MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

science

Year 5 students' science achievement in 2010/11

New Zealand results from the Trends in International Mathematics and Science Study (TIMSS)

IEA TIMSS 2010/11

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New Zealand Government

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TIMSS National Research Coordinator

Key Findings

Achievement in an international context

- New Zealand Year 5 students had relatively low science achievement when compared with other participating countries, lower than 29 countries, similar to 3, and higher than 17 countries.
- After increasing steadily between 1994/95 and 2002/03, the average science achievement of Year 5 students has decreased steadily back to 1994/95 levels.
- In the international context, the range of achievement within New Zealand was wider than nearly all of the high-performing countries and nearly all of the countries that tested in English.
- There was a relatively high proportion of very low achievers (students who did not reach the low benchmark) in this cycle of TIMSS compared with countries with similar or higher mean science achievement.
- Instructional hours in science in New Zealand middle primary classrooms were low compared with nearly all other countries.
- The decrease in mean science achievement among New Zealand students seems to be mainly due to the decreases in achievement on questions about *life science* and *Earth science*.
- This cycle of TIMSS saw a large decrease in achievement on the cognitive aspect of *knowing*. Achievement on *knowing* was higher than *applying* and *reasoning* in 2006/07 but the same in 2010/11.

Equity in the New Zealand system

- Average science achievement is the same for Year 5 girls and boys but there is a wider range of achievement among boys than among girls.
- There are advanced achievers and very low achievers in all ethnic groupings. However, there were proportionately more Pākehā/European and Asian advanced achievers compared with the Pasifika and Māori ethnic groupings. There were also more very low achievers among Pasifika and Māori groupings than among Pākehā/European and Asian groupings.
- Regardless of the measure used to assess socio-economic status (SES), students with lower SES had lower achievement than students with higher SES. In particular, on an international measure of the SES of the school attended, students in schools with a greater concentration of affluent students had higher achievement than students in schools with a greater concentration of economically disadvantaged students. On this measure, New Zealand had one of the highest differences in achievement between these two groups.

Student attitudes

- New Zealand middle primary students were generally positive about learning science.
- Students who were more positive about learning science had, on average, higher achievement than those who were more negative. The self-confidence of students had a stronger relationship with science achievement than how much they like learning science.
- Fewer New Zealand middle primary students were confident in their ability to do science compared with many other countries.

- Year 5 boys were more likely to be confident with science than girls, and similar proportions liked science. Confidence with science had a stronger relationship with achievement than liking science for both boys and girls.
- A greater proportion of Asian students reported liking science than Māori, Pasifika or Pākehā/European students. Māori and Pasifika students were more likely to report being not confident with science than students from the other ethnic groupings.

Teaching

- Fewer New Zealand middle primary teachers felt well prepared to teach topics in science compared with their peers in other countries and fewer expressed high levels of confidence in their ability to teach science.
- New Zealand teachers tended to place less emphasis on science investigations than their peers in other countries.
- New Zealand classrooms were more likely to have computers available for instructional use compared with other countries and these were more likely to be used regularly for looking up ideas and information.

School climate for learning

- Year 5 students generally perceived their school to be a good place to be. More than eight out of ten students agreed that they liked being at school and felt safe there. A higher proportion of girls than boys were positive about school and Pasifika and Asian students were the most positive of the ethnic groupings.
- Teachers and principals were generally very positive about their school climate for learning, including having a safe environment, knowledgeable staff, supportive parents, and well-behaved students. However, principals tended to be slightly less positive about the teaching staff and more positive about parental support than the teachers.
- Parents were very positive about their children's schools, although a number of the parents who responded also indicated that they would like to be better included in and informed about their child's education.
- Compared to students in other countries, a relatively high proportion of New Zealand Year 5 students reported experiencing negative behaviours from other students at least monthly. A higher proportion of boys than girls experienced these behaviours but no particular ethnic grouping experienced these negative behaviours more than would be expected based on their proportion of the population.
- Teachers of Year 5 students indicated that there were several factors that presented at least some limitations to their teaching of science, particularly having students with a lack of prerequisite knowledge or skills. Compared with most other countries, more New Zealand teachers thought that students suffering from not enough sleep were a hindrance to their teaching.
- More than half of the TIMSS Year 5 students had teachers who perceived various issues were at least a minor problem in their current school, particularly teachers having too many teaching hours or inadequate workspace. New Zealand teachers were relatively positive about their working conditions compared to most other TIMSS countries.
- A lack of teachers with a specialisation in science, and computer software for science instruction, were the resources most commonly seen by principals as having an impact on instruction. Far fewer New Zealand primary schools had science laboratories available for use by Year 5 classes compared with other countries.

- According to principals' estimates of the literacy and numeracy abilities of students when they began school, science achievement at Year 5 was higher in schools where the cohort was more able when the students began school.

School leadership

- Principals of New Zealand schools with Year 5 students in them were more likely than the international average to report spending a lot of time on promoting and developing educational goals, and on monitoring student progress.
- On average, New Zealand principals reported spending less time than their international counterparts on addressing student behaviour issues.

Introduction

This report examines the science results for New Zealand Year 5 students from the Trends in International Mathematics and Science Study (TIMSS) in 2010/11.[1] Along with the reports on New Zealand's results for science at Year 9 (Caygill, Kirkham, and Marshall, 2013a) and on mathematics at Years 5 (Caygill, Kirkham, and Marshall, 2013b) and 9 (Caygill, Kirkham, and Marshall, 2013c), this report forms the beginning of a series of publications about New Zealand's participation in TIMSS 2010/11. International findings for science for TIMSS 2010/11 have been published by the IEA[2] (Martin, Mullis, Foy, & Stanco, 2012). A separate international report on mathematics was also published at this time (Mullis, Martin, Foy, & Arora, 2012).

This report begins by examining New Zealand's science achievement in relation to other countries that participated in the study. It then looks at trends in New Zealand science achievement at the Year 5 level from 1994 to 2011. An examination of the TIMSS assessment questions in relation to New Zealand's science curriculum is presented followed by analyses of achievement by sub-groupings (such as gender and ethnicity) and student background factors. Comprehensive coverage of background questions about teaching and learning as well as the school context for learning is also provided.

What is TIMSS?

The Trends in International Mathematics and Science Study (TIMSS) is a large-scale comparative study of mathematics and science achievement at the fourth and eighth grades (Years 5 and 9) around the world. As well as examining student achievement, it also monitors curricular implementation and aims to identify the most promising instructional practices from around the world.

Conducted on a regular four-year cycle, TIMSS has assessed mathematics and science in 1994/95[3], 1998/99, 2002/03, 2006/07, and 2010/11 with planning underway internationally for 2014/15.

What does TIMSS consist of?

TIMSS consists of assessments of students' achievements in mathematics and science along with questionnaires for students, and their parents, teachers, and principals to gather background information. The background information provides a context within which the achievement can be examined.

The TIMSS assessments are organised around two dimensions: a content dimension specifying the domains or subject matter to be assessed within mathematics and science; and a cognitive dimension specifying the domains or thinking processes to be assessed. These domains are published in the *TIMSS 2011 assessment frameworks* (Mullis, Martin, Ruddock, O'Sullivan, Arora, and Preuschoff, 2009). To guide questionnaire development, the contextual factors associated with students' learning in mathematics and science are also included in the frameworks.

1 Internationally this cycle of the study is called TIMSS 2011. As New Zealand conducted TIMSS at the Year 9 level towards the end of 2010 and at the Year 5 level towards the end of 2011, it is referred to as TIMSS 2010/11 throughout this report.

2 The International Association for the Evaluation of Educational Achievement (IEA) is an independent, international cooperative of national research institutions and governmental research agencies. It conducts large-scale comparative studies of educational achievement and other aspects of education.

3 Note that this cycle of the study is called TIMSS 1995 internationally as most countries participated in 1995. However, southern hemisphere countries conducted the assessment towards the end of 1994 so in New Zealand reports the study is referred to as TIMSS 1994/95. Similarly for the subsequent cycles, the two years in which administrations occurred in participating countries are indicated.

Assessment framework for science in TIMSS

The three content dimensions for science at the middle primary level (Year 5 level in New Zealand) are: *life science*, *physical science* and *Earth science*. Briefly, each of the content areas is described in the frameworks (Mullis, Martin, et al., 2009) as follows.

> *"Life science includes understandings of the characteristics and life processes of living things, the relationships between them, and their interaction with the environment." (p. 53).*
>
> *"Physical science includes concepts related to matter and energy, and covers topics in the areas of both chemistry and physics." (p. 57).*
>
> *"Earth science is concerned with the study of Earth and its place in the solar system." (p. 60).*

In order to answer questions in the TIMSS test correctly, as well as being familiar with the science content, students need to draw on a range of cognitive skills. Also, in their lives outside and beyond school, students will need to do more than accurately recall a range of science facts. This is acknowledged in the framework with three aspects to the cognitive dimension entitled *knowing*, *applying*, and *reasoning*. Briefly, each cognitive dimension is described in the framework as follows.

> *"The first domain, knowing, covers science facts, procedures, and concepts students need to know, while the second domain, applying, focuses on the ability of the student to apply knowledge and conceptual understanding to a science problem. The third domain, reasoning, goes beyond the solution of routine science problems to encompass unfamiliar situations, complex contexts, and multi-step problems." (p. 80).*

How was TIMSS developed?

The TIMSS tests were developed cooperatively with representatives from participating countries. Questions were field-tested with a representative sample of students in these countries and the results generated were used to select and refine the questions for the final test. Questions for the background questionnaires underwent a similar process.

Who participated?

In TIMSS 2010/11, approximately 608,000 students in 63 countries and 14 economies (known as benchmarking participants) from all around the world took part. Participants included 301,603 students from 52 countries (three of which tested students at a higher grade) and 7 benchmarking participants at the middle primary level, and 307,038 students from 44 countries (two of which tested students at a higher grade) and 14 benchmarking participants at the lower secondary level.[4] This cycle of TIMSS coincided with the third cycle of PIRLS (Progress in International Reading Literacy Study).

In this cycle of TIMSS, both Year 5 and Year 9 students from New Zealand participated. Note that in the previous cycle only Year 5 students participated. Schools in New Zealand were sampled so that there was no overlap between the samples: TIMSS Year 5, TIMSS Year 9, and PIRLS Year 5. In TIMSS in New Zealand, there were 5336 students from 158 schools assessed at the Year 9 level in November 2010 and 5572 students from 180 schools assessed at the Year 5 level in October 2011.

4 Some countries only tested students who were much older than the target population. For example, middle primary students should be around 10 years old according to the design of TIMSS (in the fourth grade or the year level where the average age is closest to 10). However, in some countries these children have not covered enough of the material to achieve adequately on the TIMSS tests so the country has decided to test much older children. Throughout this report the countries that tested at a higher grade and the benchmarking participants are not discussed and do not appear in any totals or comparisons.

Participating countries and benchmarking participants					
●	Armenia	◖	Ireland	◖	Poland
●	Australia	◗	Israel	◖	Portugal
◖	Austria	●	Italy	●	Qatar
◖	Azerbaijan	●	Japan	●	Romania
●	Bahrain	◗	Jordan	●	Russian Federation
◖	Belgium (Flemish)	●	Kazakhstan	●	Saudi Arabia
●	Chile	●	Korea, Rep. of	◖	Serbia
●	Chinese Taipei	◖	Kuwait	●	Singapore
◖	Croatia	◗	Lebanon	◖	Slovak Republic
◖	Czech Republic	●	Lithuania	●	Slovenia
◖	Denmark	◗	Macedonia, Rep. of	◖	Spain
●	England	◗	Malaysia	●	Sweden
●	Finland	◖	Malta	◗	Syrian Arab Republic
●	Georgia	●	Morocco	●	Thailand
◖	Germany	◖	Netherlands	●	Tunisia
◗	Ghana	●	New Zealand	●	Turkey
●	Hong Kong SAR	◖	Northern Ireland	◗	Ukraine
●	Hungary	●	Norway	●	United Arab Emirates
◗	Indonesia	●	Oman	●	United States
●	Iran, Islamic Rep. of	◗	Palestinian Nat'l Auth.	◖	Yemen
	Benchmarking participants				
●	Alberta, Canada	◗	Alabama, US	◗	Indiana, US
●	Ontario, Canada	◗	California, US	◗	Massachusetts, US
●	Quebec, Canada	◗	Colorado, US	◗	Minnesota, US
●	Abu Dhabi, UAE	◗	Connecticut, US	●	North Carolina, US
●	Dubai, UAE	●	Florida, US		
	Out of grade participants				
	Botswana (6,9)		Honduras (6,9)		South Africa (9)
	Yemen (6)				

Note: ● means the country participated at both middle primary and lower secondary level (usually Grade 4 and 8 equivalents).

◖ means the country participated at only the middle primary level (usually Grade 4 equivalent).

◗ means the country participated at only the lower secondary level (usually Grade 8 equivalent).

Who administered TIMSS?

A consortium was responsible for managing the international activities required for the project. This consortium was comprised of: the International Study Centre, Lynch School of Education at Boston College, (Massachusetts) United States; the IEA Secretariat in Amsterdam, the Netherlands; the IEA's Data Processing Centre in Hamburg, Germany; Statistics Canada in Ottawa, Canada; and the Educational Testing Service (ETS) in Princeton, New Jersey in the United States. In New Zealand the Comparative Education Research Unit in the Ministry of Education was responsible for carrying out TIMSS.

How was TIMSS administered?

Each middle primary student was assessed in two timed sessions of 36 minutes, and answered a combination of mathematics and science questions. The assessment was a pencil-and-paper test containing both multiple-choice and constructed-response questions. Following this, students were given a questionnaire containing questions about themselves, their opinions about mathematics and science, interactions at home, their computer use, and their attitudes to school. Principals, teachers, and parents were also given questionnaires in order to gain further information about the context in which the science teaching and learning take place. In New Zealand, the assessments and questionnaires were conducted in English.[5]

What procedures were used to ensure the quality of the data?

Members of the consortium ensured procedures were adhered to by all participating countries. TIMSS procedures are designed to ensure the reliability, validity, and comparability of the data through careful planning and documentation, cooperation among participating countries, standardised procedures, and attention to quality control throughout. Procedures included verification of translations and layout of booklets and questionnaires, monitoring of sampling activities, international and national quality control observers during test administration, checking of data, detailed manuals covering procedures, and rigorous training for all involved.

Technical information

A lot of information is gathered during the TIMSS administration and a number of techniques are applied when collecting and analysing the data. The *Methods and Procedures in TIMSS and PIRLS 2011* report (Martin, & Mullis (Eds.), 2012) contains a detailed account of the assessment framework and instrument development, sampling, translation of materials, survey operations, quality assurance, creating the international databases, and scaling the achievement data. In addition, the *TIMSS 2011 user guide for the international database* (Foy, Arora, & Stanco (Eds.), 2013) contains information on how to analyse the data. Brief details of the technical information are given in the Definitions and technical notes at the end of this report.

Why participate in TIMSS?

Although it is often assumed that the international studies are only useful for international benchmarking purposes, the real value of TIMSS lies in its ability to provide a rich picture of mathematics and science achievement within New Zealand and over time.

TIMSS (along with other international assessment studies) can provide information about the performance of the New Zealand education system at the national level within a global context. The information from studies such as TIMSS is used in the development and review of policy frameworks and also to inform and improve teaching practice. Developments arising out of previous cycles of TIMSS include resource materials for schools and teachers along with teacher in-service training programmes.

The TIMSS encyclopaedia

In order to provide a context in which the TIMSS results can be examined, TIMSS also publishes the *TIMSS 2011 encyclopedia: a guide to mathematics and science education around the world* (Mullis, Martin, Minnich, Stanco, Arora, Centurino, & Castle (Eds.), 2012). This encyclopaedia contains short reports from each country describing mathematics and science education policies and practices in that country.

5 In 2002/03, tests and questionnaires were also translated into te reo Māori, but in order to make comparisons between each of the cycles, these students were excluded from analyses presented in this report.

1. New Zealand science achievement in 2010/11 in an international context

In 2010 and 2011 63 countries participated in the fifth cycle of TIMSS, a large-scale assessment of the mathematics and science skills and knowledge of middle primary and early secondary students. In addition 14 economies took part as what are known as benchmarking participants. Of these countries and economies, 52 countries and 7 benchmarking participants assessed their middle primary students. This chapter will examine the science achievement of New Zealand's Year 5 students in relation to that of other participating countries.

Science achievement in TIMSS 2010/11

The mean science score for New Zealand Year 5 students in 2011 was 497 scale score points. New Zealand's score was not significantly different from the TIMSS scale centre point, similar to Romania (505), Kazakhstan (495), and Norway (494), and higher than 17 countries (see Definitions and technical notes for details re the scales and the centre point). However, 497 is lower than the mean score of 29 countries including all the other English-speaking countries who participated. Scotland, who had a similar score to New Zealand in the 2006/07 cycle, did not participate in this cycle.

The highest achieving countries, the Republic of Korea, Singapore, and Finland, all had average achievement among their Grade 4 students of over 560 scale score points. Of the countries that tested in English, Singapore had the highest mean score (583). The next highest mean scores among the countries testing in English were the United States (544) and England (529).

It is also useful to look at the range of achievement. The lowest outer limit of the bars presented in Figure 1.1 is called the 5th percentile, the score at which only five percent of students achieved a lower score. The upper-most limit presented is the 95th percentile, the score at which only five percent of students achieved a higher score. The range of achievement from the 5th percentile (345) to the 95th percentile (626) for New Zealand Year 5 students was 281 scale score points. New Zealand's range of achievement is wider than nearly all of the high-performing countries and nearly all of the countries that tested in English. However, Singapore's range of achievement (286) was slightly wider than that of New Zealand. Similar observations can be made based on the inter-quartile range.

Table 1.1 provides information to help put science achievement in context. Countries are presented in the same order as Figure 1.1. Information about economic conditions in each country is shown along with information about education for the students tested in TIMSS. Two versions of the Gross National Income (GNI) in U.S. dollars are given in the table. The first version of GNI is a measure of income that includes GDP plus other primary income (see World Bank, 2011 for details); the second version is an adjusted value that allows comparison of real levels of expenditure between countries and is calculated by simultaneously comparing prices of similar goods and services among a large number of countries.

Many of the high-achieving countries had much higher income per capita than New Zealand, especially when purchasing power was taken into account. The exception was the Republic of Korea whose GNI was a bit smaller than that of New Zealand and a lot smaller than the other countries with high achievement. In terms of the countries that tested in English, all but Malta had higher income per capita than New Zealand.

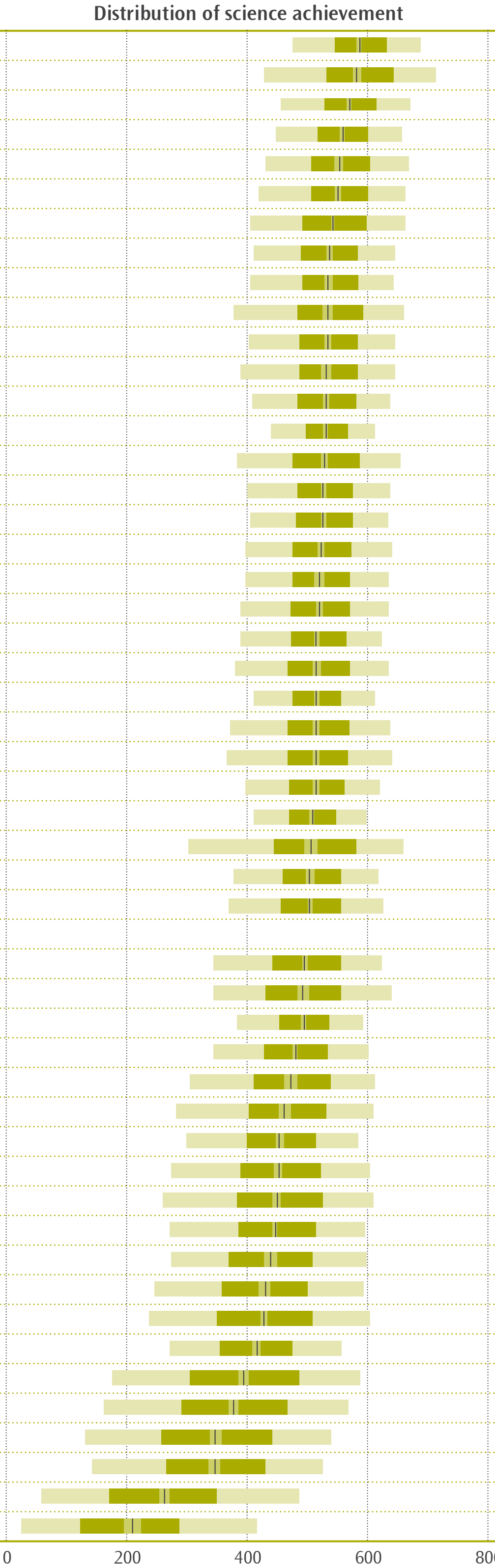
Table 1.1 also shows the average age of students at the time of testing. Students from Scandinavian and Eastern European countries tended to be more than half a year older than New Zealand students but were only in their fourth year of formal schooling. However, it is evident that some of these countries with older starting ages were teaching topics in their early childhood sectors that would be taught in our early years of schooling. Many countries had larger proportions of students beginning school knowing how to read some words or sentences compared with New Zealand (see Chapter 12 Abilities at school entry for details).

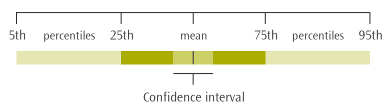
Compared to other countries, New Zealand students had a relatively low number of hours of science teaching per year (52 c.f. the international average of 85 hours). Note that this figure of 52 hours might be over-inflated as a large proportion of teachers (26%) did not answer this question. There were a number of teachers that reported that they did not teach science at all during 2011 (there were other priorities for that year). Also, some teachers found it too difficult to estimate as science was integrated into other areas of the curriculum or taught as part of an enquiry-based learning. Therefore, if some of the non-respondents were not teaching science in that year then we could expect this figure (52 hours) to be even lower.

Nearly all of the countries that tested in English had higher numbers of hours teaching science per year than New Zealand (as shown in Table 1.1). In particular, students in the United States had more than double the number of hours of science teaching than those in New Zealand.

Figure 1.1: Distribution of middle primary science achievement in TIMSS 2010/11

	Country	Mean science achievement			5th to 95th percentile	25th to 75th percentile
	Korea, Rep. of	587	(2.0)	▲	214	87
2	Singapore	583	(3.4)	▲	286	113
	Finland	570	(2.6)	▲	218	86
	Japan	559	(1.9)	▲	209	82
	Russian Federation	552	(3.5)	▲	237	98
	Chinese Taipei	552	(2.2)	▲	244	97
2	United States	544	(2.1)	▲	260	105
	Czech Republic	536	(2.5)	▲	236	95
2	Hong Kong SAR	535	(3.8)	▲	238	92
	Hungary	534	(3.7)	▲	285	110
	Sweden	533	(2.7)	▲	245	100
	Slovak Republic	532	(3.8)	▲	258	100
	Austria	532	(2.8)	▲	232	96
†	Netherlands	531	(2.2)	▲	174	71
	England	529	(2.9)	▲	269	110
2	Denmark	528	(2.8)	▲	239	95
	Germany	528	(2.9)	▲	230	95
	Italy	524	(2.7)	▲	244	96
	Portugal	522	(3.9)	▲	240	95
	Slovenia	520	(2.7)	▲	248	98
†	Northern Ireland	517	(2.6)	▲	237	93
	Ireland	516	(3.4)	▲	258	105
2	Croatia	516	(2.1)	▲	204	84
	Australia	516	(2.8)	▲	267	105
2	Serbia	516	(3.1)	▲	276	103
1 2	Lithuania	515	(2.4)	▲	223	90
	Belgium (Flemish)	509	(2.0)	▲	189	77
	Romania	505	(5.9)		357	136
	Spain	505	(3.0)	▲	242	98
	Poland	505	(2.6)	▲	258	103
	TIMSS scale centre point	**500**				
	New Zealand	**497**	**(2.3)**		**281**	**116**
2	Kazakhstan	495	(5.1)		297	127
‡	Norway	494	(2.3)		210	85
	Chile	480	(2.4)	▼	259	107
	Thailand	472	(5.6)	▼	308	128
	Turkey	463	(4.5)	▼	328	128
1	Georgia	455	(3.8)	▼	286	115
	Iran, Islamic Rep. of	453	(3.7)	▼	330	133
	Bahrain	449	(3.5)	▼	352	143
	Malta	446	(1.9)	▼	323	130
2	Azerbaijan	438	(5.6)	▼	324	140
	Saudi Arabia	429	(5.4)	▼	348	143
	United Arab Emirates	428	(2.5)	▼	366	157
	Armenia	416	(3.8)	▼	289	122
2	Qatar	394	(4.3)	▼	414	184
	Oman	377	(4.3)	▼	406	176
1ψ	Kuwait	347	(4.7)	▼	411	183
ψ	Tunisia	346	(5.3)	▼	382	166
ж	Morocco	264	(4.5)	▼	428	180
ж	Yemen	209	(7.3)	▼	393	166





▲ Country average significantly higher than New Zealand average

▼ Country average significantly lower than New Zealand average

Note: See Appendices for notes explaining the other symbols.

Benchmarking participants and countries testing at a higher grade are not included in this table.

Source: Adapted from Exhibit 1.1, Mullis, Martin, Foy, and Arora, 2012

Table 1.1: Selected contextual factors for TIMSS 2010/11 countries

Country	Gross National Income per Capita (in $US)[1]	GNI per Capita (Purchasing Power Parity)[2]	Public Expenditure on Education (% of GDP)[3]	Average age at time of testing	Average hours of instructional time in science (teacher reports)[4]
Korea, Rep. of	19,830	27,240	4	10.4	92 (2.5)
Singapore	37,220	49,780	3	10.4	96 (2.1)
Finland	45,940	35,280	6	10.8	98 (1.9)
Japan	38,080	33,440	4	10.5	91 (0.8)
Russian Federation	9,340	18,330	4	10.8	49 (0.7)
Chinese Taipei	16,471	34,520	4	10.2	90 (2.3)
United States	46,360	45,640	6	10.2	105 (3.1)
Czech Republic	17,310	23,940	4	10.4	60 (2.2)
Hong Kong SAR	31,570	44,540	5	10.1	88 (4.2)
Hungary	12,980	19,090	5	10.7	72 (2.2)
Sweden	48,840	38,050	7	10.7	75 (3.0)
Slovak Republic	16,130	22,110	4	10.4	101 (4.3)
Austria	46,450	38,410	5	10.3	96 (2.3)
Netherlands	48,460	39,740	5	10.2	42 (2.4)
England	41,370	35,860	5	10.2	76 (3.2)
Denmark	59,060	38,780	8	11.0	62 (1.9)
Germany	42,450	36,850	5	10.4	75 (3.5)
Italy	35,110	31,870	4	9.7	78 (1.8)
Portugal	21,910	24,080	5	10.0	162 (4.1)
Slovenia	23,520	26,470	6	9.9	101 (1.2)
Northern Ireland	41,370	35,860	5	10.4	72 (3.9)
Ireland	44,280	33,040	5	10.3	63 (6.6)
Croatia	13,770	19,200	5	10.7	95 (2.4)
Australia	43,770	38,510	5	10.0	65 (2.3)
Serbia	6,000	11,700	5	10.8	72 (5.0)
Lithuania	11,410	17,310	5	10.7	60 (1.5)
Belgium (Flemish)	45,270	36,610	6	10.0	- -
Romania	8,330	14,540	4	10.9	56 (6.2)
Spain	32,120	31,490	4	9.8	145 (2.6)
Poland	12,260	18,290	5	9.9	64 (3.1)
New Zealand	**28,810**	**27,790**	**6**	**9.9**	**52 (3.0)**
Kazakhstan	6,920	10,320	3	10.4	57 (1.3)
Norway	84,640	55,420	7	9.7	55 (2.2)
Chile	9,470	13,420	4	10.1	161 (6.4)
Thailand	3,760	7,640	4	10.5	109 (4.9)
Turkey	8,720	13,500	4	10.1	94 (1.8)
Georgia	2,530	4,700	3	10.0	110 (2.7)
Iran, Islamic Rep. of	4,530	11,470	5	10.2	106 (3.2)
Bahrain	25,420	33,690	–	10.4	85 (2.7)
Malta	18,360	23,170	6	9.8	39 (0.1)
Azerbaijan	4,840	9,020	3	10.2	61 (1.4)
Saudi Arabia	17,210	24,020	6	10.0	82 (4.2)
United Arab Emirates	54,738	59,993	1	9.8	108 (3.0)
Armenia	3,100	5,410	3	10.0	54 (0.6)
Qatar	71,008	–	–	10.0	135 (6.8)
Oman	17,890	24,530	4	9.9	120 (2.4)
Kuwait	43,930	53,890	–	9.7	85 (5.8)
Tunisia	3,720	7,810	7	10.0	93 (5.4)
Morocco	2,770	4,400	6	10.5	44 (5.5)
Yemen	1,060	2,330	5	11.2	91 (5.6)

Note:
1. GNI per capita in U.S. dollars is converted using the World Bank Atlas method (World Bank, 2011, pp. 10-13).
2. An international dollar has the same purchasing power over GNI as a U.S. dollar in the United States (World Bank, 2011, pp. 10-13).
3. Current and capital expenditures on education by local, regional, and national governments, including municipalities (World Bank, 2011, pp. 76-79).
4. Standard errors are presented in parentheses.

Source: Adapted from Exhibits C.1 and 8.6, Martin, Mullis, Foy, and Stanco, 2012 and from the encyclopaedia, Mullis, Martin, Minnich et al., 2012.

International trends in science achievement at the middle primary level

There have now been four cycles of TIMSS internationally at the middle primary level, 1994/95, 2002/03, 2006/07, and 2010/11. The design of TIMSS allows us to measure trends over time. Table 1.2 presents changes in mean science achievement for those countries that have participated in four cycles of TIMSS. The Islamic Republic of Iran is the country with the largest increase in science achievement since the 1994/95 cycle. Singapore and Slovenia have also had large increases in science achievement since 1994/95. New Zealand and England, after improving in earlier cycles, have both had significant decreases and returned to 1994/95 levels.

Table 1.2: Differences in mean science achievement across time for selected countries

Country	1994/95 to 2010/11 difference	2002/03 to 2010/11 difference	2006/07 to 2010/11 difference
Iran, Islamic Rep. of	73 ▲	39 ▲	17 ▲
Singapore	60 ▲	18 ▲	-3
Slovenia	56 ▲	30 ▲	2
Hong Kong SAR	27 ▲	-8	-19 ▼
Hungary	27 ▲	5	-2
Japan	5 ▲	15 ▲	11 ▲
United States	2	8 ▲	5
England	1	-11 ▼	-13 ▼
Netherlands	1	6 ▲	8 ▲
Australia	-6	-5	-12 ▼
New Zealand	**-8**	**-23** ▼	**-7** ▼
Norway	-10 ▼	28 ▲	17 ▲

Note: ▲ means the 2010/11 mean score was significantly higher than other cycle

▼ means the 2010/11 mean score was significantly lower than other cycle

Source: Adapted from Exhibit 1.5 , Martin, Mullis, Foy, and Stanco, 2012.

In addition to those countries presented in the table, Portugal (70 scale score points) has also had a large increase in science achievement since 1994/95 (this was the only other cycle Portugal participated in).

In order to help understand some of the larger country increases, information is presented below about changes in the education systems in the Islamic Republic of Iran, Singapore, Slovenia, and Portugal.

Islamic Republic of Iran

Although the mean achievement of Iranian students is still below that of New Zealand students, they have shown great improvement over recent cycles of TIMSS so it is worth considering changes they have been making to their system. Notably, results from early TIMSS assessments have been used to review objectives for science teaching (Karimi & Bakhshalizadeh, 2012). The updated objectives led to revisions of curriculum components and textbooks. TIMSS released test items[6] are disseminated for the use of classroom teachers in their teaching. Professional development sessions focussing on the TIMSS frameworks have been conducted. In particular, the cognitive classifications, *knowing*, *applying*, and *reasoning*, have been introduced to teachers for use in their classrooms.

6 TIMSS releases a selection of test questions at the end of each cycle. Other items are kept secure for the next cycle. New Zealand makes released questions available through the ARBs and on the TIMSS New Zealand webpages.

Singapore

Since 1997, when "Thinking Schools, Learning Nation" was launched, Singapore education has been undergoing a transformation. They have been moving from a centrally controlled, efficiency driven system to one that is ability driven and characterised by flexibility, diversity, and greater school autonomy (Chin, Chua, Chua, Foo, Loh, Poon, Seah, & Yen, 2012). Since 1997 the science curriculum has undergone several revisions, the latest of which was published in 2008. The curriculum has science as an inquiry at the centre and inquiry is grounded in knowledge, issues, and questions that relate to the roles played by science in daily life, society, and the environment.

Singapore places great emphasis on teacher development and all teachers are entitled to 100 hours of professional development per year. Generally, primary-level teachers teach several subjects but a few primary schools have teachers that specialise in only one subject area. Science lessons take up eight percent of instructional time at the Grade 4 level.

Slovenia

Since the first cycle of TIMSS, the Slovenian education system has undergone some significant changes. Compulsory schooling now begins at age 6 rather than age 7 and the science curriculum was revised in 1998. Subsequent to the 2007 cycle of TIMSS, the 1998 curriculum has been re-evaluated. An improved version of the science curriculum was released in 2011 that introduced many topics earlier to students and emphasised abstract thinking (Japelj Pavesic & Svetlik, 2012).

TIMSS results also showed the need for improvement in students' explanatory and writing skills. In response to this need, the Ministry of Education, Science, Culture and Sport supported a series of teacher professional development programmes aimed at improving reading literacy in science and mathematics subjects. The main teaching resources for these courses were released TIMSS science items with written responses from students.

In middle primary classrooms in Slovenia, students have a generalist teacher for nearly all subjects with only a specialist teacher for music or sports. Around one-eighth of lesson time (13%) is devoted to science.

Portugal

Portugal has had a large improvement since the 1994/95 cycle of TIMSS. In 2005 they established programmes of in-service training in experimental science for teachers in the beginning to middle primary years (Goncalves & Ferreira, 2012). These programmes required teachers to produce specific resources for use in their teaching. In addition, they have improved the definitions of curricula and established minimum hours to be dedicated to teaching core curriculum subject areas. Of the total instructional time of 25 hours per week, five hours are devoted to social and natural sciences. Of the prescribed five hours, half of the time is intended for experiments and research activities. Portugal has generalist teachers for the first four years of schooling (equivalent to Years 2 to 5 in New Zealand) and has specialist teachers thereafter.

Relative rankings among countries

Many commentators on the international studies focus on New Zealand's ranking relative to other countries. In order to inform this commentary, Table 1.3 presents New Zealand's relative ranking in science achievement compared with the other countries who have participated in TIMSS in 1994/95, 2002/03, and 2010/11. Of all the 52 countries that participated in TIMSS 2010/11 at the middle primary level, only 12 have participated in all these three cycles. In addition, standard errors are presented so that the reader can calculate whether apparent differences are real. For example, the score of 535 in Hong Kong SAR (2010/11) is not significantly different from the score of 531 in the Netherlands (see section entitled Definitions and technical notes for details of how significance can be calculated).

Table 1.3 shows that the mean science achievement in New Zealand has shifted relative to the mean for the 12 countries in each cycle. In 1994/95 New Zealand's mean was the same as the mean of all 12 countries, in 2002/03 it was above the mean, but in the latest cycle New Zealand's mean was below the mean for all 12 countries. In addition, the mean for all 12 countries has increased over time. Therefore, the ranking of New Zealand among these 12 countries was at its lowest in 2010/11 compared to the previous cycles.

Table 1.3: Relative rankings of selected countries participating in 3 cycles of TIMSS

1994/95 mean science score				2002/03 mean science score				2010/11 mean science score			
Japan	553	(1.8)	▲	Singapore	565	(5.5)	▲	Singapore	583	(3.4)	▲
USA	542	(3.3)	▲	Japan	543	(1.5)	▲	Japan	559	(1.9)	▲
Netherlands	530	(3.2)	▲	Hong Kong SAR	542	(3.1)	▲	USA	544	(2.1)	▲
England	528	(3.1)	▲	England	540	(3.6)	▲	Hong Kong SAR	535	(3.8)	▲
Singapore	523	(4.8)	▲	USA	536	(2.5)	▲	Hungary	534	(3.7)	▲
Australia	521	(3.8)	▲	Hungary	530	(3.0)	▲	Netherlands	531	(2.2)	▲
Hong Kong SAR	508	(3.3)		Netherlands	525	(2.0)	▲	England	529	(2.9)	
Hungary	508	(3.4)		**New Zealand**	**523**	**(2.3)**	▲	Slovenia	520	(2.7)	
New Zealand	**505**	**(5.3)**		Australia	521	(4.2)		Australia	516	(2.8)	▼
Norway	504	(3.7)		Slovenia	490	(2.5)	▼	**New Zealand**	**497**	**(2.3)**	▼
Slovenia	464	(3.1)	▼	Norway	466	(2.6)	▼	Norway	494	(2.3)	▼
Iran, Islamic Rep. of	380	(4.6)	▼	Iran, Islamic Rep. of	414	(4.1)	▼	Iran, Islamic Rep. of	453	(3.7)	▼
Mean for all 12	**505**	**(1.2)**		**Mean for all 12**	**516**	**(1.2)**		**Mean for all 12**	**525**	**(1.3)**	

Note: ▲ means the country mean score was significantly higher than the mean for all 12 countries.

▼ means the country mean score was significantly lower than the mean for all 12 countries.

The mean for all 12 countries has been calculated by pooling all student results for the 12 countries and weighting so that each country contributes equally to the mean.

Standard errors are presented in parentheses.

International trends on science benchmarks

In order to describe more fully what achievement on the science scale means, the TIMSS international researchers have developed benchmarks. These benchmarks link student performance on the TIMSS science scale to performance on science questions and describe what students can typically do at set points on the science achievement scale. The international benchmarks are four points on the science scale: the advanced benchmark (625), the high benchmark (550), the intermediate benchmark (475), and the low benchmark (400). The performance of students reaching each benchmark is described in relation to the types of questions they answered correctly. Table 1.4 presents the descriptions of the international benchmarks of science achievement.

Table 1.4: Descriptions of TIMSS 2010/11 international benchmarks of science achievement

Advanced international benchmark — 625
Students apply knowledge and understanding of scientific processes and relationships and show some knowledge of the process of scientific inquiry. Students communicate their understanding of characteristics and life processes of organisms, reproduction and development, ecosystems and organisms' interactions with the environment, and factors relating to human health. They demonstrate understanding of properties of light and relationships among physical properties of materials, apply and communicate their understanding of electricity and energy in practical contexts, and demonstrate an understanding of magnetic and gravitational forces and motion. Students communicate their understanding of the solar system and of Earth's structure, physical characteristics, resources, processes, cycles, and history. They have a beginning ability to interpret results in the context of a simple experiment, reason and draw conclusions from descriptions and diagrams, and evaluate and support an argument.
High international benchmark — 550
Students apply their knowledge and understanding of the sciences to explain phenomena in everyday and abstract contexts. Students demonstrate some understanding of plant and animal structure, life processes, life cycles, and reproduction. They also demonstrate some understanding of ecosystems and organisms' interactions with their environment, including understanding of human responses to outside conditions and activities. Students demonstrate understanding of some properties of matter, electricity and energy, and magnetic and gravitational forces and motion. They show some knowledge of the solar system, and of Earth's physical characteristics, processes, and resources. Students demonstrate elementary knowledge and skills related to scientific inquiry. They compare, contrast, and make simple inferences, and provide brief descriptive responses combining knowledge of science concepts with information from both everyday and abstract contexts.
Intermediate international benchmark — 475
Students have basic knowledge and understanding of practical situations in the sciences. Students recognise some basic information related to characteristics of living things, their reproduction and life cycles, and their interactions with the environment, and show some understanding of human biology and health. They also show some knowledge of properties of matter and light, electricity and energy, and forces and motion. Students know some basic facts about the solar system and show an initial understanding of Earth's physical characteristics and resources. They demonstrate ability to interpret information in pictorial diagrams and apply factual knowledge to practical situations.
Low international benchmark — 400
Students show some elementary knowledge of life, physical, and Earth sciences. Students demonstrate knowledge of some simple facts related to human health, ecosystems, and the behavioural and physical characteristics of animals. They also demonstrate some basic knowledge of energy and the physical properties of matter. Students interpret simple diagrams, complete simple tables, and provide short written responses to questions requiring factual information.

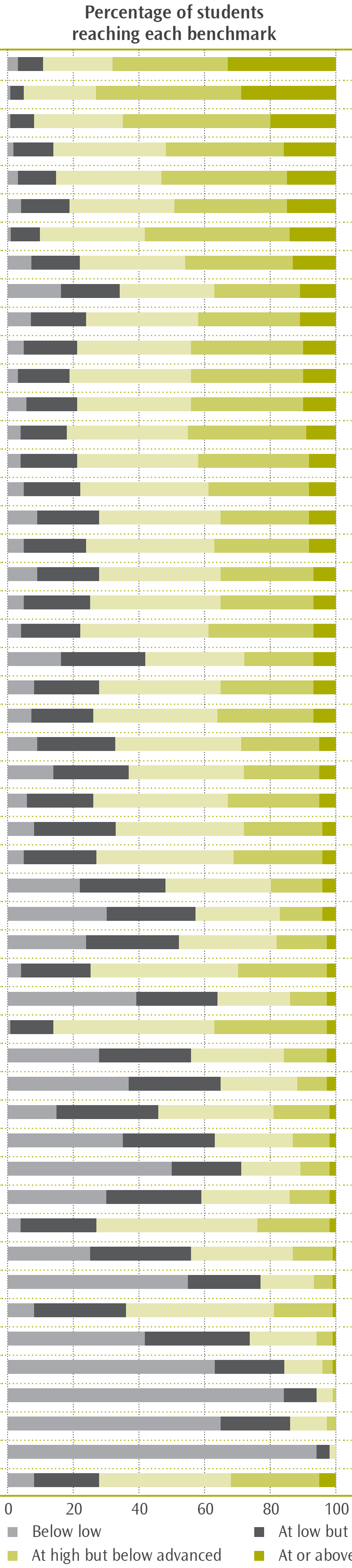
Source: Exhibit 2.1, Martin, Mullis, Foy, and Stanco, 2012.

Figure 1.2 presents two ways of looking at this data – those students achieving at each of the benchmarks (as shown in the graphical part) and those students achieving at or above each of the benchmarks (as shown in the table part). Five percent of New Zealand middle primary students reached the advanced benchmark, the point where students were deemed capable of *applying knowledge and understanding of scientific processes and relationships and showing some knowledge of the process of scientific inquiry*. In comparison, one-third of students in Singapore and just under one-third of students in the Republic of Korea reached this advanced level of science ability. There were also fewer advanced middle primary scientists in New Zealand compared with the United States (15%), England (11%), and Australia (7%).

There were 14 percent of middle primary students in New Zealand who did not demonstrate the ability to consistently perform the simplest tasks TIMSS seeks to measure (they correctly completed less than half of the low benchmark tasks). In comparison there were three percent or fewer of students in the highest-performing countries below this low benchmark. There were also fewer really low performing middle primary students (those who did not reach the low benchmark) in the United States (4%), England (7%), and Australia (9%).

Included in the figure is the international median percentage of students at each benchmark. The proportion of New Zealand students reaching the advanced benchmark was the same as the international median percentage. However, for the other benchmarks, high, intermediate, and low, fewer New Zealand students reached these benchmarks compared with the international median.

Figure 1.2: Proportion of middle primary students at each international benchmark



Country	At or above low	At or above intermediate	At or above high	At or above advanced
	Cumulative percentage of students:			
Singapore	97 (0.4)	89 (0.9)	68 (1.7)	33 (1.7)
Korea, Rep. of	99 (0.1)	95 (0.4)	73 (1.0)	29 (1.5)
Finland	99 (0.3)	92 (0.8)	65 (1.7)	20 (1.1)
Russian Federation	98 (0.4)	86 (1.2)	52 (2.0)	16 (1.4)
Chinese Taipei	97 (0.4)	85 (1.1)	53 (1.3)	15 (0.9)
United States	96 (0.4)	81 (0.8)	49 (1.1)	15 (0.8)
Japan	99 (0.2)	90 (0.7)	58 (1.3)	14 (1.0)
Hungary	93 (0.9)	78 (1.5)	46 (2.0)	13 (0.9)
Romania	84 (1.8)	66 (2.3)	37 (2.3)	11 (0.9)
England	93 (0.7)	76 (1.3)	42 (1.6)	11 (0.9)
Sweden	95 (0.5)	79 (1.1)	44 (1.5)	10 (1.0)
Czech Republic	97 (0.7)	81 (1.1)	44 (1.5)	10 (0.9)
Slovak Republic	94 (1.0)	79 (1.8)	44 (1.7)	10 (1.0)
Hong Kong SAR	96 (1.2)	82 (1.5)	45 (2.1)	9 (0.9)
Austria	96 (0.6)	79 (1.7)	42 (1.6)	8 (0.8)
Denmark	95 (0.7)	78 (1.4)	39 (1.6)	8 (0.8)
Serbia	91 (1.0)	72 (1.5)	35 (1.7)	8 (0.7)
Italy	95 (1.0)	76 (1.3)	37 (1.6)	8 (0.7)
Australia	91 (1.0)	72 (1.3)	35 (1.4)	7 (0.7)
Portugal	95 (1.0)	75 (2.0)	35 (1.8)	7 (1.1)
Germany	96 (0.7)	78 (1.5)	39 (1.6)	7 (0.6)
Kazakhstan	84 (1.6)	58 (2.6)	28 (2.1)	7 (1.1)
Ireland	92 (0.9)	72 (1.6)	35 (1.7)	7 (0.9)
Slovenia	93 (0.6)	74 (1.3)	36 (1.6)	7 (0.6)
Poland	91 (0.8)	67 (1.2)	29 (1.5)	5 (0.5)
New Zealand	**86 (0.9)**	**63 (1.3)**	**28 (1.1)**	**5 (0.5)**
Northern Ireland	94 (1.0)	74 (1.3)	33 (1.6)	5 (0.6)
Spain	92 (1.2)	67 (1.6)	28 (1.5)	4 (0.6)
Lithuania	95 (0.6)	73 (1.2)	31 (1.6)	4 (0.5)
Thailand	78 (2.2)	52 (2.3)	20 (1.7)	4 (0.6)
Bahrain	70 (1.4)	43 (1.2)	17 (1.1)	4 (0.4)
Turkey	76 (1.5)	48 (1.7)	18 (1.3)	3 (0.4)
Croatia	96 (0.5)	75 (1.4)	30 (1.1)	3 (0.4)
United Arab Emirates	61 (1.0)	36 (0.9)	14 (0.6)	3 (0.3)
Netherlands	99 (0.4)	86 (1.4)	37 (1.8)	3 (0.5)
Iran, Islamic Rep. of	72 (1.5)	44 (1.7)	16 (1.2)	3 (0.4)
Saudi Arabia	63 (2.0)	35 (1.7)	12 (1.3)	3 (0.8)
Chile	85 (1.1)	54 (1.4)	19 (0.9)	2 (0.4)
Azerbaijan	65 (2.1)	37 (2.5)	13 (1.7)	2 (0.7)
Qatar	50 (1.5)	29 (1.3)	11 (1.0)	2 (0.5)
Malta	70 (1.1)	41 (1.0)	14 (0.7)	2 (0.3)
Belgium (Flemish)	96 (0.5)	73 (1.4)	24 (1.2)	2 (0.3)
Georgia	75 (1.6)	44 (1.8)	13 (1.2)	1 (0.4)
Oman	45 (1.5)	23 (1.0)	7 (0.7)	1 (0.3)
Norway	92 (0.8)	64 (1.7)	19 (1.2)	1 (0.2)
Armenia	58 (1.8)	26 (1.5)	6 (0.8)	1 (0.2)
Kuwait	37 (1.5)	16 (1.1)	4 (0.5)	1 (0.2)
Morocco	16 (1.0)	6 (0.7)	1 (0.4)	0 (0.1)
Tunisia	35 (1.9)	14 (1.1)	3 (0.4)	0 (0.1)
Yemen	6 (0.9)	2 (0.4)	0 (0.2)	0 (0.0)
International Median	**92**	**72**	**32**	**5**

Note: Standard errors appear in parentheses.
The proportion of students at or above the low benchmark includes those that achieved at higher benchmarks also.

Source: Exhibit 2.2, Martin, Mullis, Foy, and Stanco, 2012.

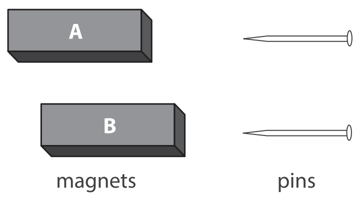
Figures 1.3 to 1.6 present examples of questions that Year 5 students achieving at or above the advanced (Figure 1.3), high (Figure 1.4), intermediate (Figure 1.5), and low (Figure 1.6) benchmarks were likely to have answered correctly. An example of a correct answer and a description of the intention of the question are presented. In addition, proportions of students successfully completing the question for a selection of countries, including the best performing country on that question, are shown. The international average is also presented as an indication of how students in all 50 countries performed on this question.

Figure 1.3: Example of a question students reaching the advanced benchmark are likely to have answered correctly

Content domain: physical science
Cognitive domain: reasoning
Description: infers that magnets have different strengths from an observation of magnets attracting pins from two different distances

Aroha has two magnets (A and B) and two metal pins that are the same.

She slides Magnet A along a table until a pin is attracted to the magnet.
She slides Magnet B along a table until a pin is attracted to the magnet.



She finds that Magnet A attracts the pin from 15cm and Magnet B attracts the pin from 10cm.

Steven says that both magnets are equally strong.

Do you agree?

(Tick one box.)

☐ Yes
☑ No

Explain your answer.

magnet A is stronger because it attracted the pin from farther away than magnet B did.

Country	Percent full credit	
Singapore	66	(2.0)
Japan	50	(1.8)
Chinese Taipei	47	(2.3)
Finland	41	(2.6)
United States	37	(1.4)
England	35	(2.4)
Slovenia	32	(2.2)
Norway	32	(3.4)
Hong Kong SAR	31	(2.3)
Northern Ireland	30	(2.3)
Netherlands	30	(2.1)
Ireland	28	(2.4)
Australia	27	(1.8)
Korea, Rep. of	27	(1.6)
Russian Federation	27	(1.9)
International Avg.	**26**	**(0.3)**
New Zealand	**25**	**(1.9)**
Malta	25	(1.9)

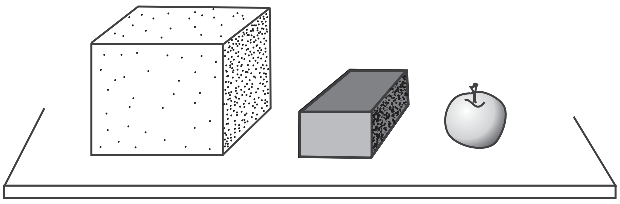
Note: Standard errors are presented in parentheses.

Source: Adapted from Exhibit 2.15, Martin, Mullis, Foy, and Stanco, 2012.

Figure 1.4: Example of a question students reaching the high benchmark are likely to have answered correctly

Content domain: physical science
Cognitive domain: reasoning
Description: justifies that objects with more volume do not necessarily weigh more using a diagram of three objects

Jack's teacher places three objects on a table, as shown below. She puts them in order according to their volume.



Jack thinks that objects with more volume weigh more.

Do you agree with him?

(Tick one box.)

☐ Yes

☑ No

Explain your answer.

It depends on what the object is made of. The brick is smaller than the styrofoam block but it is more dense so it probably weighs more.

Country	Percent full credit	
Chinese Taipei	74	(2.2)
Russian Federation	71	(1.9)
Finland	71	(2.3)
Korea, Rep. of	68	(1.9)
Norway	62	(2.4)
Singapore	52	(2.0)
Hong Kong SAR	49	(2.2)
United States	46	(1.5)
Japan	45	(2.3)
Slovenia	43	(2.1)
Australia	43	(2.2)
International Avg.	**42**	**(0.3)**
Netherlands	40	(2.7)
Northern Ireland	40	(2.1)
Ireland	39	(3.4)
England	39	(2.7)
New Zealand	**39**	**(2.2)**
Malta	19	(1.8)

Note: Standard errors are presented in parentheses.

Source: Adapted from Exhibit 2.11, Martin, Mullis, Foy, and Stanco, 2012.

Figure 1.5: Example of a question students reaching the intermediate benchmark are likely to have answered correctly

Content domain: Earth science
Cognitive domain: knowing
Description: states one form of energy Earth receives from the sun

Write down one form of energy Earth receives from the sun.

Light

Country	Percent full credit	
Singapore	82	(1.5)
Korea, Rep. of	79	(1.7)
Hong Kong SAR	73	(1.9)
Northern Ireland	69	(2.4)
Ireland	68	(2.4)
England	66	(2.6)
Australia	63	(2.3)
United States	63	(1.4)
Chinese Taipei	61	(2.1)
Japan	59	(2.0)
Norway	57	(3.1)
New Zealand	**56**	**(2.0)**
Finland	55	(2.5)
International Avg.	**54**	**(0.3)**
Slovenia	53	(3.2)
Malta	38	(2.3)

Note: Standard errors are presented in parentheses.

Source: Adapted from Exhibit 2.9, Martin, Mullis, Foy, and Stanco, 2012.

Figure 1.6: Example of a question students reaching the low benchmark are likely to have answered correctly

Content domain: life science
Cognitive domain: applying
Description: recognises that wings are common to birds, bats, and butterflies

What do birds, bats and butterflies have in common?

Ⓐ feathers
Ⓑ hair
Ⓒ internal skeleton
● wings

Country	Percent full credit	
Korea, Rep. of	99	(0.3)
United States	96	(0.5)
Singapore	95	(0.7)
Finland	95	(0.9)
Ireland	95	(0.9)
England	94	(1.4)
Norway	93	(1.3)
New Zealand	**93**	**(1.2)**
Australia	92	(1.5)
Slovenia	91	(1.3)
Northern Ireland	91	(2.0)
Japan	87	(1.5)
International Avg.	**83**	**(0.2)**
Chinese Taipei	83	(1.5)
Malta	82	(1.6)
Hong Kong SAR	79	(2.1)

Note: Standard errors are presented in parentheses.

Source: Adapted from Exhibit 2.5, Martin, Mullis, Foy, and Stanco, 2012.

Science content and cognitive domains

Questions for the TIMSS tests were written to assess the content and cognitive aspects as described in the *TIMSS 2011 assessment frameworks* (Mullis, Martin, et al., 2009). Scores were created for each of these domains so that they are comparable with each other. Note that in previous cycles of TIMSS a score of 500 on one domain was not directly comparable to 500 on another domain, but this new methodology ensures they are. The content domains describe the subject matter to be assessed. In science at the middle primary level the content domains are *life science*, *physical science*, and *Earth science*. The cognitive domains describe the thinking processes to be assessed. They describe the sets of behaviours expected of students as they engage with the content. The cognitive domains are entitled *knowing*, *applying*, and *reasoning*.

There was no consistent pattern across countries when content domains were compared. In the Republic of Korea, *Earth science* was a relative strength, whereas in Singapore *Earth science* was a relative weakness. New Zealand middle primary students performed relatively better on *Earth science* and *life science* questions compared with *physical science*.

Table 1.5: Achievement in science content domains for selected countries

Country	Life science		Physical science		Earth science	
Korea, Rep. of	571	(2.2)	597	(2.6)	603	(1.8)
Singapore	597	(4.3)	598	(3.5)	541	(3.0)
Finland	574	(2.8)	568	(2.8)	566	(2.9)
Japan	540	(1.9)	589	(1.9)	551	(1.8)
Chinese Taipei	538	(2.4)	569	(2.0)	553	(2.5)
United States	547	(2.1)	544	(2.0)	539	(2.1)
Hong Kong SAR	524	(3.7)	539	(4.4)	548	(3.3)
England	530	(2.8)	535	(3.5)	522	(3.8)
Slovenia	524	(2.6)	524	(3.4)	506	(2.7)
Northern Ireland	519	(2.9)	520	(3.2)	507	(2.7)
Ireland	513	(3.6)	517	(3.1)	520	(3.8)
Australia	516	(3.1)	514	(3.2)	520	(3.5)
New Zealand	**497**	**(2.5)**	**493**	**(2.7)**	**499**	**(3.2)**
Norway	496	(3.0)	482	(3.4)	506	(3.0)
Malta	439	(2.4)	453	(2.5)	447	(2.2)

Note: Standard errors are presented in parentheses.

Source: Adapted from Exhibit 3.1, Martin, Mullis, Foy, and Stanco, 2012.

With the exception of Finland, most of the high-achieving countries had *reasoning* as the highest of the three cognitive domains (see Table 1.6). In Finland, *knowing* was the highest of the three cognitive domains. In New Zealand, there was no difference in achievement across the three cognitive domains, *knowing*, *applying*, or *reasoning*.

Table 1.6: Achievement in science cognitive domains for selected countries

Country	Knowing		Applying		Reasoning	
Korea, Rep. of	570	(2.0)	593	(1.9)	605	(3.0)
Singapore	570	(3.4)	590	(4.0)	597	(3.8)
Finland	579	(2.5)	568	(2.3)	560	(3.2)
Japan	538	(1.8)	562	(1.6)	591	(2.0)
Chinese Taipei	542	(2.7)	552	(3.1)	568	(3.2)
United States	546	(1.9)	544	(2.1)	537	(2.3)
Hong Kong SAR	537	(3.6)	529	(3.5)	541	(4.2)
England	529	(3.2)	532	(3.1)	526	(4.4)
Slovenia	518	(2.2)	518	(2.8)	525	(3.6)
Northern Ireland	517	(2.9)	521	(2.6)	503	(3.1)
Ireland	518	(3.9)	517	(3.6)	509	(3.4)
Australia	517	(2.8)	513	(3.0)	518	(3.4)
New Zealand	**496**	**(2.7)**	**497**	**(2.6)**	**497**	**(2.9)**
Norway	502	(2.8)	487	(2.8)	493	(3.7)
Malta	437	(3.0)	449	(1.6)	459	(4.2)

Note: Standard errors are presented in parentheses.

Source: Adapted from Exhibit 3.3, Martin, Mullis, Foy, and Stanco, 2012.

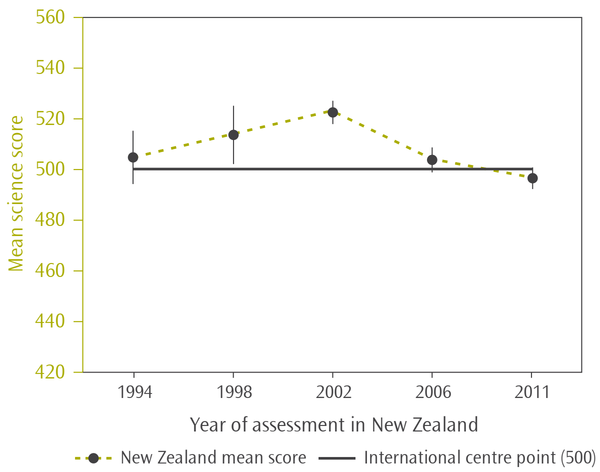
2. Trends in New Zealand science achievement 1994 to 2011

New Zealand has participated in TIMSS since its inception in 1994. In 1998, although no assessment was offered internationally at the middle primary level, New Zealand opted to repeat the 1994 assessment. Therefore, we now have information from five assessments of science achievement. This chapter will present trends for New Zealand in means, distributions, benchmarks, item statistics, and the content and cognitive domains.

Trends in means and ranges since 1994

Mean science achievement steadily increased between 1994 and 2002. However, since 2002 achievement has significantly decreased (see Figure 2.1). Both of the decreases in achievement between 2006 and 2011, and between 2002 and 2006, are significant. These decreases meant that mean science achievement in 2011 was back to the level observed in 1994 (no significant difference). As mentioned in the previous chapter, New Zealand's mean score in 2011 was not significantly different from the international scale centre point (500).

Figure 2.1: Mean science achievement of New Zealand Year 5 students from 1994 to 2011

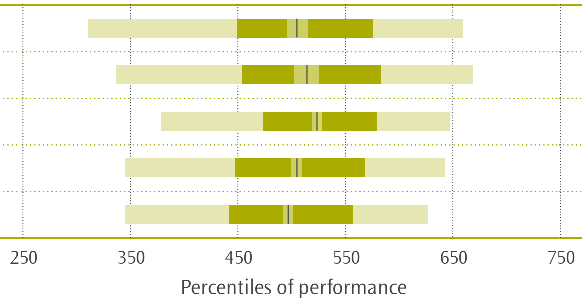


Note: The values for the points are shown in Figure 2.2.

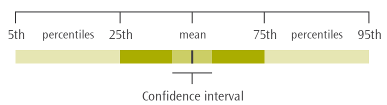
In addition to looking at the mean achievement of students, it is useful to look at the range of achievement among the students. Considerable commentary on the 'tail of underachievement' has occurred in the last few years. Therefore, it is important to explore whether any changes have happened across the spectrum of achievement. Figure 2.2 presents achievement at the 5th, 25th, 75th, and 95th percentiles. The lower limit of achievement, the 5th percentile, is the score at which five percent of students achieved a lower score. The upper limit of achievement, the 95th percentile, is the score at which five percent of students achieved a higher score.

Figure 2.2: Distribution of science achievement of New Zealand Year 5 students from 1994 to 2011

Year	Mean science score	Distribution of science achievement	Range from 5th to 95th percentile	Inter-quartile range from 25th to 75th percentile
1994	505 (5.3)		349	128
1998	514 (5.9)		332	129
2002	523 (2.3)		269	106
2006	504 (2.6)		299	121
2011	497 (2.3)		281	116



Note: Standard errors are presented in parentheses.



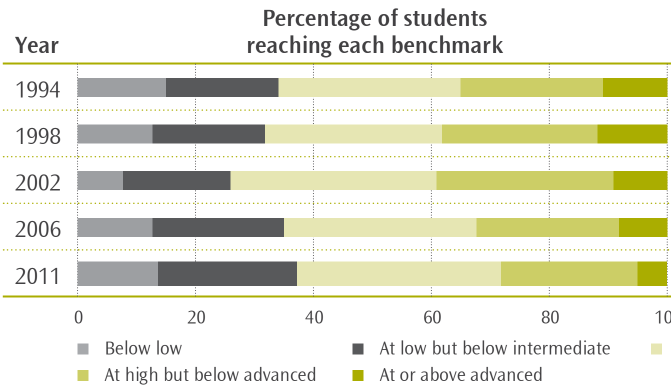
As shown in Figure 2.2, the range of achievement was relatively narrow in 2011, but the most narrow in 2002. However, both the top and bottom of the distribution, as well as the mean for 2011, were considerably lower than in 2002.

Trends in benchmarks for science

As mentioned earlier, in order to describe more fully what achievement on the science scale means, the TIMSS international researchers have developed benchmarks. These benchmarks link student performance on the TIMSS science scale to performance on science questions and describe what students can typically do at set points on the science achievement scale. Figure 2.3 presents those Year 5 students achieving at each of the benchmarks (as shown in the graphical part) and those achieving at or above each of the benchmarks (as shown in the table part) in each cycle from 1994 to 2011.

As noted earlier when comparing 2002 and 2011, the whole distribution had shifted lower (top, bottom and mean). Indeed, the proportion of students reaching the low benchmark in 2011 (86%) was a lot lower than 2002 (92%) but similar to all the other cycles. For the high and advanced benchmarks the proportion of students reaching these in 2011 was considerably lower than all other cycles (see Figure 2.3).

Figure 2.3 Trends in proportions of New Zealand Year 5 students at each benchmark from 1994 to 2011



Year	Cumulative percentage of students: At or above low		At or above intermediate		At or above high		At or above advanced	
1994	85	(1.7)	66	(1.8)	35	(1.8)	11	(1.2)
1998	87	(1.6)	68	(2.4)	38	(2.3)	12	(1.4)
2002	92	(0.7)	74	(1.3)	39	(1.3)	9	(0.7)
2006	87	(1.0)	65	(1.2)	32	(1.0)	8	(0.5)
2011	86	(0.9)	63	(1.3)	28	(1.1)	5	(0.5)

Note: Standard errors are presented in parentheses.

"At or above" means that the proportion of students at the benchmark includes those that achieved at higher benchmarks also. For example, the 86% of students in 2011 that achieved at or above the low benchmark includes 24% who achieved at the low benchmark, 34% at the intermediate, 23% at the high, and 5% at the advanced benchmark.

Trends on the science test questions from 2006 to 2011

At the end of each cycle of TIMSS, test questions are released into the public domain. At the beginning of the next cycle, new questions are developed to replace released questions. In addition, each cycle of TIMSS includes some questions from previous cycles to provide a trend measure over time. This section presents an analysis of the trend questions included in both TIMSS 2006/07 and 2010/11.

There were 70 questions common to both 2006 and 2011. Of these 70 questions, 14 questions had similar proportions of New Zealand Year 5 students correctly answering them across the two cycles (as shown in Table 2.1). More than half of the questions (41) showed a decline; that is they were correctly answered by fewer students in 2011 compared with 2006. In contrast, less than one-quarter of questions showed an increase; that is they were correctly answered by more students in 2011 compared with 2006.

These item statistics confirm the decrease shown in the overall mean. Note that the decreases were spread across all content areas: *life*, *physical*, and *Earth science* but proportionately more questions were in *Earth science*.

Table 2.1: Trends in proportions of New Zealand Year 5 students correctly answering science questions common to 2006 and 2011

	Change between 2006 and 2011				
	decrease by 5% or more	decrease by greater than 1% and less than 5%	increase or decrease by 1% or less	increase by greater than 1% and less than 5%	increase by 5% or more
Number of questions	17	24	14	13	2

Trends in science content and cognitive domains from 2006 to 2011

As mentioned earlier, questions for the TIMSS tests were written to assess the content and cognitive aspects as described in the *TIMSS 2011 assessment frameworks* (Mullis, Martin, et al., 2009). Scores were created for each of these domains using a different methodology from previous cycles (see previous chapter for details). This new methodology was applied to the questions in the 2006/07 assessment to create revised domain scores for this cycle. Therefore, comparisons can be made between 2006 and 2011 but not with earlier cycles.

In terms of content, there was a significant decrease in the mean scale score for two domains: *life science* (8 points), and *Earth science* (14). In contrast, the change in the *physical science* domain was not significant. In terms of cognitive abilities required, the only significant change was a decrease in the *knowing* domain (15 points). As can be seen from Table 2.2, *Earth science* remains an area of strength for New Zealand Year 5 students while *physical science* still remains a relative weakness.

Table 2.2: New Zealand Year 5 mean science scores on the content and cognitive domains in 2006 and 2011

	2011 mean scale score		2006 mean scale score		Difference	
Content domain						
Life Science	497	(2.5)	506	(2.8)	-8	(3.7)
Physical Science	493	(2.7)	494	(3.4)	-1	(4.3)
Earth Science	499	(3.2)	513	(3.4)	-14	(4.7)
Cognitive domain						
Knowing	496	(2.7)	511	(3.4)	-15	(4.3)
Applying	497	(2.6)	496	(2.7)	1	(3.7)
Reasoning	497	(2.9)	503	(4.0)	-6	(5.0)

Note: Due to rounding some results may appear inconsistent.
Standard errors are presented in parentheses.

3. TIMSS and the New Zealand science curriculum

The New Zealand curriculum guides teaching and learning. The alignment of curriculum levels with year levels is flexible. Teachers are expected to tailor lessons to meet students' individual needs. Students in the same year level may be working at different curriculum levels as appropriate to their abilities and pace of progression. As with previous cycles of TIMSS, teachers have given indications of what topics they have taught in the current school year to their Year 5 students and the curriculum level the majority of their Year 5 students are working at. This section will examine what is implemented in terms of the curriculum as well as the match between the TIMSS test and the intended curriculum.

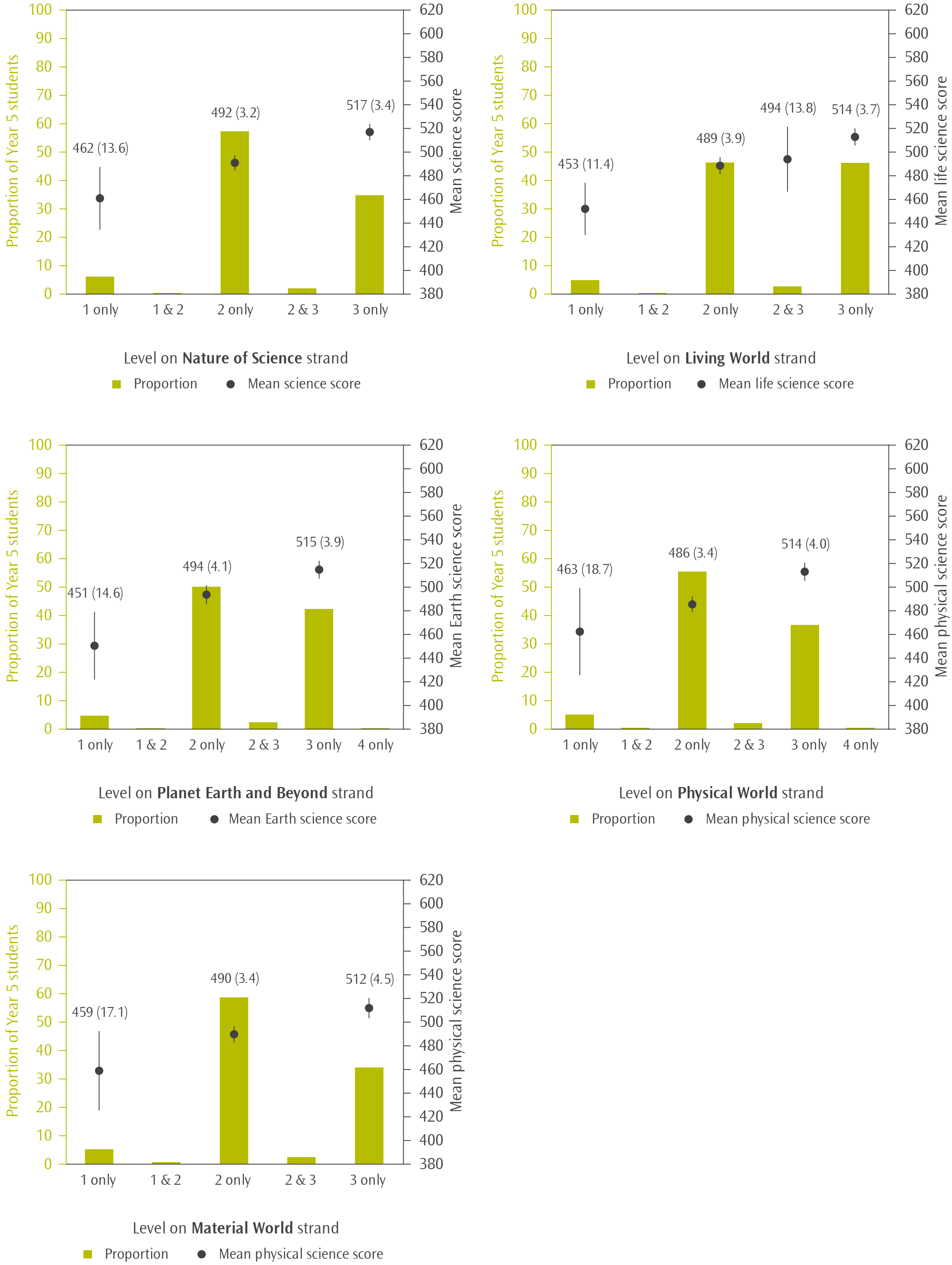
Science curriculum levels and the TIMSS content domains

New Zealand teachers were asked at which level(s) of Science in the New Zealand Curriculum were most of the Year 5 students in their class working for each of the strands: *nature of science, living world, physical world, material world*, and *planet Earth and beyond*. Figure 3.1 shows that the proportions of students working at level 3 of the curriculum varied across strands from nearly half on the *living world* strand (46%) down to around one third (34%) on the *material world* strand. Note that for questions about science teaching at this schooling level a significant proportion of teachers (around 15%) did not answer some or all questions about science, some stating that they did not teach science this year.

We can use the TIMSS content domains to examine attainment on the curriculum strands due to their similar science content. For example, the *life science* content domain for middle primary in TIMSS consists of: characteristics and life processes of living things, life cycles, reproduction, and heredity, interaction with the environment, ecosystems, and human health (see Mullis, Martin, Ruddock, O'Sullivan, Preuschoff, 2009). Similarly, the *living world* strand at level 3 of the New Zealand curriculum consists of: life processes, ecology, evolution (Ministry of Education, 2007). Within the New Zealand curriculum, human health is covered under the health and physical education learning area. Figure 3.1 shows that students whose classes are working at higher levels of the curriculum have higher achievement on the associated TIMSS content domain.

Examining these results in the international context shows that if we only included those Year 5 students working at level 3 of the curriculum in the TIMSS testing, New Zealand would still have a lower mean score than the high-performing countries (the Republic of Korea, Singapore, Finland, Japan, the Russian Federation, and Chinese Taipei). For example the average score for New Zealand students working at level 3 of the *planet Earth and beyond* strand of the curriculum is still significantly lower on the *Earth science* content domain (515) than their Korean counterparts (603 scale score points).

Figure 3.1: Curriculum levels and New Zealand Year 5 student achievement on content domains



Note: The bars on the graph represent proportions of Year 5 students whose class were working at that level of the curriculum. The points represent mean scores on the appropriate content domain while the lines extending from those points represent the 95% confidence interval associated with estimating the mean of the population from the sample. No mean achievement is presented for groups smaller than 2%.

Curriculum match

Questions about international studies often focus on the appropriateness of the assessment questions for New Zealand students. New Zealand is not unique in asking this question; other countries are also concerned with appropriateness of the tests. The TIMSS assessment questions are developed through a collaborative process that begins with the development of an assessment framework. The *TIMSS 2011 assessment frameworks* (Mullis, Martin, et al., 2009) were designed to specify the important aspects of science that participating countries agreed should be the focus of an international assessment of science achievement. However it is inevitable that the tests included questions that were unfamiliar to some students in some countries. In order to investigate the extent to which the TIMSS 2010/11 assessment was relevant to each country's curriculum, TIMSS conducted a Test-Curriculum Matching Analysis (TCMA). The TCMA was also used to investigate the impact of selecting only appropriate questions on a country's performance.

For the TCMA, each assessment question was examined using the following two criteria:

- whether or not the topic of the question is in the intended curriculum for the majority (50 percent or more) of middle primary students in the grade or school level tested (in our case Year 5); and
- whether or not the item topic was intended to be encountered by the students prior to the TIMSS testing (in our case September and October 2011).

While all questions, regardless of this analysis, were included in any overall results reported for TIMSS, this analysis was used to ascertain the level to which the results might change for New Zealand if only questions judged appropriate were included in the tests. The analysis also included an examination of how students in other countries would fare if given only the "New Zealand-appropriate" test.

Table 3.1 shows the proportion of questions considered appropriate to the New Zealand curriculum in each of the TIMSS content areas. However, it should be noted that New Zealand's science curriculum provides some challenges for deciding whether or not at least half of Year 5 students are likely to have met the question topics in the TIMSS test. The curriculum is not prescriptive, instead providing some broad guidelines of science concepts and skills that schools can choose to cover. Schools are encouraged to design science programmes that are relevant to their students and communities. Consequently, when schools plan their science programmes there is considerable variation between them. Another challenge is that the broad achievement objectives are grouped in levels that cover approximately two years of schooling. A further challenge is that some schools teach science integrated into other curriculum areas as part of 'topic' or an 'inquiry model'. Based on the approach these schools take to teaching, some schools may not cover science in a particular calendar year, rather concentrating on it in the next or previous year to the year of the TIMSS assessment (as mentioned earlier).

As shown in the previous section, New Zealand Year 5 students were generally working at levels 2 and 3 of the curriculum, so information from levels 1, 2, and 3 was used to guide judgements on the TCMA. In addition, curriculum-matched resources available on http://scienceonline.tki.org.nz/ including the building science concept series were used for further clarification.[7]

7 Thanks to Pamela Snow, Peter Saunders, Anthony Watt, Margaret Vaka-Vivili, and Elizabeth Sio-Atoa for their contributions to this work.

Table 3.1: Appropriateness of the TIMSS tests to the New Zealand Curriculum

TIMSS content domain	Number of score points judged appropriate for New Zealand curriculum	Number of score points in TIMSS assessment	Proportion of score points judged appropriate for New Zealand curriculum
Life Science	58	82	71%
Physical Science	49	64	77%
Earth Science	32	38	84%
Total	139	184	76%

Note: Life science corresponds to the living world strand in the curriculum, physical science corresponds to the physical and material world strands in the curriculum, and Earth science corresponds to the planet Earth and beyond strand in the curriculum.

As Table 3.1 shows 76 percent of the TIMSS questions were judged appropriate for New Zealand students in terms of the curriculum expectations. However, the TCMA analysis shows that even if the TIMSS test was reduced to include only those questions considered appropriate to the New Zealand curriculum, the average New Zealand Year 5 student would have got just over half the items correct (see Table 3.2). In contrast, the average student in some of the high performing countries would have got around two thirds of the items correct.

Table 3.2: Performance of middle primary students from selected countries on the New Zealand appropriate test in 2010/11

Country	Average percent correct on New Zealand test
Singapore	68
Korea, Rep. of	68
Finland	65
Japan	62
Chinese Taipei	63
Russian Federation	61
United States	60
Hong Kong SAR	60
England	57
Netherlands	57
Ireland	55
Northern Ireland	55
Australia	55
New Zealand	**51**

Source: Adapted from Exhibit F.1 in Martin, Mullis, Foy, and Stanco, 2012.

Coverage of science topics

Teachers provided information on science topics taught to Year 5 students prior to or during the year of the TIMSS assessment. For each of 20 topics, teachers were asked if the topic was *mostly taught before this year*, *mostly taught this year*, or *not yet taught or just introduced*. Just over half of students had been taught all these topics in 2011 or the preceding years (54% of students). In comparison, just under two-thirds of students (64%) on average across countries had been taught all these 20 topics (range from 38% in Japan to 93% in Kuwait).

More New Zealand students had been taught *life science* topics in 2011 or the preceding years (66%) than *Earth science* topics (56%) or *physical science* topics (44%). Note that this question was not about the proportion of time spent on these but rather the coverage of items in the *TIMSS 2011 assessment frameworks* (Mullis, Martin, et al., 2009). The TIMSS framework guided the writing of questions for the TIMSS assessment and the final formulation of the test. As mentioned earlier, *Earth science* and *life science* are the areas of TIMSS where New Zealand students show the best performance while *physical science* was lower.

The science topics covered by fewer than half of all New Zealand students were:

- Classification of objects/materials based on physical properties (e.g., weight/mass, volume, magnetic attraction) (42%);
- Forming and separating mixtures (34%);
- Familiar changes in materials (e.g., decaying, burning, rusting, cooking) (40%);
- Light (e.g., sources, behaviour) (37%);
- Electrical circuits and properties of magnets (40%);
- Forces that cause objects to move (e.g., gravity, push/pull forces) (47%); and
- Fossils of animals and plants (age, location, formation) (34%).

Table 3.3 shows a complete list of topics and coverage among New Zealand Year 5 students.

The relationship between coverage and achievement is complicated with high achieving countries having average to low coverage of topics.

Table 3.3: Science topics taught to Year 5 students in New Zealand before or during 2011

Topic	Proportion of students in classes where the topic was taught before or during 2011
Life Science	
Major body structures and their functions in humans and other organisms (plants and animals)	67
Life cycles and reproduction in plants and animals	70
Physical features, behaviour, and survival of organisms living in different environments	59
Relationships in a given community (e.g., simple food chains, predator-prey relationships)	67
Changes in environments (effects of human activity, pollution and its prevention)	72
Human health (e.g., transmission/prevention of communicable diseases, signs of health/illness, diet, exercise)	62
Physical Science	
States of matter (solids, liquids, gases) and differences in their physical properties (shape, volume), including changes in state of matter by heating and cooling	52
Classification of objects/materials based on physical properties (e.g., weight/mass, volume, magnetic attraction)	42
Forming and separating mixtures	34
Familiar changes in materials (e.g., decaying, burning, rusting, cooking)	40
Common energy sources/forms and their practical uses (e.g., the Sun, electricity, water, wind)	61
Light (e.g., sources, behaviour)	37
Electrical circuits and properties of magnets	40
Forces that cause objects to move (e.g., gravity, push/pull forces)	47
Earth Science	
Water on Earth (location, types, and movement) and air (composition, proof of its existence, uses)	52
Common features of Earth's landscape (e.g., mountains, plains, rivers, deserts) and relationship to human use (e.g., farming, irrigation, land development)	51
Weather conditions from day to day or over the seasons	68
Fossils of animals and plants (age, location, formation)	34
Earth's solar system (planets, Sun, moon)	71
Day, night, and shadows due to Earth's rotation and its relationship to the Sun	59

4. Science achievement of Year 5 boys and girls

The Government sets the National Education Goals (NEGs) to recognise the fundamental importance of education to New Zealand. The first of these goals seeks to have "the highest standards of achievement, through programmes which enable all students to realise their full potential as individuals, and to develop the values needed to become full members of New Zealand's society" (Ministry of Education, 2009). Currently the focus is on the outcomes of boys in the New Zealand system rather than girls. Some New Zealand boys appear not to be reaching their full potential in our current education system (Ministry of Education, 2007). Qualification data shows different proportions of boys and girls having success (see for example http://www.educationcounts.govt.nz/statistics/schooling/ncea-attainment/ncea-achievement-data-roll-based/ncea-attainment). This chapter will examine the science achievement of Year 5 boys and girls in TIMSS in 2011 with some comparisons with previous cycles.

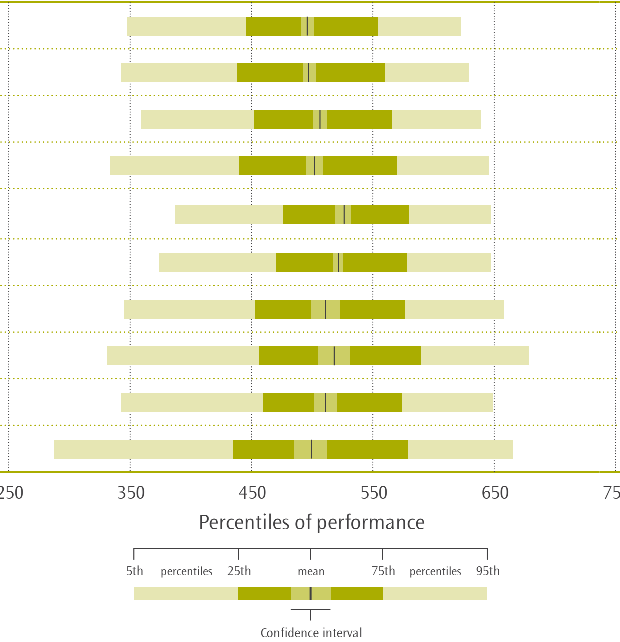
Science achievement of boys and girls

New Zealand boys and girls both had nearly the same mean science score (496 for girls and 497 for boys) in 2011. However, the range of achievement for boys was wider than for girls (as shown in Figure 4.1). This pattern is consistent with most of the previous cycles of TIMSS, where there was no significant difference in mean science achievement but a wider range for boys than for girls, with the exception of 1994. In 1994, girls had significantly higher mean science achievement than boys (12 scale score points difference).

Since 1994 the range of achievement has generally been decreasing for boys although 2002 remains the narrowest for them. Girls, however, had the widest range of achievement in 1998 and the narrowest in 2002.

Figure 4.1: Trends in distributions of achievement for New Zealand girls and boys from 1994 to 2011

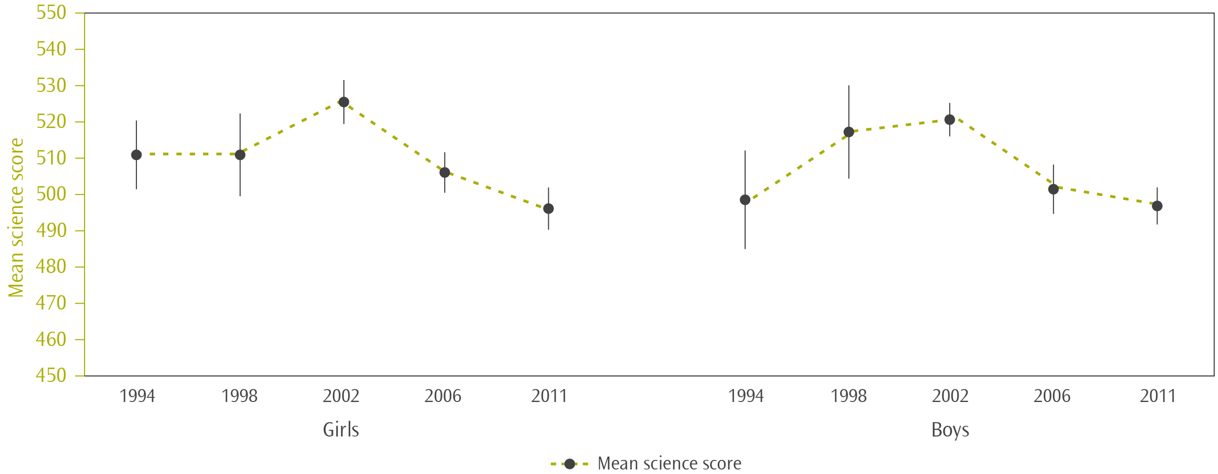
Year		Mean science score	Distribution of science achievement	Range from 5th to 95th percentile	Inter-quartile range from 25th to 75th percentile
2011	Girls	496 (3.0)		275	110
	Boys	497 (2.6)		288	122
2006	Girls	506 (2.8)		281	114
	Boys	502 (3.5)		313	130
2002	Girls	526 (3.2)		260	104
	Boys	521 (2.3)		274	108
1998	Girls	511 (5.9)		313	124
	Boys	518 (6.6)		348	134
1994	Girls	511 (4.8)		308	115
	Boys	499 (7.0)		379	145



Note: Standard errors are presented in parentheses.

Figure 4.2 presents trends in mean achievement for girls and boys. As Figure 4.2 shows, mean science achievement increased between 1994 and 2002 for boys and between 1998 and 2002 for girls. Since 2002, however, there has been a significant decrease in mean achievement for both boys and girls with a larger decrease for girls than for boys.

Figure 4.2: Trends in mean achievement for New Zealand girls and boys from 1994 to 2011



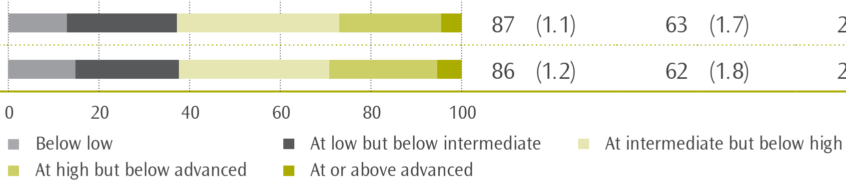
Note: The lines extending from the points represent the 95% confidence interval, i.e., the range in which we are 95 percent confident that the true population value lies.

Benchmarks for boys and girls

There was no significant difference in the proportions of girls and boys reaching each of the benchmarks as shown in Figure 4.3. There were significant proportions of both boys (14%) and girls (13%) who did not reach the low benchmark – these students did not demonstrate the ability to complete the basic science tasks that TIMSS seeks to measure.

Figure 4.3: Proportion of New Zealand boys and girls reaching each science international benchmark in 2011

	Percentage of students reaching each benchmark	Cumulative percentage of students: At or above low	At or above intermediate	At or above high	At or above advanced
Girls		87 (1.1)	63 (1.7)	27 (1.6)	5 (0.7)
Boys		86 (1.2)	62 (1.8)	29 (1.5)	6 (0.7)



Note: Standard errors are presented in parentheses.

"At or above" means that the proportion of students at the benchmark includes those that achieved at higher benchmarks also. For example, the 87% of girls that achieved at or above the low benchmark includes 24% who achieved at the low benchmark, 36% at the intermediate, 23% at the high, and just under 5% at the advanced benchmark.

Although it appears there have been some small changes in the proportions of boys and girls reaching each of the benchmarks since 2006, only the change in the proportion of boys and girls reaching the advanced benchmark is statistically significant (see Table 4.1). There were fewer girls and fewer boys with advanced achievement in 2011 compared with 2006, as measured by the proportion that reached the advanced benchmark.

Table 4.1: Proportion of New Zealand boys and girls reaching each science international benchmark in 2006

	Cumulative percentage of Year 5 students at or above each benchmark			
	Low	Intermediate	High	Advanced
Girls	89 (0.9)	67 (1.6)	31 (1.4)	7 (0.7)
Boys	85 (1.3)	63 (1.5)	33 (1.6)	9 (0.9)

Note: Standard errors appear in parentheses.

Achievement on the content and cognitive domains for boys and girls.

While there was no overall difference in mean science achievement between boys and girls, boys had significantly higher achievement on the *Earth science* questions compared with girls. Although there appeared to be differences on other content and cognitive domains, none of these were statistically significant.

Table 4.2: New Zealand Year 5 mean science scores on the content and cognitive domains by gender

	Mean domain score	
Content domain	Girls	Boys
Life Science	499 (3.2)	496 (3.1)
Physical Science	493 (3.1)	494 (3.2)
Earth Science	494 (4.3)	504 (3.2) ▲

	Mean domain score	
Cognitive Domain	Girls	Boys
Knowing	494 (3.1)	498 (3.3)
Applying	497 (3.3)	498 (2.8)
Reasoning	501 (3.8)	492 (3.8)

Note: ▲ mean domain score was significantly higher than other gender.

Standard errors are presented in parentheses.

Source: Exhibits 3.9 & 3.11, Martin, Mullis, Foy, and Stanco, 2012.

5. Science achievement, ethnicity of students, and language of the home

The Ministry of Education is currently placing priority on improving outcomes for Māori learners and for Pasifika learners (as well as students with special needs and those with low socio-economic status). While this is not a new focus, with previous documents and programmes aimed in this direction, it is important to review our progress towards this goal. It is not the ethnicity of these groups per se that influences outcomes but rather ethnicity can be indicative of underlying social, cultural, educational, and economic influences. Thus the existence of a relationship between ethnicity and achievement demonstrated in this section does not imply that being classified in a particular ethnic group is a cause of poor or good achievement. This section will examine science achievement among ethnic groupings and language users.

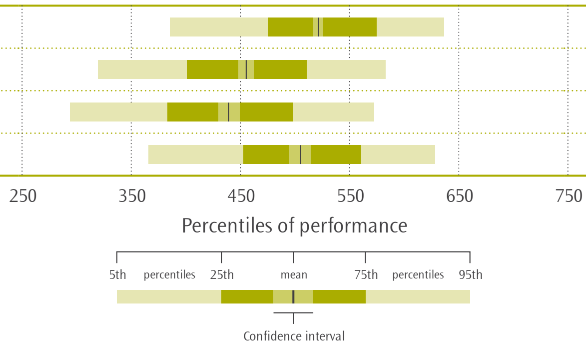
Science achievement among ethnic groupings

Five broad categories are used to describe ethnicity in this report: Pākehā/European, Māori, Pasifika, Asian, and 'Other'.[8] The majority of students were classified as Pākehā/European (58%) or Māori (20%). Of the remainder, 11 percent were classified as Pasifika, nine percent as Asian and only one percent as 'Other'.

As shown in Figure 5.1, there was a range of achievement within each ethnic grouping, with the widest range among Pasifika students. On average, Pākehā/European and Asian students had higher achievement than Māori and Pasifika students.

Figure 5.1: Distribution of New Zealand Year 5 science achievement for each ethnic grouping in TIMSS 2011

Ethnic grouping	Mean science score	Distribution of science achievement	Range from 9th to 95th percentile	Inter-quartile range from 25th to 75th percentile
Pākehā/European	522 (2.3)		252	100
Māori	455 (3.6)		263	110
Pasifika	439 (5.0)		280	115
Asian	505 (5.1)		262	108



Note: There were too few students in the 'Other' ethnic grouping to report achievement.

Standard errors are presented in parentheses.

8 Note that information was collected from both schools and students and the data presented summarises this information. Also note that although students were able to identify more than one ethnic grouping, each student was assigned to only one group using prioritisation as per previous cycles. This allows groups to be compared with each other. See the appendix for the results of multiple categorisation of ethnicity.

In terms of trends over time, the average science achievement of Pākehā/European students has shown a significant decrease since 1994. While the increase for Asian students is of a similar magnitude to the decrease of Pākehā/European students, due to the higher uncertainty (represented by high standard errors) around their 1994 result, this increase is not statistically significant. Between 2006 and 2011 there has been a significant decrease in the average science achievement of Asian students. Although the differences in the average results between 2006 and 2011 for Māori and Pasifika students are not significant, it is of particular concern that the decrease observed between 2002 and 2006 has been maintained.

Table 5.1: Trends in New Zealand science achievement 1994 to 2011 by ethnic grouping

	Mean science achievement										Change	
Ethnic grouping	1994		1998		2002		2006		2011		1994 to 2011	
Pākehā/European	534	(3.9)	541	(4.8)	532	(3.0)	528	(2.3)	522	(2.3)	-12	(4.5)
Māori	457	(12.0)	478	(8.0)	509	(4.9)	459	(4.9)	455	(3.6)	-2	(12.5)
Pasifika	441	(14.9)	436	(13.8)	496	(5.2)	431	(5.4)	439	(5.0)	-2	(15.7)
Asian	493	(16.7)	517	(10.0)	529	(4.2)	529	(6.8)	505	(5.1)	12	(17.5)

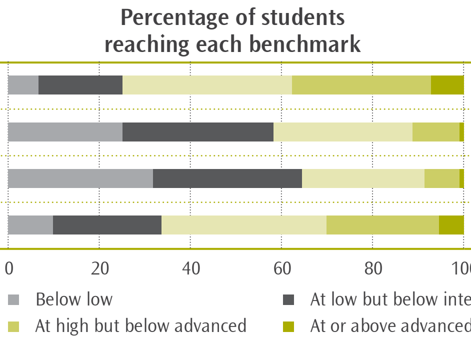
Note: Due to rounding some results may appear inconsistent.

Standard errors are presented in parentheses.

Benchmarks of science achievement among ethnic groupings

The TIMSS benchmarks provide an understanding of achievement beyond mere averages and ranges (see Chapter 1 for details of these benchmarks). There were high achieving students in all ethnic groupings as measured by the high and advanced benchmarks. However, there were larger proportions of Asian and Pākehā/European students in these high achieving groups compared with Māori and Pasifika students. As shown in Figure 5.2 there were students in all ethnic groupings who did not demonstrate the ability to complete a reasonable number of the simplest science tasks which TIMSS seeks to measure (that is they did not reach the low benchmark). However, there were larger proportions of Māori and Pasifika students in this very low achieving group (below the low benchmark) compared with Asian and Pākehā/European students.

Figure 5.2: Proportion of New Zealand Year 5 students reaching each international science benchmark by ethnic grouping



	Cumulative percentage of students:							
Ethnic grouping	At or above low		At or above intermediate		At or above high		At or above advanced	
Pākehā/European	93	(0.7)	75	(1.4)	38	(1.4)	7	(0.7)
Māori	75	(1.8)	42	(2.8)	12	(1.8)	1	(0.4)
Pasifika	69	(3.0)	35	(2.3)	9	(1.3)	1	(0.5)
Asian	90	(1.8)	66	(3.1)	30	(2.8)	6	(1.2)

Note: Standard errors are presented in parentheses.

"At or above" means that the proportion of students at the benchmark includes those that achieved at higher benchmarks also. For example, the 93% of Pākehā/European students that achieved at or above the low benchmark includes 18% who achieved at the low benchmark, 37% at the intermediate, 31% at the high, and 7% at the advanced benchmark.

There were proportionately fewer higher achieving Asian students (at the high and advanced benchmarks) this cycle (2011) compared with the previous cycle (2006 – see Table 5.2). Similarly there were proportionately fewer very high achieving Pākehā/European students (at the advanced benchmark) this cycle (2011) compared with the previous cycle. The proportions for Māori and Pasifika students are similar to the previous cycle.

Table 5.2: Proportion of New Zealand Year 5 students reaching each international science benchmark in 2006, by ethnic grouping

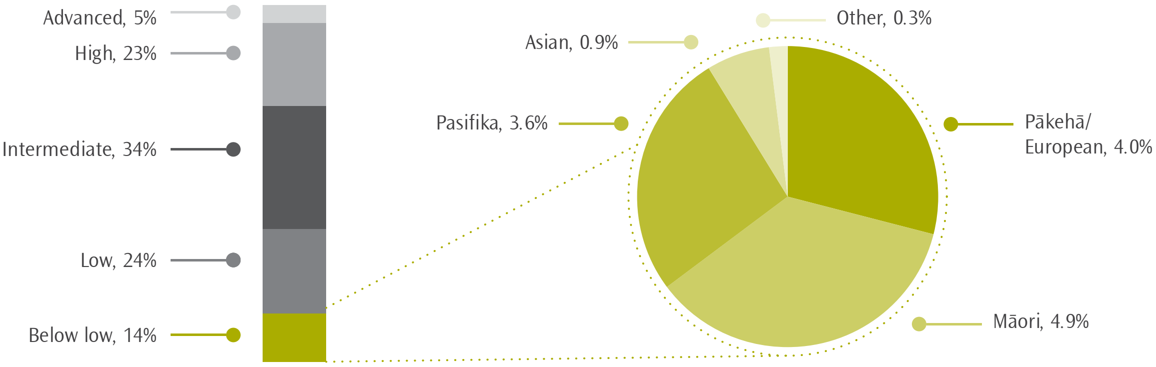
	Cumulative percentage of Year 5 students from 2006 at or above each benchmark			
	Low	Intermediate	High	Advanced
Pākehā/European	93 (0.8)	76 (1.2)	41 (1.2)	10 (0.7)
Māori	76 (2.6)	44 (2.7)	14 (1.9)	2 (0.7)
Pasifika	64 (3.4)	31 (3.0)	7 (1.4)	1 (0.6)
Asian	92 (2.0)	72 (2.9)	43 (3.1)	14 (2.1)

Note: Standard errors are presented in parentheses.

Source: Caygill, 2008.

We can also examine the composition of the group who did not reach the low benchmark (just under 14% of students over all New Zealand). The majority of these students were Māori or Pākehā/European as shown in Figure 5.3. However both Māori and Pasifika students are over-represented in this lower achieving group compared to their proportion in the population.

Figure 5.3: Ethnic composition of the New Zealand students who did not reach the low benchmark



Note: That the values presented in the pie chart are proportions of the whole population and add to just under 14% - the proportion of students in the 'below low' group.

Science achievement of boys and girls within ethnic groupings

As mentioned earlier, the science achievement of boys overall was the same as girls overall. Similarly, girls within each ethnic grouping had the same science achievement as the boys in that ethnic grouping.

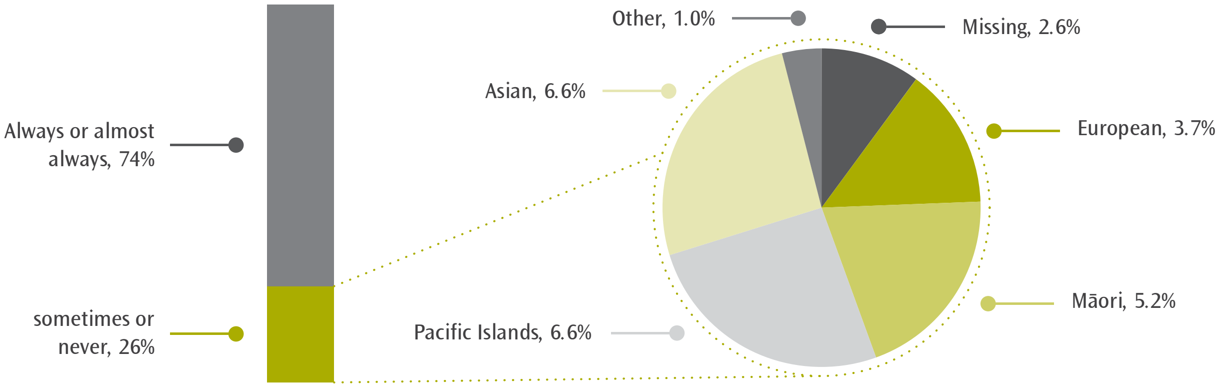
Science achievement by language

Students were asked how often they spoke English at home. Nearly three quarters of students indicated that they always or almost always spoke English at home.[9] Nearly all of the rest of the students indicated that they sometimes spoke English and sometimes another language. Less than two percent of students reported never speaking English at home. Of those who spoke another language, it was most common to speak an Asian or Pacific Islands language with Māori a close third (see Figure 5.4).

9 This question was formulated differently in 2010/11 so no comparisons can be made with previous cycles.

Many studies point to the advantages of bilingualism (or indeed multilingualism) including greater flexibility of thinking (see for example Adesope, O. O., Lavin, T., Thompson, T., and Ungerleider, C., 2010). However, students who reported that they always or almost always spoke English at home had higher achievement on average (40 scale score points difference) than those who said they sometimes or never spoke it at home.

Figure 5.4: Languages spoken by New Zealand students who sometimes or never spoke English at home



Note: The values presented in the pie chart are proportions of the whole population and add to just under 26% - the proportion of students who sometimes or never spoke English at home. The label 'missing' refers to those students who did not name a language.

Use of English at home, ethnicity and socio-economic status

Among ethnic groupings, students with higher socio-economic status and those with a greater use of English at home (the language used for the TIMSS test within New Zealand), had higher average achievement than those with lower socio-economic status and lower use of English. This result is consistent with previous cycles of TIMSS (see Caygill, 2008).

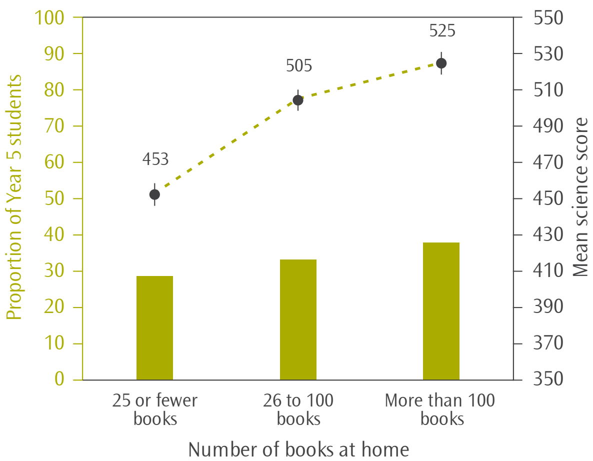
6. Science achievement and socio-economic status

The New Zealand education system recognises that students from homes poor in wealth and educational resources may need extra help to achieve at the same level as students from well-resourced homes. Schools with larger numbers of these students with low socio-economic status are provided with extra funding per student. TIMSS only provides a snap-shot measure of achievement so cannot provide a measure of value-adding that schools do for these students. Numerous studies, including previous TIMSS studies, have shown that students with fewer resources at home have lower achievement, on average, than those with more resources. Therefore, it is important to continue to measure the level of socio-economic status of students as well as the achievement of these students. This chapter will present details of some of the measures used to examine socio-economic status along with their association with achievement.

Home possessions and books as proxies for SES

Home possessions and books in the home can be used to give a measure of both the wealth of the home and the level of importance given to education and culture. The TIMSS questionnaires asked students about the presence in their home of five resources that could be used for educational purposes: a computer, a study desk or table for their use (presumably for learning activities at home), their own books, their own room (a quiet place for undertaking learning activities on their own), and an internet connection. Additionally, countries could specify their own list of resources that might be indicators of relative wealth – in New Zealand this list was: musical instruments, clothes dryer, dishwasher, two or more bathrooms, their own computer or laptop, and swimming or spa pool. Students were also asked about the number of books in their home. This next section will discuss the results of these questions.

Figure 6.1: Mean science achievement of New Zealand students by number of books in the home



Note: The bars on the graph represent proportions of Year 5 students. The points represent mean scores while the lines extending from those points represent the 95% confidence interval associated with estimating the mean of the population from the sample.

Books in the home

TIMSS has asked about the number of books in the home since 1994/95. In 2002/03, the question was changed slightly to include pictures of what each of the five categories might look like. Figure 6.1 shows proportions of students in three summarised categories of numbers of books in the home and their mean achievement.

Just under one-third of students (29%) reported that they had 25 or fewer books in their home. Just over one-third of students (38%) reported that they had more than 100 books in their home. This proportion of students with more than 100 books is the same as 2006/07 but much lower than in 1994 (62% - as mentioned earlier there was the same wording in 1994 but no pictures with the question).

As shown in Figure 6.1, students that reported more books in the home had higher science achievement than those with fewer books.

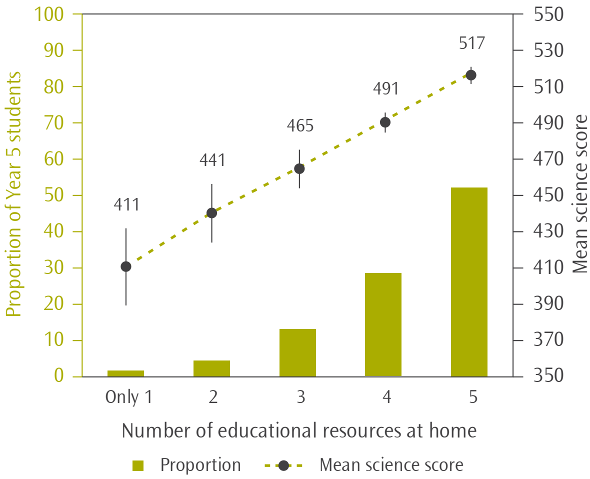
Educational resources in the home

Table 6.1 shows the proportions of students that had each of the educational resources in their homes. Nearly all students reported having a computer in their home (95%) and the majority of students had an internet connection (86%). The least common resources students possessed were their own desk and their own room. Note that adults who supervised the questionnaire administration, regularly reported receiving questions about how to answer this question from students who lived in more than one house as part of a shared custody arrangement.

Table 6.1: Proportions of New Zealand students with educational resources in their homes

Educational resource	Proportion of Year 5 students having resource
Computer	95
Study desk/table	75
Own books (do not count school books)	93
Own room	78
Internet connection	86

Figure 6.2: Mean science achievement of New Zealand students by number of educational resources at home



Note: The bars on the graph represent proportions of Year 5 students. The points represent mean scores while the lines extending from those points represent the 95% confidence interval associated with estimating the mean of the population from the sample.

Less than one percent of students had none of the educational resources at home.

Just over half of all students (52%) had all five educational resources; less than one percent had none of the resources. Students with a greater number of these resources had higher achievement than those with fewer of the resources. Figure 6.2 shows the relationship between the number of these educational resources and science achievement.

The relationship between educational resources in the home and achievement was evident among all ethnic groupings. However, far fewer Māori (38%) and Pasifika (32%) students had all five educational resources compared with Asian (53%) and Pākehā/European students (61%).

Number of items in the home

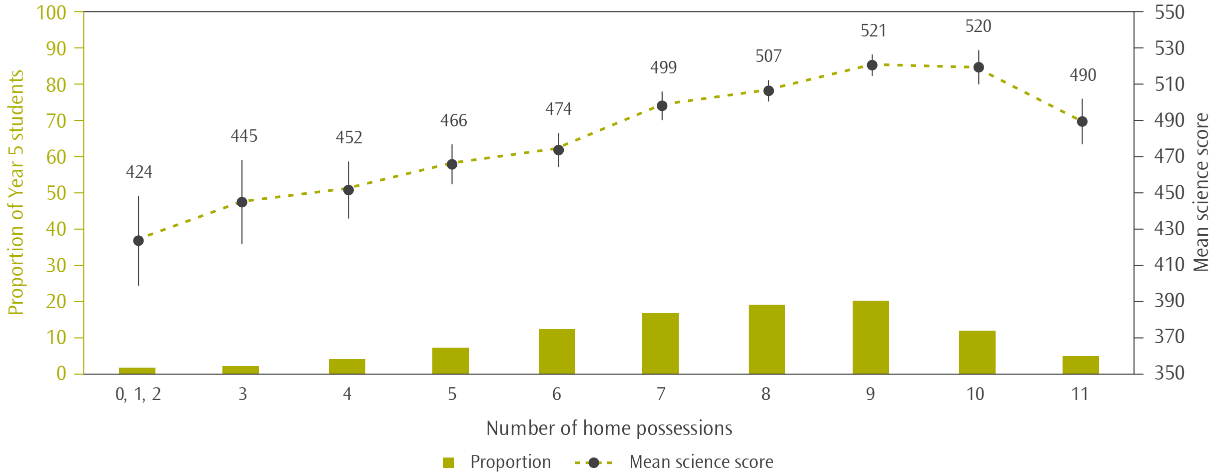
Table 6.2 shows the proportions of students that had each of the items used as an indicator of wealth in their homes. The majority of students reported having a clothes dryer (82%) and many had a dishwasher (75%). The least common resources students possessed were their own computer or laptop (31%) and having a swimming or spa pool at home (25%). Among these items, in most cases, those students who reported having them at home had higher achievement than those who did not. The exceptions were the pools and their own computer or laptop. Students who said they had these items had the same (pools) or lower achievement (own computer or laptop) than those who did not.

Table 6.2: Proportions of New Zealand students with items in their homes

Items used as a surrogate for SES	Proportion of Year 5 students having resource
Musical instruments (e.g., piano, violin, guitar)	69
Clothes dryer	82
Dishwasher	75
Two or more bathrooms	54
Your own computer or laptop	31
Swimming pool or spa pool	25

Generally, students who had more items in the home had higher achievement than those who had fewer. However, with the pools and own computer or laptop included in analysis of number of items in the home, those who had all the educational resources and all the other items had lower achievement than those who had only nine of the resources (see Figure 6.3).

Figure 6.3: Mean science achievement of New Zealand students by number of home possessions



Note: The bars on the graph represent proportions of Year 5 students. The points represent mean scores while the lines extending from those points represent the 95% confidence interval associated with estimating the mean of the population from the sample.

A higher proportion of Pākehā/European (44%) and Asian students (36%) had nine or more of the home possessions compared with Māori (26%) or Pasifika (22%) students. With home possessions used as a proxy for socio-economic status, we could conclude that more Pākehā/European and Asian students have higher socio-economic status compared with Māori or Pasifika students.

Socio-economic indicators of schools attended

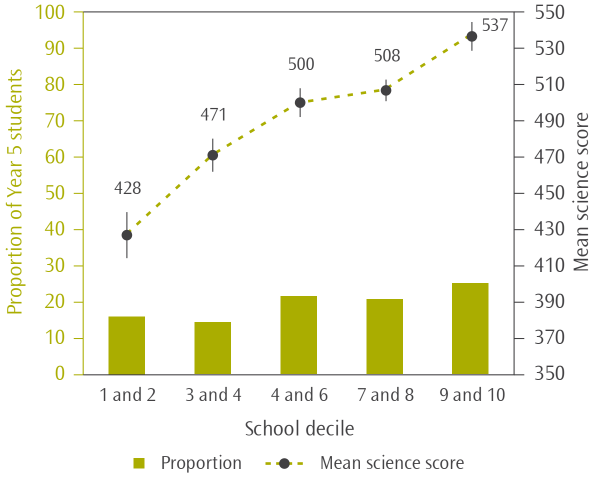
Schools with larger numbers of students from low socio-economic communities are provided with extra funding per student. The school decile indicator within New Zealand is used to allocate differentiated funding. Decile 1 schools are the schools with the highest proportion of students from socio-economically disadvantaged communities, while decile 10 schools have the lowest proportion of students from these communities.

Internationally, there was also information collected from principals that allows examination of the socio-economic status of the school intake. The School Questionnaire included two questions, one that asked about the approximate proportions of students in the school from economically disadvantaged homes and one that asked about approximate proportions from economically affluent homes. The responses to these two questions were combined to give a measure of school composition by student economic background. This measure allows us to compare the equity of our system with other countries. It is important to note that principals were providing estimates so this measure can provide only an approximate view of economic disadvantage.

Decile

Previous cycles of TIMSS have shown that students attending schools with fewer students from lower socio-economic backgrounds (higher decile schools) had higher science achievement than those attending schools with more students from lower socio-economic backgrounds (lower decile schools; see for example Caygill, 2008). As shown in Figure 6.4, this is also true of the latest cycle of TIMSS, with students from higher decile schools (9 and 10) having higher achievement (537 scale score points) than those from the low decile schools (1 and 2 – 428 scale score points).

Figure 6.4: Mean science achievement of New Zealand students by decile of school attended

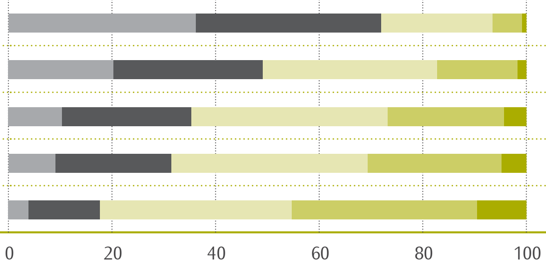


Note: The bars on the graph represent proportions of Year 5 students. The points represent mean scores while the lines extending from those points represent the 95% confidence interval associated with estimating the mean of the population from the sample.

The TIMSS benchmarks provide an understanding of achievement beyond mere averages and ranges (see Chapter 1 for details of these benchmarks). Figure 6.5 presents two different ways of looking at this data – those students achieving at each of the benchmarks (as shown in the graphical part) and those students achieving at or above each of the benchmarks (as shown in the table part). Presenting those students achieving at or above the benchmarks allows the reader to make comparisons with other countries' data as presented in the international reports.

There were high achieving students in all decile groupings as measured by the high and advanced benchmarks (see Figure 6.5). However, there were larger proportions of students in the higher decile schools achieving at or above the high benchmarks (45% in decile 9 and 10 schools) compared with the lower decile schools (7% in decile 1 and 2 schools). As shown in the figure there were students in all decile groupings who did not demonstrate the ability to complete a reasonable number of the simplest science tasks that TIMSS seeks to measure (that is they did not reach the low benchmark). However, there were larger proportions of students in the lower decile groupings in this low achieving group (36% of decile 1 and 2 students below low) compared with high decile groupings (4% of decile 9 and 10 students).

Figure 6.5: Proportion of New Zealand Year 5 students in each decile grouping at each international benchmark



School decile grouping	Cumulative percentage of students: At or above low	At or above intermediate	At or above high	At or above advanced
1 and 2	64 (3.6)	28 (3.0)	7 (1.8)	1 (0.5)
3 and 4	80 (2.4)	51 (2.8)	17 (2.3)	2 (0.4)
5 and 6	90 (1.3)	65 (3.1)	27 (2.2)	5 (1.1)
7 and 8	91 (1.3)	69 (2.3)	31 (1.7)	5 (0.8)
9 and 10	96 (0.8)	82 (1.8)	45 (2.5)	9 (1.3)

Note: Standard errors are presented in parentheses.

"At or above" means that the proportion of students at the benchmark includes those that achieved at higher benchmarks also. For example, the 64% of students in deciles 1 and 2 schools that achieved at or above the low benchmark includes 36% who achieved at the low benchmark, 21% at the intermediate, 6% at the high, and 1% at the advanced benchmark.

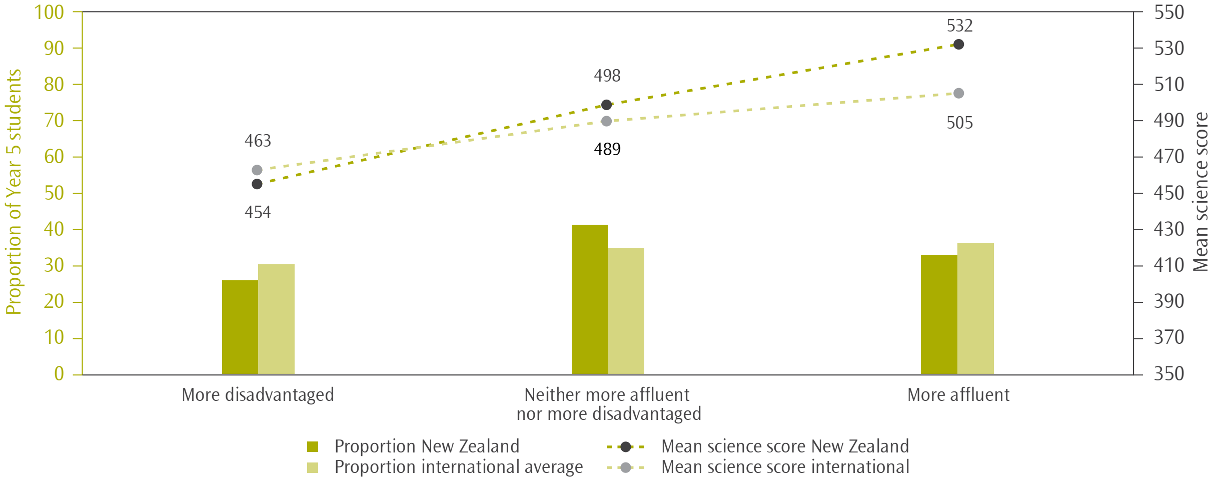
School composition by student economic background

As mentioned earlier, there was also information collected from principals across the TIMSS countries that allows examination of the socio-economic status of the combined student population in the schools. Principals were asked to choose from four categories to estimate the percentage of students in their school that came from economically disadvantaged homes as well as the percentage from economically affluent homes. The international researchers combined the responses from these two questions into three categories: *schools with more affluent than disadvantaged students*, *schools with more disadvantaged than affluent students*, and *schools with neither more affluent nor more disadvantaged students.*[10]

As shown in Figure 6.6, one-third of New Zealand students were in schools with more affluent students, while just over one-quarter were in schools with more disadvantaged students. Science achievement was higher for students in schools with more affluent students (532 scale score points) than those in schools with more economically disadvantaged students (454 scale score points). The difference in science achievement between these two groupings within New Zealand (78 scale score points) was higher than most other countries in the TIMSS study. Only Turkey (85) and Yemen (89) had higher differences than New Zealand between the students in more affluent schools and those in more economically disadvantaged schools. On average internationally, this difference was only 42 scale score points. In comparison, Australia (56), England (54), and the United States (58) all had relatively large differences between the students in more affluent schools and those in more economically disadvantaged schools.

10 Schools with more affluent than disadvantaged students are defined as those where the principal estimated that 25% or fewer came from economically disadvantaged homes and more than 25% came from affluent homes. Schools with more disadvantaged than affluent students are defined as those where the principal estimated that more than 25% came from economically disadvantaged homes and 25% or fewer came from affluent homes. All other students were assigned to the third category: schools with neither more affluent nor more disadvantaged students.

Figure 6.6: Mean science achievement of students by economic composition of school attended



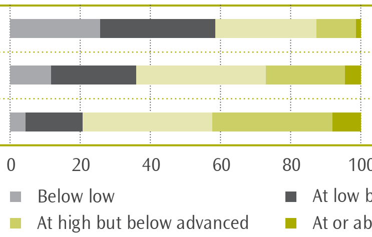
Source: Adapted from Exhibit 5.3, Martin, Mullis, Foy, and Stanco, 2012.

As with the measure of decile, the TIMSS benchmarks show that within each of these three categories of economic composition of the school population, there were high and low achievers. Figure 6.7 presents two different ways of looking at this data – those students achieving at each of the benchmarks (as shown in the graphical part) and those students achieving at or above each of the benchmarks (as shown in the table part).

There were larger proportions of students in the more affluent schools achieving at or above the high benchmarks (42% in schools with more affluent than economically disadvantaged students) compared with the economically disadvantaged schools (13% in schools with more economically disadvantaged than affluent students). As shown in the figure there were students in each of the three categories of school composition who did not demonstrate the ability to complete a reasonable number of the simplest science tasks that TIMSS seeks to measure (that is they did not reach the low benchmark). However, there were larger proportions of students in the economically disadvantaged schools in this low achieving group (26% in schools with more economically disadvantaged than affluent students) compared with affluent schools (4% in schools with more affluent than economically disadvantaged students).

Figure 6.7: Proportion of New Zealand Year 5 students at each international benchmark by economic composition of school attended

School composition grouping	Percentage of students reaching each benchmark	Cumulative percentage of students: At or above low	At or above intermediate	At or above high	At or above advanced
Disadvantaged		74 (2.9)	42 (3.1)	13 (1.7)	2 **(0.5)**
Middle		88 (1.1)	64 (1.9)	27 (1.6)	4 **(0.8)**
Affluent		96 (1.0)	79 (1.8)	42 (2.3)	8 **(1.3)**



Note: Standard errors are presented in parentheses.

'Disadvantaged' refers to those schools with more economically disadvantaged than affluent students, 'Affluent' refers to those schools with more affluent than economically disadvantaged students, and 'Middle' refers to all other schools. 'At or above' means that the proportion of students at the benchmark includes those that achieved at higher benchmarks also. For example, the 74% of students in 'disadvantaged' schools that achieved at or above the low benchmark includes just under 33% who achieved at the low benchmark, just under 29% at the intermediate, 11% at the high, and just under 2% at the advanced benchmark.

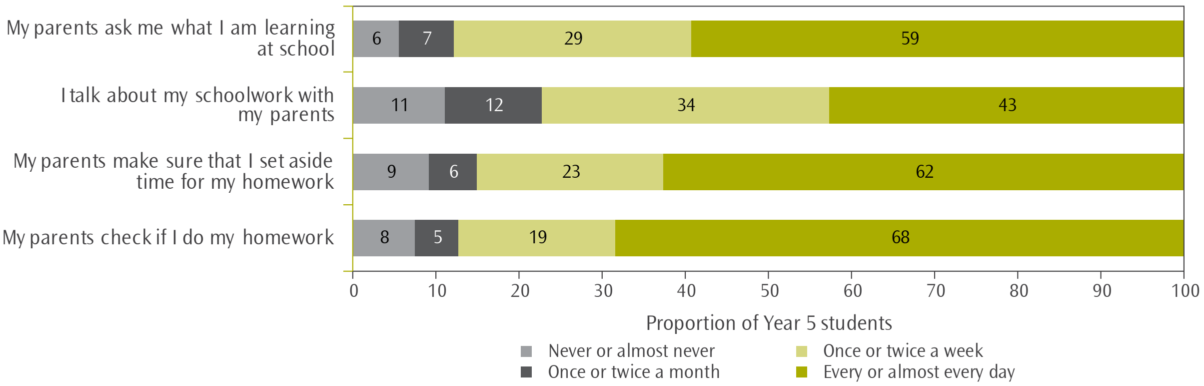
7. More about the home climate for learning science

As shown in the previous chapter, the home matters. Much of the information about the home of the students in the previous chapter focussed on socio-economic status. However, educational resources in the home were also discussed. This chapter will focus on interactions with parents about education, reading for enjoyment, and computer use.

Interactions with parents

Interactions with parents about school may be indicative of the importance placed on education in the home. However, there may be a lower frequency of interactions between parents and children if a child is highly self-motivated, or the parents have many interactions with the school directly. Students were asked four questions about the frequency of discussions about schoolwork and homework (shown in Figure 7.1). More than two-thirds of Year 5 students reported that their parents checked on a daily basis whether they had done their homework and just under two-thirds had parents making sure that they set aside time for their homework each day. Just over one-fifth of students rarely talked with their parents about their schoolwork (11% *never or almost never* and 12% *once or twice a month*).

Figure 7.1: Frequency New Zealand Year 5 students reported interacting with parents about schoolwork and homework

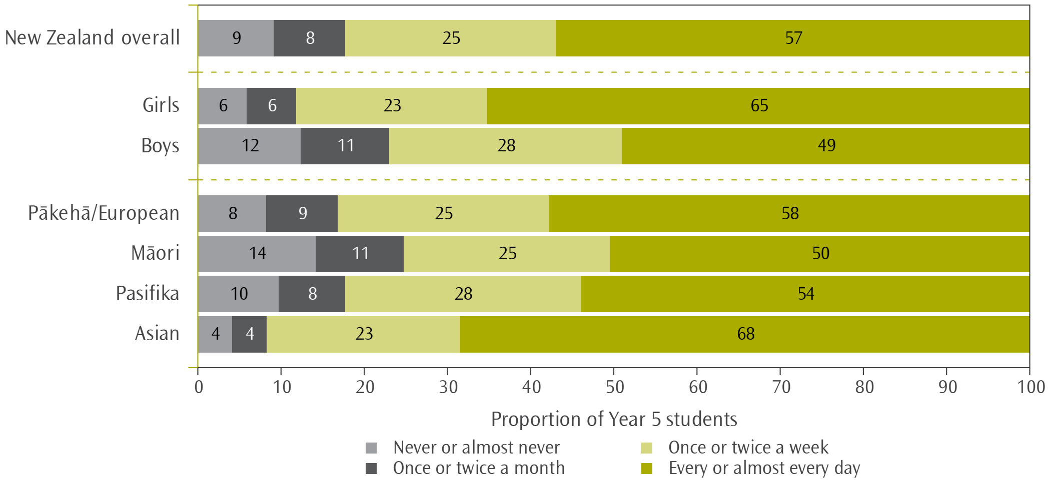


With the exception of parents ensuring they set aside time for homework, students with daily interactions about schoolwork or homework had lower achievement than those with less frequent interactions. Those students that had no interactions with their parents had lower science achievement on average than students who reported interacting with their parents about schoolwork or homework.

Reading for enjoyment

Just under one-third of students (29%) reported that they had 25 or fewer books in their home as mentioned in the previous chapter. However, most children in New Zealand have access to libraries at school and many have libraries in their local community. Therefore, the lack of books in their home need not be an impediment to reading activities. In New Zealand we asked students how often they read a book for enjoyment. As shown in Figure 7.2, over half of all students read a book daily (57%). However, more girls (65%) read books for enjoyment daily compared with boys (49%). More Asian students read for enjoyment daily compared with any other ethnic grouping.

Figure 7.2: How regularly New Zealand Year 5 students read a book for enjoyment



Students who reported that they read a book for enjoyment daily had higher science achievement than those who did not. Students who never or almost never read a book for enjoyment had lower science achievement than their peers who read once a month or once or twice a week.

Computer use

The digital age has given students access to more information and entertainment than they had in the first cycle of TIMSS. Although some of the information available online is of dubious quality, an inquisitive mind is an asset to a learner. Students were asked how often they used a computer at home, at school, or at some other place (not defined). Most students (95%) had computers at home. Of these students, many (77%) used the computer regularly. Of those that didn't have one (5%), most used a computer at school or some other place.

8. Student attitudes to and engagement with science

The vision of what we want for our young people, as presented in The New Zealand Curriculum, includes that they will be "confident, connected, actively involved, and lifelong learners" (Ministry of Education, 2007, p.8). In addition the curriculum document notes that "Science is able to inform problem solving and decision making in many areas of life. Many of the major challenges and opportunities that confront our world need to be approached from a scientific perspective, taking into account social and ethical considerations." (Ministry of Education, 2007, p.28).

As a nation we want to maximise the contribution of education to the New Zealand economy (Ministry of Education 2012). In particular, science, technology, engineering, and mathematics (STEM subjects), are seen by many as a means to increase innovation in society and have been identified as a priority area. The Tertiary Education Commission's guidance to tertiary education organisations includes eight priorities for new plans, one of which is that there will be "more learners engaged in study toward STEM qualifications…to better meet workforce demand." (Tertiary Education Commission, 2012, p.13).[11] Similarly, an education and skills survey in the United Kingdom found employers calling for action to improve the quantity and quality of STEM graduates, with almost half of firms still experiencing difficulties recruiting STEM skilled staff. The authors of the report on this survey asserted that "these skills will be vital if the UK is to harness opportunities in growth areas such as green technologies and creative industries" (CBI, 2010).

To meet these objectives we need more learners confident, engaged, and continuing in science beyond the compulsory years. This chapter will examine students' attitudes towards learning science – their enjoyment, confidence levels and the importance they attach to it.

Student attitudes toward science

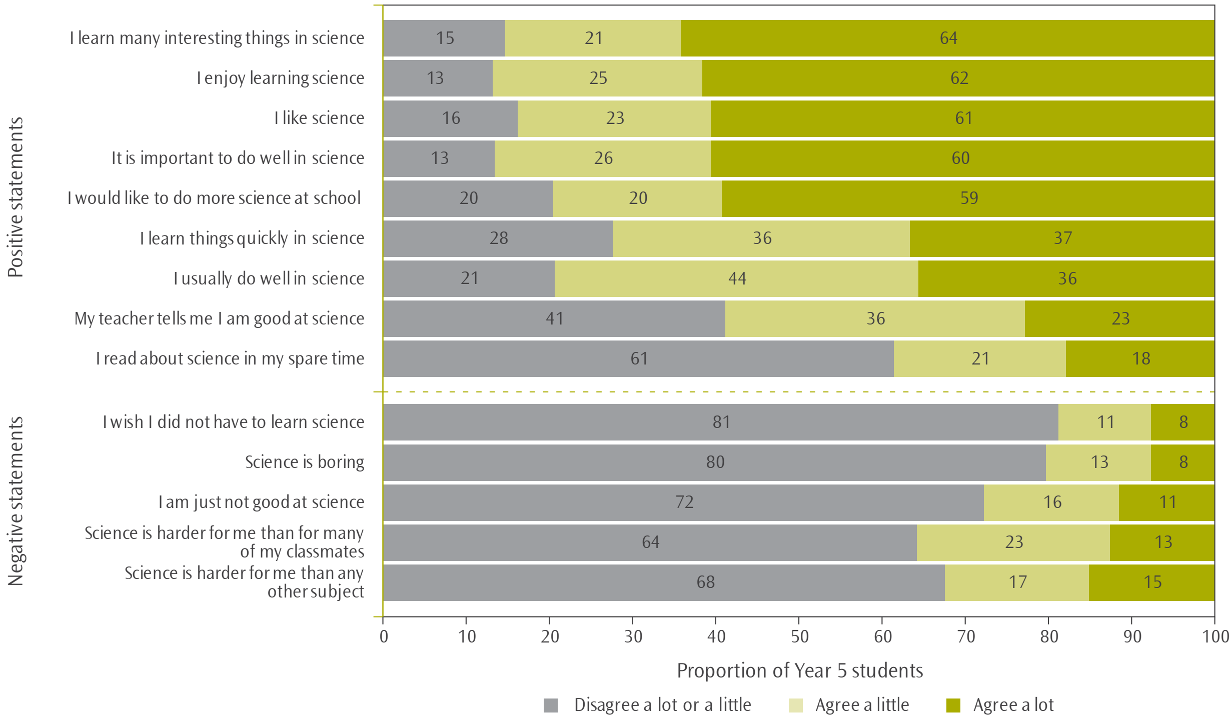
To gauge their enjoyment and confidence, students were asked how much they agreed with a series of fourteen statements about learning science.[12] They were given four response options: *agree a lot*, *agree a little*, *disagree a little* and *disagree a lot*. Positive and negative statements were interwoven in the questionnaire but are reordered in Figure 8.1 for ease of reading.

Of all the statements, New Zealand Year 5 students were most likely to agree that: *I enjoy learning science* and *it is important to do well in science*, with 87 percent agreeing either a little or a lot with each of these statements. The proportion who agreed that they *enjoy learning science* was similar or slightly higher than in previous years, however, the proportion who agreed that *it is important to do well in science* had dropped from 93 percent in 1998 when the statement was last included in the questionnaire. Among the negative statements, students were most likely to agree that *Science is harder for me than for many of my classmates*. While 36% of New Zealand students agreed with this statement in 2011, this was a smaller proportion than in either 2002 (44%) or 2006 (41%).

11 Earle (2009) identified ongoing skill-shortages in New Zealand in engineering and related technologies, architecture and building, information technology and accounting; and ongoing demand in medical studies, nursing and health

12 It should be noted that science is often integrated with other areas of the curriculum in New Zealand primary education, and there may be some variation in students' understandings of what is included in this subject area. Test administrators were alerted to this, and encouraged to offer clarifications, where necessary, in the context of each school's approach.

Figure 8.1: New Zealand Year 5 student attitudes to science



Note: Due to rounding, some results may appear inconsistent.

Positive and negative statements were interwoven in the questionnaire but are reordered here for ease of reading.

Generally, students with positive attitudes towards science had higher achievement than students with negative attitudes. To further examine the relationship with achievement the international researchers combined the data on two scales: the Students Like Learning Science (SLS) scale and the Students Confident in Science (SCS) scale. Each student's responses to a particular set of statements were used to generate a single score on a continuous scale.[13] For ease of interpretation, each scale was then divided into three categories.

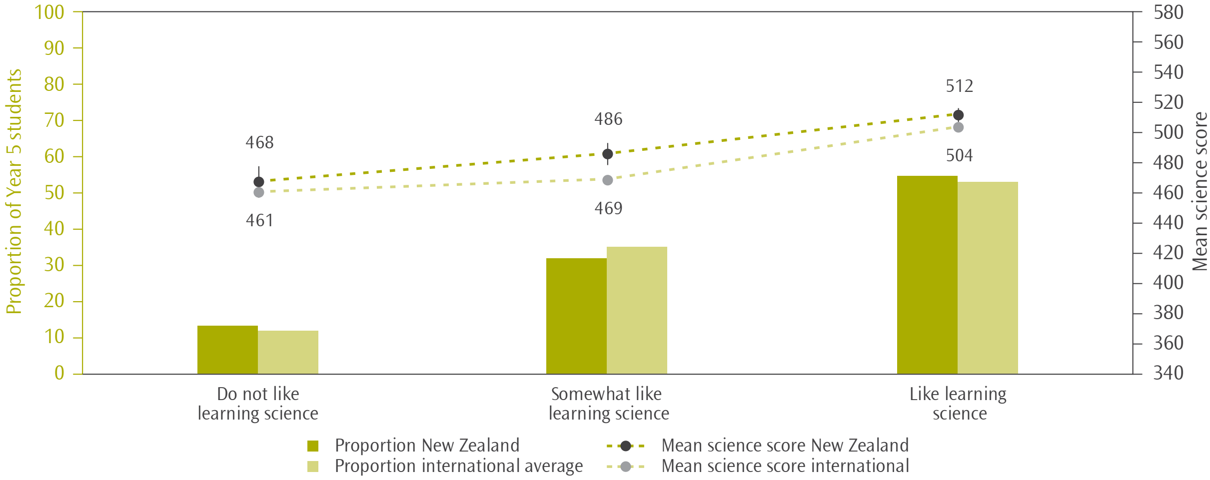
Students like learning science

Students were categorised into one of three groups, *Like Learning Science*, *Somewhat Like Learning Science*, or *Do Not Like Learning Science* according to their responses to five statements: *I enjoy learning science*; *I wish I did not have to learn science*; *Science is boring*; *I learn many interesting things in science*; and *I like science*.

Fifty-five percent of New Zealand Year 5 students *Like Learning Science*, 32 percent *Somewhat Like Learning Science*, while the remaining 13 percent *Do Not Like Learning Science*. As shown in Figure 8.2, students who were most positive about learning science had higher achievement than those in the middle group, who in turn performed better than those in the least positive group. In 2006, a different index was used, but this also showed higher mean achievement by those in the most positive grouping.

13 See *Created scales for contextual variables* in the Definitions and technical notes section for a brief description of the methodology.

Figure 8.2: Proportion and mean science achievement of students in each category of the Students Like Learning Science (SLS) scale



Note: The bars on the graph represent the proportions of Year 5 students while the points represent the mean scores. Lines extending from the points represent the 95% confidence interval, i.e., the range within which we are 95 percent confident that the true population value lies.

Students who *Like Learning Science* had a score on the Students Like Learning Science (SLS) scale of at least 9.7, which corresponds to their "agreeing a lot" with three of the five statements and "agreeing a little" with the other two, on average. Students who *Do Not Like Learning Science* had a score no higher than 7.6, which corresponds to their "disagreeing a little" with three of the five statements and "agreeing a little" with the other two. All other students *Somewhat Like Learning Science.* Negative statements were reverse coded.

Source: Adapted from Exhibit 8.1, Martin, Mullis, Foy, and Stanco, 2012.

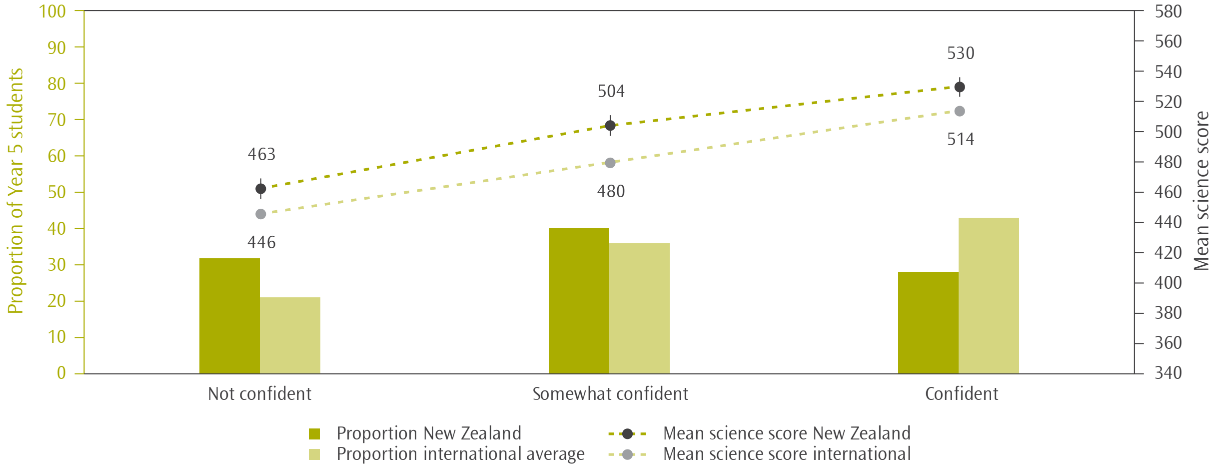
The proportions of New Zealand students in each category of the *Students Like Learning Science* scale were very similar to the international average for each category (55, 32 and 13 percent compared with 53, 35 and 12 percent internationally). The difference in mean achievement of 44 scale score points between those who *Like Learning Science* compared with those who *Do Not Like Learning Science* in New Zealand was also very similar to the international average. The mean difference internationally between students in these two categories was 43 scale score points.

Students confident in science

Students were categorised into one of three groups, *Confident*, *Somewhat Confident*, or *Not Confident* with science according to their responses to six statements: *I usually do well in science*; *Science is harder for me than for many of my classmates*; *I am just not good at science*; *I learn things quickly in science*; *My teacher tells me I am good at science;* and *Science is harder for me than any other subject.*

Twenty-eight percent of New Zealand Year 5 students were *Confident*, 40 percent *Somewhat Confident*, and thirty-two percent *Not Confident* with science. As shown in Figure 8.3, students who were more confident about their abilities to learn science (in the *Confident* category) had higher mean achievement than those who were less confident. Those students with the lowest self-confidence had the lowest science achievement on average. Note that the difference in mean science score between students who were *Confident* and those who were *Not Confident* (67 scale score points) is greater than those in the corresponding groups on the Students Like Learning Science scale (44 scale score points). Thus the self-confidence in science of students had a stronger relationship with science achievement than how much they like learning science.

Figure 8.3: Proportion and mean science achievement of students in each category of the Students Confident in Science (SCS) scale



Note: The bars on the graph represent the proportions of Year 5 students while the points represent the mean scores. Lines extending from the points represent the 95% confidence interval, i.e., the range within which we are 95 percent confident that the true population value lies.

Students *Confident* with science had a score on the Students Confident in Science (SCS) scale of at least 10.1, which corresponds to their "agreeing a lot" with three of the six statements and "agreeing a little" with the other three, on average. Students who were *Not Confident* had a score no higher than 8.3, which corresponds to their "disagreeing a little" with three of the six statements and "agreeing a little" with the other three, on average. All other students were *Somewhat Confident* with science. Negative statements were reverse coded.

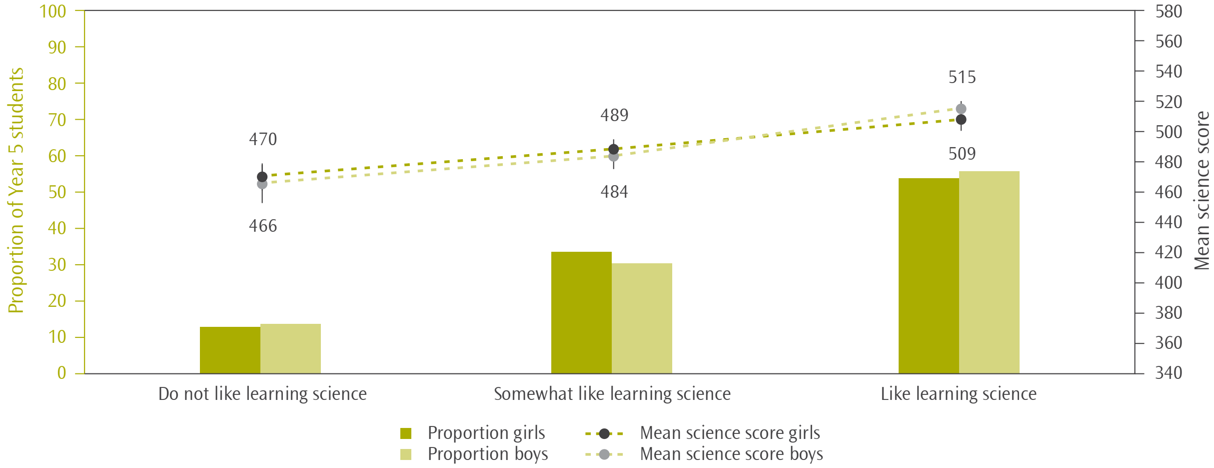
Source: Adapted from Exhibit 8.4, Martin, Mullis, Foy, and Stanco, 2012

New Zealand had a smaller proportion of *Confident* students (28%) than the international average (43%), and a greater proportion of *Not Confident* students (32% compared with 21% on average internationally). Several of the high-performing countries had quite low proportions of *Confident* students (Singapore 26%, Rep. of Korea 15% and Japan 17%). However, within each country, those students who had the highest levels of confidence in their science abilities had higher average achievement than those who were less confident. The international average difference in achievement between those in the most confident category and those in the least, was 68 scale score points (similar to New Zealand – 67 scale score points).

Attitudes to science by gender

The proportions of New Zealand boys and girls in each category of the Students Like Learning Science scale were quite similar, although girls were slightly more likely to *Somewhat Like Science* (34% compared with 30% of boys). Liking science had a positive relationship with science achievement for both boys and girls in New Zealand, but more so for boys (see Figure 8.4). The difference in average achievement between those in the most positive category of the Students Like Learning Science scale and those in the least was 50 scale score points for boys compared with 38 for girls.

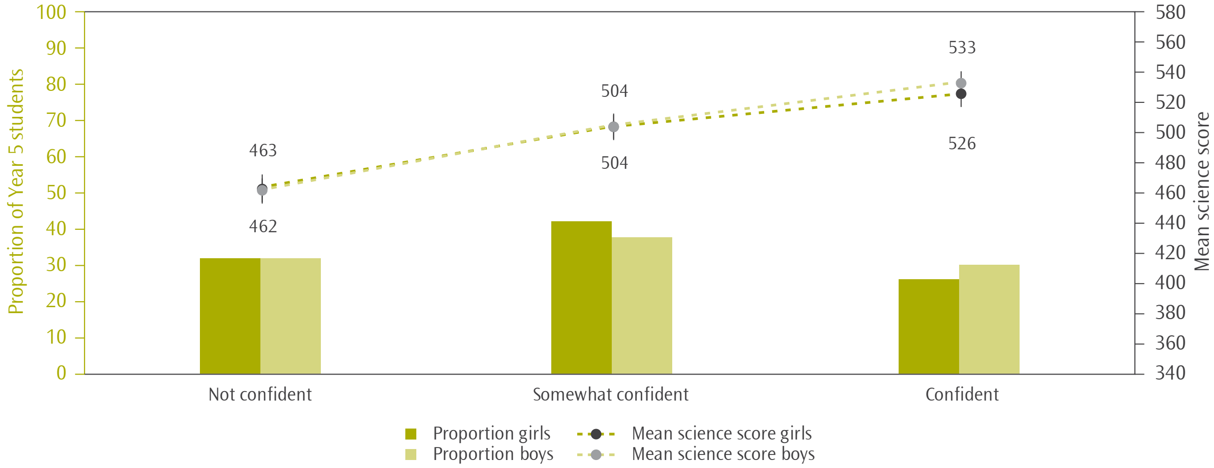
Figure 8.4: Proportion and mean science achievement of New Zealand boys and girls in each category of the Students Like Learning Science (SLS) scale



Note: The bars on the graph represent the proportions of Year 5 students while the points represent the mean scores. Lines extending from the points represent the 95% confidence interval, i.e., the range within which we are 95 percent confident that the true population value lies. See Figure 8.2 for details of the method used to calculate the scale.

On the Students Confident in Science scale 30 percent of boys were *Confident* with science compared with 26 percent of girls (see Figure 8.5). Confidence with science had a stronger relationship with achievement than liking science for both boys and girls. Boys who were *Confident* with science scored 71 points higher on average than those who were *Not Confident* with science; for girls the difference was 63 scale score points.

Figure 8.5: Proportion and mean science achievement of New Zealand girls and boys in each category of the Students Confident in Science (SCS) scale

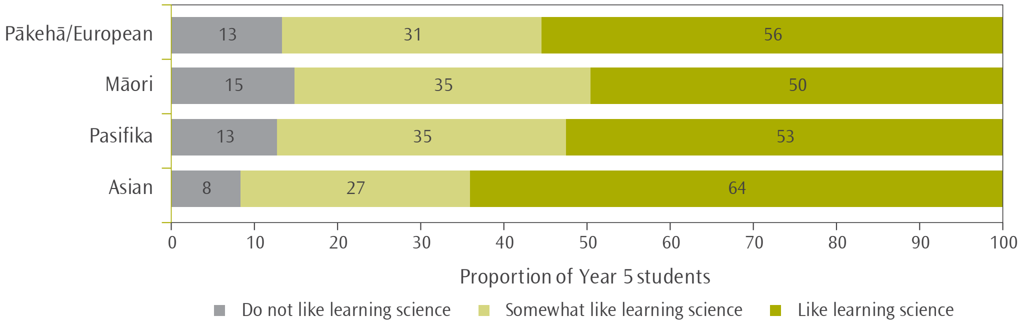


Note: The bars on the graph represent the proportions of Year 5 students while the points represent the mean scores. Lines extending from the points represent the 95% confidence interval, i.e., the range within which we are 95 percent confident that the true population value lies. See Figure 8.3 for details of the method used to calculate the scale.

Attitudes to science by ethnicity

Some differences were evident among the ethnic groupings when attitudes to science were considered. A greater proportion of Asian students (64%) reported positive attitudes to science and *Like Learning Science* than Māori (50%), Pasifika (53%) or Pākehā/European students (56%) as shown in Figure 8.6.

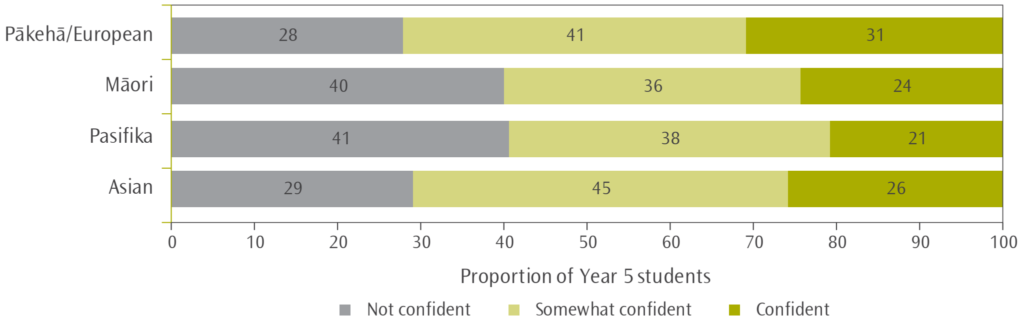
Figure 8.6: Proportion of New Zealand students in each ethnic grouping by category of the Students Like Learning Science (SLS) scale



Note: See Figure 8.2 for details of the method used to calculate the scale.

On the Students Confident in Science scale, a greater proportion of Māori and Pasifika students (40% and 41% respectively) were *Not Confident* with science than students from the other ethnic groupings (Asian 29% and Pākehā/European 28% - see Figure 8.7). Among Asian and Pākehā/European students, boys (33% and 34%) were more likely to report high levels of confidence in science than girls (20% and 28% respectively). However, among Māori students, boys (44%) were more likely to report low levels of confidence than girls (35%).

Figure 8.7: Proportion of New Zealand students in each ethnic grouping by category of the Students Confident in Science (SCS) scale



Note: See Figure 8.3 for details of the method used to calculate the scale.

Within each ethnic grouping, students' degree of confidence in science had a stronger relationship with achievement than how much they reported liking science. That is, the differences in mean scores between those who were *Confident* and those who were *Not Confident* were greater than the differences in mean scores between those who *Like Learning Science* and those who *Do Not Like Learning Science*.

9. Teaching science

Recent media coverage of education has focussed on the quality of teaching. 'Supporting improvement in teaching practice' is part of the current operating framework of the Ministry of Education (Ministry of Education, 2012). One of the useful aspects of TIMSS is that it examines the context of student achievement, collecting information from students, teachers, and school leadership (usually principals). This section will report information collected about what happens in classrooms with a focus on science teaching. Note that this section will talk about the science teachers of primary students who were usually, but not always the classroom teacher of the students. In some cases, classes were reorganised for science lessons.

Characteristics of primary teachers

It seems intuitive to believe that more experienced and better educated teachers will lead to higher achievement among students. However, it is difficult to examine this belief in a snapshot study like TIMSS, particularly because there are schools that assign the more experienced teachers to groups of students with the highest need. However, it is useful to know if well-educated people are being attracted into teaching and if they are being retained. TIMSS allows us to compare these rates of recruitment and retention with other countries. This section will look at these characteristics of experience and education.

Experience

One-quarter of Year 5 students had science teachers who had 20 years or more teaching experience. Similarly, just under one-quarter of students (23%) had teachers with less than 5 years teaching experience. On average, the New Zealand Year 5 science teachers had had 13 years teaching experience. As Table 9.1 shows, New Zealand teachers generally had less teaching experience than many other countries with the average years of teaching experience across countries being 17 years. On average internationally, 40 percent of middle primary students had science teachers with 20 years or more teaching experience.

Countries with more experienced teachers than New Zealand included Australia, Japan, Slovenia, Finland and Northern Ireland (average years of experience 17, 17, 21, 17, and 16 respectively). Countries with similarly experienced teachers included Hong Kong and the United States. England had slightly more students whose teachers had less than five years teaching experience (30% of students).

Table 9.1: Proportion of students by the years of experience of their science teacher

	Years of experience of science teachers (percentage of students)				
	Less than 5 years	At least 5 but less than 10 years	At least 10 but less than 20 years	20 years or more	Average years of experience
New Zealand	23 (2.8)	26 (2.8)	26 (2.6)	25 (2.6)	13 (0.6)
International Avg.	14 (0.4)	16 (0.4)	30 (0.5)	40 (0.5)	17 (0.1)

Note: Standard errors are presented in parentheses.

Source: Exhibit 7.5, Martin, Mullis, Foy, and Stanco, 2012.

Education

Just under one-fifth of New Zealand Year 5 students (19%) had teachers with some form of postgraduate university education and just under two-thirds (65%) had teachers with a bachelor's degree or equivalent. As shown in Table 9.2, these proportions are similar to the international average across countries. However, there were large variations in proportions across countries. For example, there were quite a few countries where a large proportion of teachers had postgraduate university degrees. These countries included the Slovak Republic (99%), Poland (96%), the Czech Republic (92%), Finland (80%), and the Russian Federation (80%). In contrast, there were also quite a few countries where the large majority of students had teachers with a bachelor's degree but no postgraduate qualification. These countries included Spain (99%), Belgium (Flemish – 99%), the Netherlands (98%), Hungary (96%), Norway (94%), Kuwait (91%), and Portugal (91%).

Table 9.2: Proportion of students by education level of their science teacher

	Education levels of science teachers (percentage of students)							
	No further than upper-secondary education		Completed post-secondary education but not a bachelor's degree		Completed bachelor's degree or equivalent but not a postgraduate degree		Completed postgraduate university degree	
New Zealand	0	(0.0)	16	(2.2)	65	(2.7)	19	(2.4)
International Avg.	6	(0.2)	15	(0.3)	57	(0.4)	23	(0.3)

Note: Standard errors are presented in parentheses.

Source: Exhibit 7.1, Martin, Mullis, Foy, and Stanco, 2012.

Around three-quarters of New Zealand students had teachers who had trained as primary teachers and did not have a specialisation in science. A further 13 percent of students had teachers who had also specialised in science. In contrast, on average across all countries, 25 percent of students had teachers who had majored in primary education with a specialisation in science as shown in Table 9.3.

Table 9.3: Proportion of students by specialisation in education of their science teacher

	Specialisation in education of science teachers (percentage of students)									
	No formal education beyond upper-secondary		Major in primary education but no major (or specialisation) in science		Major in science but no major in primary education		Major in primary education and major (or specialisation) in science		All other majors	
New Zealand	0	(0.0)	77	(2.6)	1	(0.6)	13	(2.1)	8	(1.5)
International Avg.	6	(0.2)	48	(0.4)	12	(0.3)	25	(0.4)	10	(0.3)

Note: Standard errors are presented in parentheses.

Source: Exhibit 7.3, Martin, Mullis, Foy, and Stanco, 2012.

Preparation and confidence of primary teachers

How well prepared do primary teachers feel?

Teachers were asked how well prepared they felt to teach 20 topics in science based on the *TIMSS 2011 assessment frameworks* (Mullis, Martin, et al., 2009).[14] Of these 20 topics, 6 were life science topics, 8 physical science topics (including both chemistry and physics concepts), and 6 Earth science topics. On average across all 20 topics, 42 percent of New Zealand students were taught science by teachers who felt very well prepared to teach the topics.[15] Fewer New Zealand teachers felt very well prepared compared with the average internationally as shown in Table 9.4. In general, New Zealand teachers were more likely to say they felt very well prepared to teach the life or Earth science topics (both 47% of students respectively) than physical science topics (35%).

Most of the higher-achieving and all the English-speaking countries had larger proportions of teachers who felt very well prepared to teach the science topics. In particular, the feeling of preparedness among teachers in the England (69% of students), United States (60%), Singapore (58%), Northern Ireland (54%), and Australia (51%), was higher. In contrast, teachers in Japan (29% of students) had lower levels of reported feelings of preparedness.

Table 9.4: Proportion of students whose science teacher felt very well prepared to teach topics

	Feel very well prepared to teach topics (percentage of students)			
	Overall science (20 topics)	Life science (6 topics)	Physical science (8 topics)	Earth science (6 topics)
New Zealand	42 (2.2)	47 (2.7)	35 (2.8)	47 (2.5)
International Avg.	62 (0.3)	70 (0.4)	62 (0.4)	53 (0.4)

Note: Standard errors are presented in parentheses.

'Not applicable' responses are not included in the totals from which these percentages are calculated for life science and physical science, but were internationally for Earth science topics. The New Zealand Earth science average excluding 'not applicable' responses was 51%.

Source: Exhibit 7.9, Martin, Mullis, Foy, and Stanco, 2012.

Among the individual topics, there were five topics that far fewer New Zealand teachers felt very well prepared to teach. *Forming and separating mixtures* was the topic with the fewest teachers agreeing they were very well prepared (23% of students). *Classification of objects/materials based on physical properties (e.g., weight/mass, volume, magnetic attraction)* (27%), *fossils of animals and plants (age, location, formation)* (27%), *familiar changes in materials (e.g., decaying, burning, rusting, cooking)* (29%) and *electrical circuits and properties of magnets* (29%) were the other four topics that fewer teachers felt very well prepared to teach. Nearly all of these topics were in the physical science area of the curriculum – this is the topic area where New Zealand students also perform the least well (see section in this report in Chapter 1 entitled Science content and cognitive domains for details).

14 There were four options given: *not applicable*, *very well prepared*, *somewhat prepared*, and *not well prepared*

15 All analysis in this section calculates the percentage of students whose teachers felt very well prepared. However, for ease of reading, the text will often refer to 'teachers'.

Confidence to teach science

Along with asking about preparedness to teach science content, TIMSS also asked teachers how confident they felt doing a range of teaching activities. The activities listed are shown in Table 9.5 and teachers were given the response categories: *very confident*, *somewhat confident*, and *not confident*. Less than one-quarter of New Zealand students had science teachers who felt very confident to answer students' questions about science. Similarly, less than one-quarter of New Zealand students (23%) had teachers who felt very confident to explain science concepts or principles by doing science experiments.

Table 9.5: Proportion of students whose science teacher felt very confident to do teaching activities

Proportion of students whose science teachers felt very confident to:	Percentage of students	
	New Zealand	International Avg.
Answer students' questions about science	23 (2.3)	62 (0.5)
Explain science concepts or principles by doing science experiments	23 (2.3)	51 (0.5)
Provide challenging tasks for capable students	21 (2.2)	43 (0.5)
Adapt my teaching to engage students' interest	40 (3.1)	63 (0.5)
Help students appreciate the value of learning science	36 (3.1)	68 (0.5)

Note: Standard errors are presented in parentheses.

Source: Exhibit 7.12, Martin, Mullis, Foy, and Stanco, 2012.

As with the issue of preparedness, New Zealand teachers were less likely to express high confidence than many of their peers in other countries. In order to more explicitly make comparisons like this, the international researchers created a scale that combined teachers' responses to these five items and called it the Confidence in Teaching Science scale.

Proportions of students with very confident teachers ranged from 95 percent in Romania down to 14 percent in Japan (as shown in Table 9.6). On average across countries, over half of students had very confident science teachers (59%). Fewer New Zealand teachers were very confident (26%) using these techniques than their counterparts in other English-speaking countries. In comparison, many more New Zealand secondary teachers, questioned as part of TIMSS at the Year 9 level, felt very confident teaching science (80% – see Caygill, Kirkham, and Marshall, 2013a).

Table 9.6: Proportion of students whose science teachers felt very confident according to the Confidence in Teaching Science scale for selected countries

	Percentage of students			
Country	Teacher somewhat confident		Teacher very confident	
Romania	5	(1.4)	95	(1.4)
Russian Federation	8	(2.0)	92	(2.0)
Kazakhstan	9	(2.4)	91	(2.4)
Portugal	29	(4.7)	71	(4.7)
England	37	(4.6)	63	(4.6)
Chinese Taipei	42	(3.7)	58	(3.7)
United States	43	(2.2)	57	(2.2)
Singapore	44	(2.6)	56	(2.6)
Malta	46	(0.1)	54	(0.1)
Norway	50	(5.1)	50	(5.1)
Slovenia	51	(3.7)	49	(3.7)
Australia	57	(3.9)	43	(3.9)
Korea, Rep. of	58	(4.0)	42	(4.0)
Ireland	59	(4.2)	41	(4.2)
Northern Ireland	60	(4.1)	40	(4.1)
Netherlands	61	(4.1)	39	(4.1)
Finland	68	(3.0)	32	(3.0)
Hong Kong SAR	74	(4.0)	26	(4.0)
New Zealand	**74**	**(2.4)**	**26**	**(2.4)**
Japan	86	(2.9)	14	(2.9)
International Avg.	**41**	**(0.5)**	**59**	**(0.5)**

Note: Standard errors are presented in parentheses.

A score for the five items combined was created using Item Response Theory. For any score 9.9 or greater, the teacher was assigned to the 'very confident' grouping which corresponds to their teachers being 'very confident' in using three of the five instructional strategies and 'somewhat confident' in using the other two, on average. Otherwise, they were assigned to the 'somewhat confident' grouping.

Source: Exhibit 7.11, Martin, Mullis, Foy, and Stanco, 2012.

Professional development

Professional development has many purposes. It may be used to bring teachers up-to-date with the latest methodologies and understandings about the way students learn, or to demonstrate how new technology can be integrated into the classroom. Whatever the purpose, it may also help teachers gain confidence and gain the skills to help them feel better able to fulfil the needs of their students. Teachers were asked about the types of professional development they had participated in in the past two years. As shown in Table 9.7, few New Zealand teachers had participated in any professional development in science. The most common area of professional development was around the curriculum or content (both 16% of students). On average internationally, more students had teachers who had had professional development in any of these areas.

Table 9.7: Proportion of students whose science teacher had participated in professional development in the past two years

Type of professional development:	Percentage of students: New Zealand	International Avg.
Science content	16 (2.6)	35 (0.5)
Science pedagogy / instruction	14 (2.6)	34 (0.5)
Science curriculum	16 (2.3)	34 (0.5)
Integrating information technology into science	14 (2.4)	28 (0.5)
Science assessment	9 (1.9)	27 (0.4)

Note: Standard errors are presented in parentheses.

Source: Exhibit 7.7, Martin, Mullis, Foy, and Stanco, 2012.

Science teaching and learning activities

A series of questions were asked of both teachers and students about the extent to which the teachers tried to engage students in the learning activities. Along with this, the teachers were also asked about the way they worked with the class (whole class teaching or getting students to explain their answers). This section will explore these questions.

Extent to which teachers engage students

Teachers were asked about the frequency with which they used certain instructional techniques for engaging the students (listed in Table 9.8). Nearly all New Zealand students had science teachers who reported that they praised students for good effort every or almost every lesson (92% of students). Most students were in classes where teachers reported encouraging all students to improve their performance every or almost every lesson (88% of students). More than half of students had teachers who brought interesting materials to class (20% every or almost every lesson, 51% about half of lessons).

Table 9.8: Frequency with which New Zealand teachers used methods for engaging the students when teaching the class

Methods for engaging the students when teaching the class:	Percentage of students: never	some lessons	about half the lessons	every or almost every lesson
Summarise what students should have learned from the lesson	<1	13	38	49
Relate the lesson to students' daily lives	0	14	38	48
Use questioning to elicit reasons and explanations	0	1	15	84
Encourage all students to improve their performance	0	<1	12	88
Praise students for good effort	0	1	7	92
Bring interesting materials to class	0	30	51	20

Note: Results may appear inconsistent due to rounding

In order to summarise responses to this question, the international researchers created a scale that combined teachers' responses to these six items and called it the Instruction to Engage Students in Learning scale.

As is shown in Table 9.9, on average, New Zealand teachers engaged students in learning with about the same frequency as on average internationally. However, most of the other English-speaking countries had higher proportions of students whose teachers attempted to engage them in learning *most lessons* while many of the high-achieving Asian countries had smaller proportions. Proportions of students ranged from 88 percent in the United States down to 52 percent in Japan whose teachers tried to engage them in learning *most lessons*. This implies that there could be different cultural expectations for these types of instructional techniques.

Table 9.9: Frequency with which teachers used Instruction to Engage Students in Learning

	Percentage of students		
	Some lessons	About half the lessons	Most lessons
New Zealand	0 (0.4)	32 (3.0)	67 (3.1)
International Avg.	2 (0.1)	27 (0.4)	71 (0.5)

Note: Standard errors are presented in parentheses.

Results may appear inconsistent due to rounding.

A score for the six items combined was created using Item Response Theory. For any score 9.1 or greater, the teacher was assigned to the 'most lessons' grouping which corresponds to them using three of the six practices 'every or almost every lesson' and using the other three in 'about half the lessons', on average. For any score 6 or smaller, the teacher was assigned to the 'some lessons' grouping which corresponds to them using three of the six practices in 'some lessons' and using the other three in 'about half the lessons', on average. Otherwise, they were assigned to the 'about half the lessons' grouping.

Source: Exhibit 8.14, Martin, Mullis, Foy, and Stanco, 2012.

Students were asked their agreement with a series of five questions (shown in Table 9.10) to gauge their level of engagement with their science lessons. Most New Zealand Year 5 students (88%) agreed a little or a lot that they know what their teacher expects them to do in their science lessons. Similar proportions found their teacher easy to understand (87%), had interesting things to say (86%) and gave them interesting things to do (88%). Just under half of students (45%) admitted thinking of things not related to the lesson.

Table 9.10: Percentage of New Zealand students who agreed at least a little with statements about their engagement with their science lessons

Statements	Percentage of students who agreed at least a little with each statement	Is agreeing with the statement associated with higher science achievement?
I know what my teacher expects me to do	88 (0.6)	agreeing and disagreeing the same
I think of things not related to the lesson	45 (0.8)	students agreeing lower
My teacher is easy to understand	87 (0.6)	agreeing and disagreeing the same
I am interested in what my teacher says	86 (0.7)	students agreeing higher
My teacher gives me interesting things to do	88 (0.6)	agreeing and disagreeing the same

Note: Standard errors are presented in parentheses.

Students who agreed they were interested in what their teacher had to say had higher science achievement than those who disagreed. Students who admitted that they thought of things not related to the lesson had lower science achievement than those who did not. There was no difference in science achievement between those who agreed they know what their teacher expected them to do and those who did not. Similarly, those who agreed that their teacher gave them interesting things to do or those who agreed their teacher was easy to understand had similar achievement to those who disagreed.

The international researchers created a scale that combined students' responses to these five items and called it the Students Engaged in Science Lessons scale. Fewer New Zealand students were engaged in science lessons according to this measure than on average internationally (see Table 9.11). New Zealand students who were engaged had higher science achievement than those who were only somewhat engaged (21 scale score points difference) or not engaged (23 scale score points lower than engaged). The same pattern was observed across nearly all other countries.

Table 9.11: Proportion of Students Engaged in Science Lessons

	Percentage of students		
	Not engaged	Somewhat engaged	Engaged
New Zealand	10 (0.6)	51 (0.9)	39 (0.9)
International Avg.	8 (0.1)	47 (0.2)	45 (0.2)

Note: Standard errors are presented in parentheses.

A score for the five items combined was created using Item Response Theory. For any score 10.1 or greater, the student was assigned to the 'engaged' grouping which corresponds to them "agreeing a lot" with three of the five statements and "agreeing a little" with the other two, on average. For any score 7.4 or smaller, the student was assigned to the 'not engaged' grouping which corresponds to them "disagreeing a little" with three of the five statements and "agreeing a little" with the other two, on average. Otherwise, they were assigned to the 'somewhat engaged' grouping.

Source: Exhibit 8.17, Martin, Mullis, Foy, and Stanco, 2012.

Emphasis on science investigation

Teachers were asked about their use of investigations in their science teaching along with asking students to give explanations or relate what they are learning to their own lives. As mentioned earlier in this report, compared to other countries, New Zealand students had a relatively low number of hours of science teaching per year and there were a number of teachers that reported that they did not teach science at all during 2011 (there were other priorities for that year). In addition, some teachers found it too difficult to estimate hours of teaching as science was integrated into other areas of the curriculum or taught as part of an enquiry-based learning. Therefore, the information presented in this section should be read with all of that in mind.

New Zealand teachers most frequently asked students to give explanations about something they were studying or relate what they were learning to their lives (57% of students were asked to do these about half the lessons or more often – see Table 9.12). Designing and planning or carrying out experiments or investigations were relatively commonplace science activities for more than one-third of students.

Table 9.12: Frequency of doing investigations in science lessons in New Zealand

	Percentage of students		
	never	some lessons	about half the lessons or more often
Observe natural phenomena such as the weather or a plant growing and describe what they see	10	65	24
Watch me demonstrate an experiment or investigation	16	64	20
Design or plan experiments or investigations	12	54	34
Conduct experiments or investigations	5	56	39
Give explanations about something they are studying	2	41	57
Relate what they are learning in science to their daily lives	4	39	57

Note: Results may appear inconsistent due to rounding.

To summarise the use of these activities in classrooms the international researchers created a scale that combined teachers' responses to these six items and called it the Emphasise Science Investigation scale. On average, New Zealand teachers emphasised science investigation less than their peers in other countries as shown in Table 9.13. The Republic of Korea, Chinese Taipei, Japan, and Singapore, all had over half of their students in classes where science investigations was used in about half the lessons or more.

Table 9.13: Proportion of students whose science teachers regularly conducted science investigations

	Level on the Emphasise Science Investigation scale (percentage of students)	
Country	Less than half the lessons	About half the lessons or more
New Zealand	80 (2.4)	20 (2.4)
International Avg.	60 (0.5)	40 (0.5)

Note: Standard errors are presented in parentheses.

A score for the six items combined was created using Item Response Theory. For any score 10.7 or greater, the teacher was assigned to the 'about half the lessons or more' grouping which corresponds to their teachers using all six activities at least about half the lessons, on average. Otherwise, they were assigned to the 'less than half the lessons' grouping.

Source: Exhibit 8.27, Martin, Mullis, Foy, and Stanco, 2012.

Use of resources

There is interesting variation around the world in the way resources are used for teaching science. Teachers were asked if their use of textbooks, workbooks or worksheets, concrete materials and computer software in their science lessons was as a basis for instruction, as a supplement, or not used at all. As Table 9.14 shows, in New Zealand the most commonly used resources in terms of a basis for instruction were science equipment and materials (46% of students). Workbooks or worksheets (82% of students) were most commonly used as a supplementary resource.

Table 9.14: Use of resources in New Zealand classrooms

	Percentage of students whose teacher used the resources as a:		
	Basis for instruction	Supplement	Not used
Textbooks	5	43	53
Workbooks or worksheets	9	82	10
Science equipment and materials	46	50	4
Computer software for science instruction	13	61	26

Note: Results may appear inconsistent due to rounding

In comparison to New Zealand, textbooks were most commonly used as a basis for instruction in many of the countries. Table 9.15 shows the international average but there was quite a variation among countries. Countries like the Korean Republic, Chinese Taipei and Finland had nearly all teachers using textbooks as a basis for instruction (94% of students or more). New Zealand had nearly the lowest proportion of students (5%) with science teachers using textbooks as a basis for instruction with only England having a lower proportion (4%).

Table 9.15: Use of resources in classrooms on average internationally

	Percentage of students on average internationally whose teacher used the resources as a:		
	Basis for instruction	Supplement	Not used
Textbooks	70	22	8
Workbooks or worksheets	41	56	4
Science equipment and materials	36	60	5
Computer software for science instruction	11	53	36

Note: Results may appear inconsistent due to rounding

Source: Exhibit 8.25, Martin, Mullis, Foy, and Stanco, 2012.

Use of computers

As shown in Tables 9.14 and 9.15, more New Zealand teachers used computer software as a supplementary resource in their instruction than on average internationally. Nearly all New Zealand teachers used computers for preparation (99% of students), for administration purposes (99%) and in their classroom instruction (96% - note this question was not about science instruction specifically so differs from the proportion in Table 9.14). Most teachers felt comfortable using computers in their teaching (77% of students had teachers who agreed a lot and 19% agreed a little).

Specifically during science lessons, New Zealand had the highest proportion of students (85%) whose teachers responded that computers were available for use during lessons. In comparison, 47 percent of students on average internationally were in classes where computers were available for use during science lessons. New Zealand also had the highest use of computers to look up ideas and information (see Table 9.16 for details). There were only a few countries with higher proportions using computers for the other activities.

Table 9.16: Computer availability and use during science lessons

	Percentage of students			
	New Zealand		International Avg.	
Have computers available for science lessons	85	(2.3)	47	(0.5)
Computers used for:				
looking up ideas and information	79	(2.5)	41	(0.5)
do scientific procedures or experiments	42	(3.3)	24	(0.4)
study natural phenomena through simulations	47	(2.9)	25	(0.4)
practicing skills and procedures	40	(3.3)	31	(0.5)

Note: Standard errors are presented in parentheses.

Source: Exhibit 8.29, Martin, Mullis, Foy, and Stanco, 2012.

Monitoring student progress

According to the National Administration Guidelines, schools in New Zealand are required to: "through a range of assessment practices, gather information that is sufficiently comprehensive to enable the progress and achievement of students to be evaluated" (Ministry of Education, 2012). Teachers were asked how much emphasis they placed on different sources to monitor students' progress in science (sources shown in Table 9.17). As shown in the table, more New Zealand teachers placed major emphasis on evaluation of students' ongoing work (69% of students in such classes) than on tests.

On average internationally, proportions of students were much higher for the level of emphasis placed on all of these sources: evaluation of students' ongoing work (major emphasis 81% of students), classroom tests (major emphasis 57%) and national or regional achievement tests (major emphasis 27%).

Table 9.17: Emphasis New Zealand teachers placed on sources for monitoring students' progress

	Emphasis placed by teachers (percentage of students)		
	Little or no emphasis	Some emphasis	Major emphasis
Evaluation of students' ongoing work	5	25	69
Classroom tests (for example, teacher-made or textbook tests)	28	58	13
National or regional achievement tests	59	34	7

Note: Results may appear inconsistent due to rounding.

Monitoring teacher practice

The National Administration Guidelines for New Zealand schools require schools to maintain an on-going programme of self-review (Ministry of Education, 2012). Principals were asked what sources of information they used to evaluate the practice of Year 5 teachers. Nearly all principals reported that they or their senior staff observed the teachers to evaluate their practice (less than 1% did not). Observations by people not part of the school staff were also used but not in as many schools (59% of students in such schools). Student achievement was also commonly used to evaluate the practice of teachers (88% of students in such schools).

Table 9.18: Sources of information used to evaluate the practice of Year 5 teachers in New Zealand

Evaluation method	Percentage of students whose principal responded 'yes'	
Observations by the principal or senior staff	99	(0.5)
Student achievement	88	(2.7)
Teacher peer review	77	(3.6)
Observations by inspectors or other persons external to the school	59	(3.7)

Note: Standard errors are presented in parentheses.

10. School climate

"Providing a caring, safe and respectful school environment in which learning can flourish is a key priority for educators…" (Boyd & Barwick, 2011). Student learning takes place for the individual within a classroom, situated in a school. It seems intuitive that a positive schooling environment would result in positive academic results for students.

In addition to data on achievement in mathematics and science, TIMSS collects a vast amount of contextual information, including responses to questions about the school gathered from teachers, school principals, students and parents. This section examines student, teacher, principal, and parents' perceptions of the climate for learning, teachers' beliefs on the limitations to science learning, and perceptions of school safety and student behaviour. This chapter also looks at the responses of teachers to the conditions in which they find themselves teaching and how they feel about their role as teacher. The relationships between some school context variables and science achievement are also examined and comparisons with previous cycles are presented where possible.

"…to bring about change we need to understand the contribution of, and relationship between, the different parts of the system." (Boyd & Barwick, 2011).

Student perceptions of climate for learning

Students in all countries were asked if they agreed with three statements about their schools: *I like being at school*, *I feel safe when I am at school*, and *I feel like I belong at this school*. They were able to respond with one of four options: *agree a lot*, *agree a little*, *disagree a little*, and *disagree a lot*. In addition, New Zealand students were asked if they agreed with a further statement: *I think that students at this school care about each other*.

Most New Zealand Year 5 students were positive about their schools and their teachers, with more than eight out of every 10 students agreeing with statements as shown in Table 10.1. The statement with the lowest level of agreement was *I think that students at this school care about each other* with 13 percent disagreeing a little and four percent disagreeing a lot – in total, 83 percent of students agreed with this statement. The statement with the highest level of agreement was *I feel safe when I am at school*, with 61 percent agreeing a lot and 27 percent agreeing a little. A higher percentage of girls than boys agreed with all four statements listed in Table 10.1.

Table 10.1: New Zealand Year 5 student agreement with statements about their school

	Proportion of students agreeing (agreeing a little and a lot combined)		
Statements about the school	**Total**	**Girls**	**Boys**
I like being at school	84 (0.6)	91 (0.7)	77 (1.0)
I feel safe when I am at school	88 (0.6)	93 (0.6)	84 (0.9)
I feel like I belong at this school	85 (0.7)	90 (0.8)	81 (0.9)
I think that students at this school care about each other	83 (0.7)	87 (0.9)	79 (1.0)

Note: Standard errors are presented in parentheses.

All four ethnic groupings were very positive about their schools and a high proportion agreed with the four statements (see Table 10.2). There were some differences between proportions of the ethnic groupings agreeing with individual statements but these were either small or non-significant.

Table 10.2: New Zealand Year 5 student agreement with statements about their school, by ethnic grouping

	Proportion of students agreeing (agreeing a little and a lot combined)			
Statements about the school	**Pākehā/European**	**Māori**	**Pasifika**	**Asian**
I like being at school	82 (0.9)	85 (1.4)	91 (1.2)	91 (1.7)
I feel safe when I am at school	88 (0.8)	88 (1.4)	91 (1.5)	90 (1.7)
I feel like I belong at this school	85 (0.9)	86 (1.1)	87 (1.3)	86 (2.0)
I think that students at this school care about each other	83 (0.8)	79 (1.4)	86 (1.6)	86 (1.6)

Note: Standard errors are presented in parentheses.

There were too few students in the 'Other' ethnic grouping to include that grouping in the table.

Three of the four statements showed a significant relationship with achievement for New Zealand students overall: *I feel safe when I am at school* and *I feel like I belong at this school*, and *I think that students care about each other*. The students who disagreed with those statements had lower science achievement than their counterparts who agreed with the statements.

There is not a consistent pattern across TIMSS countries in terms of the relationship between student achievement and to what degree students agreed with the statement *I like being at school* (see Table 10.3). However, it seems that for many countries, those who answered with *agree a little* or *disagree a little* scored higher than those who responded at the extremes with *agree a lot* or *disagree a lot*. Those countries that had the highest number of students agreeing with the statement (Azerbaijan, Georgia, and Tunisia; all three with 98% agreeing either a little or a lot) all had lower science achievement than New Zealand. The three countries with the highest proportions of students who disagreed with this statement however (Northern Ireland 27%, Austria and Czech Republic, both 28%) all had significantly higher science achievement than New Zealand. So while within a country there may be some pattern with achievement being better amongst students who agreed that they liked school, higher proportions of students agreeing with this statement did not necessarily mean the country as a whole achieved better.

Table 10.3: Student agreement with the statement "I like being at school" for selected countries in TIMSS 2010/11

Country	Proportion of students agreeing (agreeing a little and a lot combined)
Azerbaijan	98
Georgia	98
Tunisia	98
Singapore	90
Korea, Rep. of	86
New Zealand	**84**
England	81
Malta	81
Australia	81
United States	78
Chinese Taipei	77
Hong Kong SAR	75
Ireland	74
Northern Ireland	73
Austria	72
Czech Republic	72
International Avg.	**86**

Note: The order of this table is based on proportion of students agreeing.

Trends in student perceptions

The first statement listed in Table 10.1 was also posed to TIMSS students in 2002/03 and 2006/07. The proportion of New Zealand students agreeing with the statement *I like being at school* was approximately the same in 2002/03 (83%), 2006/07 (84%) and 2010/11 (84%). As in 2010/11, this statement did not have a significant relationship with science achievement in 2006/07 or 2002/03. The question *I think that students at this school care about each other* was first asked in TIMSS 2006/07. There was little change in the percentage who agreed with this statement between 2006/07 (85%) and 2010/11 (83%).

Teacher perceptions of climate for learning

Teachers of Year 5 students were asked how they would characterise eight aspects of life at their school from teachers' job satisfaction to students' desire to do well in school, as listed in Table 10.4. They were given five response options: *very high*, *high*, *medium*, *low*, and *very low*.

Of all the statements listed, teachers were most positive about other teachers in their schools. In particular, most teachers felt their expectations for student achievement were *very high* or *high*, with 95 percent of students having teachers who indicated this. Conversely, teachers were not so enthusiastic about parental support and involvement, with around half of the students having teachers who indicated parental support for student achievement (50%) and parental involvement in school activities (46%) was *very high* or *high*. Teachers were also less enthusiastic about students' regard for school property, with just under half of students having teachers who indicated this aspect was *medium*, *low*, or *very low*.

Table 10.4: Extent to which science teachers characterised aspects of school climate in New Zealand in TIMSS 2010/11

	Proportion of Year 5 students		
Statements on aspects of school climate	Very low or Low	Medium	High or Very high
Teachers' job satisfaction	1 (0.4)	18 (2.1)	81 (2.1)
Teachers' understanding of the school's curricular goals	<1 (0.3)	14 (2.3)	86 (2.3)
Teachers' degree of success in implementing the school's curriculum	2 (1.3)	15 (2.0)	83 (2.3)
Teachers' expectations for student achievement	<1 (0.2)	5 (1.0)	95 (1.1)
Parental support for student achievement	8 (1.2)	42 (3.0)	50 (3.1)
Parental involvement in school activities	14 (1.4)	40 (3.0)	46 (3.1)
Students' regard for school property	9 (1.7)	40 (3.3)	52 (3.4)
Students' desire to do well at school	2 (0.8)	30 (2.9)	68 (2.9)

Note: Standard errors are presented in parentheses.

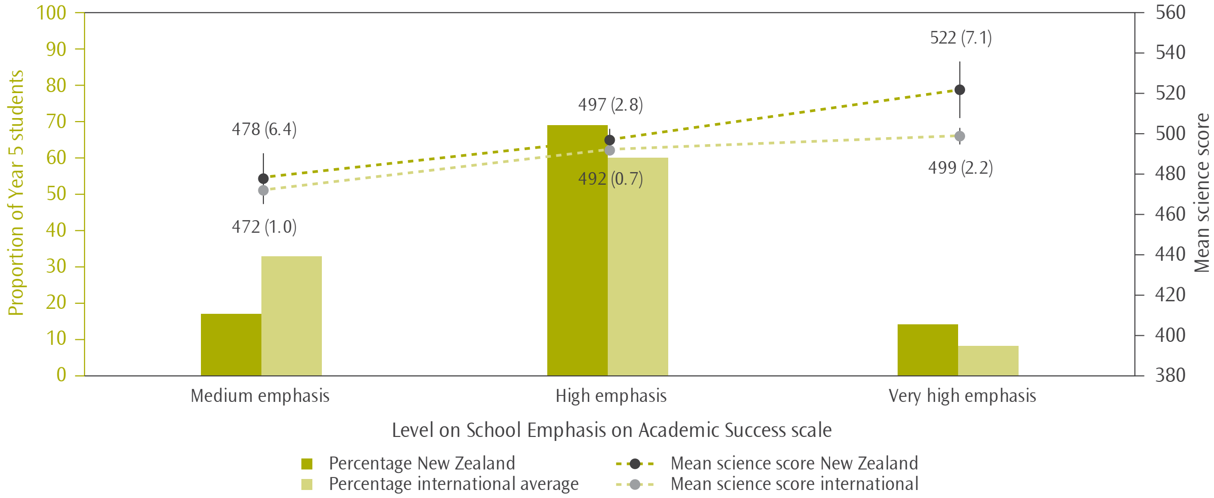
Proportions in each row should add to 100%; inconsistencies are due to rounding.

Out of the statements in Table 10.4, those that had the greatest impact on student achievement in science were the ones related to parental support or involvement and the lower the teachers rated the statement, the lower the associated average science achievement. There was little difference in science achievement across the categories (*very high/high*, *medium*, *low/very low*) for those statements pertaining to teachers. Out of the two statements relating to students, only one had significant differences between the categories: students' desire to do well at school. The higher this statement was regarded by the teachers, the higher the students' science achievement was, on average, showing student attitude, perhaps unsurprisingly, has a particular impact on achievement.

Principals were also asked how they would characterise the same eight aspects of life at their school (refer to section Principal perceptions of climate for learning later in this chapter). Responses to five out of these eight statements, intended to represent academic optimism in schools, were summarised into two continuous scales, one for teachers' responses and one for principals, referred to as the School Emphasis on Academic Success scale. The statements that did not go into the creation of this scale were: *Teachers' job satisfaction*, *Parental involvement in school activities*, and *Students' regard for school property*. To report the scale in a meaningful way, values were grouped into three categories, *Very high*, *High*, and *Medium* emphasis. As teachers had responded very positively to these statements, there was no *low* or *very low* category in the scale.

The general pattern, as shown by the international average, indicated that the higher the emphasis by the teacher on the scale, the higher the associated achievement scores in TIMSS for science, and this was true for New Zealand schools (see Table B.1 in the Appendix). In New Zealand, there was a difference of more than 40 achievement score points for science, on average, between those students whose teachers rated *Very high* on the scale and those who rated *Medium* (see Figure 10.1). This pattern was not consistent across all countries, however.

Figure 10.1: Levels on the School Emphasis on Academic Success scale (based on teachers' reports) by mean science achievement for New Zealand Year 5 students in TIMSS 2010/11



Note: A classification as *Very high* meant that students in a school had teachers who responded with at least *very high* for an average of three of the five statements and *high* for the other two. *Medium* meant students in the school had teachers who responded to an average of no more than three of the five statements as *medium* and the others as *high*. Those left over were classified as *High*.

Source: Adapted from Exhibit 6.3, Martin, Mullis, Foy, and Stanco, 2012

For the first time in TIMSS, teachers were also asked about their feelings about being a teacher. See Table 10.5 below for the six statements with which teachers could *agree a lot*, *agree a little*, *disagree a little*, or *disagree a lot*. There was complete agreement amongst the teachers who responded to the questionnaire that the work they do is important and more than 90 percent said they were content with their profession (94%), were satisfied with being a teacher at their school (94%), and plan to continue as a teacher for as long as they can (90%). Despite a number of teachers being positive about their role and school, around 40 percent of teachers agreed that they had more enthusiasm when they started teaching than they had when they completed the questionnaire (45%) and were frustrated as a teacher (40%).

Table 10.5: New Zealand science teachers' agreement with statements about teaching in TIMSS 2010/11

Statements about teaching	Proportion of students with teachers agreeing (agreeing a little and a lot combined)	
I am content with my profession as a teacher	94	(1.4)
I am satisfied with being a teacher at this school	94	(1.1)
I had more enthusiasm when I began teaching than I have now	45	(3.1)
I do important work as a teacher	100	(0.0)
I plan to continue as a teacher for as long as I can	90	(1.6)
I am frustrated as a teacher	40	(3.1)

Note: Standard errors are presented in parentheses.

Students in the selection of English speaking and high achieving countries shown in Table 10.6 have teachers who agreed with almost perfect accordance that they do important work as teachers. There was also a high level of agreement across the board that the teachers were content with their profession. There was a larger range however for the two statements about enthusiasm and frustration. In particular, Korea and Singapore had the highest proportions of students with teachers who agreed that they had more enthusiasm when they began teaching (77% and 74% respectively). In contrast, Malta and Ireland had a much lower rate of teacher agreement for having more enthusiasm when they began teaching (35% and 37% of students respectively).

Table 10.6: Middle primary science teacher agreement with statements about their role as teachers for selected countries in TIMSS 2010/11

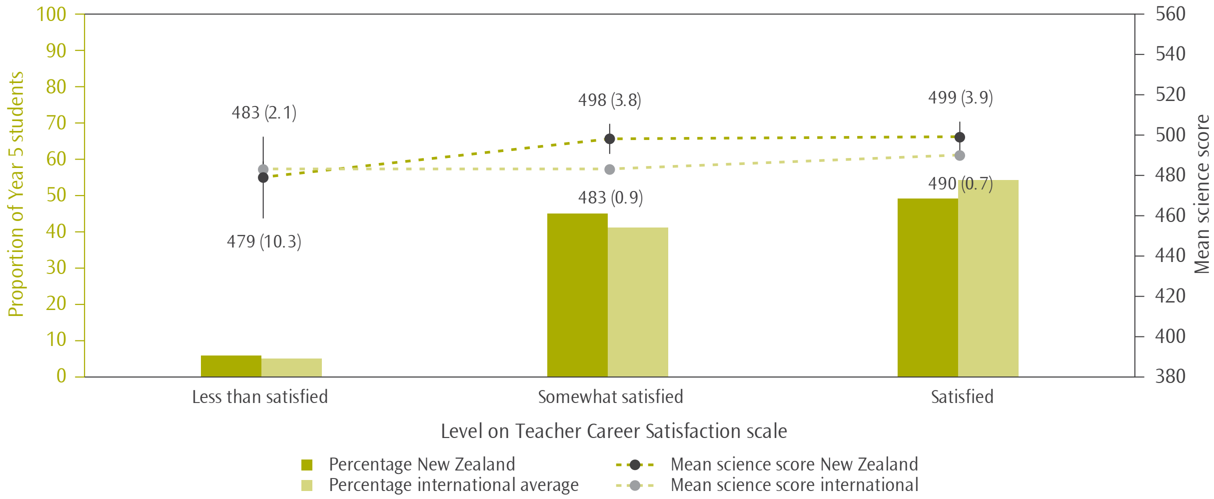
	Proportion of students with teachers agreeing (agreeing a little and a lot combined)			
Country	**Contentment with profession as teacher**	**More enthusiasm when began teaching**	**Do important work as a teacher**	**Frustrated as a teacher**
Korea, Rep. of	94	77	99	22
Singapore	94	74	96	42
Chinese Taipei	96	68	98	37
United States	92	52	99	51
Hong Kong SAR	98	63	98	30
England	91	50	99	43
Northern Ireland	96	49	100	43
Ireland	98	37	100	36
Australia	93	51	100	41
New Zealand	**94**	**45**	**100**	**40**
Malta	96	35	100	16
International Avg.	**96**	**55**	**99**	**21**

Note: The order of this table is based on achievement order in science.

The international TIMSS team also constructed a Teachers' Career Satisfaction scale, based on how much teachers agreed with the six statements about their role as a teacher. Science teachers' responses were combined into a continuous scale to describe the extent to which they agreed with the statements and the scale values were then grouped into three categories, *Satisfied*, *Somewhat satisfied*, and *Less than satisfied*, to report the scale in a meaningful way.

The proportion of New Zealand Year 5 students taught by teachers who were satisfied with their career (i.e., in the Satisfied category) was lower than the international average for science (49% versus 54% – see Figure 10.2). New Zealand also had one of the lowest rates of students with satisfied science teachers out of the English speaking countries who took part in TIMSS at Year 5 (see Table B.2 in the Appendix). On average, higher satisfaction was related to higher achievement in science but the differences between some of the categories were not great and the pattern differed from country to country. For New Zealand, those students with science teachers who were less than satisfied had lower achievement than those in the other two categories but the average achievement for students who had teachers in the top two categories was not that different from each other.

Figure 10.2: Levels on the Teacher Career Satisfaction scale by mean science achievement in TIMSS 2010/11



Note: The category Satisfied covers the proportion of students who had teachers that marked agree a lot for at least three out of the six statements and agree a little with the other three, on average. Less than satisfied teachers at most disagreed a little with three of the six statements and agreed a little with the other three, on average. The rest of students were classified as having Somewhat satisfied teachers.

Source: Adapted from Exhibit 7.15, Martin, Mullis, Foy, and Stanco, 2012.

Trends in teacher perceptions

The questions given to teachers about school climate were first introduced in 2002/03. The proportions of students whose teachers gave positive responses to the individual questions did not change significantly between 2002/03 and the following cycle in 2006/07. However, between 2006/07 and 2010/11, the proportions who answered *very high* or *high* for *Teachers' job satisfaction*, *Teachers' expectations for student achievement*, and *Students' desire to do well* have all increased, showing how teachers' feelings about their job and their students seems to have increased in positivity.

Principal perceptions of climate for learning

Principals of Year 5 students were asked how they would characterise the same eight aspects of life at their school as the teachers, and these are listed in Table 10.7. They were given the same five response options as the teachers: *very high*, *high*, *medium*, *low*, and *very low*.

While percentages were different, the pattern was similar when teachers' responses and principals' responses to these questions were compared. The statements where principals were most positive were the four statements relating to teachers with more than 80 percent of students having principals who indicated these aspects were *very high* or *high*, although these were less positive than the responses from the teachers themselves. Principals were also very positive about students' desire to do well in school, with 88 percent of students having principals who indicated this was *very high* or *high*, considerably higher than the 68 percent of students who had teachers that responded in this way.

Aspects relating to parental support and involvement attracted fewer positive responses from principals, a similar pattern to that expressed by teachers. Principals were however more positive than teachers on this matter with 72 percent of students having principals who responded to *parental support for student achievement* with *very high* or *high* (c.f. 50% for teachers' responses) and 57 percent responding *very high* or *high* for *parental involvement in school activities* (c.f. 46% for teachers' responses). Principals were also more positive than teachers about *students' regard for school property*, with 66 percent of students having principals who responded with *very high* or *high*, compared to 52 percent for teachers.

Table 10.7: Extent to which principals characterised aspects of school climate in New Zealand in TIMSS 2010/11

	Proportion of Year 5 students		
Statements on aspects of school climate	Very low or Low	Medium	High or Very high
Teachers' job satisfaction	0 (0.0)	13 (2.2)	87 (2.2)
Teachers' understanding of the school's curricular goals	<1 (0.4)	12 (2.4)	88 (2.5)
Teachers' degree of success in implementing the school's curriculum	0 (0.0)	15 (2.6)	85 (2.6)
Teachers' expectations for student achievement	0 (0.0)	9 (2.2)	91 (2.2)
Parental support for student achievement	4 (1.4)	23 (3.0)	72 (3.3)
Parental involvement in school activities	9 (2.2)	34 (3.6)	57 (3.9)
Students' regard for school property	3 (1.0)	31 (3.7)	66 (3.9)
Students' desire to do well at school	1 (0.6)	10 (2.5)	88 (2.6)

Note: Standard errors are presented in parentheses.

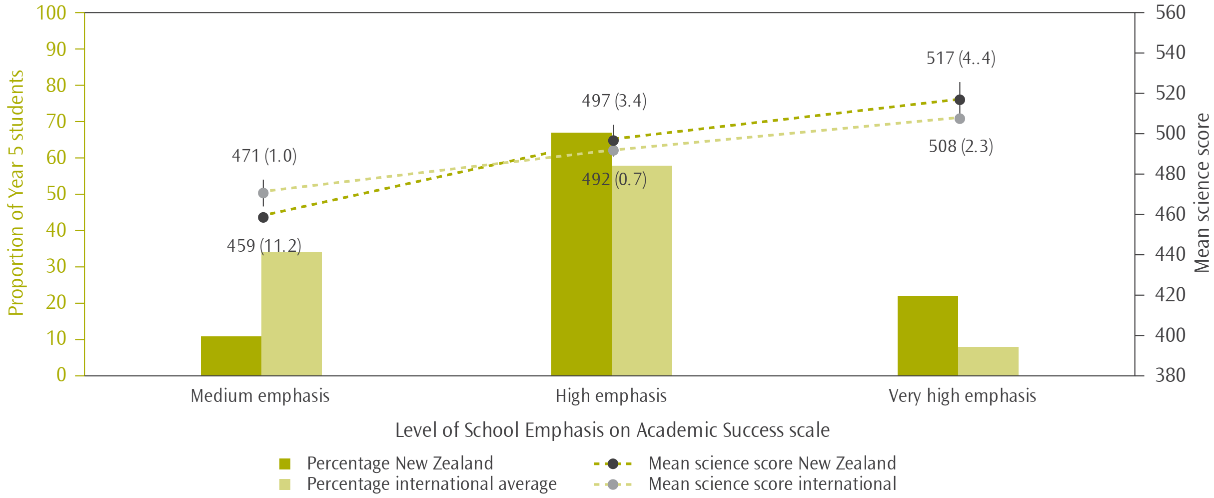
Proportions in each row should add to 100%; inconsistencies are due to rounding.

The responses of the principals across these eight statements and their relationship with achievement differed from the relationship between the teachers' responses and achievement scores. While the teachers' responses saw the greatest differences in achievement for the questions relating to parental support and involvement, the pattern was less clear-cut for the principals. Two of the statements (*Teachers' understanding of the school's curricular goals*, and *Teachers' expectations for student achievement)* have no apparent relationship with science achievement. For *Parental support for student achievement*, achievement for those in the *high* group was statistically higher than for the *medium* but the *medium* was not statistically different in terms of achievement from the *low* group. Students whose principals categorised *students' regard for school property* as *low* had lower science achievement than those in the other groups. For the rest of the statements, the higher the aspect of the school climate, the higher the achievement for science.

Responses to five out of these eight statements, intended to represent academic optimism in schools, were summarised into two scales, one for teachers and one for principals, referred to as the School Emphasis on Academic Success scale (the results for teachers can be found in Figure 10.1 earlier in this chapter). As mentioned earlier, the statements that did not go into the creation of this index were: *Teachers' job satisfaction*, *Parental involvement in school activities*, and *Students' regard for school property*. To report the scale in a meaningful way, values were grouped into three categories, *Very high*, *High*, and *Medium* emphasis. As principals had responded very positively to these statements, there was no *low* or *very low* category on this scale.

The general pattern, as shown by the international average, was that the higher on the scale the emphasis by the principal, the higher the associated achievement scores in TIMSS for science, and this was true for New Zealand schools. In New Zealand, there was a difference of more than 50 achievement score points for science, on average, between those students whose principals rated *Very high* on the scale and those who rated *Medium* (see Figure 10.3). This pattern was not consistent across all countries (see Table B.3 in the Appendix).

Figure 10.3: Levels on the School Emphasis on Academic Success scale (based on principals' reports) by mean science achievement in TIMSS 2010/11



Note: A classification as Very high meant that students in a school had a principal who responded with very high for at least three of the five statements and high for the other two. Medium meant students in the school had a principal who responded to an average of no more than three of the five statements as medium and the others as high. Those left over were classified as High.

Source: Adapted from Exhibit 6.1, Martin, Mullis, Foy, and Stanco, 2012.

For New Zealand, the overall pattern of those students in schools with higher ratings on the scale having higher average achievement appears to be the same, regardless of whether it was teachers or principals reporting it. Internationally however, there was a greater difference in terms of achievement scores between the *Very high* and *High* categories when reported by principals than there was when reported by teachers and there were also countries for which this difference was negligible.

Trends in principal perceptions

The questions given to principals about school climate were first introduced in 2002. Comparisons between 2002 and 2006 showed no significant changes in the proportions of New Zealand students whose principals gave positive responses to the individual statements. However, between 2006/07 and 2010/11 there have been changes for most of the statements regarding school climate. In 2010/11, fewer principals responded with *very high* or *high* for *Teachers' understanding of the school's curricular goal*s and *Teachers' degree of success in implementing the school's curriculum* (91% in 2006/07, 88% in 2010/11 and 91% in 2006/07, 85% in 2010/11, respectively), probably due to the introduction of the new curriculum. There was a rise in positive responses between 2006/07 and 2010/11 for those answering *very high* or *high* for all four of the parent and student related statements: from 62 to 72 percent for *Parental support for student achievement*, 41 to 57 percent for *Parental involvement in school activities*, 59 to 66 percent for *Students' regard for school property* and 74 to 88 percent for *Students' desire to do well at school*.

Parent perceptions of climate for learning

Parents of TIMSS students were given questionnaires for the first time in 2010/11. Across the students who participated in TIMSS 2010/11 at Year 5, 59 percent of parents returned completed questionnaires so the results in this section should be read with this in mind.

Parents were asked if they agreed with statements about the school that their child attended, as listed in Table 10.8. They were given the response options *agree a lot*, *agree a little*, *disagree a little*, and *disagree a lot*. Overall, parents who responded to the questionnaire were very positive about their children's school. Over 90 percent of parents agreed that their child's school includes them in their child's education (93%), cares about their child's progress at school (95%), and does a good job in helping their child become better in reading (93%) and mathematics (90%). There was still, however, around 50 percent of parents who agree that their child's school should make a greater effort to include them in their child's education (48%) and should do better at keeping parents informed of their child's progress (53%). The percentage of parents who agreed that the school was doing a good job in helping their child become better in science, while not low (78%), was still lower than those who agreed that the school was doing a good job in helping their child become better in mathematics or reading. This may reflect the strong focus on literacy and numeracy in schools and also the integrated nature of science in a lot of primary schools, making it sometimes difficult to ascertain when and how science is being taught.

Table 10.8: New Zealand Year 5 parents' agreement with statements about their child's school

Statements about the school	Proportion of students whose parents agreed (agreeing a little and a lot combined)
My child's school includes me in my child's education	93 (0.6)
My child's school should make a greater effort to include me in my child's education	48 (1.1)
My child's school cares about my child's progress at school	95 (0.5)
My child's school should do better at keeping me informed of his/her progress	53 (1.2)
My child's school does a good job in helping him/her become better in reading	93 (0.5)
My child's school does a good job in helping him/her become better in maths	90 (0.8)
My child's school does a good job in helping him/her become better in science	78 (1.1)

Note: Standard errors are presented in parentheses.

Student perceptions of school safety and student behaviours

Year 5 students were asked how often they had experienced negative behaviours during the year (the behaviours are listed in Table 10.9). They were given the response options *never*, *a few times a year*, *once or twice a month*, and *at least once a week*.

The two most commonly reported negative behaviours were being made fun of or called names (41% once a month or more frequently) and being left out of games or other activities by other students (39%). The least commonly reported behaviour was being made to do things they didn't want to by other students (22%). The proportions of students in 2010/11 that indicated they had experienced these behaviours at least once a month, meaning they indicated it had happened *at least once a week* or *once or twice a month*, are shown in Table 10.9.

Table 10.9: New Zealand Year 5 students' agreement with statements about other students' behaviour

Statements	Proportion of Year 5 students that replied once a month or more frequently
I was made fun of or called names	41 (1.0)
I was left out of games or activities by other students	39 (0.9)
Someone spread lies about me	32 (0.9)
Something was stolen from me	29 (1.0)
I was hit or hurt by other student(s)	32 (1.0)
I was made to do things I didn't want to do by other students.	22 (0.8)

Note: Standard errors are presented in parentheses.

For all statements in Table 10.9, achievement in science in TIMSS was higher for those students who experienced these behaviours less frequently (i.e., responded with *a few times a year* or *never*).

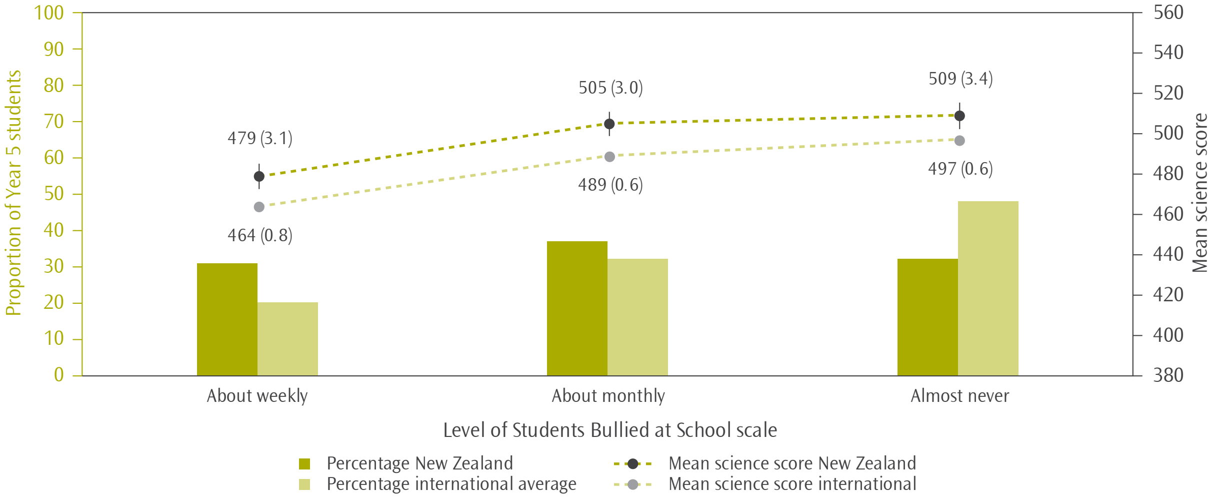
Students' responses to these statements were combined into a continuous scale, the Students Bullied at School scale, to describe the extent to which they experienced bullying behaviours at school. To report the scale in a meaningful way, values on the scale were grouped into three categories. *Almost never* on the scale meant that at most the student responded with *never* to three of the six statements and *a few times a year* to the other three, on average. Students who were categorised as experiencing these behaviours *About weekly* on the scale experienced at least each of three of the six behaviours *once or twice a month* and the other three *a few times a year*, on average. All other students were classified as *About monthly* being bullied.[16] Note that the titles for these categories, as used internationally, may overstate the frequency of the bullying behaviours as can be seen from these descriptors. This data should be read with caution as the reader could assume that 31 percent of students had reported that they were bullied about weekly. However, the scale is based on individual behaviours and could range from a repeated behaviour on a weekly basis from a group of individuals to three different behaviours, with each behaviour happening on separate occasions only once a month and instigated by different perpetrators.

New Zealand had a relatively high proportion of students who often experience these negative behaviours and a relatively low proportion that almost never experienced them, when compared to the international average (see Figure 10.4). In comparison with other countries, almost a third of New Zealand Year 5 students were classified as being in the *Almost never* portion of the scale (32%), lower than the international average of 48 percent, and there were only four other countries that had a lower percentage of students in this category on the scale (Bahrain, Oman, Qatar, and Thailand). New Zealand also had one of the highest proportions of students in the *About weekly* category on the scale (31%), with only four countries having higher (Morocco, Bahrain, Qatar, Thailand) and three countries with the same proportion. (Chile, United Arab Emirates, and Oman).

Looking at achievement across the levels of the scale, there was a general pattern of students who were categorised as being bullied less having higher achievement than those who were categorised as being bullied more, as shown by the international average for science (see Figure 10.4). The biggest difference tended to be between those who were categorised as *About weekly* being bullied at school and the other two categories rather than large differences between all three sections of the scale. Most countries followed this general pattern, including New Zealand (see Table B.4 in the Appendix), but there were one or two countries who were exceptions, such as the Islamic Republic of Iran where there was little difference in science achievement across the three categories.

16 The descriptions here explain the cut points for the category, not the categories themselves. That is, the cut point represents the maximum score that a student could get, on average, and still be assigned to a category. For example, for the About weekly category, the maximum cut score of 8.3 corresponds to students experiencing each of three bullying behaviours once or twice a month and each of the other three a few times a year, on average. Any response corresponding to more frequent bullying behaviour than this will also fall into the About weekly category. Students with a score higher than 10.1 were assigned to the Almost never category.

Figure 10.4: Percentages of students on the Students Bullied at School scale by mean science achievement in TIMSS 2010/11



Source: Adapted from Exhibit 6.11, Martin, Mullis, Foy, and Stanco, 2012.

Different experiences of bullying behaviours within New Zealand

Bullying behaviours can affect different groups in different ways. Consequently, the analysis below is broken down into gender differences, differences amongst socio-economic groups, and differences amongst ethnic groupings.

For the Students Bullied at School scale, the proportion of boys who experienced the bullying behaviours about weekly was higher than the proportion of girls for the same category. For both genders, those in the most frequent category had significantly lower science achievement than those in the other two categories (*Almost never* and *About monthly*), although for girls, the gap in achievement was greater than it was for boys.

For the individual items by gender, the items where there was a difference between boys and girls experiencing them at least once a month were *I was made fun of or called names* (45% and 37% respectively), *I was left out of games or activities by other students* (42% and 37% respectively) and *I was hit or hurt by other students* (36% and 28% respectively). For the other three items in the questions, similar proportions of boys and girls responded with similar levels of frequency.

For girls, those who indicated that they experienced any of the behaviours more frequently (at least monthly) had significantly lower science achievement that those girls who indicated that they experienced these behaviours less frequently or never. The biggest differences were for those who said they were hit or hurt by other student(s) and those who said they were made to do things they did not want to do by other students. Those girls who experienced these more frequently had an average achievement score in science approximately 40 score points below those who experienced the behaviours less frequently.

For boys, achievement followed a similar pattern to the girls, with those who experienced the behaviours at least monthly having lower average achievement than those who experienced them less frequently. The differences however were not as great as for the girls, except for boys who were made to do things they did not want to by other students, with those who experienced this at least monthly having an average science score almost 40 score points lower than those who experienced the behaviour less frequently.

As mentioned previously, the socio-economic status of students has been found to have a strong relationship with achievement and TIMSS asked school principals to report on the economic composition of their school by estimating the proportion of students in their school from economically disadvantaged homes and economically affluent homes. Schools were categorised as being advantaged if more than a quarter of their students were from affluent homes and one quarter or fewer were from disadvantaged homes. Schools that were categorised as disadvantaged had the opposite situation and those schools remaining were classified as Neither Advantaged nor Disadvantaged.

Within each category of the Students Bullied at School scale, the proportions of students from each of the socio-economic groups (economically disadvantaged, neither disadvantaged or advantaged, and economically affluent) were reflective of the population as a whole. In other words, none of the socio-economic groups were over- or under-represented at each level of the scale. These findings are supported by looking at the decile groupings.

The Students Bullied at School scale was also examined by ethnicity. None of the ethnic groups were significantly disproportionately represented at either the more positive or more negative ends of the scale.

Trends in student perceptions about school safety

The questions given to students about school safety have changed since TIMSS was first implemented in 1994. One question from the 1994 cycle remained through to the 2006/07 assessment; a variation on *something was stolen from me*. Five out of the six questions asked in 2006/07 were also asked in the 2010/11 cycle but the response options were changed between the two cycles. In 2006/07, students were asked to indicate by ticking yes or no if the behaviours listed had happened to them at school during the last month. In the 2010/11 cycle, they were given options for how often the behaviours happened to them at school. To compare the two cycles, Table 10.9 earlier in this chapter shows combined categories *at least once a week* and *once or twice a month* as an approximation to the proportions of students who ticked yes for the various behaviours in 2006/07. While the proportions can be compared across the two cycles, it should be viewed with caution, as it is not clear to what degree differences are due to actual changes amongst the students and how much is due to the rephrasing of the questions. For four out of the five behaviours, there were similar or lower proportions in TIMSS 2010/11 (refer to Table 10.10 for details of the 2006/07 percentages). The only behaviour that had a higher proportion in 2010/11 was *I was left out of (games or)*[17] *activities by other students* and this rise was small (35% in 200/07 to 39% in 2010/11).

Table 10.10: Proportion of students that experienced each of these behaviours during the last month in New Zealand in TIMSS 2006/07

Statements	Proportion of Year 5 students
Something of mine was stolen	39 (1.0)
I was hit or hurt by other students (e.g., shoved, punched or kicked)	44 (1.0)
I was made to do things I didn't want to do by other students	24 (0.9)
I was made fun of or called names	42 (1.2)
I was left out of activities by other students	35 (0.9)

Note: Standard errors are presented in parentheses.

Source: Table 25, Caygill, Lang, and Cowles, 2010b.

17 The words in parentheses were not included in 2006/07.

Teacher perceptions of school safety and student behaviours

Teachers of Year 5 students were asked to indicate the extent to which they agreed or disagreed with five statements on the general levels of safety they experienced at their schools. The statements are shown in Table 10.11. There were four possible response options given: *agree a lot*, *agree*, *disagree*, and *disagree a lo*t.

Almost all New Zealand students in TIMSS were taught by teachers who agreed their school was a safe place, with 99 percent agreeing with the statement *I feel safe at this school*, as shown in Table 10.11. There was least agreement with the statement *This school is located in a safe neighbourhood*, with nine percent of students having teachers who disagreed to some extent.

Table 10.11: Extent to which teachers agreed with statements on school safety in New Zealand in TIMSS 2010/11

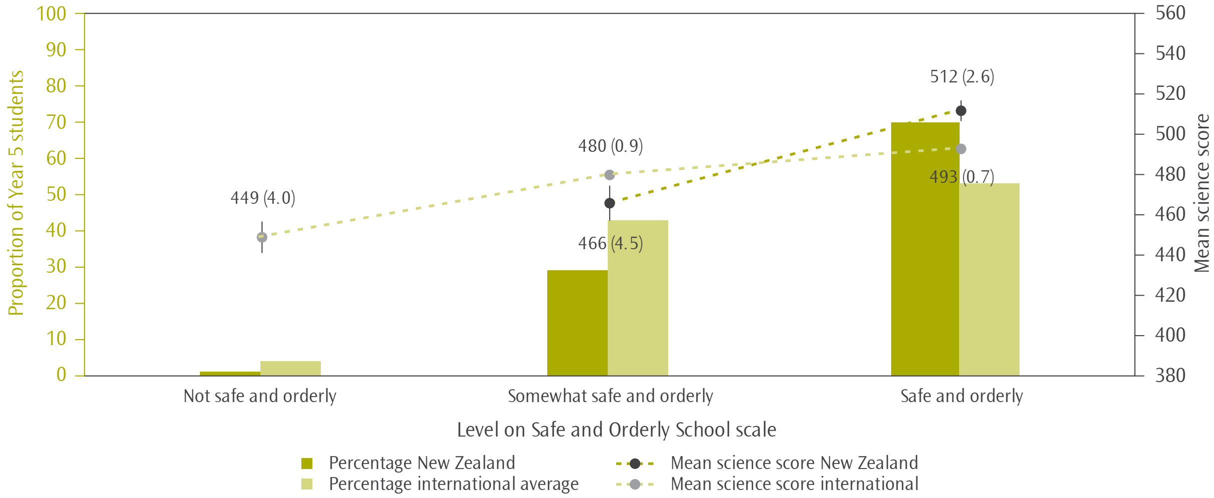
Statements on school safety	Proportion of students with teachers agreeing (agreeing a little and a lot combined)
This school is located in a safe neighbourhood	91 (1.2)
I feel safe at this school	99 (0.5)
This school's security policies and practices are sufficient	96 (1.0)
The students are well behaved	94 (1.4)
The students are respectful of the teachers	93 (1.5)

Note: Standard errors are presented in parentheses.

Teachers' responses to these statements were summarised into a continuous scale, the Safe and Orderly School scale, to describe the extent to which they felt their school was a safe and orderly environment. To report the scale in a meaningful way, values on the scale were grouped into three categories; *Safe and orderly*, *Somewhat safe and orderly*, and *Not safe and orderly*.

Seventy percent of New Zealand Year 5 students had teachers who agreed that their school was a safe and orderly place, which was higher than the international average of 53 percent. The English speaking countries in TIMSS tended to have a high percentage of students in this *Safe and orderly* category (see Table B.5 in the Appendix). A number of countries had such low proportions in the *Not safe and orderly* category that it was not viable to have an average achievement score for them for that category. However, the general pattern relating achievement to safety and order on this scale, as shown by the international average in Figure 10.5, seems to indicate higher science achievement being associated with higher ratings of safety and order. This was the case for a number of countries but there were also some for whom similar science achievement occurred amongst students with teachers who rated in the two higher levels of safety and order (such as Portugal and Hong Kong SAR).

Figure 10.5: Levels on the Safe and Orderly School scale by mean science achievement in TIMSS 2010/11



Notes: Those students whose teachers agreed a lot with three out of the five statements and agreed a little with the other two, on average, were classified in the Safe and orderly school category. Teachers disagreed a little with at least three of the five statements and agreed a little with the other two, on average, for students to be classified as being in schools that were Not safe and orderly. All others were allocated to Somewhat safe and orderly.

There were too few students whose schools were categorised as Not safe and orderly in New Zealand to report the mean science score.

Source: Adapted from Exhibit 6.7, Martin, Mullis, Foy, and Stanco, 2012.

Trends in teacher perceptions

The first three questions about school safety in Table 10.11 were given to teachers for the first time in 2002/03. Comparisons between that cycle, 2006/07 and 2010/11 show no significant change in the proportions of students whose teachers gave positive responses to the individual questions. The other two questions in the table were asked for the first time in 2010/11.

Principal perceptions of school safety and student behaviours

To help foster a healthy learning environment, minimal or no disruption to learning is desirable. In previous cycles, principals were asked how frequently a series of problem behaviours occurred in their school and the severity of the problem. In 2010/11, this question was adjusted to ask how much of a problem these behaviours (listed in Table 10.12) were in the school rather than whether or not they were present.

Principals expressed the extent to which these behaviours were a problem amongst Year 5 students in their school with one of the following response options: *not a problem*, *minor problem*, *moderate problem*, or *serious problem*. The majority of Year 5 students attended schools where these behaviours were perceived by the principal to be a minor problem at the most. Few students had principals that acknowledged any of these behaviours as posing a serious problem in their school. *Classroom disturbance* was the behaviour with the highest proportions in the moderate and serious problem categories combined, but this was still only seven percent.

Table 10.12: Extent to which principals classified behaviours of New Zealand Year 5 students as a problem in TIMSS 2010/11

	Proportion of Year 5 students in each category of severity of behaviours			
Behaviours	Serious problem	Moderate problem	Minor problem	Not a problem
Arriving late at school	<1 (0.4)	4 (1.5)	53 (4.1)	42 (4.0)
Absenteeism	1 (0.7)	5 (1.7)	49 (3.5)	45 (3.3)
Classroom disturbance	1 (0.7)	7 (2.1)	44 (3.8)	48 (3.8)
Cheating	0 (0.0)	1 (0.7)	18 (2.9)	81 (3.0)
Profanity	<1 (0.3)	4 (1.7)	24 (3.4)	71 (3.8)
Vandalism	0 (0.0)	1 (0.9)	22 (3.0)	76 (3.1)
Theft	0 (0.0)	<1 (0.3)	30 (3.6)	70 (3.5)
Intimidation or verbal abuse among students	0 (0.0)	5 (1.5)	42 (3.5)	53 (3.3)
Physical fights among students	0 (0.0)	3 (1.3)	34 (3.6)	63 (3.6)
Intimidation or verbal abuse of teachers or staff	0 (0.0)	3 (1.3)	12 (2.5)	85 (2.8)

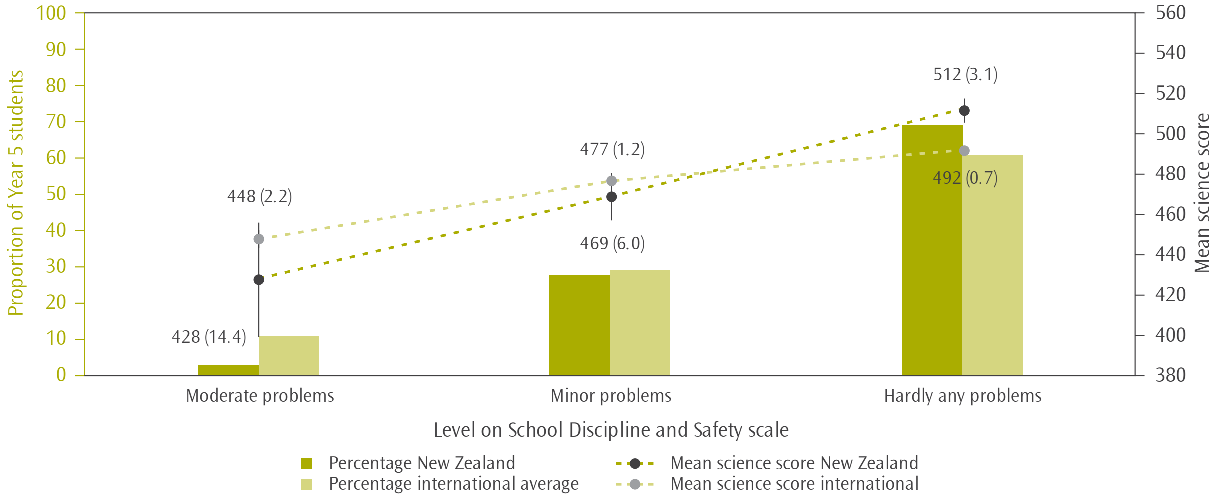
Note: Standard errors are presented in parentheses.

Proportions in each row should add to 100%; inconsistencies are due to rounding.

Generally, being in a school with less of a problem with the behaviours listed above was associated with higher achievement in science. To summarise the extent to which school discipline and safety affects student learning, the TIMSS international team created a continuous scale, the School Discipline and Safety scale, based on principals' views on the extent to which the ten behaviours listed above occurred among middle primary students in their schools. To report the scale in a meaningful way, values on the scale were grouped into three categories, *Moderate problems*, *Minor problems*, and *Hardly any problems*.

Over two-thirds of Year 5 students in New Zealand (69%) attended schools whose principals indicated that there were hardly any problems with school discipline and safety and only a small minority (3%) attended schools where there were moderate problems. All of the English speaking countries who participated in TIMSS at this year level had a proportion of students above the international average (61%) in the *Hardly any problems* category, as did a number of the higher achieving countries (refer Table B.6 in the Appendix). Kazakhstan had the highest proportion in this category, with 91 percent of students going to schools deemed to have hardly any problems with school discipline and safety.

Figure 10.6: Levels on the School Discipline and Safety scale by mean science achievement in TIMSS 2010/11



Note: Students whose principals reported not a problem on average for five out of the ten statements and only minor problems for the other five rated as having Hardly any problems on the scale. A rating of Moderate problems corresponded to students whose principals responded with moderate problem for, at most, five of the ten statements and minor problem, for the other five, on average.

Source: Adapted from Exhibit 6.9, Martin, Mullis, Foy, and Stanco, 2012.

The overall pattern shown by the international average (see Figure 10.6) is that higher achievement is related to higher safety and order ratings on the scale but this is not consistent over all countries. Several countries show little variation in achievement scores for science across the categories (Japan and Chinese Taipei for example). In some countries (such as Bahrain and Morocco) students whose school is categorised as having *Minor problems* have lower average achievement scores than those in the *Moderate problems* category.

Trends in principal perceptions

The behaviours in Table 10.12 were asked about in the 2002/03 and 2006/07 cycles. The question was phrased in a slightly different way in these previous cycles however, asking the frequency of occurrence of the problems in the school and then how severe they were. Compared to the proportions indicating these behaviours were not a problem in the previous cycles, the proportions were lower in 2010/11 for *arriving late at school*, *absenteeism*, and *cheating* (fewer principals saying they were not a problem). However, all the other statements had higher proportions in 2010/11.

Parent perceptions of school safety

In 2010/11 TIMSS, parents were also asked to what extent they agreed with the statement that their child's school provides a safe environment. Ninety-seven percent of parents who responded (as mentioned earlier, 59 percent of parents returned the questionnaire) agreed with this statement and achievement in science was higher for those students than it was for the three percent whose parents had disagreed.

Relationship between home and school

In *The Complexity of Community and Family Influences on Children's Achievement in New Zealand:Best Evidence Synthesis*, Biddulph, Biddulph, and Biddulph (2003) state that "A key message emerging from the New Zealand and international research is that effective centre/school-home partnerships can strengthen supports for children's learning in both home and centre/school settings. What is remarkable about such partnerships is that when they work the magnitude of the positive impacts on children can be so substantial, compared to traditional institutionally-based educational interventions." [18]

In New Zealand, Boards of Trustees are required under the National Administrative Guidelines (Ministry of Education) to report to students, parents and the school's community on individual student achievement, on the achievement of students as a whole, and on groups such as Māori students, evaluating these against established targets.[19] As part of this and the associated National Standards, schools must report to parents twice a year and in plain language. Ka Hikitia, the Māori Education Strategy, also has a strong emphasis on the involvement of parents, families and whānau in students' learning and engagement. Similarly, the Pasifika Education Plan puts Pasifika learners, their parents, families, and communities at the centre of the education system (Ministry of Education, 2012).

Given the important role that parents, and the interface between parents and schools, play in enriching their child's education, the TIMSS study examined parental involvement in various school activities. Principals were asked about their interactions with parents about the administration of the school and education within the school in general, and education of their child specifically. Principals were also asked whether their school had asked parents to be involved in various school activities such as school projects, programmes and trips, school committees, and raising funds for the school.

In terms of interactions about education, the most frequent interaction reported on in TIMSS between schools and parents about the school was informing parents about school accomplishments with almost all New Zealand Year 5 students having principals who said they did this at least two to three times a year (*2 to 3 times a year* and *more than 3 times a year* combined). The next most frequent interaction was informing parents about the overall academic achievement of the school, with over 80 percent of students having principals who indicated they did this at least two to three times a year. Of the list of general school interactions in TIMSS, these two would be the most likely to be covered by sending out regular newsletters from schools to parents about the notable activities and achievements happening in the school, a practice that seems to be quite common for New Zealand schools.

For interactions regarding individual students, all Year 5 students had principals who indicated that they informed parents about their child's learning progress and almost all had principals who indicated that they informed parents about the behaviour and well-being of their child. These two interactions, along with discussing parents concerns or wishes about their child's learning (approximately 97% at least 2 to 3 times a year) could be covered by the usual practice of issuing student reports 3 to 4 times a year (per term) and the accompanying interviews between teachers and parents, which normally occur 1 to 2 times a year in New Zealand schools.

18 This BES contains an extensive synthesis on the effect of community and family on student achievement, as well as the effect of partnerships between these groups and schools/centres, supporting the results that have come from TIMSS.

19 National Administration Guidelines 2c.

Table 10.13: Frequency of schools' interactions with parents, as indicated by the New Zealand principals

School-parent interaction	Proportion of Year 5 students whose principals indicated they interacted with parents: Never		Once a year		2 to 3 times a year		More than 3 times a year	
In general								
Inform parents about the overall academic achievement of the school	1	(0.6)	17	(2.9)	63	(3.6)	19	(3.0)
Inform parents about school accomplishments	0	(0.0)	1	(0.7)	8	(2.3)	91	(2.4)
Inform parents about the educational and pedagogic principles of the school	0	(0.0)	26	(3.4)	51	(3.6)	24	(3.1)
Inform parents about the rules of the school	2	(1.1)	32	(3.5)	37	(3.9)	29	(3.7)
Discuss parents' concerns or wishes about the school's organisation	0	(0.0)	30	(3.7)	36	(3.8)	34	(4.0)
Provide parents with additional learning materials for their child to use at home	10	(2.4)	20	(3.5)	28	(3.6)	43	(4.2)
Organise workshops or seminars for parents on learning or pedagogical issues	4	(1.5)	38	(3.8)	45	(3.9)	13	(2.3)
For individual students								
Inform parents about their child's learning progress	0	(0.0)	0	(0.0)	69	(3.2)	31	(3.2)
Inform parents about the behaviour and well-being of their child at school	0	(0.0)	1	(0.8)	54	(3.7)	44	(3.7)
Discuss parents' concerns or wishes about their child's learning	0	(0.0)	3	(1.1)	47	(4.2)	49	(4.3)
Support individual parents in helping their child with schoolwork	1	(0.9)	9	(2.5)	40	(4.0)	49	(3.9)

Note: Standard errors are presented in parentheses.

Proportions in each row should add to 100%; inconsistencies are due to rounding.

Principals' reports also show that New Zealand schools strongly encourage parental involvement. For two out of the three activities, *Volunteer for school projects, programmes and trips*, and *Raise funds for the school*, at least 90 percent of students were in schools where the principal asked parents to be involved at least 2 to 3 times a year.

Table 10.14: Schools' encouragement of parental involvement in New Zealand in TIMSS 2010/11

Activity	Proportion of Year 5 students whose principals reported they asked parents: Never		Once a year		2 to 3 times a year		More than 3 times a year	
Volunteer for school projects, programmes and trips	0	(0.0)	1	(0.7)	26	(3.4)	73	(3.4)
Serve on school committees	4	(1.5)	37	(4.1)	27	(3.3)	32	(3.7)
Raise funds for the school	3	(1.3)	7	(2.3)	26	(3.4)	64	(3.5)

Note: Standard errors are presented in parentheses.

Proportions in each row should add to 100%; inconsistencies are due to rounding.

These were similar proportions to those found for the 2006/07 cycle, although the phrasing of the question was changed between the two cycles. In the 2006/07 cycle, principals were asked "Does your school ask parents to do the following…" and given five different school-related activities to respond to. In 2010/11, they were asked for the frequency with which they asked parents and were given three activities.

Interactions between teachers

Teachers as professionals spend time learning and improving their practice throughout their careers. An excellent way to learn is through interactions and collaborations with other teachers. TIMSS asked teachers how often they interact with other teachers, with five types of interaction provided in the questionnaire, as shown in Table 10.15. Four possible response options for the frequency of interactions were: *never or almost never*, *2 or 3 times a month*, *1 to 3 times per week*, and *daily or almost daily*. Teachers' most common interaction was discussing how to teach a particular topic, with more than two-thirds of students (68%) having teachers who reported doing this at least weekly, followed closely by less than two-thirds of students (59%) having teachers who reported sharing what they have learned about teaching experiences at least weekly. Visiting another classroom to learn more about teaching was the least common interaction by a considerable margin.

Table 10.15: Frequency of interactions among New Zealand Year 5 science teachers in TIMSS 2010/11

	Proportion of Year 5 students whose teachers indicated the types of interactions occurred:			
Types of interactions	**Never or almost never**	**2 or 3 times a month**	**1 to 3 times a week**	**Daily or almost daily**
Discuss how to teach a particular topic	3 (1.1)	29 (2.9)	47 (3.1)	21 (2.5)
Collaborate in planning and preparing instructional materials	6 (1.3)	45 (3.3)	38 (3.0)	10 (1.6)
Share what I have learned about my teaching experiences	8 (2.2)	33 (2.6)	41 (2.6)	18 (2.3)
Visit another classroom to learn more about teaching	52 (3.1)	42 (3.1)	4 (1.3)	1 (0.5)
Work together to try out new ideas	15 (2.1)	48 (3.0)	29 (2.6)	8 (1.6)

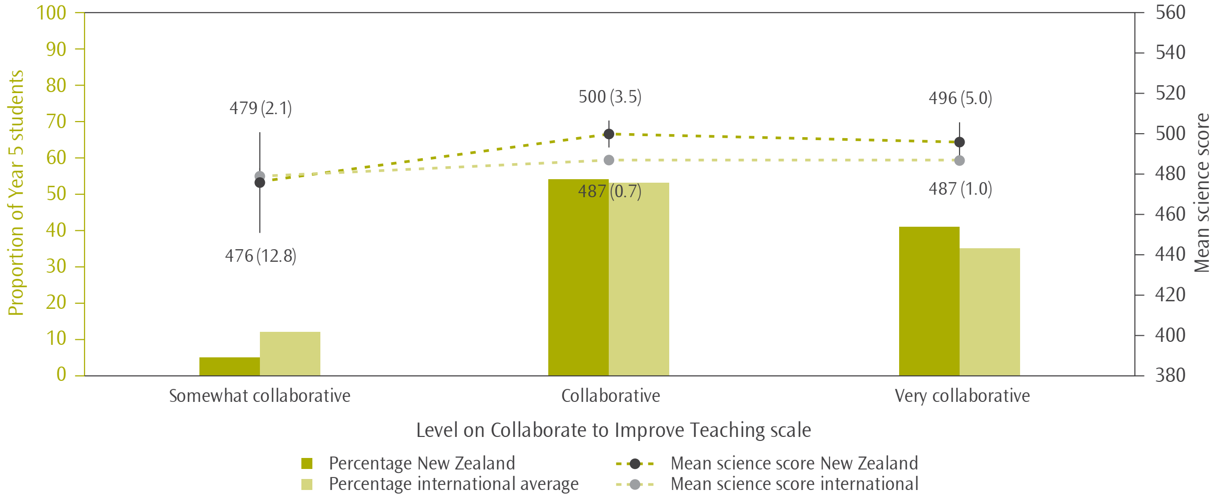
Note: Standard errors are presented in parentheses.

Proportions in each row should add to 100%; inconsistencies are due to rounding.

The different interactions had differing relationships with student achievement. *Discuss how to teach a particular topic* and *Share what I have learned about my teaching experiences* generally had higher achievement in science the more frequently it was carried out. *Collaborate in planning* and *preparing instructional materials* had similar achievement across the categories. *Visit another classroom to learn more about teaching* showed the opposite trend, with greater frequency categories being linked with lower achievement. The frequency of *Work together to try out new ideas* showed little difference across science achievement.

Teachers' responses to the questions about the frequency of their interactions with other teachers were combined into a continuous scale, the Collaborate to Improve Teaching scale. To report the scale in a meaningful way, values on the scale were grouped into three categories; *Very collaborative*, *Collaborative*, and *Somewhat collaborative*.

Figure 10.7: Levels on the Collaborate to Improve Teaching scale by mean science achievement in TIMSS 2010/11



Note: Students who were classified in the Very collaborative portion of the scale had teachers who answered at least three of the five statements with one to three times a week and two or three times per month for the other two, on average. Those in the Somewhat collaborative category had teachers who responded with never or almost never to three of the five statements and two or three times per month to the other two, on average. All others were classified as Collaborative.

Source: Adapted from Exhibit 8.12, Martin, Mullis, Foy, and Stanco, 2012.

Forty-one percent of New Zealand Year 5 students had science teachers who reported themselves as being *Very collaborative*, higher than the international average of 35 percent. Fifty-four percent of students had teachers who reported themselves as being *Collaborative* and only five percent of students were classified as having teachers who were *Somewhat collaborative*.

For science internationally, there was no difference between science achievement across the top two levels of the scale but for the small percentage of students internationally who had teachers who were *Somewhat collaborative* (12%), their science achievement was lower than for the other two categories on the scale (see Table B.7 in the Appendix). For New Zealand, there was no significant difference in science achievement across the three categories of the scale. Most countries followed either the same pattern as the international average (Japan for example) or the same pattern as New Zealand (the United States and Singapore for example).

Trends in interactions with other teachers

Questions about interactions with other teachers were first introduced in the 2002/03 cycle. The questions asked in previous cycles were too different to those asked in 2010/11 to analyse trend data.

School and classroom size

School size

The total enrolment of each New Zealand school that participated in TIMSS 2010/11 at the Year 5 level ranged from 20 to 1,448 students, with an average of 358. Around three-quarters (72%) of all New Zealand Year 5 students attended mid-size schools with between 175 and 679 students, which was a similar proportion to 2006/07 (74%) and a little less than 2002/03 (77%). Relatively few students attended large schools with 680 students or more (7%), and 22 percent were in small schools with fewer than 175 students.

Table 10.16: Proportion of New Zealand Year 5 students and mean achievement scores by size of school band in TIMSS 2010/11

School size band	Proportion of students	Mean science achievement score
Small (fewer than 175 students)	22	498 (6.4)
Small to Medium (175 to 399 students)	39	496 (4.5)
Medium to Large (400 to 679)	33	494 (4.0)
Large (680 students or more)	7	522 (13.5)
New Zealand	**100**	**497 (2.3)**

Note: Standard errors are presented in parentheses.

Proportions in the Proportion of students column should add to 100%; inconsistencies are due to rounding.

New Zealand primary schools have increased in size since the first cycle of TIMSS in 1994/95. Only 26 percent of schools taking part in TIMSS at the Year 5 level had 400 students or more in 1994/95, compared with 40 percent in 2010/11. The proportion of students in small schools of fewer than 175 students was similar in 2010/11 to what it was in 1994/95 (25%) but higher than it was in 2006/07 (18%).

Most school sizes had similar results for science achievement in 2010/11, except for large schools (680 students or more), which had significantly higher results in science. This is the first cycle with a significant difference in achievement between any of the groups; in 1994/95 and 2006/07 there were no significant variations.

Classroom size

TIMSS asked teachers about the size of their science classes, as larger or smaller classes can influence how the teacher chooses to teach science topics. At Year 5, composite classes combining year levels are a common feature in New Zealand primary schools.[20] The average TIMSS class size for science in New Zealand was 25 students in 2010/11, the same as the international average. In the majority of countries, students are in classes with between 20 and 35 students, with the exception of Austria and Azerbaijan, which had 19 and 18 students per class on average respectively, and Singapore and Yemen, both of which had average class sizes of more than 35 students (37 and 45 respectively).

It is difficult to disentangle the relationship between class size and achievement. For example, in some countries smaller classes tend to be in rural areas where there are fewer resources, and larger classes in urban areas with more resources. Remedial classes may also be smaller. However, TIMSS studies repeatedly show that high performing Asian countries, such as Singapore and Hong Kong SAR, have some of the largest class sizes. On the other hand, most non-Asian top performing countries tend to have class sizes between 20 and 25 students.

Class sizes in New Zealand have decreased since the first cycle of TIMSS; in 1994/95, the average class size was 29 students, significantly higher than 25 students in 2010/11.

20 New Zealand is unusual in the prevalence of composite classes. According to a literacy study carried out in 1993 (Wagemaker (ed.), 1993), Portugal, Trinidad and Tobago, and Ireland were the only other countries in the 28 country sample that had at least 50% composite classes at the Standard 3 (Year 5) level.

Limitations to teaching

Science teachers of Year 5 TIMSS classes were asked to what extent the factors listed in Table 10.17 limit teaching in their classes. Responses were given on a four-point scale; *not applicable*, *not at all*, *some*, and *a lot*. The *not applicable* category is likely to mean there are no students in the class that meet the criteria. Table 10.17 shows the proportions of students whose teachers indicated that some or all of these factors limited how they taught science to their Year 5 students. *Not applicable* and *not at all* were grouped into one category *no limitations*. In general, higher proportions of students had teachers who thought that having students in the class with a lack of prerequisite knowledge or skills (76%) put some or a lot of limitations on teaching compared with disruptive students (71%) or students who had not had enough sleep (69%). The factor that seemed to be the least likely to place limitations on teaching was lack of basic nutrition.

Table 10.17: Extent to which New Zealand science teachers indicated these factors limited their teaching in TIMSS 2010/11

	Proportion of Year 5 students whose teachers indicated the factors presented:		
Factors	A lot of limitations	Some limitations	No limitations
Lack of prerequisite knowledge or skills	12 (1.6)	64 (3.0)	24 (3.1)
Lack of basic nutrition	3 (0.9)	34 (2.7)	63 (2.7)
Not enough sleep	9 (1.6)	60 (3.0)	31 (2.9)
Special needs	5 (1.5)	54 (3.5)	41 (3.3)
Disruptive	11 (1.6)	60 (2.6)	29 (2.4)
Uninterested	3 (0.9)	61 (3.1)	36 (3.1)

Note: Standard errors are presented in parentheses.
Proportions in each row should add to 100%; inconsistencies are due to rounding.

When compared to other countries, New Zealand had one of the highest proportions of students whose teachers reported that instruction was limited by students suffering from not enough sleep (69%); only the United States had higher (73%) and Saudi Arabia (68%) had a similar proportion. Compared to European, Asian, and English-speaking countries, there was a relatively large proportion of New Zealand students whose teachers reported that instruction was limited by students suffering from a lack of basic nutrition (37%) compared with Finland (9%), Japan (1%) and Northern Ireland (20%), for example. However, the proportion in New Zealand was similar to the United States (39%) and much lower than Morocco (79%) and Yemen (87%).

In TIMSS 2006/07, teachers were asked a similar question but only three of the factors were common across the two implementations (*special needs, disruptive*, and *uninterested*), and the question was specifically separated out for science teachers rather than asked in the general section of the questionnaire. In a rough comparison, similar proportions of teachers found that the three factors presented a lot of limitations to their teaching. However, the possible responses in 2006/07 included *a little* as an option in addition to the four included in the 2010/11 questions and so comparisons of the other categories are less viable.

Quality and availability of school buildings and resources

Teachers in TIMSS 2010/11 were asked how much of a problem various issues were in their current school. These issues are listed in Table 10.18. Teachers not having adequate workspace and too many teaching hours had the highest percentages of students with teachers indicating that these were moderate to serious problems (both 28%). Over half of the students had teachers who indicated that classrooms being overcrowded was at least a minor problem. The least problematic of these five issues in the opinions of the teachers were *not having adequate instructional materials and supplies*, and *the school building needing significant repair*, with 57 percent and 49 percent of students respectively having teachers who indicated these were not problems at all.

Table 10.18: How much science teachers perceived various issues were problems in their current schools in New Zealand in TIMSS 2010/11

	Proportion of Year 5 students with teachers who indicated these issues were:		
Issues	**Not a problem**	**Minor problem**	**Moderate to serious problem**
The school building needs significant repair	49 (3.2)	35 (2.8)	16 (2.2)
Classrooms are overcrowded	47 (3.0)	33 (2.5)	20 (2.6)
Teachers have too many teaching hours	39 (3.0)	33 (2.9)	28 (2.7)
Teachers do not have adequate workspace	42 (3.2)	30 (2.6)	28 (3.0)
Teachers do not have adequate instructional materials and supplies	57 (2.7)	30 (2.5)	13 (2.1)

Note: Standard errors are presented in parentheses.

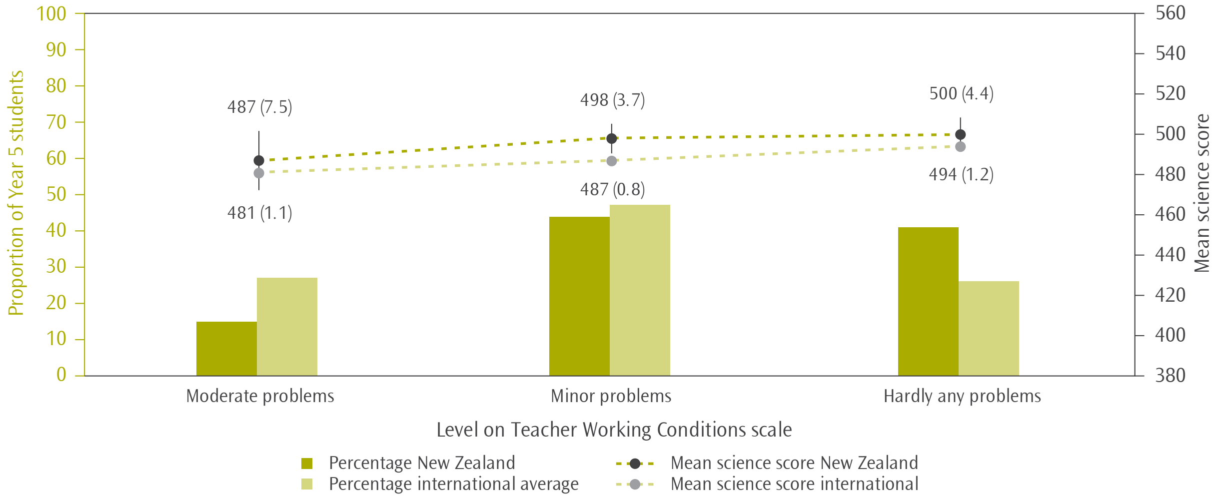
Proportions in each row should add to 100%; inconsistencies are due to rounding.

Science teachers' responses to these questions were combined into a continuous scale, the Teacher Working Conditions scale, to describe the extent to which various issues created problems for them. To report the scale in a meaningful way, values on the scale were grouped into three categories; *Moderate problems*, *Minor problems*, and *Hardly any problems*.

New Zealand science teachers were relatively positive about their working conditions compared with teachers from other countries, although not as positive as teachers from the United States, Australia, and England (see Table B.8 in the Appendix). However, fewer New Zealand science teachers were negative about their working conditions compared with their counterparts in some high achieving countries.

In general, the international average indicates that the more positive teachers were on the scale, the higher the average science achievement of students (see Figure 10.8). However, New Zealand was one of a group of countries, including England and Hong Kong SAR, where there was no significant difference in science achievement across the different levels of positivity.

Figure 10.8: Levels on the Teacher Working Conditions scale by mean science achievement in TIMSS 2010/11



Note: The students who had teachers who selected at most not a problem for three out of the five statements and only minor problems for the other two, on average, were classified under the Hardly any problems category. Those classified under Moderate problems had teachers who selected at least moderate problem for three out of the five statements and minor problem for the other two, on average. All the rest were classified under Minor problems.

Source: Adapted from Exhibit 5.9, Martin, Mullis, Foy, and Stanco, 2012.

Impact of shortages of resources

Principals were asked to rate if their school's capacity to provide instruction was affected by a shortage or inadequacy of any of 20 selected resources using a four-point scale, the response options being *none*, *a little*, *some*, or *a lot*. The resources relating to science instruction and general resources are listed in Table 10.19. Of all the resources listed, the resources most commonly seen as having an impact on instructional capability by New Zealand principals were lack of teachers with a specialisation in science and computer software for science instruction. A lack of school buildings and grounds, and computers for instruction were the next most common resources indicated as hindering instruction.

Table 10.19: How much principals perceived instructional capability was limited by lack of resources in New Zealand in TIMSS 2010/11

Resources	Proportion of Year 5 students with principals indicating instruction was limited:							
	A lot		Some		A little		None	
General								
Instructional materials	<1	(0.4)	6	(1.7)	35	(4.0)	58	(4.2)
Supplies	0		2	(1.1)	15	(3.0)	82	(3.1)
School buildings and grounds	7	(2.1)	10	(2.1)	28	(3.6)	55	(3.8)
Heating/cooling and lighting systems	1	(0.8)	6	(1.6)	22	(3.4)	71	(3.7)
Instructional space	4	(1.5)	14	(2.5)	24	(3.0)	58	(3.6)
Technologically competent staff	3	(1.3)	21	(3.3)	48	(3.9)	28	(3.4)
Computers for instruction	8	(2.2)	22	(3.3)	42	(4.1)	29	(3.7)
For science instruction								
Teachers with a specialisation in science	15	(2.7)	34	(3.4)	44	(3.8)	8	(2.2)
Computer software for science instruction	13	(2.5)	27	(3.2)	45	(4.2)	15	(3.1)
Library materials relevant to science instruction	2	(0.9)	20	(3.2)	49	(4.0)	30	(3.7)
Audio-visual resources for science instruction	7	(2.1)	27	(3.5)	48	(4.2)	18	(3.3)
Science equipment and materials	6	(2.0)	39	(3.8)	42	(3.8)	13	(2.9)

Note: Standard errors are presented in parentheses.

Proportions in each row should add to 100%; inconsistencies are due to rounding.

This table is based on a selection of resources from the School Questionnaire. Principals were also asked about resources for mathematics and reading instruction.

Most of the general school resources and the resources for science instruction were also asked about in previous cycles of TIMSS. Where there were differences between the proportions in 2002/03 and 2010/11, these had not changed by much.

Computers and software

As shown in Table 10.19, almost three-quarters of New Zealand Year 5 students were in schools where their principal reported that a lack of computers hindered the school's capacity to provide instruction at least a little. A lack of software for science instruction was an issue with the principals of 85 percent of students indicating this was at least a little hindrance.

To supplement the questions on computer resources, principals were asked specifically about the number of computers that can be used for instructional purposes by Year 5 students. Just over two-thirds of students (70%) were in schools where the number of computers available for use by Year 5 students was large enough that the ratio could be described as one computer to every one to two Year 5 students. However, it should be noted that these may well have to be shared with other year levels.

Teachers and support staff

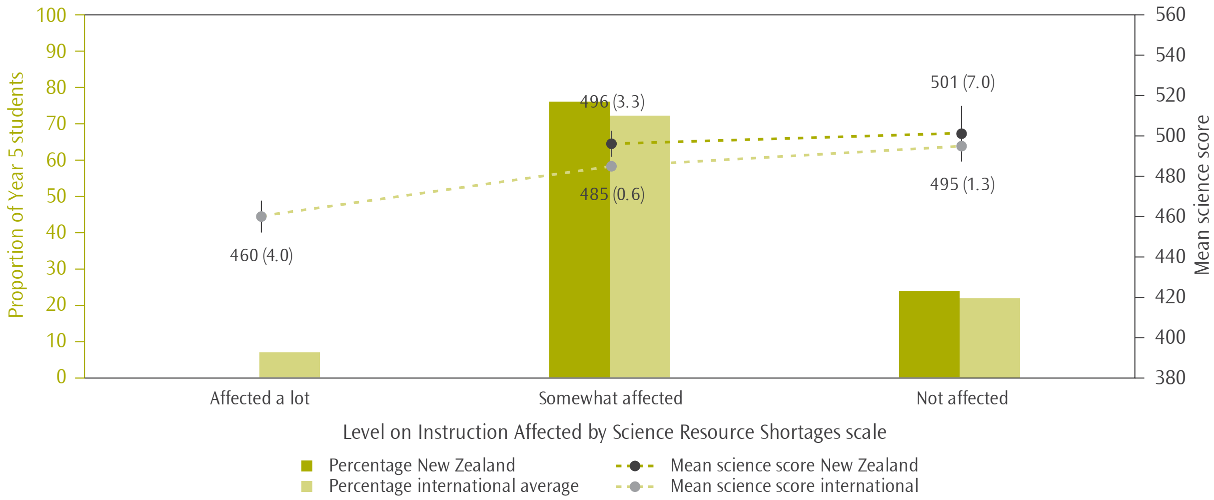
As shown in Table 10.19, a lack of specialist science teachers was indicated as a hindrance to the school's capacity to provide instruction for over 90 percent of the students. More than two-thirds of students attended schools where the principal perceived that a lack of technologically competent staff hindered the school's capacity to provide instruction at least a little.

Instruction affected by resource shortages

Principals' responses about how lack of some of the resources listed in Table 10.19 affected schools' capacity to provide instruction were combined into a continuous scale, the Instruction Affected by Science Resources Shortages scale. The scale used the seven general school resources and five subject-specific resources (i.e., for science instruction). To report the scale in a meaningful way, values were grouped into three categories; *Not affected*, *Somewhat affected*, and *Affected a lot*.

Just under a quarter of New Zealand Year 5 students (24%) were at schools where the principals indicated that science resource shortages had not affected instruction (see Figure 10.9). Seventy-six percent of students were in schools where science resource shortages somewhat affected instruction and no students were in schools where the principal indicated that instruction was affected a lot by shortages in science resources. The percentage of students internationally who were in schools where the principal felt that science resource shortages had no impact on instruction (22%) was not that different to the percentage in New Zealand.

Figure 10.9: Proportions of students on the Instruction Affected by Science Resources Shortages scale by science achievement in TIMSS 2010/11



Note: The proportion of students with principals who responded at most with not at all for six of the twelve resources and a little for the other six on average were categorised under Not affected. The proportions of students in schools where the principals reported at least that shortages in six out of the twelve resources affected instruction a lot and some for the other six, on average, are at schools classified as having instruction Affected a lot. All others were in the Somewhat affected category.

There were too few New Zealand students whose schools were Affected a lot by science resource shortages to report achievement.

Source: Adapted from Exhibit 5.7, Martin, Mullis, Foy, and Stanco, 2012.

The general pattern of achievement, as seen in the international average, for the scale across the three categories is that the less affected the principal reported the school as being by a shortage of science resources, the higher the achievement scores. However, few of the countries listed in Table B.9 in the Appendix had sufficient proportions of students in all three categories to calculate three corresponding achievement scores and so it is difficult to draw conclusions on a pattern from two points on the scale. With the achievement scores that are available for this selection of countries, it is possible to see that the relationship between mean science score and rating on the scale is not consistent across countries.

No New Zealand principal reported that science instruction was affected a lot by resource shortages, regardless of the decile, size or location of their school (urban versus rural). Within each of the other two categories of the scale (*Somewhat affected* and *Not affected*), the proportions of students from each of the decile groupings, school size, and the two location types were reflective of their proportions of the population as a whole. In other words, none of these things (decile grouping, size, and location) seemed to change the extent to which a school was affected by science resource shortages. The only exception was when it came to size of schools, small-medium schools were slightly under-represented in the *Not affected* category but this is not really enough to imply a pattern relating to school size.

Science laboratories

As mentioned in Table 10.19, principals were asked about the impact of a lack of science equipment and materials on instructional capability. Principals were also asked specifically if the school had a science laboratory that can be used by Year 5 students. No definition was given in the question of what was meant by a science laboratory. Five percent of students in New Zealand attended schools with a science laboratory that could be used by Year 5 students, compared to the international average of 36 percent. Of those New Zealand schools that indicated they had a science laboratory available for Year 5 students to use, almost half were small schools (as opposed to small-medium or large schools), 60 percent were full primary (as opposed to composite), and the decile grouping that had the highest proportion was deciles 7 and 8 with 41 percent.[21]

On average internationally, the science achievement of students in schools where there were science laboratories available for middle primary students was higher than those in schools without, although within some countries the difference was not significant (see Table 10.20) and in some cases, achievement was actually higher in schools without laboratories. Like all resources, having a science laboratory may not make any different to achievement unless it is used to enhance the teaching that happens outside the laboratory.

Table 10.20: Proportion of students in schools with a science laboratory for selected countries in TIMSS 2010/11

	Have science laboratory in school				Do not have science laboratory in school			
Country	**Percentage of students**		**Mean science score**		**Percentage of students**		**Mean science score**	
Korea, Rep. of	100	(0.0)	587	(2.0)	0	(0.0)	~	
Kuwait	100	(0.0)	348	(4.7)	0	(0.0)	~	
Singapore	100	(0.0)	583	(3.4)	0	(0.0)	~	
Japan	99	(0.6)	559	(1.9)	1	(0.6)	~	
Chinese Taipei	89	(2.3)	551	(2.4)	11	(2.3)	562	(4.6)
United States	25	(2.7)	549	(5.4)	75	(2.7)	545	(2.5)
Malta	18	(0.1)	477	(4.0)	82	(0.1)	440	(2.0)
Finland	16	(3.4)	566	(5.1)	84	(3.4)	571	(2.8)
Australia	13	(2.4)	535	(7.4)	87	(2.4)	514	(2.9)
England	9	(2.1)	559	(10.6)	91	(2.1)	524	(3.5)
Austria	8	(2.5)	534	(9.6)	92	(2.5)	531	(2.9)
New Zealand	**5**	**(1.9)**	**530**	**(13.9)**	**95**	**(1.9)**	**496**	**(2.6)**
Ireland	0	(0.0)	~		100	(0.0)	517	(3.4)
Northern Ireland	0	(0.0)	~		100	(0.0)	517	(3.0)
International Avg.	**36**	**(0.4)**	**489**	**(1.2)**	**64**	**(0.4)**	**483**	**(0.8)**

Note: Standard errors are presented in parentheses.
Tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 5.15, Martin, Mullis, Foy, and Stanco, 2012.

21 Please note that the percentages listed here are for each separate type of school ie. size is out of 100%, full primary versus composite is out of 100%, and the decile groupings plus independent schools are out of 100%

11. School leadership

Leaders in schools, through a multitude of possible actions, have the opportunity to influence the learning that takes place there. Recent research has proposed a variety of approaches for exercising school leadership. Davies (2009) offers no less than ten different possibilities including Leithwood and Jantzi's model of *Transformational leadership*. This model identifies three categories of leadership practices: *setting directions*; *developing people*; *redesigning the organisation*.

With a particular focus on the New Zealand context, but drawing on a range of international studies, Robinson, Hohepa and Lloyd (2009) identified five dimensions of school leadership that all have some effect on student achievement: *establishing goals and expectations*; *strategic resourcing*; *planning, coordinating and evaluating teaching and the curriculum*; *promoting and participating in teacher learning and development*; and *ensuring an orderly and supportive environment*. The fourth of these dimensions was found to have the biggest effect, and the key finding from this Best Evidence Synthesis was that "the closer educational leaders get to the core business of teaching and learning, the more likely they are to have a positive impact on students" (Robinson et al., 2009, p.47).

This chapter examines a question in TIMSS that collected estimates of the relative time principals spent on a range of activities. The components of the question were defined using research from a variety of sources in response to findings that the school leadership style has an indirect effect on student achievement (Mullis, Martin, et al. 2009). It should be noted that the responses to the question relate only to time spent by principals and so will not reflect tasks that may be taken on by other staff in schools.

Time spent by principals on leadership activities

In TIMSS 2010/11, principals were asked how much time they had spent on a range of leadership activities in their role as a school principal, ticking either *no time*, *some time* or *a lot of time* for each activity. The leadership activities identified are shown in Table 11.1 and can be grouped into three broad dimensions: establishing and monitoring the attainment of educational goals; dealing with student behaviour; and developing self and teachers.

The principals of schools with Year 5 students in New Zealand were more likely than many of their international counterparts to report spending a lot of time on the goals-related activities, with only *monitoring teachers' implementation of the school's educational goals in their teaching* being less frequent than the international average. By contrast, in both the student behaviour and development dimensions, New Zealand principals were in general less likely to report spending *a lot of time* than their international counterparts. The two activities involving *creating a climate of trust* and *initiating educational projects* were exceptions, with New Zealand principals' responses following a similar pattern to the international average.

Table 11.1: Principals' time spent on leadership activities

Leadership activities	Percentage of students whose principals spent a lot of time	
	New Zealand	International Average
Goals		
Promoting the school's educational vision or goals	65	59
Developing the school's curricular and educational goals	70	60
Monitoring teachers' implementation of the school's educational goals in their teaching	45	53
Monitoring students' learning progress to ensure that the school's educational goals are reached	71	57
Student Behaviour		
Keeping an orderly atmosphere in the school	47	69
Ensuring that there are clear rules for student behaviour	37	59
Addressing disruptive student behaviour	21	45
Development		
Creating a climate of trust among teachers	53	58
Initiating a discussion to help teachers who have problems in the classroom	23	40
Advising teachers who have questions or problems with their teaching	24	39
Visiting other schools or attending educational conferences for new ideas	11	24
Initiating educational projects or improvements	41	43
Participating in professional development activities specifically for school principals	18	39

TIMSS 2010/11 reveals some clear variations in the way principals report spending their time in different countries. For example, in Japan the average percentages for principals spending *a lot of time* on each leadership activity range between 15 and 49 percent, while in the Republic of Korea, which is similarly high-performing, the range is 72 to 89 percent. However, it is not so obvious what the source of this difference might be – does it reflect different expectations of principals or simply different perceptions of what constitutes *a lot of time*? While acknowledging the subjectivity in categorising time spent on these activities, the higher than average frequency of principal time spent on promoting and developing educational goals perhaps reflects New Zealand's high degree of devolution to individual schools of responsibility for curriculum and assessment. The lower than average frequency of principal time spent on addressing student behaviour issues in New Zealand is reassuring.

Time spent on leadership activities and school characteristics

Within New Zealand, both the socio-economic status and the size of schools had some impact on the time spent by principals on particular leadership activities.

Principals of lower decile schools with Year 5 students in New Zealand were more likely to report spending *a lot of time* than their colleagues in higher decile schools on:

- monitoring students' progress and teachers' implementation of educational goals,(but not on promoting or developing educational goals);
- activities relating to student behaviour,(including helping teachers who have "problems in the classroom");
- and initiating educational projects or improvements.

When time spent on leadership activities is considered in terms of school size, the only leadership activity for which there was a significant difference was monitoring teachers' implementation of the school's educational goals in their teaching. Principals in medium to large schools (400 to 679 students) were more likely to report spending time on this activity than principals in smaller schools.

Time spent on leadership activities and student achievement

There were differences observed in achievement for a minority of items. However, these differences seem to be related to the school context in which each principal was working. For example, for the leadership activity *monitoring teachers' implementation of the school's educational goals in their teaching*, the mean science achievement of New Zealand Year 5 students was 505 when the principal reported spending *some time*, but only 488 where the principal reported spending *a lot of time*. However, when analysed in terms of the socio-economic status of each school, there was no significant difference in mean achievement within decile bands. Rather, principals of decile 1 to 4 schools were much more likely to report spending *a lot of time* on this activity than their higher-decile counterparts, and the lower mean achievement of students in these schools is reflected in the overall New Zealand figures for this item.

School leaders' engagement with the core educational activities of their school will take a variety of forms depending on the context. The focus of TIMSS on the amount of time spent offers some insights into the relative priority accorded to various activities by New Zealand principals. It is less useful in judging how well those choices might match the needs of each school, and hence the effectiveness of any particular leadership model.

12. Abilities at school entry

As mentioned earlier, home circumstances influence the achievement of school-age children. The 'Parents as First Teachers' programme (Ministry of Social Development, no date) recognises that early learning experiences are extremely important for setting strong foundations. In addition to the home setting, there are a wide range of early childhood education services in New Zealand. The majority of New Zealand children begin primary school having some form of early childhood experiences (95% overall in July 2010, Ministry of Education, no date). This chapter will examine expectations in the New Zealand early childhood curriculum, along with principals' responses when asked to estimate the proportion of students with early literacy and numeracy abilities when they began school.

Early childhood education in New Zealand

Early childhood education (ECE) in New Zealand takes place in a mixture of teacher-led and parent-led services. The early childhood curriculum framework, Te Whāriki, is used by most New Zealand ECE services to guide children's learning opportunities. Within a framework of five strands: *well-being*, *belonging*, *contribution*, *communication*, and *exploration*, the curriculum specifies particular learning outcomes associated with the goals of each strand. Those most pertinent to the early literacy and numeracy skills surveyed in this study are found in the communication strand (Ministry of Education, 1996). In particular, Goal 3 of the Communication strand is: "Children experience an environment where they experience the stories and symbols of their own and other cultures" (p.78).

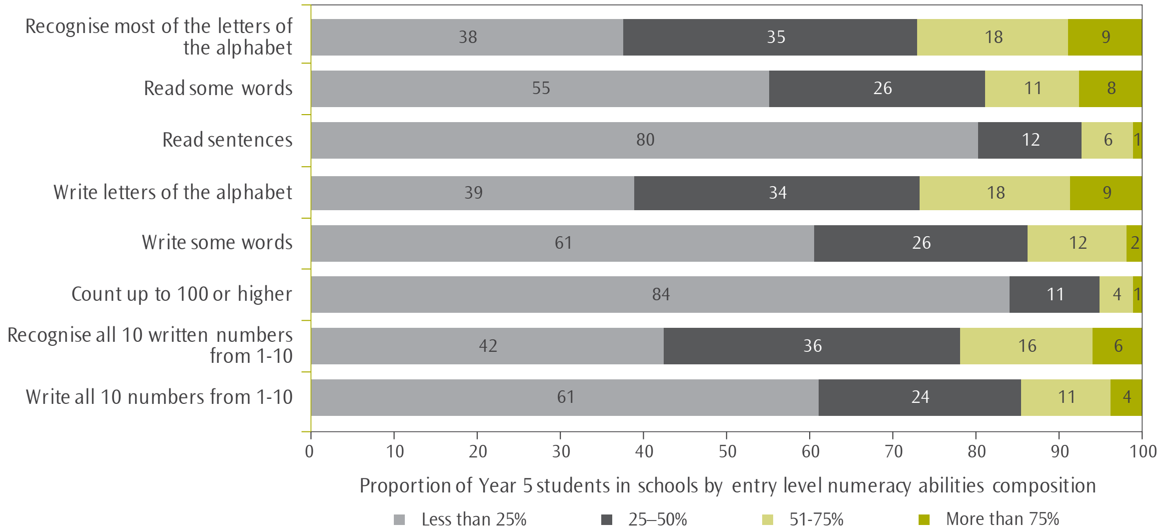
Recognising the long-term benefits of high-quality early childhood education the Ministry of Education's Statement of Intent 2012-2017 includes a commitment to "raise the quality of early childhood education provision overall, while increasing participation rates of Māori children, Pasifika children and children from low socio-economic backgrounds. This will be in a variety of languages, and in programmes designed to attract, and meet the needs of, children from diverse backgrounds" (Ministry of Education, 2012, p.17).

Estimate of abilities at school entry

Principals were asked to estimate the proportions of students in their school that could do a range of early literacy and numeracy skills (listed in Figure 12.1 – note the question did not specify a particular year level) when they began primary school. Principals ticked either *Less than 25%*, *25-50%*, *51-75%*, or *More than 75%* for each of these skills.

As shown in Figure 12.1, a majority of Year 5 New Zealand students were in schools where more than a quarter of students in the school could recognise most of the letters of the alphabet, write letters of the alphabet and recognise the written numbers from 1 to 10 prior to school entry. However all the other skills listed were more likely to have been mastered by less than a quarter of the student body by the time they started school.

Figure 12.1: New Zealand primary school principals' estimates of literacy and numeracy abilities at school entry of their student body



To put these expectations in context within the New Zealand situation, note that the Number Framework from the New Zealand Numeracy Development Projects places the ability to identify all of the numbers in the range 0 to 10 at the earliest *Emergent* stage of number knowledge (Ministry of Education, 2008). The earliest emergent stage corresponds to pre-level 1 of the New Zealand Curriculum. The National Standards expectation is that students will be working at early level 1 of the curriculum after one year at school (Ministry of Education, 2009). In addition, the New Zealand Curriculum has "Know the forward and backward counting sequences of whole numbers to 100" as a level 1 Achievement Objective (Ministry of Education, 2007).

Relationship with achievement

As shown in Table 12.1, for each of these early literacy and numeracy skills, Year 5 science achievement was lower on average for students in schools where less than a quarter of their peers entered school with the skill.

It should be noted that the socio-economic composition of schools had a strong relationship with the proportion of their student body estimated to have early literacy and numeracy skills at school entry (see Chamberlain, 2013 and Caygill et al., 2013b).

Table 12.1: Science achievement in New Zealand at Year 5 by entry level literacy and numeracy abilities school composition

	Mean science achievement of students in schools where			
	less than 25% enter with skills	25 to 50% enter with skills	51 to 75% enter with skills	more than 75% enter with skills
Recognise most of the letters of the alphabet	470 (4.5)	506 (4.2)	520 (5.8)	529 (9.7)
Read some words	488 (4.3)	501 (5.2)	514 (8.9)	528 (9.4)
Read sentences	493 (3.0)	512 (5.6)	529 (12.6)	~
Write letters of the alphabet	473 (4.8)	509 (4.2)	517 (5.8)	522 (9.6)
Write some words	488 (4.0)	510 (5.4)	513 (6.5)	522 (32.1)
Count up to 100 or higher	493 (3.1)	518 (5.6)	524 (18.2)	~
Recognise all 10 written numbers from 1-10	479 (4.7)	506 (3.5)	512 (5.8)	537 (13.3)
Write all 10 numbers from 1-10	484 (3.4)	515 (4.0)	522 (8.0)	521 (16.0)

Note: Standard errors are presented in parentheses.

A tilde (~) indicates insufficient data to report achievement.

Conclusion

This report has examined New Zealand's science achievement in relation to other countries that participated in the study. It looked at trends in New Zealand science achievement at the Year 5 level from 1994 to 2011. An examination of the TIMSS assessment questions in relation to New Zealand's science curriculum was presented followed by analyses of achievement by sub-groupings (such as gender and ethnicity) and student background factors. Comprehensive coverage of background questions about teaching and learning as well as the school context for learning was also provided. This section will recap these results and pose questions to reflect on them.

Achievement in an international context

New Zealand Year 5 students had relatively low science achievement when compared with other participating countries, lower than 29 countries, similar to 3, and higher than 17 countries. After increasing steadily between 1994/95 and 2002/03, the average science achievement of Year 5 students has decreased steadily back to 1994/95 levels. The decrease in mean science achievement among New Zealand students seems to be mainly due to the decreases in achievement on questions about life science and Earth science. This cycle of TIMSS saw a large decrease in the cognitive aspect of *knowing* which was higher than *applying* and *reasoning* in 2006/07, but is now the same in 2010/11.

When compared with other countries, the range of achievement within New Zealand was wider than nearly all of the high-performing countries and nearly all of the countries that tested in English. There was a relatively high proportion of very low achievers (students who did not reach the low benchmark) in this cycle of TIMSS compared with countries with similar or higher mean science achievement.

Clearly there are strengths and weaknesses reflected in these results. The advantage of this large-scale international assessment is that we can see what other countries have done to improve their systems and learn from them. The TIMSS encyclopaedia (Mullis, Martin, Minnich, et al., 2012) has articles from participating countries, giving summaries of curriculum expectations and details of changes they have made in their system since the beginning of TIMSS in 1994/95. For example, some countries have fewer learning areas in their early school curriculum than others. In the Republic of Korea, a high performing country in science, the curriculum focuses on language activities, mathematics, and learning how to be a learner – there is no curriculum for science until Grade 3.

Equity in the New Zealand system

This report has raised some concerns about equity in the New Zealand education system. Average science achievement is the same for Year 5 girls and boys but there is a wider range of achievement among boys than among girls.

There are advanced achievers and very low achievers in all ethnic groupings. However, there were proportionately more Pākehā/European and Asian advanced achievers compared with the Pasifika and Māori ethnic groupings. There were also more very low achievers among Pasifika and Māori groupings than among Pākehā/European and Asian groupings.

Regardless of the measure[22] used to assess socio-economic status (SES), students with lower SES had lower achievement than students with higher SES. In particular, on an international measure of the SES of the school attended, students in schools with a greater concentration of affluent students had higher achievement than students in schools with a greater concentration of disadvantaged students. On this measure, New Zealand had one of the largest differences in achievement between these two groups.

The Ministry has, as one of its highest priorities, a focus on raising achievement for priority learners (Māori learners, Pasifika learners, learners with special education needs, and learners from poor socio-economic backgrounds). The findings from this latest cycle of TIMSS are consistent with those from earlier cycles and from other studies (e.g., PISA and NEMP) that the education system is not delivering equitable outcomes for these learners. The challenge for all involved in education is how we are going to support these learners to reach their potential. For example, two things the evidence demonstrates are critical for priority learners are the importance of early learning before a child reaches school age and the quality of relationships between the school and parents and whānau.

Student attitudes

New Zealand middle primary students were generally positive about learning science. Students who were more positive about learning science had, on average, higher achievement than those who were more negative. The self-confidence of students had a stronger relationship with science achievement than how much they like learning science. Fewer New Zealand middle primary students were confident in their ability to do science compared with many other countries.

Year 5 boys were more likely to be confident with science than girls, and similar proportions liked science. Confidence with science had a stronger relationship with achievement than liking science for both boys and girls. A greater proportion of Asian students reported liking science than Māori, Pasifika or Pākehā/European students. Māori and Pasifika students were more likely to report being not confident with science than students from the other ethnic groupings.

Teaching

Instructional hours in science in New Zealand middle primary classrooms were low compared with nearly all other countries. During these fewer hours, New Zealand teachers tended to place less emphasis on science investigations than their peers in other countries. New Zealand classrooms were more likely to have computers available for instructional use compared with other countries and these were more likely to be used regularly for looking up ideas and information.

Fewer New Zealand middle primary teachers felt well prepared to teach topics in science compared with their peers in other countries and fewer expressed high levels of confidence in their ability to teach science.

22 SES measures included collection of proxy information from students such as the number of books at home and home possessions as well as measures of the SES of the school such as decile and principals' estimates of the level of affluence and disadvantage among the school population.

School climate for learning

Year 5 students generally perceived their school to be a good place to be. More than eight out of ten students agreed that they liked being at school and felt safe there. A higher proportion of girls than boys were positive about school and Pasifika and Asian students were the most positive of the ethnic groupings.

Teachers and principals were generally very positive about their school climate for learning, including having a safe environment, knowledgeable staff, supportive parents, and well-behaved students. However, principals tended to be slightly less positive about the teaching staff and more positive about parental support than the teachers.

Parents were very positive about their children's schools, although a number of the parents who responded also indicated that they would like to be better included in and informed about their child's education.

Compared to students in other countries, a relatively high proportion of New Zealand Year 5 students reported experiencing negative behaviours from other students at least monthly. A higher proportion of boys than girls experienced these behaviours but no particular ethnic grouping experienced these negative behaviours more than would be expected based on their proportion of the population.

Teachers of Year 5 students indicated that there were several factors that presented at least some limitations to their teaching of science, particularly having students with a lack of prerequisite knowledge or skills. Compared with most other countries, more New Zealand teachers thought that students suffering from not enough sleep was a hindrance to their teaching.

More than half of the TIMSS Year 5 students had teachers who perceived various issues were at least a minor problem in their current school, particularly teachers having too many teaching hours or inadequate workspace. New Zealand teachers were relatively positive about their working conditions compared to most other TIMSS countries.

A lack of teachers with a specialisation in science and computer software for science instruction were the resources most commonly seen by principals as having a negative impact on instruction. Far fewer New Zealand primary schools had science laboratories available for use by Year 5 classes compared with other countries.

According to principals' estimates of the literacy and numeracy abilities of students when they began school, science achievement at Year 5 was higher in schools where more students had these skills when they began school.

School leadership

Principals of New Zealand schools with Year 5 students in them were more likely than the international average to report spending a lot of time on promoting and developing educational goals, and on monitoring student progress. On average, New Zealand principals reported spending less time than their international counterparts on addressing student behaviour issues but those from low decile schools tended to report spending more time than their higher decile colleagues. Previous cycles of TIMSS have shown that New Zealand principals spend more of their time on administrative tasks than nearly all other countries.

Final comment

When the 2006/07 results were released showing a significant decrease in science achievement since the 2002/03 cycle, we had just released the new curriculum. Although concern was expressed with these results, there was hope that this was an anomaly and there would be an improvement next cycle. However, the next cycle has seen a further decline.

Vannier (2012) in his review of science education in New Zealand, recommended that as a country we agree that science education is important and requires attention. In particular, he recommended to the Ministry of Education that it:

- provide schools with consistent, tailored support for science,
- enable collaboration and strong leadership within schools, and
- include science in formulating current polices on teacher preparation.

As well as providing us with a snapshot of achievement in science at the middle primary level, TIMSS also provides us with valuable information about how the New Zealand education system changes – or does not – over time. This view of our system, along with that of other systems, allows education stakeholders at all levels of the education system to reflect on the different aspects examined in TIMSS as part of a review of their policies and practices.

Appendices

Sampling notes for Figure 1.1

1. National Target Population does not include all of the International Target Population.
2. National Defined Population covers 90% to 95% of National Target Population.

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

‡ Nearly satisfied guidelines for sample participation rates after replacement schools were included.

ψ Reservations about reliability of average achievement because the percentage of students with achievement too low for estimation does not exceed 25% but exceeds 15%.

ж Average achievement not reliably measured because the percentage of students with achievement too low for estimation exceeds 25%.

Results of multiple classifications of ethnicity

Students were asked to identify their ethnicity using 12 categories, the 12th one being 'Other' group. In order to have groupings large enough to make reasonable predictions among the population, these twelve categories were summarised into five broad ethnic groupings, Pākehā/European, Māori, Pasifika, Asian, and 'Other'. Students were able to select more than one ethnic group so students categorised here as Pākehā/European may also be in at least one of the other four ethnic groupings. As a result of these overlapping groupings, achievement cannot be compared across ethnic groupings or with New Zealand as an overall group.

Table A1: New Zealand Year 5 science achievement for overlapping ethnic groupings (multiple classification of ethnicity)

Overlapping ethnic grouping - student ticked the listed group and may also have ticked another group	Mean science score
Student ticked Pākehā/European or Other European	525 (2.2)
Student ticked Māori	472 (2.7)
Student ticked at least one of the Pacific Islands groups	443 (4.5)
Student ticked at least one of the Asian groups	503 (4.7)

Note: Standard errors are presented in parentheses.

International comparisons for school climate

Table B.1: Proportion of students at each level of the School Emphasis on Academic Success (teachers' reports) scale and science achievement in TIMSS 2010/11

	Proportion of students in each level of the School Emphasis on Academic Success (teachers' reports) scale											
	Medium emphasis				High emphasis				Very high emphasis			
Country	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Northern Ireland	6	(1.9)	496	(9.8)	66	(4.3)	514	(3.8)	28	(4.2)	527	(6.6)
Ireland	8	(1.8)	481	(8.9)	70	(3.5)	514	(4.5)	22	(3.4)	537	(5.0)
Croatia	10	(2.2)	520	(5.6)	69	(3.6)	516	(2.5)	21	(3.0)	515	(3.8)
England	16	(3.4)	504	(7.6)	67	(4.4)	529	(4.1)	17	(2.9)	554	(8.0)
United States	15	(1.8)	514	(5.3)	68	(2.7)	547	(2.5)	17	(2.1)	563	(4.3)
Korea, Rep of	18	(3.4)	574	(3.7)	65	(3.7)	587	(2.1)	17	(3.4)	600	(6.1)
Australia	20	(3.1)	494	(5.4)	64	(4.4)	520	(4.1)	16	(2.9)	548	(11.3)
New Zealand	**17**	**(2.5)**	**478**	**(6.4)**	**69**	**(2.9)**	**497**	**(2.8)**	**14**	**(2.1)**	**522**	**(7.1)**
Malta	17	(0.1)	423	(3.3)	69	(0.1)	448	(2.1)	14	(0.1)	467	(3.5)
Chinese Taipei	17	(2.7)	538	(6.2)	73	(3.1)	554	(2.5)	11	(2.7)	562	(6.4)
Romania	30	(3.3)	472	(11.7)	61	(3.7)	521	(6.3)	9	(2.3)	497	(20.9)
Spain	39	(4.1)	488	(4.2)	54	(4.4)	517	(3.2)	7	(2.1)	515	(10.2)
Hong Kong SAR	31	(4.4)	529	(8.7)	63	(4.6)	538	(5.0)	6	(2.1)	536	(10.1)
Finland	33	(3.4)	561	(4.4)	63	(3.2)	575	(2.6)	5	(1.7)	577	(8.6)
Singapore	34	(2.5)	569	(5.8)	62	(2.7)	589	(5.0)	4	(1.1)	619	(19.2)
Japan	42	(3.9)	555	(3.1)	56	(3.9)	561	(2.1)	1	(1.1)	~	~
International Avg.	**33**	**(0.5)**	**472**	**(1.0)**	**60**	**(0.5)**	**492**	**(0.7)**	**8**	**(0.3)**	**499**	**(2.2)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Very high emphasis category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 6.3, Martin, Mullis, Foy, and Stanco, 2012.

Table B.2: Proportion of students at each level of the Teachers Career Satisfaction scale and science achievement in TIMSS 2010/11

	Proportion of students in each level of the Teachers Career Satisfaction scale											
	Less than satisfied				Somewhat satisfied				Satisfied			
Country	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Ireland	2	(0.8)	~	~	29	(3.4)	518	(7.8)	68	(3.4)	516	(3.9)
Malta	2	(0.0)	~	~	32	(0.1)	437	(2.6)	66	(0.1)	452	(2.2)
Northern Ireland	5	(1.9)	512	(12.5)	40	(4.6)	513	(5.7)	55	(4.3)	520	(3.8)
Australia	6	(1.7)	505	(10.3)	41	(3.7)	512	(5.4)	53	(3.8)	526	(4.1)
England	11	(2.7)	507	(8.9)	37	(3.8)	531	(7.1)	52	(3.9)	534	(4.3)
New Zealand	**6**	**(1.3)**	**479**	**(10.3)**	**45**	**(3.0)**	**498**	**(3.8)**	**49**	**(3.0)**	**499**	**(3.9)**
United States	7	(1.3)	522	(9.1)	46	(2.3)	546	(3.3)	48	(2.4)	546	(3.0)
Hong Kong SAR	5	(2.0)	519	(15.9)	49	(4.3)	534	(7.4)	46	(4.3)	537	(4.3)
Chinese Taipei	9	(2.4)	540	(6.7)	55	(3.7)	550	(2.7)	36	(3.1)	556	(4.2)
Singapore	12	(1.7)	572	(10.7)	56	(2.7)	580	(4.4)	32	(2.6)	592	(6.3)
Japan	15	(3.0)	555	(5.2)	60	(4.1)	559	(2.4)	26	(3.6)	559	(3.6)
Korea, Rep of	10	(2.8)	578	(6.0)	68	(4.0)	588	(2.5)	21	(3.3)	586	(3.4)
International Avg.	**5**	**(0.2)**	**483**	**(2.1)**	**41**	**(0.5)**	**483**	**(0.9)**	**54**	**(0.5)**	**490**	**(0.7)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Satisfied category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 7.15, Martin, Mullis, Foy, and Stanco, 2012.

Table B.3: Proportion of students at each level of the School Emphasis on Academic Success (principals' reports) scale and science achievement in TIMSS 2010/11

	Proportion of students in each level of the School Emphasis on Academic Success (principals' reports) scale											
	Medium emphasis				High emphasis				Very high emphasis			
Country	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Northern Ireland	7	(2.5)	495	(12.1)	60	(4.3)	511	(3.9)	33	(4.2)	532	(4.2)
Ireland	4	(1.7)	493	(7.8)	67	(3.9)	512	(4.6)	28	(4.0)	532	(5.1)
United States	18	(2.1)	520	(5.0)	60	(2.7)	546	(3.3)	22	(2.5)	566	(4.5)
New Zealand	**11**	**(2.1)**	**459**	**(11.2)**	**67**	**(3.3)**	**497**	**(3.4)**	**22**	**(3.0)**	**517**	**(4.4)**
Korea, Rep of	20	(3.4)	576	(3.1)	58	(4.3)	586	(2.5)	22	(3.5)	597	(3.4)
Chinese Taipei	12	(2.5)	543	(4.6)	71	(3.7)	553	(2.7)	17	(3.0)	551	(6.0)
Australia	21	(3.0)	487	(5.1)	64	(3.8)	519	(3.4)	16	(3.0)	544	(7.3)
Malta	18	(0.1)	402	(3.4)	69	(0.1)	455	(2.2)	13	(0.1)	462	(4.0)
England	17	(3.8)	508	(8.5)	72	(4.7)	531	(4.3)	10	(2.9)	539	(7.0)
Oman	18	(2.2)	348	(7.8)	73	(3.0)	377	(5.7)	9	(1.8)	368	(10.8)
Austria	17	(3.9)	515	(8.2)	75	(4.4)	535	(2.6)	8	(2.1)	534	(9.0)
Singapore	31	(0.0)	565	(6.6)	62	(0.0)	589	(4.6)	8	(0.0)	611	(12.9)
Kazakhstan	30	(4.1)	491	(9.9)	65	(4.4)	497	(7.1)	5	(1.9)	483	(29.5)
Hong Kong SAR	38	(4.6)	534	(7.5)	60	(4.5)	536	(3.8)	1	(0.9)	~	~
Japan	51	(4.5)	552	(2.8)	48	(4.5)	565	(2.5)	1	(1.0)	~	~
International Avg.	**34**	**(0.5)**	**471**	**(1.0)**	**58**	**(0.5)**	**492**	**(0.7)**	**8**	**(0.3)**	**508**	**(2.3)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Very high emphasis category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 6.1, Martin, Mullis, Foy, and Stanco, 2012.

Table B.4: Proportion of students at each level of the Students Bullied at School scale and science achievement in TIMSS 2010/11

Country	Proportion of students in each level of the Students Bullied at School scale											
	About weekly				About monthly				Almost never			
	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Ireland	12	(0.9)	474	(6.1)	25	(1.0)	511	(3.9)	64	(1.3)	528	(3.4)
Northern Ireland	14	(1.0)	490	(6.7)	29	(1.0)	519	(3.2)	57	(1.3)	523	(2.6)
Korea, Rep of	15	(0.6)	577	(3.7)	32	(0.8)	592	(2.4)	53	(1.2)	587	(2.3)
Chinese Taipei	17	(0.8)	535	(4.1)	30	(0.8)	551	(2.8)	53	(1.3)	558	(2.5)
United States	20	(0.6)	525	(3.6)	29	(0.5)	547	(2.1)	51	(0.7)	552	(2.5)
Japan	17	(0.8)	550	(3.8)	33	(0.8)	563	(2.6)	50	(1.2)	559	(2.2)
Hong Kong SAR	17	(0.7)	516	(8.8)	33	(0.9)	538	(3.7)	50	(1.2)	540	(3.8)
England	20	(0.8)	505	(5.1)	36	(1.0)	533	(3.8)	45	(1.3)	537	(3.6)
Malta	22	(0.6)	421	(3.5)	36	(0.7)	448	(3.2)	42	(0.7)	458	(2.8)
Iran, Islamic Rep. of	23	(1.3)	456	(5.0)	35	(1.2)	456	(5.0)	41	(1.7)	450	(5.4)
Singapore	23	(0.8)	560	(4.4)	38	(0.6)	587	(3.5)	39	(0.9)	595	(3.5)
Australia	25	(0.7)	501	(4.1)	38	(1.0)	519	(3.3)	38	(1.1)	525	(2.9)
New Zealand	**31**	**(0.9)**	**479**	**(3.1)**	**37**	**(1.0)**	**505**	**(3.0)**	**32**	**(1.0)**	**509**	**(3.4)**
International Avg.	**20**	**(0.1)**	**464**	**(0.8)**	**32**	**(0.1)**	**489**	**(0.6)**	**48**	**(0.2)**	**497**	**(0.6)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Almost never category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 6.11, Martin, Mullis, Foy, and Stanco, 2012.

Table B.5: Proportion of students at each level of the Safe and Orderly School scale and science achievement in TIMSS 2010/11

	Proportion of students in each level of the Safe and Orderly School scale											
	Not safe and orderly				Somewhat safe and orderly				Safe and orderly			
Country	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Northern Ireland	0	(0.4)	~	~	15	(2.6)	493	(7.2)	85	(2.7)	521	(3.5)
Ireland	2	(1.0)	~	~	20	(3.3)	482	(7.0)	78	(3.3)	527	(3.6)
Australia	4	(1.4)	462	(15.4)	21	(3.2)	497	(7.8)	75	(3.5)	528	(3.5)
New Zealand	**1**	**(0.6)**	**~**	**~**	**29**	**(2.3)**	**466**	**(4.5)**	**70**	**(2.3)**	**512**	**(2.6)**
England	2	(1.2)	~	~	30	(3.9)	504	(7.0)	68	(4.0)	541	(3.8)
United States	5	(0.9)	497	(7.7)	30	(1.9)	530	(4.2)	65	(2.1)	556	(2.3)
Singapore	3	(0.5)	576	(17.5)	33	(2.1)	564	(5.3)	64	(2.1)	594	(4.1)
Malta	2	(0.0)	~	~	43	(0.1)	437	(2.6)	56	(0.1)	456	(2.2)
Hong Kong SAR	4	(1.8)	467	(60.0)	47	(4.9)	536	(6.4)	49	(5.0)	539	(3.8)
Portugal	4	(1.3)	493	(14.4)	50	(4.9)	516	(4.5)	46	(5.1)	530	(8.0)
Chinese Taipei	4	(1.5)	526	(15.7)	59	(4.1)	550	(2.5)	37	(4.1)	557	(3.7)
Korea, Rep of	7	(2.1)	574	(5.4)	68	(3.7)	586	(2.1)	25	(3.7)	593	(5.0)
Japan	16	(2.8)	551	(4.3)	80	(3.4)	559	(2.1)	5	(1.8)	569	(10.5)
International Avg.	**4**	**(0.2)**	**449**	**(4.0)**	**43**	**(0.5)**	**480**	**(0.9)**	**53**	**(0.5)**	**493**	**(0.7)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Safe and orderly category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 6.7, Martin, Mullis, Foy, and Stanco, 2012.

Table B.6: **Proportion of students at each level of the School Discipline and Safety scale and science achievement in TIMSS 2010/11**

Country	Proportion of students in each level of the School Discipline and Safety scale											
	Moderate problems				Minor problems				Hardly any problems			
	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Armenia	4	(1.7)	445	(20.7)	8	(2.3)	422	(13.9)	87	(2.7)	414	(4.0)
Northern Ireland	0	(0.0)	~	~	15	(3.7)	502	(7.3)	85	(3.7)	520	(3.4)
Hong Kong SAR	1	(0.0)	~	~	15	(2.8)	505	(19.5)	84	(2.9)	540	(3.0)
Ireland	1	(1.0)	~	~	16	(3.0)	499	(11.2)	83	(3.1)	521	(3.5)
Chinese Taipei	0	(0.0)	~	~	23	(3.3)	551	(4.4)	77	(3.3)	552	(2.7)
England	3	(1.6)	486	(7.3)	20	(4.2)	500	(10.0)	77	(4.1)	537	(3.5)
Korea, Rep of	6	(2.0)	582	(7.0)	18	(3.4)	580	(3.6)	76	(3.6)	588	(2.3)
Japan	4	(1.6)	557	(8.2)	24	(3.3)	558	(4.2)	72	(3.2)	559	(2.1)
New Zealand	**3**	**(1.3)**	**428**	**(14.4)**	**28**	**(3.2)**	**469**	**(6.0)**	**69**	**(3.4)**	**512**	**(3.1)**
Singapore	0	(0.0)	~	~	33	(0.0)	581	(6.5)	67	(0.0)	584	(4.1)
United States	2	(0.7)	~	~	34	(2.6)	532	(3.6)	64	(2.7)	555	(3.0)
Australia	2	(1.0)	~	~	34	(3.8)	510	(5.0)	64	(3.9)	523	(4.1)
Malta	6	(0.1)	419	(7.2)	30	(0.1)	429	(2.7)	64	(0.1)	457	(2.3)
Bahrain	12	(4.7)	452	(7.3)	25	(4.1)	437	(9.7)	63	(4.2)	453	(5.3)
Morocco	62	(3.9)	271	(6.3)	24	(3.1)	244	(8.6)	14	(2.4)	271	(12.0)
International Avg.	**11**	**(0.3)**	**448**	**(2.2)**	**29**	**(0.5)**	**477**	**(1.2)**	**61**	**(0.5)**	**492**	**(0.7)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Hardly any problems category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 6.9, Martin, Mullis, Foy, and Stanco, 2012.

Table B.7: Proportion of students at each level of the Collaborate to Improve Teaching scale and science achievement in TIMSS 2010/11

Country	Proportion of students in each level of the Collaborate to Improve Teaching scale											
	Sometimes collaborative				Collaborative				Very collaborative			
	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
Korea, Rep of	3	(1.5)	570	(10.3)	48	(3.6)	582	(2.6)	49	(3.7)	592	(2.7)
United States	11	(1.7)	535	(6.8)	40	(2.7)	546	(3.8)	49	(2.8)	547	(2.9)
Australia	13	(2.8)	515	(8.5)	44	(3.9)	520	(5.4)	43	(3.4)	520	(5.4)
England	11	(2.0)	537	(13.8)	47	(3.9)	534	(4.4)	42	(3.7)	523	(5.8)
New Zealand	**5**	**(1.3)**	**476**	**(12.8)**	**54**	**(2.9)**	**500**	**(3.5)**	**41**	**(3.1)**	**496**	**(5.0)**
Japan	13	(2.8)	543	(5.2)	55	(4.2)	559	(2.4)	32	(3.8)	563	(2.8)
Singapore	9	(1.4)	580	(14.4)	61	(2.8)	584	(4.3)	31	(2.5)	581	(5.9)
Chinese Taipei	18	(3.0)	547	(5.1)	56	(4.0)	552	(3.1)	27	(3.6)	556	(4.5)
Northern Ireland	24	(3.7)	514	(7.0)	54	(4.9)	519	(4.1)	22	(4.1)	515	(5.7)
Hong Kong SAR	10	(2.5)	538	(8.6)	74	(3.7)	534	(4.9)	16	(3.6)	536	(7.0)
Ireland	25	(3.1)	525	(5.6)	59	(3.6)	512	(3.8)	16	(2.6)	522	(9.7)
Malta	41	(0.1)	441	(2.4)	45	(0.1)	447	(2.5)	14	(0.1)	461	(3.5)
International Avg.	**12**	**(0.3)**	**479**	**(2.1)**	**53**	**(0.5)**	**487**	**(0.7)**	**35**	**(0.5)**	**487**	**(1.0)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Very collaborative category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 8.12, Martin, Mullis, Foy, and Stanco, 2012.

Table B.8: Proportion of students at each level of the Teacher Working Conditions scale and science achievement in TIMSS 2010/11

Country	Proportion of students in each level of the Teacher Working Conditions scale											
	Moderate problems				Minor problems				Hardly any problems			
	% of students		Mean science score		% of students		Mean science score		% of students		Mean science score	
United States	10	(1.5)	522	(6.8)	39	(2.3)	544	(3.4)	51	(2.2)	550	(2.6)
Australia	18	(2.6)	507	(8.1)	37	(4.3)	514	(5.9)	45	(4.1)	528	(5.6)
England	7	(2.2)	518	(12.3)	52	(4.5)	533	(4.9)	41	(4.2)	528	(5.4)
New Zealand	**15**	**(2.3)**	**487**	**(7.5)**	**44**	**(3.1)**	**498**	**(3.7)**	**41**	**(3.3)**	**500**	**(4.4)**
Ireland	15	(2.5)	522	(8.2)	47	(3.8)	510	(4.9)	38	(4.0)	522	(5.4)
Slovak Republic	13	(2.3)	548	(6.6)	49	(3.3)	529	(5.4)	38	(3.5)	529	(5.6)
Northern Ireland	16	(3.5)	506	(7.4)	50	(4.3)	517	(4.3)	34	(4.7)	522	(5.6)
Singapore	17	(2.1)	583	(8.2)	50	(2.9)	578	(5.4)	33	(2.5)	592	(6.0)
Malta	21	(0.1)	422	(3.0)	49	(0.1)	455	(2.9)	30	(0.1)	449	(2.8)
Chinese Taipei	22	(3.3)	546	(5.6)	55	(3.9)	555	(2.8)	23	(3.4)	551	(5.1)
Japan	43	(3.5)	559	(2.3)	38	(3.9)	556	(3.3)	19	(3.3)	564	(4.6)
Hong Kong SAR	34	(4.1)	531	(10.1)	50	(4.2)	536	(3.9)	16	(3.7)	539	(8.0)
Korea, Rep of	33	(4.0)	590	(3.3)	52	(4.0)	586	(2.9)	15	(3.1)	583	(4.6)
International Avg.	**27**	**(0.5)**	**481**	**(1.1)**	**47**	**(0.5)**	**487**	**(0.8)**	**26**	**(0.5)**	**494**	**(1.2)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Hardly any problems category.

Source: Adapted from 5.9, Martin, Mullis, Foy, and Stanco, 2012.

Table B.9: Proportion of students at each level of the Instruction Affected by Science Resource Shortages scale in TIMSS 2010/11

	Proportion of students in each level of the Instruction Affected by Science Resource Shortages scale					
	Affected a lot		Somewhat affected		Not affected	
Country	% of students	Mean science score	% of students	Mean science score	% of students	Mean science score
Korea, Rep. of	1 (0.6)	~ ~	36 (4.3)	586 (3.7)	63 (4.4)	587 (2.5)
England	0 (0.0)	~ ~	63 (4.7)	529 (4.4)	37 (4.7)	527 (6.4)
Singapore	7 (0.0)	575 (14.5)	57 (0.0)	586 (4.7)	36 (0.0)	580 (5.4)
United States	2 (0.7)	~ ~	65 (2.9)	542 (2.9)	34 (2.8)	555 (4.0)
Kazakhstan	11 (2.7)	499 (20.0)	57 (4.0)	497 (7.3)	32 (3.8)	490 (8.9)
Australia	1 (0.5)	~ ~	68 (3.7)	511 (3.7)	32 (3.7)	529 (5.1)
Malta	3 (0.0)	449 (8.9)	72 (0.1)	441 (2.0)	25 (0.1)	462 (3.8)
New Zealand	**0 (0.0)**	**~ ~**	**76 (3.5)**	**496 (3.3)**	**24 (3.5)**	**501 (7.0)**
Northern Ireland	3 (2.4)	501 (8.0)	74 (4.0)	516 (3.6)	23 (4.1)	523 (6.9)
Japan	2 (1.4)	~ ~	75 (3.7)	560 (2.3)	23 (3.4)	558 (3.0)
Ireland	2 (1.2)	~ ~	81 (3.6)	517 (4.0)	17 (3.4)	518 (8.6)
Chinese Taipei	19 (3.0)	551 (4.5)	71 (3.4)	551 (2.6)	9 (2.5)	563 (6.4)
Hong Kong SAR	9 (2.6)	536 (8.7)	91 (2.6)	535 (4.6)	0 (0.0)	~ ~
International Avg.	**7 (0.3)**	**460 (4.0)**	**72 (0.5)**	**485 (0.6)**	**22 (0.4)**	**495 (1.3)**

Note: Standard errors are presented in parentheses.
The order of this table is based on percentage of students in the Not affected category.
A tilde (~) indicates insufficient data to report achievement.

Source: Adapted from Exhibit 5.7, Martin, Mullis, Foy, and Stanco, 2012.

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Definitions and technical notes

This section gives a brief overview of the technical details and definitions applicable to this report. For a comprehensive description of the technical details pertaining to TIMSS see Methods and Procedures in TIMSS and PIRLS 2011 (Martin & Mullis, (Eds.), 2011).

Benchmarks

To describe more fully what achievement on the science scale means, the TIMSS international researchers have developed benchmarks. These benchmarks link student performance on the TIMSS science scale to performance on science questions and describe what students can typically do at set points on the science achievement scale. The international science benchmarks are four points on the science scale, the advanced benchmark (625), the high benchmark (550), the intermediate benchmark (475), and the low benchmark (400). The performance of students reaching each benchmark is described in relation to the types of questions they answered correctly.

Exclusions

Each country was permitted to exclude some students for whom the assessment was not appropriate or was difficult to administer. Countries were required to keep the amount of excluded students as small as possible, with a guideline of five percent of the 'target' population as the maximum. Any countries that exceeded this value are indicated in the international exhibits. The target population in New Zealand was Year 5 students.

School-level exclusions in New Zealand consisted of very small schools (fewer than four Year 5 students; fewer than seven Year 9 students), special education schools, the Closed Brethren School, the Correspondence School, and schools that provide more than 50% of their instruction in te reo Māori. Within-school exclusions consisted of special education classes, special needs students, students with insufficient instruction in English, and units within schools that provide more than 50% of their instruction in te reo Māori.

The New Zealand exclusion rate was 4.93% for Year 5 and 3.23% for Year 9.

Mean, medians, and averages

There are three measures of central tendency but only the mean and the median are used in this report.

The mean of a set of scores is the sum of the scores divided by the number of scores, and is also sometimes referred to as 'the average', particularly in the international reports. Note that for TIMSS, as with other large-scale studies, the means for a country are adjusted slightly (in technical terms 'weighted') to reflect the total population of Year 5 rather than just the sample.

A median is the middle number when all numbers are put in order.

TIMSS scale centre point

To make comparisons, student achievement scores generated in each cycle are placed on the same scale. The scale was established during the second cycle of TIMSS to have a mean of 500 and a standard deviation of 100 based on the mean of country means from 1994. Equating is possible because a proportion of questions are the same in each assessment as in the two previous cycles. A score of 500 in 2010/11 is the same as a score of 500 in all previous cycles.

In earlier cycles of TIMSS, an international mean was reported. However as the number of countries participating changed, this mean shifted so that it was difficult to make comparisons across years. In TIMSS 2010/11, only the TIMSS scale centre point of 500 is reported. This is the same as the TIMSS scale average reported in TIMSS 2006/07 but renamed to avoid confusion with a calculated mean of country means.

Minimum group size for reporting achievement data

In this report, student achievement data is not reported where the group size is fewer than 50 students or fewer than 10 schools.

Percentile

The percentages of students performing below or above particular points on the scale can be used to describe the range of achievement. The lowest outer limit of achievement reported in ranges is the 5th percentile – the score at which only five percent of students achieved a lower score and 95 percent of students achieved a higher score. The highest outer limit is the 95th percentile – the score at which only five percent of students achieved a higher score and 95 percent of students a lower score. Therefore 90 percent of the Year 5 student scores lie between the 5th and 95th percentiles.

Sampling

Schools were sampled for PIRLS and TIMSS together so that each was a unique sample. This was done to minimise the burden on individual schools. They were sampled from pre-defined groups. These pre-defined groups, or explicit strata, were based on size of school (small, small Year 5 and large Year 9, and large), language of instruction (Māori-medium schools were explicitly sampled for PIRLS and not for TIMSS), and year levels contained in the school. To improve the precision of sampling, the schools were ordered by decile, level of urbanisation, and for Year 9 only, school gender. This methodology meant that the schools selected better represented the population of schools in New Zealand. Within each school, classes were sampled with equal probability and all Year 5 students within each class were selected.

Scale score points

The design of TIMSS allows for a large number of questions to be used in mathematics and science; each student answers only a portion of these questions. TIMSS employs techniques to enable population estimates of achievement to be produced for each country even though a sample of students responded to differing selections of questions. These techniques result in scaled scores that are on a scale with a mean of 500 and a standard deviation of 100.

Created scales for contextual variables

A new feature of this cycle of TIMSS was that the international researchers used a different methodology to summarise responses to contextual questions given by students, teachers and principals. In previous cycles, responses to a series of contextual questions were given a number and summed. In this cycle, item response theory was applied to the responses so that clustering was taken into account. For example if nearly every student gave a highly positive response to one item then it did not overly contribute to the sum. Each respondent was then given a score which was put on a scale. Cut points on that scale were defined and descriptions provided that detailed the kind of responses given in the original questions.

Significance tests

In this report, all the comparisons that have been made are tested for statistical significance using the *t* statistic, with the probability of making an incorrect inference set at five percent. To compare the means of two groups of students, the formula to generate the test statistics computed in this report is:

1) $$t = \frac{\bar{X}_1 - \bar{X}_2}{se_{diff}}$$

The calculation of se_{diff}, the standard error of the difference, varies depending on whether the groups were sampled independently or not. If the means for two groups that were sampled independently are being compared, for example, boys' achievement in 1994 and 2006, then the standard error of the difference is calculated as the square root of the sum of the squared standard errors of each mean:

2) $$se_{diff} = \sqrt{se_1^2 + se_2^2}$$

For most of the comparisons, this formula was not applicable and so the se_{diff} is computed more accurately by combining variances using custom-written SAS programs. However, as a rough estimate, the above formula will give a similar result.

Note that in all calculations, unrounded figures are used in these tests, which may account for some results appearing to be inconsistent.

When you are trying to compare a mean (say of New Zealand) to a mean it contributes to (say the international mean) then you cannot use the simple formula (2) for the standard error of the difference. Instead we use the following formula:

3) $$\frac{\sqrt{\left(\sum_{i=1}^{n}(se_i^2) + n(n-2)se_k^2\right)}}{n}$$

where the se_i are the standard errors of all the contributing means (e.g., all countries) and se_k is the standard error of the mean that is being compared (e.g., NZ) and n is the number of means overall (e.g., number of countries).

Standard error

Because of the technical nature of TIMSS, the calculation of statistics such as means and proportions has some uncertainty due to (i) generalising from the sample to the total Year 5 school population, and (ii) inferring each student's proficiency from their performance on a subset of questions. The standard errors provide a measure of this uncertainty. In general, we can be 95 percent confident that the true population value lies within an interval of 1.96 standard errors either side of the given statistic. This confidence interval is represented in graphs by the lines extending in either direction from the points.

Statistically significant

To determine if a difference between two means is actual, it is usual to undertake tests of significance. These tests take into account the means and the error associated with them. If a result is reported as not being statistically significant then, although the means might be slightly different, we do not have sufficient evidence to infer that they are different. All tests of statistical significance referred to in this report are at the 95 percent confidence level.

Weighting

Due to the use of sampling, weights need to be applied when analysing the TIMSS data. Weighting ensures that any information presented more closely reflects the total population of Year 5 students rather than just the sample. The TIMSS weighting takes into account school, class, and student level information and the overall sampling weight is a product of the school, class, and student weights.

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