousness of student absenteeism, tardiness, and skipping class (SCA Index) was developed. Students in schools at the high level category were in schools that reported that all three behaviours were not a problem; students in schools at the low level were in schools where two or more problems rated as serious problems. Fifteen percent of New Zealand students were in schools where these behaviours were not serious (ie, on the high level of the SCA Index) compared with 52 percent of Belgium (Flemish), 19 percent of United States, and 17 percent of Australian students. Sixteen percent of New Zealand students were in schools that rated these behaviours as serious (ie, low level of the SCA Index) compared to 13 percent of Australian and United States students. In the case of New Zealand and many other countries the mean achievement for students in the low SCA category was lower than students in the high SCA category.

Sixteen percent of New Zealand students were in schools where student absenteeism, tardiness, and skipping class was considered by principals to be a serious problem.

Information on the frequency and seriousness of student behaviour which threatens a safe school environment (eg, vandalism, theft, physical injury to other students, intimidation or verbal abuse of other students, and intimidation or verbal abuse of teachers or staff) was also collected from schools. While cross-national comparisons are difficult because of differing perceptions of what constitutes a serious problem, the international researchers noted that the incidence of these student behaviours in most countries was generally low.

Finally

This summary has merely touched on a vast array of descriptive information, particularly the contextual data, generated by the study. It is recommended that the findings presented here are not viewed in isolation, and that readers refer to the international publications for more detail. The reports can be viewed on the international web site. A national report will also be available on the ministry's web site in December, and copies will be distributed to schools early in the school year.

International TIMSS-R web site: www.timss.org

Sources for this summary:

Martin, M O, Mullis, I V S, Gonzalez, E J, Gregory K D, Smith, T A, Chrostowski, S J, Garden, R A, and O'Connor, K M (2000). *TIMSS 1999 International Science Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade.* Chestnut Hill, MA: International Study Center, Boston College.

Mullis, I V S, Martin, M O, Gonzalez, E J, Gregory K D, Garden, R A, O'Connor, K M, Chrostowski, S J, and Smith, T A (2000). *TIMSS 1999 International Mathematics Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade.* Chestnut Hill, MA: International Study Center, Boston College.

Also for additional technical information, readers should refer to:

Martin, M O, Gregory, K A, and Stemler, S E (eds) (2000). *The TIMSS 1999 Technical Report*, Chestnut Hill, MA: International Study Center, Boston College.

For further information in New Zealand

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This report is also available on www.minedu.govt.nz