Summing it up: Mathematics achievement in Australian schools in TIMSS 2002

(TIMSS Australia Monograph no 6)

Sue Thomson and Nicole Fleming

Australian Council *for* Educational Research

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Executive summary

The *Trends in International Mathematics and Science Study* (TIMSS 2002/03) is the latest in a series of international studies of mathematics and science, conducted under the aegis of the *International Association for the Evaluation of Educational Achievement* (IEA). These studies extend back to First International Mathematics Study (FIMS) that was conducted in secondary schools in 12 countries in 1964. A second international study of mathematics education was conducted in 1980-1982. The present study is the third combined mathematics and science study in which Australia has participated since 1994; others being the Third International Mathematics and Science Study (TIMSS 1994/95), and the partial repeat of TIMSS at Year 8 in 1998/99 (TIMSS 1998/99).

Australia's participation in TIMSS provides an opportunity to continue to build a comprehensive picture of trends in, and patterns of, achievement in mathematics and science for students in Year 4 and Year 8. Countries differ in the way their school education is organised, in the approaches adopted to teaching, their curricula, the preparation of their teachers, in their expectations of students, and in many other factors potentially related to effective learning. Those who established the IEA wanted to study organisational and curriculum-related issues that could not easily be investigated in a single school system or country. They believed that naturally occurring differences from country to country in the ways that education is organised and delivered would provide opportunities to study relationships of such factors with student achievement. The sequence of studies that have followed provide an opportunity to study changes over time as well as differences among countries.

This volume, *Summing it up*, analyses and interprets the Australian mathematics data collected as part of the TIMSS study. Another Australian report, *Examining the evidence* (Thomson & Fleming, 2004), presents the science results. Where appropriate, these reports make comparisons with the results of a number of countries and the international average to better understand the Australian achievement and context.

Research design

Building on previous IEA studies, TIMSS uses the curriculum as the major organising concept in considering how educational opportunities are provided to students and how students use these opportunities. It considers three levels of the curriculum in relation to the context in which they operate. The first level refers to mathematics that it is intended that students should learn and the educational system within which that curriculum is realised. This is called the *Intended Curriculum*. The second level refers to what is taught in classrooms, who teaches it and how it is taught; the *Implemented Curriculum*. The third level refers to what students have learned and their attitudes towards what they have learned; the *Attained Curriculum*.

From this broad framework TIMSS develops mathematics tests to describe what students have learned and questionnaires to find out about what is intended to be taught and about how it is actually taught in classrooms. These instruments are based on assessment frameworks that are developed after extensive analysis of national curricula with input from an international panel of mathematics and assessment experts and review by the *National Research Coordinators* (NRCs) in each country. This ensures that goals of mathematics education regarded as important in a significant number of countries are included and that what is assessed links to previous studies as well as being oriented to future developments in mathematics education.

So that the full range of the assessment framework is covered TIMSS divides the assessment material among students using a matrix sampling approach.

This involves dividing the material among a set of student test booklets with each student completing just one of the booklets. Mathematics items are grouped in 14 blocks that are used to build the 12 booklets with each booklet containing six blocks of mathematics and science items (there are also 14 blocks of science items). At Year 8 each block contains 15 minutes of assessment items and at Year 4 each block contains 12 minutes of assessment items. Thus each student in Year 8 completes 90 minutes of testing and each student at Year 4 completes 72 minutes of testing. The total amount of combined mathematics and science material covered is equivalent to 420 minutes of testing at Year 8 and 336 minutes of testing at Year 4. The questionnaire that students complete takes 30 minutes.

Who is assessed?

TIMSS 2002/03 focuses on two populations of students. Population 1 is students in Year 4. In most countries it is the year level that contains most nine-year-olds. Population 2 is students in Year 8. In most countries this is the year level that contains most 13-year-olds.

TIMSS 2002/03 took place in 46 countries around the world. Population 2 students were assessed in all participating countries. In 25 of the participating countries, Population 1 students were also assessed. The testing took place at the end of the school year, which was October-November 2002 in the southern hemisphere and May-June 2003 in the northern hemisphere.

TIMSS 2002/03 used a two-stage sampling procedure to ensure a nationally representative sample of students. In the first stage, schools were randomly selected to represent states and sectors. In the next stage, one mathematics class of Year 4 or Year 8 students was randomly selected to take part in the study.

In Australia, 10,030 students in 414 schools participated in the main sample of TIMSS 2002/03. In addition, in Australia, an extra sample of Year 9 students in participating schools in Queensland, South Australia, Western Australia and the Northern Territory was collected to enable comparisons with data collected in TIMSS 1994/95 and 1998/99. An extra sample of Indigenous students in all participating schools was also collected. These extra samples will provide data for further analysis on trends in mathematics and science achievement, and a more detailed examination of the achievements of Australia's Indigenous students.

What is assessed?

TIMSS tests are intended to generate achievement data that are valid for their intended purpose and reliable. They include items that require students to select a response from a set of multiple choices and questions that require students solve a problem and construct a response in an open-ended format. The items balance across five content domains (number, algebra, measurement, geometry and data) and four cognitive domains (knowing facts and procedures, using concepts, solving routine problems and reasoning). Of course some items span more than one of the content domains and the balance across domains differs between Year 4 and Year 8. In TIMSS 2002/03 the intended balance was as shown:

Mathematics content domains	Year 4	Year 8
Number	40%	30%
Algebra	15%	25%
Measurement	20%	15%
Geometry	15%	15%
Data	10%	15%

Mathematics cognitive domains	Year 4	Year 8
Facts & procedures	20%	15%
Using concepts	20%	20%
Routine problems	40%	40%
Reasoning	20%	25%

How are results reported?

Results are reported as average scores with the standard error, as distributions of scores, and as percentages of students who attain the international benchmarks, for countries and specific groups of students within Australia. The international benchmarks were developed using scale anchoring techniques. Internationally it was decided that performance should be measured at four levels: the '*Advanced International Benchmark*', which was set at 625; the '*High International Benchmark*', which was set at 550; the '*Intermediate International Benchmark*', which was set at 475; and the '*Low International Benchmark*', which was set at 400.

Australia's performance in TIMSS Mathematics 2002/03

Some highlights from the TIMSS 2002/03 mathematics results are given below. Differences are only mentioned if tests of statistical significance showed that the differences were likely to indicate real differences.

Performance internationally

- Australian students acquitted themselves moderately well in mathematics, with the performance of Australian students not statistically different to the international average at Year 4, and significantly higher than the international average at Year 8.
- At Year 4, Singapore and Hong Kong SAR outperformed all other countries, while at Year 8, Singapore outperformed all other countries.
- There was no significant change in average scale score at either year level for Australia from TIMSS 1994/95 to 2002/03. However, a number of other countries show a significant improvement over this period, raising their position relative to that of Australia.
- Australia's average score at Year 4 in TIMSS 1994/95 was significantly higher than the international average, however in TIMSS 2002/03 there was no significant difference between the Australian and international average scores. At Year 8, Australia's average score was significantly higher than the international average in both TIMSS 1994/95 and TIMSS 2002/03.

Performance on international benchmarks in mathematics

- Only five per cent of Australian Year 4 students reached the advanced international benchmark, 26 per cent reached the high international benchmark, 64 per cent reached the intermediate international benchmark and 88 per cent reached the low international benchmark. The proportion of Australian students reaching the advanced international benchmark was lower than the international average of eight per cent. However, the percentage of Australian Year 4 students achieving the low international benchmark was higher than the international average of 82 per cent.
- Seven per cent of Australian Year 8 students reached the advanced international benchmark, 29 per cent reached the high international benchmark, 65 per cent reached the intermediate international benchmark and 90 per cent reached the low international benchmark. A greater proportion of Australian Year 8 students reached each of the international benchmarks than the international average.

Performance in the mathematics content areas

- Australian Year 4 students' achievement was significantly higher than the international average in the content areas of *measurement*, *geometry* and *data*, equal for *patterns and relationships* and significantly lower than the international average for *number*.
- Australian Year 8 students' achievement was significantly higher than the international average in all content areas. *Data* is clearly the strongest achievement area, with *geometry* the weakest.

Performance of males and females

- There was no significant gender difference in overall mathematics achievement in Australia at either year level.
- Year 4 females outperformed males in *geometry*. At Year 8, males significantly outperformed females in *number* and *measurement*.

Performance of the Australian states and territories

- Year 4 students in Western Australia performed significantly below the national and international averages and the averages for students in New South Wales, Victoria and the Australian Capital Territory. The achievement of students in the other states was not significantly different from the national, international or other state averages.
- Year 8 students in New South Wales performed significantly better than students in Queensland, Western Australia and the Northern Territory. Scores for students in the Northern Territory were significantly lower than scores for students in the Australian Capital Territory and the national average. Students in all states except for the Northern

Territory achieved average scores significantly higher than the international average. The Northern Territory's score was at the international average level.

- The Australian Capital Territory had the greatest proportion of Year 4 students attaining each of the international benchmarks. The Northern Territory had the least amount of students reaching either the advanced international benchmark or the low international benchmark.
- New South Wales had the greatest proportion of Year 8 students reaching the advanced international benchmark, whereas the Australian Capital Territory had the greatest proportion reaching the low international benchmark. The Northern Territory had the least proportion of students reaching either the advanced international benchmark or the low international benchmark.

Student background characteristics

- Year 8 students were asked the highest level of education reached by their mother and father. The highest of these was used as the parental education variable, and achievement in mathematics was found to be higher for students whose parents had completed a university degree or higher.
- At both year levels there was a clear and strong relationship between books in the home and achievement in mathematics. Home education resources were also found to be positively related to mathematics achievement.
- Overall, the achievement of Indigenous students at both year levels was significantly lower than that of non-Indigenous students. For both Year 4 and Year 8 students the difference between the scores of the two groups was similar to that in TIMSS 1994/95.
- The relationship between mathematics achievement and language background was not clear. At Year 4 there were no apparent differences between the groups, while for Year 8, students whose family background was from a non-English speaking country, but who spoke English at home, performed significantly better than those in the other two categories.

Out-of-school activities

- There was not a clear relationship between mathematics homework and mathematics achievement for Australian students. However, those students who spend some time, but less than four hours a day, on any homework have higher achievement than those who do no homework or four or more hours of homework a day.
- In Australia, 92 per cent of Year 4 students and 96 per cent of Year 8 students have a computer at home. At both year levels, students who used a computer at home and at school had higher mathematics achievement than students who only used a computer in one of these locations.

Students' attitudes and beliefs

- Students' self-confidence in learning mathematics had a clear positive relationship with mathematics achievement. Males had higher self-confidence in learning mathematics than females in both year levels.
- Students' enjoyment of learning mathematics is also related to mathematics achievement. Australia was one of a small number of countries that showed a significant increase from TIMSS 1994/95 at both year levels in the percentage of students who agreed 'a lot' that they enjoy learning mathematics.
- At both year levels, males enjoy learning mathematics more than females.
- About half of Australian Year 8 students place a high value on mathematics, about the same as the international average. In Australia, valuing mathematics is positively related to mathematics achievement.
- Only 40 per cent of Australian Year 8 students expect to finish university compared to the international average of 54 per cent. Students with higher educational aspirations were found to have higher mathematics achievement.

Australian mathematics teachers and their preparation for teaching

- 75 per cent of Year 4 students and 49 per cent of Year 8 students were taught by women, and most teachers were in the 30–49 years age group.

- Most teachers felt prepared to teach most mathematics topics, and had participated in some form of professional development throughout the year.
- Thirty per cent of Year 8 mathematics teachers did not have mathematics as their major area of study.

Classroom activities and characteristics

- In some states, there appear to be factors limiting instruction that are not apparent in other states. In the Northern Territory in particular, there appeared to be problems with children with different academic abilities, the wide range of student backgrounds, uninterested students, low levels of student morale and disruptive students.
- The majority of Year 8 mathematics teachers surveyed agreed with statements reflecting a constructivist way of teaching mathematics, although around 25 per cent supported the use of learning strategies such as memorisation.
- Only 70 per cent of Australian Year 4 teachers use a textbook at all and less than five per cent of those who use a textbook use it as their primary resource, compared to the almost universal use of a textbook in all other countries. For Australian Year 8 teachers, those who had a mathematics major in their undergraduate degree were less likely than those teachers who did not to use a textbook as their primary resource.
- In Australia, very few teachers at either year level have a high emphasis on mathematics homework in comparison with the international average.
- 76 per cent of Australian Year 4 students and 54 per cent of Year 8 students have access to a computer in the classroom. However, very few mathematics classes use the computer very often as part of their lessons.

School contexts for mathematics learning

- Geographic location did not have an effect on mathematics achievement, other than Year 8 students in remote schools scoring at a significantly lower level than students in metropolitan and regional schools.
- Socioeconomic composition was related to mathematics achievement, with achievement levels significantly higher in schools with low proportions of students from disadvantaged economic backgrounds.
- Student achievement was higher in schools in which principals reported high levels of teacher satisfaction and cohesion, where teachers had high expectations of their students, parents were supportive and involved, and students were engaged and had high expectations of themselves.
- The proportion of Australian Year 4 students reporting a low perception of school safety (that is, a high level of bullying in the school) was the equal third highest of all TIMSS 2002/03 countries. There was a direct relationship between feelings of school safety and mathematics achievement at both year levels.
- Achievement was lower in schools where absenteeism, truancy and late arrivals were a problem.

Multilevel analyses of influences on achievement

- At both year levels, self-confidence in learning mathematics has the strongest influence on mathematics achievement, followed by having an Indigenous background.
- Other influences on Year 4 achievement are language background, gender, the number of books in the home, computer usage, perception of safety at school, the number of possessions in the home, and the amount of mathematics homework at the student level, and the school's level of economic disadvantage and the principals' rating of school and class attendance at the school/classroom level.
- Other influences on Year 8 achievement are educational aspirations, computer usage, the number of books in the home, and parents' education at the student level and the teacher's emphasis on mathematics homework, the principal's perception of school climate, and the principals' rating of school and class attendance at the school/classroom level.

Implications for Australian schools and school systems

There are a number of policy considerations arising from these analyses. Mathematics is regarded as one of the foundation areas of learning in the compulsory years of schooling. Studies in other curriculum areas, and many occupations in modern society, require a broad base of mathematical literacy, and it is argued that changing societal conditions provide an imperative to broaden and strengthen the base of knowledge and skills in mathematics and science developed through Australia's school systems.

The results from large, comparative international studies such as TIMSS 2002/03 indicate that achievement in mathematics can be improved over a relatively short period of time. The rich database developed for TIMSS 2002/03 can be used to gain further insights into how this might be achieved.

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Membership of the Advisory Committee

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Chapter 1
Introduction

Chapter 1 Introduction

Towards the end of 2002, just over 10 000 Australian students in Year 4 and Year 8 participated in the Trends in International Mathematics and Science Study[1]. These students completed tests in mathematics and science and answered questionnaires on their background and experiences in learning mathematics and science at school. School principals and the students' mathematics and science teachers also completed detailed questionnaires. In 45 other countries students, teachers and principals completed the same tests and questionnaires.

TIMSS 2002/03 continued Australia's participation in studies devised and managed in conjunction with ACER by the International Association for the Evaluation of Educational Achievement (IEA) in the areas of mathematics and science. The other studies in which Australia participated were the First International Mathematics Study (FIMS), 1964; the First International Science Study (FISS), 1970–1971; and the Second International Science Study (SISS), 1983–1984. The Third International Mathematics and Science Study (TIMSS 1994/95) combined achievement in mathematics and science into a single study, and was partially replicated by TIMSS – Repeat in 1998 and 1999 (which is hereafter referred to as TIMSS 1998/99).

This report provides the Australian perspective for achievement in mathematics in TIMSS 2002/03 – how do our students score, how does this compare internationally and what is happening within Australia? How has achievement changed since 1998/99 and 1994/95, if indeed it has? Has Australia's achievement remained the same in comparison to other countries both which we would normally compare ourselves? Another characteristic of TIMSS is that data are also collected at the teacher and school levels, so that such data can be used to highlight characteristics of teaching and learning mathematics in Australia.

Benefits of international studies

Countries differ in the ways their school education is organised, in the curricula they offer, in the preparation they require of their teachers, in the styles the teachers use to present the curricula, and in many other factors potentially related to effective teaching and learning. The researchers who established the IEA wanted to study organisational and curriculum-related issues that could not easily be investigated in a single school system or country. They believed that naturally occurring differences from country to country in the ways that education is organised and delivered would provide a ready-made 'laboratory' for studying relationships of such factors with student achievement.

Different countries have different purposes for participating in studies such as TIMSS. A range of purposes is both possible and justifiable from the nature of the data. Possible purposes include: determining what are reasonable upper limits to expect of students; understanding students' achievements in an international context; examining the effects of a major curriculum reform; gauging where reform might be needed; stimulating the allocation of more funds for education; and monitoring where the areas of greatest educational need might lie in their own country. IEA studies have become increasingly rigorous in their design and standardisation of their procedures, necessary for making valid inferences from their results.

[1] For comparability across countries and across assessments, testing was conducted at the end of the school year. The countries in the Southern Hemisphere (Australia, Botswana, Chile, Malaysia, New Zealand, Singapore and South Africa) tested in October to December 2002. The remaining countries tested at the end of the 2002–2003 school year: May – June 2003.

Research model for IEA studies

TIMSS has continued the practice begun in the second IEA mathematics study (Robitaille & Garden, 1996) of focusing attention on three levels of the curriculum, all considered in relation to the context in which they occur. These levels and the research questions associated with them are:

- The *intended* curriculum – defined as the curriculum as specified at national or system level. *What are mathematics and science students around the world expected to learn? How do countries vary in their intended goals, and what characteristics of education systems, schools and students influence the development of these goals?*
- The *implemented* curriculum – defined as the curriculum as interpreted and delivered by classroom teachers. *What opportunities are provided for students to learn mathematics and science? How do instructional practices vary among countries and what factors influence these variations?*
- The *attained* curriculum – which is that part of the curriculum that is learned by students, as demonstrated by their attitudes and achievements. *What mathematics and science concepts, processes and attitudes have students' learned? What factors are linked to students opportunity to learn, and how do these factors influence students' achievements?*

The intended curriculum was measured using an international curriculum matching analysis, completed by personnel with expertise in the mathematics and science curriculum areas.

The three aspects of the curriculum bring together three major influences on student achievement. The intended curriculum states society's goals for teaching and learning. These goals reflect the ideals and traditions of the greater society and are constrained by the resources of the education system. The implemented curriculum is what is taught in the classroom. Although presumably inspired by the intended curriculum, actual classroom events are usually determined in large part by the teacher, whose behaviour may be greatly influenced by his or her education, training, and experience, by the nature and organisational structure of the school, by interaction with teaching colleagues, and by the composition of the student body. The attained curriculum is what the students actually learn. Student achievement depends partly on the implemented curriculum and its social and educational context, and to a large extent on the characteristics of individual students, including ability, attitude, interests and effort.

Data on the implemented curriculum were collected as part of the TIMSS 2002/03 survey of student achievement. Questionnaires completed by the mathematics and science teachers of the students in the survey, and by the principals of their schools, provided information about the topics in mathematics and science that were taught, the instructional methods used in the classroom, the organisational structures that supported teaching, and the factors that were seen to facilitate or inhibit teaching and learning. The student achievement survey provided data for the study of the attained curriculum. The wide-ranging mathematics and science tests that were administered to nationally representative samples of students provided not only a sound basis for international comparisons of student achievement, but a rich resource for the study of the attained curriculum in each country. Information about students' characteristics, and about their attitudes, beliefs, and experiences, was collected from each participating student. This information was used to identify the student characteristics associated with learning and provide a context for the study of the attained curriculum.

Design and administration of TIMSS

Organisation

Like all previous IEA studies, TIMSS 2002/03 was essentially a cooperative venture among independent research centres around the world. While country representatives came together to work on instruments and procedures, they were each responsible for conducting TIMSS 2002/03 in their own country, in accordance with the international standards. Each national centre provided its own funding and contributed to the support of the international coordination of the study. A study of the scope and magnitude of TIMSS 2002/03 offers a tremendous operational and logistic challenge. In order to yield comparable data, the achievement survey must be replicated in each participating country in a timely and consistent manner. This was the responsibility of the National Research Coordinator (NRC) in each country.

Participant	Year 4	Year 8
Armenia	4	8
Australia	4	8
Bahrain		8
Belgium (Flemish)	4	8
Botswana		8
Bulgaria		8
Chile		8
Chinese Taipei	4	8
Cyprus	4	8
Egypt		8
England	4	8
Estonia		8
Ghana		8
Hong Kong SAR	4	8
Hungary	4	8
Indonesia		8
Iran, Islamic Republic of	4	8
Israel		8
Italy	4	8
Japan	4	8
Jordan		8
Korea, Republic of		8
Latvia	4	8
Lebanon		8
Lithuania	4	8
Macedonia, Republic of		8
Malaysia		8
Moldova	4	8
Morocco	4	8
Netherlands	4	8
New Zealand	4	8
Norway	4	8
Palestinian National Authority		8
Philippines	4	8
Romania		8
Russian Federation	4	8
Saudi Arabia		8
Scotland	4	8
Serbia & Montenegro		8
Singapore	4	8
Slovak Republic		8
Slovenia	4	8
South Africa		8
Sweden		8
Tunisia	4	8
United States of America	4	8

Benchmarking participants

Participant	Year 4	Year 8
Basque Country, Spain		8
Indiana State, United States of America	4	8
Ontario Province, Canada	4	8
Quebec Province, Canada	4	8

Legend

4 Year 4

8 Year 8

Figure 1.1 Participants in TIMSS 2002/03

Internationally, TIMSS was organised by the IEA and managed by the International Study Centre, Lynch School of Education, at Boston College in the United States of America. The IEA Data Processing Centre (DPC) in Hamburg, Germany, was responsible for checking and processing data and for constructing the international database. The IEA Secretariat in Amsterdam, the Netherlands, coordinated all translations and adaptations and organised the international quality control monitors. Statistics Canada, based in Ottawa, Canada, advised NRCs on their sampling plans, monitored sampling progress, and calculated the sampling weights. Educational Testing Service (ETS) in New Jersey, USA, conducted psychometric analysis of the field-test data and scaled the achievement data from the main data collection. In Australia, the study was funded by the Australian Government Department of Education, Science and Training (DEST) and by State and Territory Departments of Education in proportion to the size of their student population. The study was managed in Australia by the Australian Council for Educational Research (ACER), which represents Australia on the IEA.

International participation in TIMSS

Testing for TIMSS 2002/03 was carried out in 46 countries. Two provinces of Canada, one state of the USA[2] and Basque Country, Spain, were also in the study as benchmarking[3] participants. The countries and regions and the year levels at which they participated are shown in Figure 1.1.

The Australian sample of schools and students

There are differences in the samples of students that have an impact on compatibility of results across TIMSS cycles. For TIMSS 1994/95, students were selected from the two adjacent year levels containing the largest number of nine year olds (defined as Population 1) and 13 year olds (defined as Population 2). School entry age is not standard in Australia, nor is the year level into which students start school or move from primary schooling to secondary schooling, which meant that a range of years had to be selected from which to sample students. Due to these differences, data collection for TIMSS 1994/95 was undertaken at the following year levels:

- Years 3 and 4 and Years 7 and 8 in the Australian Capital Territory, New South Wales, Victoria and Tasmania; and

[2] In addition to the United States of America as a whole, one state (Indiana) was included as an entity.

[3] Benchmarking participants: Provinces or regions that participated in TIMSS for their own internal benchmarking. Data from these provinces are not included in the international average and are not included in the national reports.

- Years 4 and 5 and Years 8 and 9 in Queensland, South Australia, Western Australia and the Northern Territory.

The target population for TIMSS 1998/99 was defined as the upper of the two adjacent years identified in TIMSS 1994/95 as Population 2. In Australia, this was interpreted as Year 8 in the Australian Capital Territory, New South Wales, Victoria and Tasmania, and Year 9 in Queensland, South Australia, Western Australia and the Northern Territory, and students were sampled from these year levels. Population 1 was not sampled internationally in TIMSS 1998/99.

For the TIMSS 2002/03 and subsequent cycles, a decision was made by the IEA and the International Study Centre that the focus for Population 1 would be Year 4 and for Population 2 Year 8, as these were in most cases the upper of the two adjacent year levels containing the most 9 or 13 year olds. The implication of this decision for Australia is that simple trend comparisons cannot be made between TIMSS 2002/03 and TIMSS 1998/99, as the populations are different. Internationally, however, this is not the case, and a number of countries are able to make comparisons between each of the TIMSS cycles for Population 2. However comparisons for Australia can be made with TIMSS 1994/95, using data sets containing only the revised target years from each state and territory.

Figure 1.2 shows the structure of the three TIMSS data sets. An extra sample of Year 9 students was taken in 2002 in the four states of Australia in which this was the year level sampled in TIMSS 1998/99. In a follow-up report, data for Year 8 in the Australian Capital Territory, New South Wales, Victoria and Tasmania and Year 9 in Queensland, South Australia, Northern Territory and Western Australia for TIMSS 2002/03 will be combined.

By combining Year 8 students in New South Wales, Victoria, Tasmania and the Australian Capital Territory, and Year 9 students in Queensland, South Australia, Western Australia and the Northern Territory, for TIMSS 1994/95 and TIMSS 2002/03, we will create data sets with year levels that match those of TIMSS 1998/99. In this way we will be able to examine changes in achievement and contextual factors in mathematics and science over the eight-year span from 1994 to 2002.

Table 1.1 shows the effect that the structural differences in Australian state and territory[4] education systems have on the ages of students in the target populations. The youngest students in any year level were those in Queensland and Western Australia, which were the only states that, at the time when these cohorts of students were entering school, enrolled students directly into Year 1. All other states had some form of preparatory school year. The main conclusion that can be drawn from this table is that students in Queensland and Western Australia may have had up to a year less schooling than their counterparts in the rest of Australia at the time of testing. On average there is about eight months difference in the ages of Year 4 or Year 8 students in

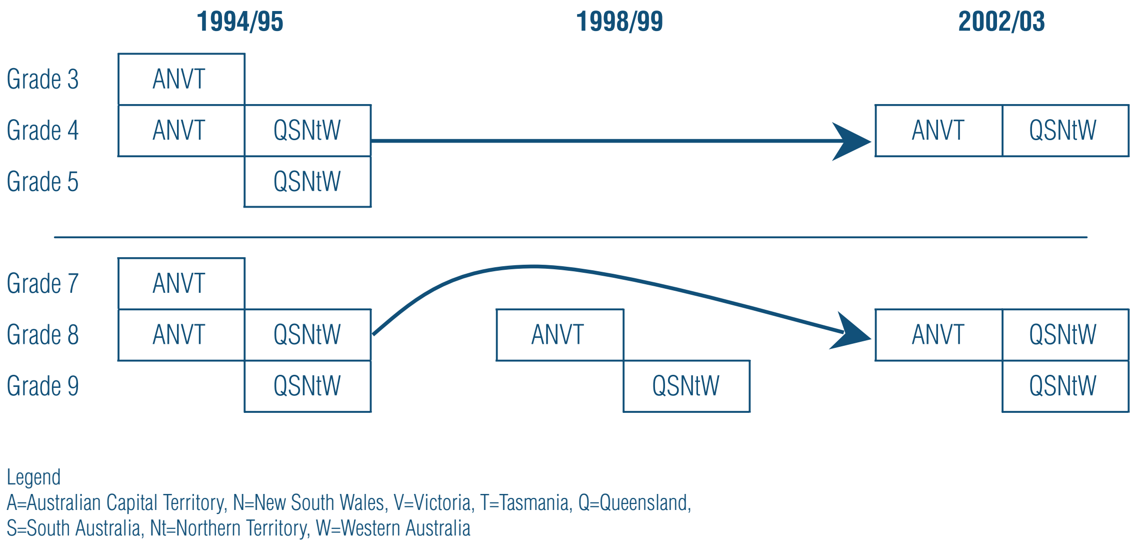


Figure 1.2 Structure of the Australian samples for each of the three TIMSS studies

[4] For the remainder of this report, the Australian states and territories will be collectively referred to as the 'states'.

Table 1.1 School starting and school entry grades and ages of TIMSS students, by state

State	First year of full-time school	TIMSS 2002/03 Population 1		First year of secondary school	TIMSS 2002/03 Population 2	
		Age range	Average age		Age range	Average age
NSW	Kindergarten	9.0 – 11.7	10.0	Year 7	12.2 – 15.5	14.0
VIC	Preparatory	8.8 – 11.2	10.1	Year 7	13.1 – 16.1	14.1
QLD	Year 1	8.8 – 11.0	9.4	Year 8	11.8 – 15.8	13.4
SA	Reception	8.5 – 11.8	9.9	Year 8	12.8 – 15.2	13.8
WA	Year 1	8.2 – 11.0	9.4	Year 8	12.5 – 14.9	13.4
TAS	Preparatory	9.0 – 11.3	10.2	Year 7	12.9 – 15.6	14.2
NT	Transition	8.9 – 10.9	9.8	Year 8	12.9 – 15.5	13.8
ACT	Kindergarten	9.1 – 11.8	10.1	Year 7	13.0 – 15.2	14.1

Queensland and Western Australia compared to their respective cohort in other states.

The international sample design for TIMSS is generally referred to as a two-stage stratified cluster sample design. The first stage consists of a sample of schools, which in Australia is stratified by State and by sector; the second stage consists of a sample of one classroom from the target year in each sampled school. To ensure unbiased data, the International Study Center set minimum participation rates of 85 per cent of sampled schools and 85 per cent of sampled students (or a combined schools and students participation rate of 75 per cent). Non-participating sampled schools could be replaced by replacement schools that had been matched according to strata and size. However, countries that only achieved these requirements by the use of replacement schools are annotated in the International Reports. Countries with less than 50 per cent of sampled schools participating are segregated in the International Reports. Australia achieved the required participation rate for Population 2 (Year 8). However, the participation rate for Population 1 (Year 4) fell just under the requirement, resulting in an annotation in the International Reports[5]. Despite this annotation, the sample is believed to be representative and sufficient for the reporting and analysis that follows. Sampling weights were calculated by Statistics Canada to ensure that the population at each year level was appropriately represented by the students participating in TIMSS. The weighted numbers for Australia for Population 1 and Population 2, along with the number of schools and actual number of students participating are shown in Table 1.2.

How is mathematics assessed in TIMSS?

Two organising dimensions, a content dimension and a cognitive dimension, framed the mathematics assessment for TIMSS 2002/03, analogous to those used in the earlier TIMSS assessments. There are five content domains: *number*, *algebra*, *measurement*, *geometry*, and *data*, and there are four cognitive domains: knowing facts and procedures, using concepts, solving routine problems, and reasoning. The two dimensions and their domains are the foundation of the mathematics assessment. The content domains define the specific mathematics subject matter covered by the assessment, and the cognitive domains define the sets of behaviours expected of students as they engage with the mathematics content.

Table 1.2 Australia's designed and achieved sample in TIMSS 2002/03, by state

State	Designed school sample	Population 1				Designed school sample	Population 2			
		N Schools	N students	Weighted N	Weighted %		N Schools	N students	Weighted N	Weighted %
NSW	40	35	912	90781	35.3	40	34	880	84456	32.8
VIC	35	32	675	62852	24.4	35	34	860	65435	25.4
QLD	35	31	759	43597	16.9	35	33	881	48270	18.8
SA	30	27	600	20901	8.1	30	28	703	18902	7.3
WA	30	27	661	26123	10.2	30	26	702	27616	10.7
TAS	30	25	501	6444	2.5	30	26	625	6424	2.5
NT	15	13	251	2300	.9	15	14	321	1578	.6
ACT	15	14	316	4224	1.6	15	15	383	4727	1.8
Total	230	204	4675	257222	100.0	230	210	5355	257408	100.0

[5] The combined schools and students participation rate for Population 1 was 73% and over 75% for Population 2.

Content domains

For each of the five content domains, the mathematics framework identifies several topic areas to be included in the assessment, as shown in Table 1.3. For example, *number* is further categorised by *whole numbers, fractions and decimals, integers,* and *ratio, proportion, and percent.* Each topic area is presented as a list of objectives covered in the curriculum of a majority of participating countries, at either Year 4 or Year 8. The organisation of topics across the content domains reflects some minor revision from the reporting categories used in the 1994/95 and 1998/99 assessments. However, each of the trend items[6] from TIMSS 1994/95 and TIMSS 1998/99 may be mapped directly into the content domains defined for TIMSS 2002/03.

Cognitive domains

To respond correctly to TIMSS test items, students need to be familiar with the mathematics content of the items. Just as important, however, items were designed to elicit the use of particular cognitive skills (see Figure 1.3). The TIMSS assessment framework (Mullis, Martin, Smith, Garden, Gonzalez, Chrostowski and O'Connor, 2003) presents detailed descriptions of the skills and abilities that make up the cognitive domains and that are assessed in conjunction with the content. These skills and abilities play a central role in developing items and achieving a balance in learning outcomes assessed by the items in fourth and eighth years. The student behaviors used to define the mathematics framework have been classified into four cognitive domains, as follows:

Knowing facts and procedures: Facts encompass the factual knowledge that provide the basic language of mathematics and the essential mathematical facts and properties that form the foundation for mathematical thought. *Procedures* form a bridge between more basic knowledge and the use of mathematics for solving routine problems, especially those encountered by people in their daily lives. Students need to be efficient and accurate in using a variety of computational procedures and tools.

Using concepts: Familiarity with mathematical concepts is essential for the effective use of mathematics for problem solving, for reasoning,

Table 1.3 TIMSS mathematics content domains and proportion of assessment for each domain

Mathematics content domains	Topics	Target percentages of TIMSS assessment devoted to content domains: Year 4	Year 8
Number	Whole numbers Fractions and decimals Integers (Year 8 only) Ratio, proportion and percent	40	30
Algebra (Patterns, equations and relationships at Year 4 level)	Patterns Algebraic expressions (Year 8 only) Equations and formulas Relationships	15	25
Measurement	Attributes and units Tools, techniques and formulas	20	15
Geometry	Lines and angles Two- and three-dimensional shapes Congruence and similarity Locations and spatial relationships Symmetry and transformations	15	15
Data	Data collection and organisation Data representation Data interpretation Uncertainty and probability (Year 8 only)	10	15

[6] Trend items are items which are repeated in two or more cycles of assessment.

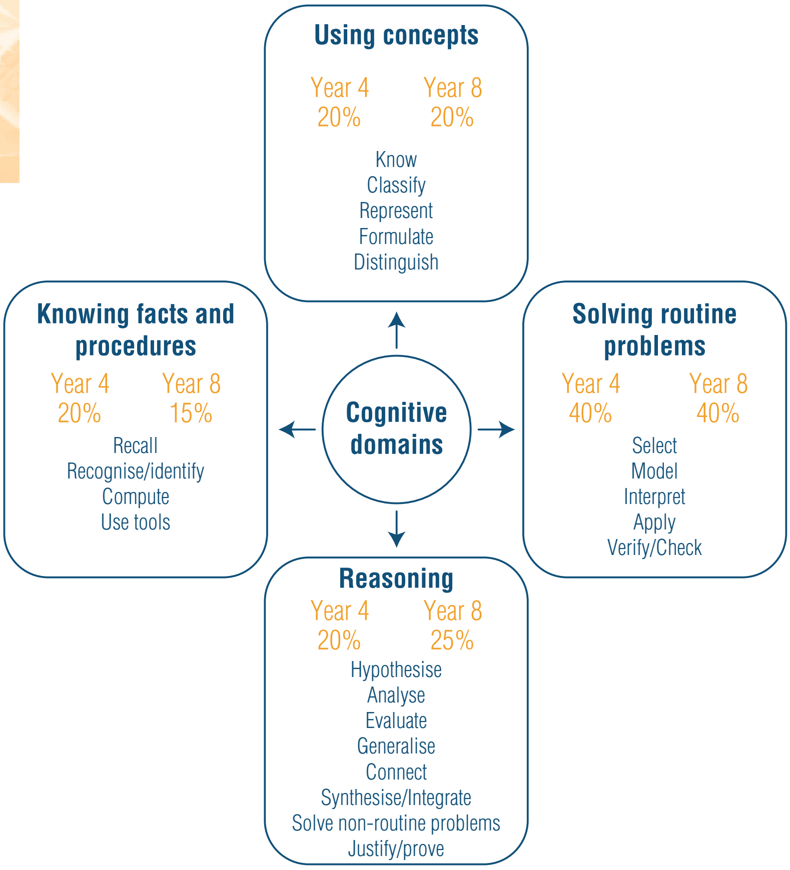


Figure 1.3 TIMSS mathematics cognitive domains and proportion of assessment for each domain

and thus for developing mathematical understanding. Knowledge of concepts enables students to make connections between elements of knowledge, make extensions beyond their existing knowledge, and create mathematical representations.

Solving routine problems: Problem solving is a central aim of teaching school mathematics and features prominently in school mathematics textbooks. Routine problems may be standard in classroom exercises designed to provide practice in particular methods or techniques. Some of these problems may be set in a quasi-real context, and may involve extended knowledge of mathematical properties (e.g., solving equations). Though they range in difficulty, routine problems are expected to be sufficiently familiar to students that they essentially involve selecting and applying learned procedures.

Reasoning: Mathematical reasoning involves the capacity for logical, systematic thinking. It includes intuitive and inductive reasoning based on patterns and regularities that can be used to arrive at solutions to non-routine problems, i.e., problems very likely to be unfamiliar to students. Such problems may be purely mathematical or may have real-life settings, and involve application of knowledge and skills to new situations, with interactions among reasoning skills usually a feature.

Examples of the behaviours associated with each of the cognitive domains can be found in Mullis et al. (2003).

Communicating mathematically

Communicating mathematical ideas and processes is important for many aspects of living and fundamental to the teaching and learning of mathematics. In the TIMSS framework, communication is not a separate cognitive domain but rather an overarching dimension across all mathematics content areas and processes. Communication is fundamental to each of the four TIMSS cognitive domains *(knowing facts and procedures, using concepts, solving routine problems, and reasoning),* and students' communication in and about mathematics should be regarded as assessable in each of these areas. Students in TIMSS may demonstrate communication skills through description and explanation, such as describing or discussing a mathematical object, concept, or model. Communication also occurs in using mathematical terminology and notation, demonstrating the procedure used in solving an equation, or using particular representational modes to present mathematical ideas.

Test design and administration

The development of the mathematics and science tests used in TIMSS 2002/03 was a collaborative process. The curriculum guides and textbooks of many countries were analysed to identify priority and common topics, and curriculum specialists collaborated to produce an international framework for each of mathematics and science which guided the test development. Test items submitted by many countries were reviewed by mathematics and science specialists, and by testing specialists, and were examined for possible gender, racial or cultural bias, before they were field-tested.

The focus of TIMSS is on curriculum-based learning, and for greater resemblance to classroom activities about one-third of the TIMSS testing time was devoted to items requiring students to construct their answers. Most of these required only short answers, some just a word or a number, but more often a sentence or phrase or diagram. In some cases students had to write down a complete explanation or show some extended, detailed working.

The inclusion of open-ended questions in TIMSS meant that scoring guides had to be developed that would be able to be applied reliably in all countries. TIMSS also used a two-digit coding scheme for all items that required a short or extended answer. The first digit registered the degree of correctness of the students' answer. For short-answer items, the first digit was 1 (correct) or 7 (incorrect). The second digit was used to code the type of correct or incorrect response given. These codes provide a rich source of information for further research on students' problem solving strategies, thought processes and misconceptions.

A large number of test items were required to cover the range of topics and abilities, at both Year 4 and Year 8. For each year level, mathematics and science items were grouped into clusters, which were then rotated through 12 booklets, with each cluster found in more than one booklet. The booklets were designed to be administered in two sessions, separated by a short break. Each session was of 45 minutes duration at Year 8 and 36 minutes at Year 4. Each booklet contained both mathematics and science items, and included multiple choice, short answer and extended response items. Participating students completed only one of these booklets, which were evenly distributed within classes. This meant that only two or three students in each class completed the same booklet.

Procedures for administering the test were determined by the TIMSS International Study Centre so that data from all students from all schools in all countries could be considered equivalent. These were operationalised by National Centres in each country, such as the ACER in Australia. School Coordinators, nominated by the school principal, assisted the National Centre with the management of TIMSS within the school, including administering the school and teacher questionnaires. The actual test and student questionnaires were administered, in most cases, by a teacher from the school. The Test Administrator followed strict guidelines and had to complete a report about any situation that constituted a deviation from these guidelines. A National Quality Control Observer visited 10 per cent of schools to observe the test administration. An International Quality Control Observer visited a further 15 schools as well as examining the operations of the National Centre.

TIMSS contextual framework

It is very important in a study such as TIMSS that student achievement is not considered in isolation from the economic, social, cultural and educational contexts in which achievement occurs. To ensure that these data were available, TIMSS included four background questionnaires. The development of these questionnaires was also a collaborative process, and was based on a thorough review of the school, teacher, and student factors which had been shown in previous research to be related to student achievement. Separate questionnaires were developed for principals, mathematics teachers, science teachers and students. Briefly:

- the School Questionnaire sought information about school characteristics (location, size, year levels catered for etc), resources, time for planning, and curriculum offerings;

- the Teacher Questionnaires asked about teacher qualifications and preparation, how teachers organise and carry out instruction in mathematics and science, pedagogical practices, teaching styles, and views on current issues in mathematics and science education;
- the Student Questionnaire collected demographic information, data on how students spend their time both in and out of school, and their attitudes towards mathematics and science.

As well, a questionnaire was developed that the NRC completed which gathered information about major organisational factors at the system level, such as age of starting school, division between primary and secondary school, teacher certification requirements, and curriculum documentation.

In primary schools, the class teacher of the sampled class was asked to complete a combined mathematics and science questionnaire, unless they specified that science was taught by another teacher. In secondary schools, the mathematics teacher of the sampled class completed the Mathematics Teacher Questionnaire, and all teachers who taught science to that class were asked to complete a Science Teacher Questionnaire.

Calculator policy

The TIMSS policy on calculator use at Year 8 is to give students the best opportunity to operate in settings that mirror their classroom experience. Beginning with TIMSS 2002/03, calculators were permitted but not required for newly developed Year 8 assessment materials. Participating countries could decide whether or not their students were allowed to use calculators for the new items. Since calculators were not permitted at Year 8 in the 1994/95 or 1998/99 assessments, the 2002/03 Year 8 test booklets were designed so that items from these assessments were placed in the first half and items new in 2002/03 placed in the second half. In Australia, as in other countries that chose to permit Year 8 students to use calculators, students could use them for the second half of the booklet only. For the Year 4 assessment, TIMSS 2002/03 continued the TIMSS 1994/95 policy of not permitting calculator use.

Organisation of this report

Chapters 2 and 3 of this report focus on the achievements of Australia's Year 4 and Year 8 students in mathematics. Chapter 2 places Australian students in an international context and allows educators to review Australian students' results in comparison with other countries. Chapter 2 also describes the international benchmarks, and shows Australian students' performance in comparison with the other TIMSS countries. Chapter 3 focuses on results for Australian states and examines achievement in the individual TIMSS content areas. Chapter 4 examines the Australian TIMSS students in detail, including their attitudes and beliefs about mathematics, and relationships between these variables and student achievement. Results for males and females, Indigenous students and those with a language background other than English are included in this section. Chapter 5 profiles the TIMSS teachers and schools and examines achievement in relation to teachers' and principals' perceptions of the school and class environment, and school size and geographic location. TIMSS sampling methodology is such that intact mathematics classrooms are taken as the sampling unit, therefore we are able to examine class-level as well as school-level issues and relate them to student achievement.

Multilevel analyses of school, class and student factors related to achievement are presented in Chapter 5. Chapter 6, the final chapter, presents a summary and policy considerations arising from the TIMSS results.

Chapter 2
Australia's mathematics results in an international context

Chapter 2
Australia's mathematic results in an international context

In this chapter, the international TIMSS results in mathematics are shown in terms of averages and distribution of achievement for all of the participating countries, presented and discussed from an Australian perspective. Gender differences are also shown and the International Benchmarks are defined and explicated, with Australia's level of performance at each of the benchmarks shown along with that of some similar countries and trading partners. Results are included for both Year 4 and Year 8 in this chapter.

Interpreting between-country similarities and differences

Twenty-five countries or education systems took part in the testing at Year 4 level, and 46 countries or education systems at Year 8 level. Table 2.1 presents the average mathematics scores for all of the countries that participated in TIMSS 2002/03 relative to the average for Australian students for Year 4, and Table 2.2 presents the same data for Year 8.

When interpreting the comparative results presented in this chapter and others, it is important to remember that each country's result is an estimate of the total population value, inferred from the result obtained by the sample of students tested. Because it is an estimate, it is subject to some potential level of error.

An idea of the variability of the average scores is given by the standard error of the average (se) presented in the tables with the average score. We can say with 95% confidence that the true population average lies within about two standard errors (1.96, to be precise) each side of the sample average, and as a guide, a country's result is not different from another country's result if these confidence intervals overlap. Standard errors are influenced by the size and design of the sample and the variation in the sample.

To illustrate the use of standard errors with the average to evaluate difference, we could ask the question: *Does Australia's Year 4 achievement level in mathematics differ from the international average?* From Table 2.1, Australia's average score is 499 with a standard error of 3.9, while the international average is 495 with a standard error of 0.8.

The population average for Australia therefore lies somewhere between 491.2 and 506.8 (the *confidence interval*), while the international average lies between 493.4 and 496.6.

As these intervals overlap, we cannot say that the means are statistically different. We could also ask: *Is Singapore's achievement level in mathematics significantly higher than that of Hong Kong SAR?* From Table 2.1, Singapore's average is 594 with a standard error of 5.6, giving a confidence interval of 582.8–605.2 , while Hong Kong SAR's average is 575 with a standard error of 3.2, giving a confidence interval of 568.6–581.4.

As the upper level of Hong Kong SAR's confidence interval does not overlap the lower level of Singapore's confidence interval then we can say (with 95% confidence) that Singapore's average is significantly higher than that of Hong Kong SAR[1].

To assist identifying where Australia stands in an international context, we have annotated each table (in the column headed '2002/03') as follows:

- Countries that are shaded at the top of the table and are annotated with a ▲ are countries whose students achieved significantly higher scores than Australian students;

[1] When comparing many countries at one time, a statistical adjustment must be made so that the probability level remains at 0.05. This is referred to as 'adjusting for multiple comparisons'.

- Australian students performed at similar levels to those students in countries annotated with a •;
- Australian students performed significantly better than students in countries shaded at the bottom of the table that are annotated with a ▼.

This notation (but not the shading) has also been used in the column headed '1994/95' to provide a comparison of Australia's performance with that in TIMSS 1994/95 (upper year). Countries that did not participate in TIMSS 1994/95 are noted with a dash.

Also shown in Table 2.1 and Table 2.2 is the average age of students in the year level and a measure of the level of development of the country – the United Nations Development Program's human development index (HDI). This index is a summary measure of human development in a country over three basic dimensions: life expectancy at birth, knowledge – measured by adult literacy rate and combined primary, secondary and tertiary gross enrolment ratio, and GDP per capita. Australia's HDI is 0.939, which is the highest of any country in the Year 4 group and second only to the Scandinavian countries in the Year 8 group of countries.

Both of these items should be taken into account when examining differences between countries' performance. For example the students in the Russian Federation scored significantly better in the mathematics tests at Year 4 than students from Australia, and yet their level of human development, measured by the HDI, is 0.779, compared to Australia's 0.939. However the average age of students in the Russian Federation was 10.6 years, a little more than half a year older than Australian students sitting the same test.

Some notes about sampling

Readers will notice several footnotes about sampling on the international comparative achievement charts. These footnotes indicate where there is some concern about the sampling, and that this should be borne in mind when interpreting the results. For example, Korea, while testing the same cohort of students as other countries, did so at the beginning of the 2003 school year, rather than at the end of the year. Several countries did not completely meet the sample requirements. These were specified as 85 per cent of originally sampled schools, without replacement, and 85 per cent of students within the schools, or a combined rate of 75 per cent. Testing in the southern hemisphere countries was done late in the school year, and although in Australia, sufficient schools initially agreed to participate in TIMSS, when faced with the reality of scheduling testing along with reports, camps, concerts and other end of year activities, some schools changed their minds. While project staff were in many cases able to enlist the sampled schools, Australia did not quite achieve this for the Year 4 sample, and so Australia's results are annotated as 'met guidelines for sample participation only after replacement schools were included'. Given that the replacement schools were selected by Statistics Canada at the same time as the main study schools, this should not mean that Australia's results are any less valid.

Other countries had more difficulty than Australia in reaching the sample participation rates without the use of replacement schools. These are also annotated in the tables. In many countries participation in studies such as TIMSS is highly regarded, and in other countries testing is conducted by the Ministry of Education and for these countries sampling is generally not an issue.

In the International Reports, the achievement level of England is 'below the line' at Year 8 level as it did not meet the minimum sample participation rates. Whilst for the purposes of this report the results for England are included in the main body of the table, it is purely for a general comparison with our own results.

How did Australia compare internationally?

Mathematics – Year 4

The average ages of students varied by a full year between countries – from around 11 years in Latvia, Moldova, Lithuania, Armenia and Morocco, to under 10 years in Cyprus, Italy, Australia, Scotland, Slovenia and Norway. Years of schooling was most commonly 4 years, but ranged from 3 years in the Russian Federation and Slovenia through to 5.5 years in New Zealand.

At Year 4, Singapore outperformed all other countries, and Hong Kong SAR outperformed all countries other than Singapore[2] (Table 2.1). The

[2] The multiple comparison tables for the international results are included in Appendix 1.

Table 2.1 Distribution of mathematics achievement at Year 4

All Year 4 TIMSS 2002/03 countries	Average scale score (se)	2002/03	1994/95	Average Age	Years of schooling	Human Development Index*
Singapore	594 (5.6)	▲	▲	10.3	4	0.884
†Hong Kong SAR	575 (3.2)	▲	▲	10.2	4	0.889
Japan	565 (1.6)	▲	▲	10.4	4	0.932
Chinese Taipei	564 (1.8)	▲	-	10.2	4	–
Belgium (Flemish)	551 (1.8)	▲	-	10.0	4	0.937
†Netherlands	540 (2.1)	▲	▲	10.2	4	0.938
Latvia	536 (2.8)	▲	▼	11.1	4	0.811
[1]Lithuania	534 (2.8)	▲	-	10.9	4	0.824
Russian Federation	532 (4.7)	▲	-	10.6	3 or 4	0.779
†England	531 (3.7)	▲	▼	10.3	5	0.930
Hungary	529 (3.1)	▲	•	10.5	4	0.837
†United States of America	518 (2.4)	▲	•	10.2	4	0.937
Cyprus	510 (2.4)	▲	▼	9.9	4	0.891
Moldova, Rep. of	504 (4.9)	•	-	11.0	4	0.700
Italy	503 (3.7)	•	-	9.8	4	0.916
†Australia	499 (3.9)			9.9	4 or 5	0.939
International average	**495 (0.8)**			**10.3**	**4**	**-**
New Zealand	493 (2.2)	•	▼	10.0	4.5 or 5.5	0.917
†Scotland	490 (3.3)	•	▼	9.7	5	0.930
Slovenia	479 (2.6)	▼	•	9.8	3 or 4	0.881
Armenia	456 (3.5)	▼	-	10.9	4	0.729
Norway	451 (2.3)	▼	▼	9.8	4	0.944
Iran, Islamic Rep. of	389 (4.2)	▼	▼	10.4	4	0.719
Philippines	358 (7.9)	▼	-	10.8	4	0.751
Morocco	347 (5.1)	▼	-	11.0	4	0.606
Tunisia	339 (4.7)	▼	-	10.4	4	0.740

* Taken from United Nations Development Program's Human Development Report 2003, p237–240
† Met guidelines for sample participation rates only after replacement schools were included
[1] National Desired Population does not cover all of International Desired Population
( ) Standard errors appear in parentheses.
\- Did not participate in TIMSS 1994/95 at this Year level
▲ score statistically higher than Australia's
• score statistically no different than Australia's
▼ score statistically lower than Australia's

achievement levels of Japan and Chinese Taipei were significantly higher than that of the countries below them in Table 2.1, followed by Belgium (Flemish), which was significantly higher than any country below it in the table. These four countries were followed by a group of European countries, including the Netherlands, Russian Federation and England, as well as the United States of America, all of which achieved at a significantly higher level than Australia. Australia's achievement level was not significantly different from the international average, and was the same as that of students in Year 4 in Moldova, Italy, New Zealand and Scotland. Australia's performance was significantly higher than that of seven other countries, including the Philippines.

There was no significant change in average scale score for Australia from TIMSS 1994/95, but there was significant improvement by a number of countries, including New Zealand by 26 score points, Latvia by 34 score points and Hong Kong SAR by 18 score points[3]. It should be noted that in TIMSS 1994/95, Australia's score was signficantly above the international average. It is difficult to make a direct comparison with TIMSS 1994/95 in terms of the relative position of Australia internationally because there are different countries in each assessment. However there are a great many more countries in TIMSS 2002/03 whose performance surpasses that of Australia than in TIMSS 1994/95.

[3] For England there was an improvement of 47 score points but this needs to be considered in relation to the fact that England did not satisfy sampling requirements.

Table 2.2 Distribution of mathematics achievement at Year 8

All Year 8 TIMSS 2002/03 countries	Average scale score (se)	2002/03	1994/95	Average Age	Years of schooling	Human Development Index*
Singapore	605 (3.6)	▲	▲	14.3	8	0.884
⋈Korea, Rep. of	589 (2.2)	▲	▲	14.6	8	0.879
†Hong Kong SAR	586 (3.3)	▲	▲	14.4	8	0.889
Chinese Taipei	585 (4.6)	▲	-	14.2	8	–
Japan	570 (2.1)	▲	▲	14.4	8	0.932
Belgium (Flemish)	537 (2.8)	▲	▲	14.1	8	0.937
†Netherlands	536 (3.8)	▲	•	14.3	8	0.938
Estonia	531 (3.0)	▲	-	15.2	8	0.833
Hungary	529 (3.2)	▲	•	14.5	8	0.837
Malaysia	508 (4.1)	•	-	14.3	8	0.790
Latvia	508 (3.2)	•	▼	15.0	8	0.811
Russian Federation	508 (3.7)	•	•	14.2	7 or 8	0.779
Slovak Republic	508 (3.3)	•	▲	14.3	8	0.836
Australia	505 (4.6)			13.9	8 or 9	0.939
‡United States of America	504 (3.3)	•	▼	14.2	8	0.937
[1]Lithuania	502 (2.5)	•	▼	14.9	8	0.824
Sweden	499 (2.6)	•	•	14.9	8	0.941
†Scotland	498 (3.7)	•	▼	13.7	9	0.930
ǂEngland	498 (4.7)	•	▼	14.3	9	0.930
[2]Israel	496 (3.4)	•	•	14.0	8	0.905
New Zealand	494 (5.3)	•	▼	14.1	8.5 or 9.5	0.917
Slovenia	493 (2.2)	▼	•	13.8	7 or 8	0.881
Italy	484 (3.2)	▼	-	13.9	8	0.916
Armenia	478 (3.0)	▼	-	14.9	8	0.729
[1]Serbia & Montenegro	477 (2.6)	▼	-	14.9	8	–
Bulgaria	476 (4.3)	▼	•	14.9	8	0.795
Romania	475 (4.8)	▼	▼	15.0	8	0.773
International average	**467 (0.5)**			**14.5**	**8**	**-**
Norway	461 (2.5)	▼	▼	13.8	7	0.944
Moldova, Rep. of	460 (4.0)	▼	-	14.9	8	0.700
Cyprus	459 (1.7)	▼	▼	13.8	8	0.891
[2]Macedonia, Rep. of	435 (3.5)	▼	-	14.6	8	0.784
Lebanon	433 (3.1)	▼	-	14.6	8	0.752
Jordan	424 (4.1)	▼	-	13.9	8	0.743
Iran, Islamic Rep. of	411 (2.4)	▼	▼	14.4	8	0.719
[1]Indonesia	411 (4.8)	▼	▼	14.5	8	0.682
Tunisia	410 (2.2)	▼	-	14.8	8	0.740
Egypt	406 (3.5)	▼	-	14.4	8	0.648
Bahrain	401 (1.7)	▼	-	14.1	8	0.839
Palestinian Nat'l Auth.	390 (3.1)	▼	-	14.1	8	0.731
Chile	387 (3.3)	▼	-	14.2	8	0.831
[1]‡Morocco	387 (2.5)	▼	-	15.2	8	0.606
Philippines	378 (5.2)	▼	-	14.8	8	0.751
Botswana	366 (2.6)	▼	-	15.1	8	0.614
Saudi Arabia	332 (4.6)	▼	-	14.1	8	0.769
Ghana	276 (4.7)	▼	-	15.5	8	0.567
South Africa	264 (5.5)	▼	▼	15.1	8	0.684

* Taken from United Nations Development Program's Human Development Report 2003, p237–240
⋈ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year
† Met guidelines for sample participation rates only after replacement schools were included
‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included
ǂ Did not satisfy guidelines for sample participation rates
1 National Desired Population does not cover all of International Desired Population
2 National Desired Population covers less than 90% of National Desired Population
( ) Standard errors appear in parentheses.
- Did not participate in TIMSS 1994/95 at this Year level
▲ score statistically higher than Australia's
• score statistically no different than Australia's
▼ score statistically lower than Australia's

Mathematics – Year 8

The oldest students in the Population 2 (Year 8) sample were more than 15 years old – from 15.5 years in Ghana to 15.2 in Morocco and Estonia, 15.1 in South Africa and Botswana, and 15 in Latvia and Romania. With an average age of 13.9 years, Australian students were amongst the youngest in the sample. Other countries with students under 14 years were Scotland, Slovenia, Italy, Norway, Cyprus and Jordan. While there is clearly a wide variety in age, most students had had 8 years of formal schooling. Years of schooling ranged from seven years in Norway to 9.5 in New Zealand.

Table 2.2 provides the international achievement data for Year 8 students. Again, Singapore's achievement level was significantly higher than any other country, followed by Korea, Hong Kong SAR, Chinese Taipei and Japan, all of which performed significantly better than any other country. At this year level, Australian students performed at a level significantly higher than the international average, along with 11 other countries, including England, the United States of America, Scotland and Malaysia. Australian students performed better than students in 25 other countries, including Indonesia and the Philippines.

There was no significant change in Australia's achievement level from TIMSS 1994/95, but scores increased significantly for a number of other countries, including other Asia-Pacific countries and countries with similar educational systems – such as Hong Kong SAR by 17 score points and the United States of America by 12 score points.

Of the six countries in both TIMSS 1994/95 and 2002/03 whose average score surpassed that of Australia, five still do so. However, half of the countries that Australia outscored in TIMSS 1994/95 performed on a statistically similar level to Australia in 2002/03.

Gender differences in mathematics achievement

The average mathematics achievement scores for all participating countries, separately for male and female students, are shown in Figure 2.1 for Year 4 and 2.2 for Year 8.

In the figures, gender differences are shown by a horizontal bar for each country, illustrating the amount of 'difference' between the average achievement scores of males and females in that country. Of course, many 'differences' are simply an artefact of sampling and measurement error. If a difference is large enough to be statistically significant, the horizontal bar is shaded rather than outlined.

The analysis of achievement by gender presents some very interesting differences between countries. In TIMSS 1994/95 all of the significant gender differences at Year 4 and Year 8 level were in favour of males. There was no significant gender difference in the average score for mathematics at either year level either for Australia or the international average.

In TIMSS 2002/03, gender differences in mathematics were not consistently in favour of either males or females. At Year 4 level, males scored significantly higher than females in the Netherlands, the United States of America, Italy, Cyprus and Scotland. Females scored significantly higher than males in Singapore, Moldova, the Philippines and Armenia. The significant differences ranged in size from six score points in the Netherlands to 12 score points in the Philippines and Armenia.

At Year 8 level in mathematics, males scored significantly higher than females in the United States of America, Italy, Hungary, Lebanon, Belgium (Flemish), Chile, Ghana, Tunisia, and Morocco. Females scored significantly higher than males in Serbia and Montenegro, Macedonia, Armenia, Moldova, Singapore, Philippines, Cyprus, Jordan, and Bahrain. The differences in scale scores range from six points for the United States of America and Italy to 27 points in Jordan and 33 points in Bahrain.

In Australia, at both year levels, males scored slightly (but not significantly) higher than females. This difference was three score points for Year 4 students and 13 score points for Year 8 students.

The trends analysis shows that at Year 4 level, the average achievement levels of Australian males and females have changed by the same amount, about four score points, while at Year 8 level the average achievement level of females has declined by 13 score points while the average achievement level of males has increased by four score points. None of these changes were significant.

In all of the countries at Year 4 level, a significant increase (or decrease) in the average scores of one gender between TIMSS 1994/95 and TIMSS 2002/03 was accompanied by a similar significant increase (or decrease) in the average achievement

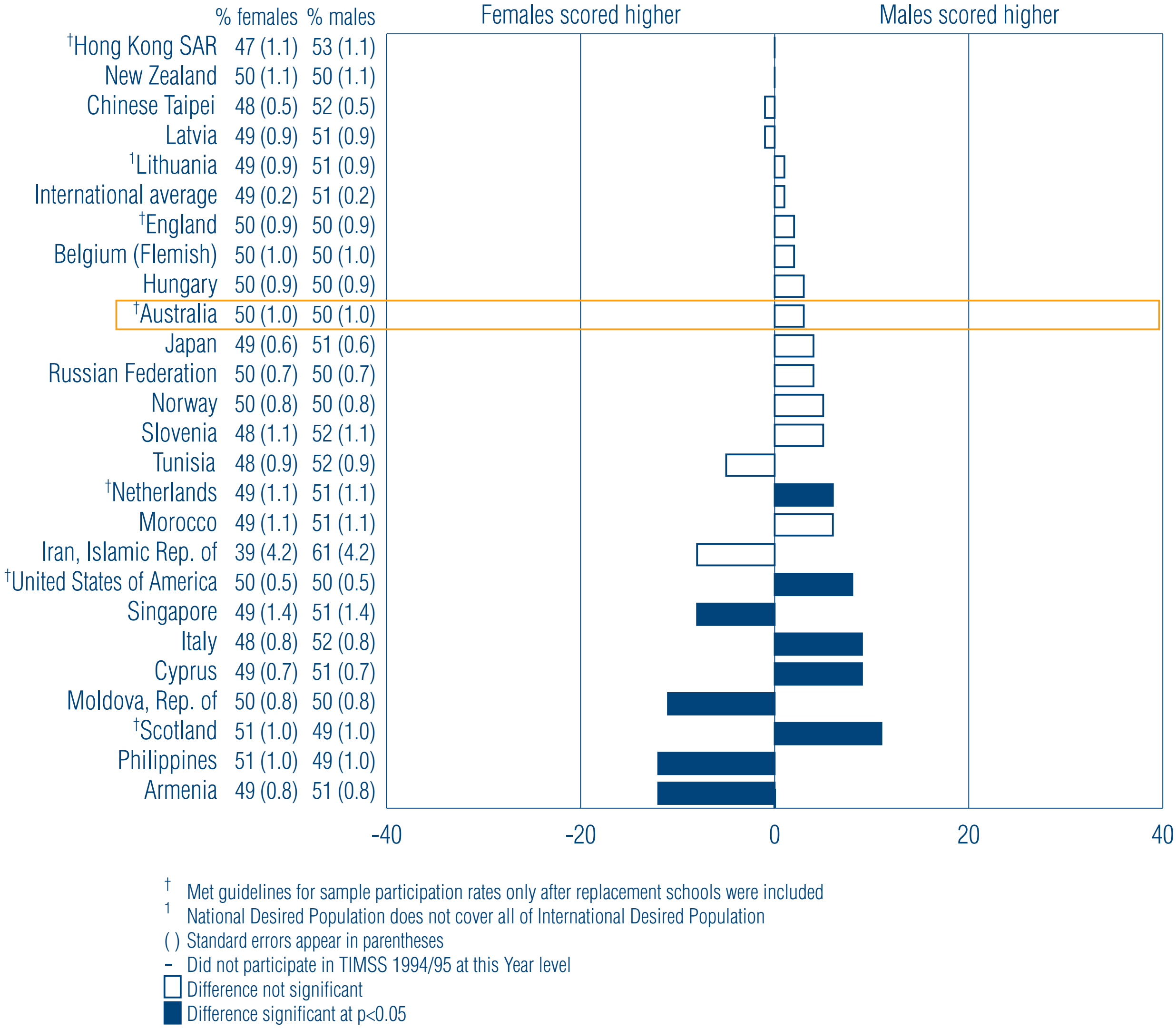


Figure 2.1 Achievement differences in mathematics between males and females, Year 4

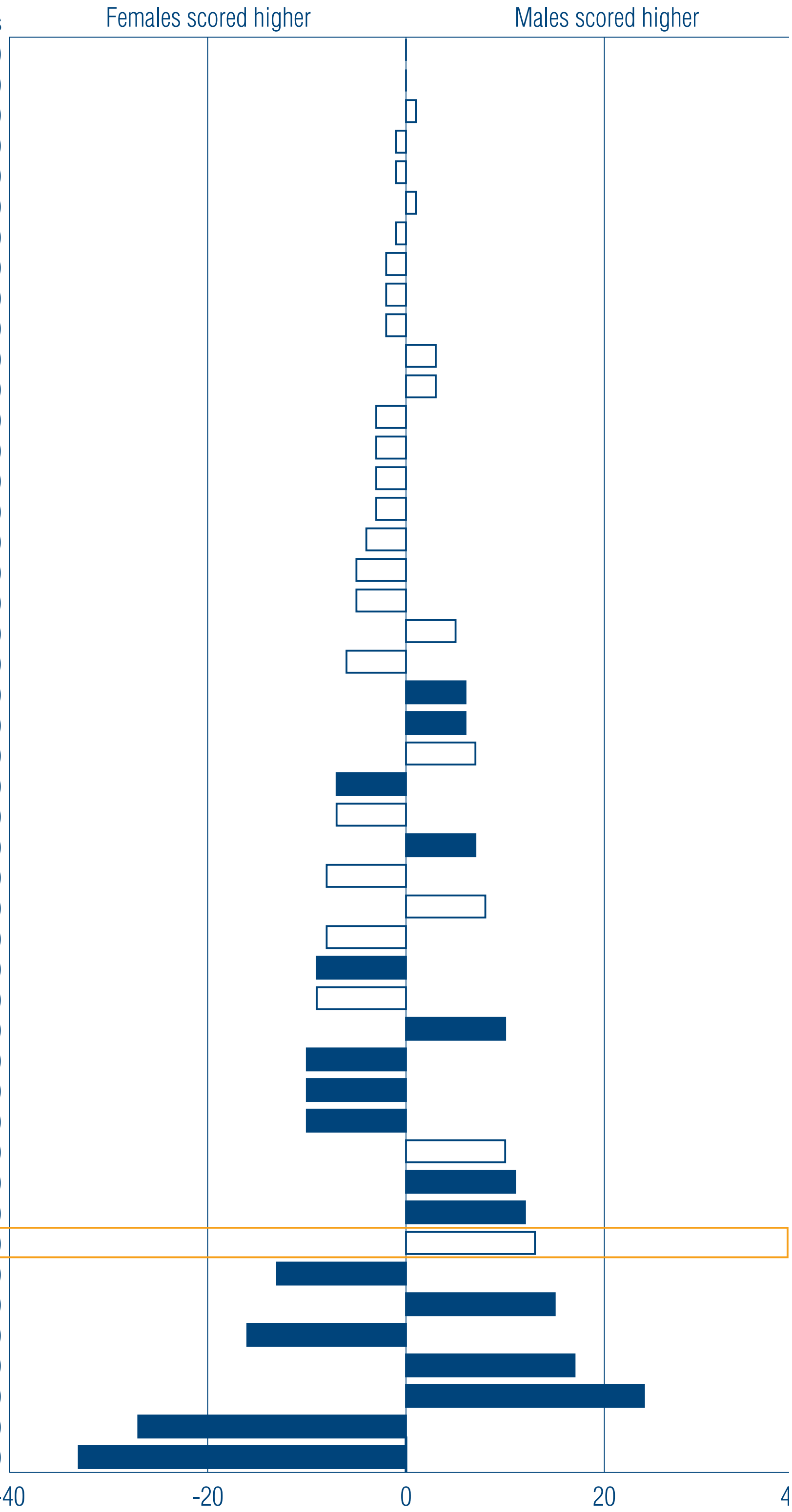
of the other gender with the exception of the Netherlands, where the average score of males decreased, but the average score of females did not change. For example, significant increases in the average scores of both males and females were seen in Cyprus, England, Hong Kong SAR, Latvia, New Zealand and Slovenia. Only in Norway did average achievement levels decline for both males and females.

At Year 8 a different picture emerges. In Lithuania and the United States of America, average achievement levels for both males and females increased significantly between TIMSS 1994/95 and TIMSS 2002/03 although the amount of this increase was substantially greater for Lithuania.

In some countries, achievement by females has improved substantially while that of males has remained static. Females' achievement levels in Hong Kong SAR, Korea, Latvia and Scotland have increased significantly since TIMSS 1994/95, and in England since TIMSS 1998/99, while achievement levels for males have remained statistically the same.

In Belgium (Flemish), females' average achievement significantly declined from TIMSS 1994/95 to TIMSS 2002/03. In Japan, Iran and Moldova, males' achievement levels have declined significantly between each TIMSS testing, while that of females has remained the same. In Bulgaria, Cyprus, the Russian Federation, achievement levels for both males and females declined significantly between each TIMSS study.

	% females	% males
ǂEngland	50 (2.4)	50 (2.4)
Slovak Republic	48 (1.3)	52 (1.3)
Sweden	51 (0.9)	49 (0.9)
†Indonesia	50 (0.7)	50 (0.7)
Egypt	46 (2.7)	54 (2.7)
Bulgaria	48 (1.3)	52 (1.3)
International average	50 (0.2)	50 (0.2)
†Hong Kong SAR	50 (2.4)	50 (2.4)
Estonia	50 (1.0)	50 (1.0)
New Zealand	52 (1.7)	48 (1.7)
Japan	49 (1.2)	51 (1.2)
South Africa	51 (0.9)	49 (0.9)
Norway	50 (0.8)	50 (0.8)
Russian Federation	49 (1.2)	51 (1.2)
Slovenia	50 (0.9)	50 (0.9)
Botswana	51 (0.7)	49 (0.7)
Romania	52 (0.9)	48 (0.9)
[1]Lithuania	50 (0.9)	50 (0.9)
†Scotland	50 (1.3)	50 (1.3)
⋈Korea, Rep. of	48 (2.8)	52 (2.8)
Latvia	49 (0.8)	51 (0.8)
†United States of America	52 (0.7)	48 (0.7)
Italy	50 (0.9)	50 (0.9)
†Netherlands	49 (1.2)	51 (1.2)
Serbia & Montenegro	49 (0.8)	51 (0.8)
Chinese Taipei	48 (1.0)	52 (1.0)
Hungary	50 (1.0)	50 (1.0)
Malaysia	50 (1.8)	50 (1.8)
[2]Israel	52 (1.6)	48 (1.6)
Palestinian Nat'l Auth.	55 (2.4)	45 (2.4)
[2]Macedonia, Rep. of	49 (0.9)	51 (0.9)
Iran, Islamic Rep. of	40 (4.1)	60 (4.1)
Lebanon	57 (1.8)	43 (1.8)
Armenia	53 (0.7)	47 (0.7)
Moldova, Rep. of	51 (0.8)	49 (0.8)
Singapore	49 (0.8)	51 (0.8)
Saudi Arabia	43 (2.3)	57 (2.3)
Belgium (Flemish)	54 (2.1)	46 (2.1)
[1]‡Morocco	50 (1.8)	50 (1.8)
Australia	51 (2.2)	49 (2.2)
Philippines	58 (0.9)	42 (0.9)
Chile	48 (1.6)	52 (1.6)
Cyprus	49 (0.6)	51 (0.6)
Ghana	45 (0.9)	55 (0.9)
Tunisia	53 (0.7)	47 (0.7)
Jordan	49 (1.7)	51 (1.7)
Bahrain	50 (0.4)	50 (0.4)



⋈ Korea tested the same cohort of students as other countries, but later in 2003, at the beginning of the next school year
† Met guidelines for sample participation rates only after replacement schools were included
‡ Nearly satisfied guidelines for sample participation rates only after replacement schools were included
ǂ Did not satisfy guidelines for sample participation rates
1 National Desired Population does not cover all of International Desired Population
2 National Desired Population covers less than 90% of National Desired Population
( ) Standard errors appear in parentheses
☐ Difference not significant
■ Difference significant at p<0.05

Figure 2.2 Achievement differences in mathematics between males and females, Year 8

How did Australian students compare with the international benchmarks in mathematics?

To describe students' performance in mathematics across countries, international benchmarks were developed by the International Study Centre using scale anchoring techniques (see below) and student achievement data from all countries that participated in TIMSS 2002/03. A similar exercise was carried out for both the TIMSS 1994/95 and the TIMSS 1998/99 study, and Mullis, Martin, Gonzalez, Gregory & Garden, O'Connor, Chrowtowski and Smith (2000) noted that three factors seemed to differentiate between student performance at each level:

- the mathematical operation required;
- the complexity of the numbers or number system;
- the nature of the problem situation.

Scale anchoring is a way of describing students' performance on the TIMSS 2002/03 achievement scales at both year levels in terms of the types of items that students at the particular year level answered correctly. It has both empirical and qualitative components. The empirical component used Item Response Theory to identify items that discriminated between successive points on the scale. For the empirical component, the results of all students taking part in TIMSS 2002/03 were pooled so that the levels describe what the best students at each level can do, irrespective of which country they come from. For the qualitative component, subject matter specialists examined the content of the items and generalised to the students' knowledge and understanding.

Internationally it was decided that performance should be measured at four levels. These four levels summarise the achievement reached by:

- the *'Advanced International Benchmark'*, which was set at 625;
- the *'High International Benchmark'*, which was set at 550;
- the *'Intermediate International Benchmark'*, which was set at 475;
- and the *'Low International Benchmark'*, which was set at 400.

The descriptions of the levels are cumulative, so that a student who reached the high international benchmark can typically demonstrate the knowledge and skills for levels for both the intermediate and low benchmarks.

Benchmarks are only one way of examining student performance. The benchmarks discussed in this report are based solely on student performance in TIMSS 2002/03, on items that were developed specifically for the purpose of obtaining information on the mathematics domains in the TIMSS framework. There are undoubtedly other curricular elements on which students at the various benchmarks would have been successful if they had been included in the assessment.

Figure 2.3 for Year 4 Mathematics and Figure 2.5 for Year 8 Mathematics summarise what students scoring at these benchmarks typically know and can do.

Benchmarks – Year 4 mathematics

At Year 4 students at the advanced benchmark showed the ability to solve a variety of problems whereas those at the low benchmark demonstrated only a basic understanding of whole numbers, the properties of basic geometrical shapes, and how to read simple bar charts. More detailed descriptions of these benchmarks are also provided in Figure 2.3 and the final section of this chapter provides example test items illustrating the benchmarks and students' performance at each level.

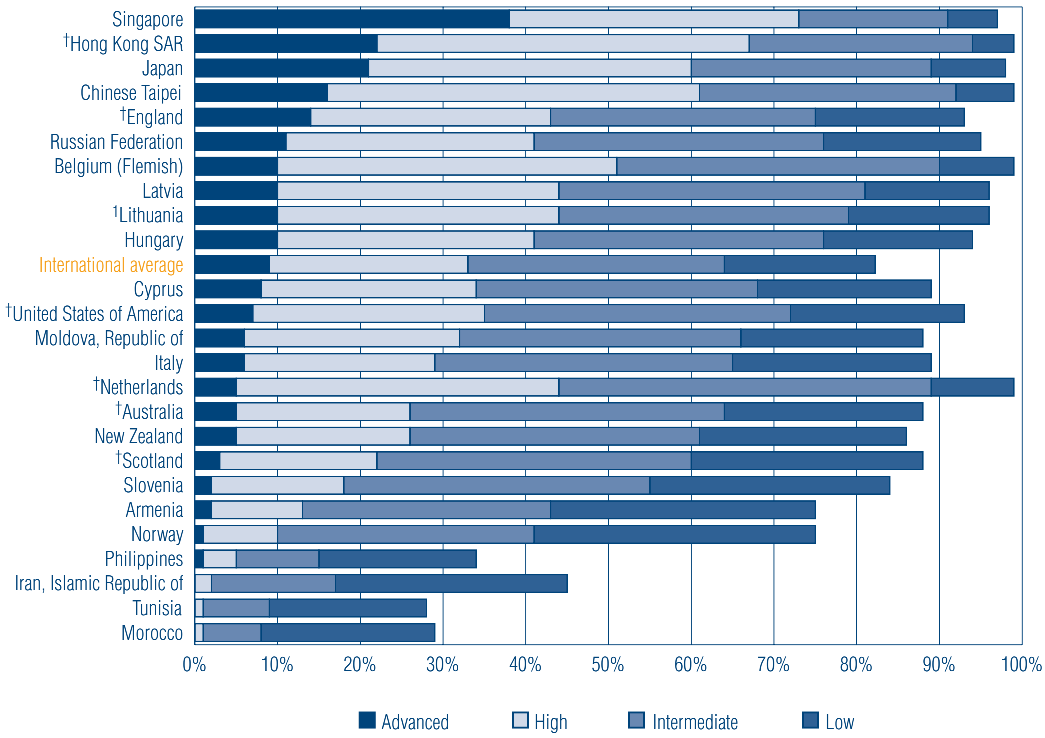
Australia performed well at some levels against the international benchmarks. Only five per cent of Australian students achieved at the advanced international benchmark, compared with an international average of 8 per cent, and 26 per cent achieved at the high international benchmark, compared with 33 per cent internationally. At the lower levels of achievement, 64 per cent of Australian Year 4 students achieved the intermediate international benchmark, similar to the international average of 63 per cent, and 88 per cent achieved above the international low benchmark, above that of the international average (82%). Figure 2.4 shows the proportion of students at each benchmark for all TIMSS 2002/03 countries.

The highest achieving country, Singapore, maintained the high proportion of students achieving at the advanced international benchmark that was established for TIMSS 1994/95 with 38 per cent of students attaining this level. A little over one-fifth of students in both Hong Kong SAR and Japan also achieved at the advanced international benchmark. What is particularly impressive about achievement in these countries is that almost all (97% to 99%) of the fourth year students in these high achieving countries achieved the low international benchmark. Not only are a substantial proportion of students doing exceptionally well, but also almost all students are attaining the basic levels of mathematics achievement.

In the lower achieving countries, particularly in developing countries, the picture is not so bright. In the Philippines, for example, only one per cent of students reached the advanced international benchmark, and only 34 per cent achieved the low benchmark. Other countries, while not achieving high proporations of students in the advanced benchmark, appear to do an excellent job of educating all of their students to an average standard. For example the Netherlands has five per cent at the advanced benchmark, but achieves 99 per cent above the low benchmark. In nine of the 25 countries participating in TIMSS

Year 4	Low International Benchmark (400)	Intermediate International Benchmark (475)	High International Benchmark (550)	Advanced International Benchmark (625)
	Students have some basic mathematical knowledge. Students demonstrate an understanding of whole numbers and can do simple computations with them. They demonstrate familiarity with the basic properties of triangles and rectangles. They can read information from simple bar graphs.	*Students can apply basic mathematical knowledge in straightforward situations.* They can read, interpret, and use different representations of numbers. They can perform operations with three- and four-digit numbers and decimals. They can extend simple patterns. They are familiar with a range of two-dimensional shapes and read and interpret different representations of the same data.	*Student can apply their knowledge and understanding to solve problems.* Students can solve multi-step word problems involving addition, multiplication, and division. They can use their understanding of place value and simple fractions to solve problems. They can identify a number sentence that represents situations. Students show understanding of three-dimensional objects, how shapes can make other shapes, and simple transformation in a plane. They demonstrate a variety of measurement skills and can interpret and use data in tables and graphs to solve problems.	*Students can apply their understanding and knowledge in a wide variety of relatively complex situations.* They demonstrate a developing understanding of fractions and decimals and the relationship between them. They can select appropriate information to solve multi-step word problems involving proportions. They can formulate or select a rule for a relationship. They show understanding of area and can use measurement concepts to solve a variety of problems. They show some understanding of rotation. They can organise, interpret, and represent data to solve problems.

Figure 2.3 Descriptors of international benchmarks in mathematics, Year 4



† Met guidelines for sample participation rates only after replacement schools were included
¹ National Desired Population does not cover all of International Desired Population
- Did not participate in TIMSS 1994/95 at this Year level
☐ Difference not significant
■ Difference significant at $p<0.05$

Figure 2.4 Proportion of Year 4 students reaching the mathematics international benchmarks, internationally

2002/03 at the Year 4 level, more than 95 per cent of students achieved the low international benchmark.

The percentages of Year 4 Australian students reaching each of the international benchmarks is provided in Table 2.3, along with the 2002/03 international average for trend countries, and for reference, the percentages of students reaching these benchmarks in TIMSS 1994/95.

The proportion of Australian students reaching both the advanced and high international benchmarks declined slightly from TIMSS 1994/95, although this was not significant. The proportion of those attaining the intermediate and low benchmarks increased slightly, although again not significantly.

The proportion of English and Cyprian Year 4 students achieving each of the benchmarks increased significantly from TIMSS 1994/95, while each of the proportions of students in Norway decreased significantly.

A number of countries significantly improved the proportion of students achieving at least the low international benchmark; Singapore, Hong Kong SAR, England, Hungary, Latvia, Cyprus, New Zealand and Slovenia.

Table 2.3 Percentages of Year 4 Australian students reaching the international benchmarks of mathematics achievement in TIMSS 2002/03 and TIMSS 1994/95

	TIMSS 2002/03		TIMSS 1994/95	
	Proportion of Australian students (%)	International average for trend countries (%)	Proportion of Australian students (%)	International average for trend countries (%)
Advanced	5 (0.7)	10 (0.3)	6 (0.6)	10 (0.3)
High	26 (1.7)	36 (0.4)	27 (1.4)	33 (0.4)
Intermediate	64 (1.9)	69 (0.4)	61 (1.6)	63 (0.4)
Low	88 (1.3)	88 (0.3)	86 (1.1)	85 (0.3)

Benchmarks – Year 8 mathematics

Figure 2.5 provides the descriptors for the international benchmarks in mathematics at Year 8 level. At this level, performance ranged from using relatively complex algebraic and geometric concepts and relationships at the advanced benchmark to having some basic mathematical knowledge at the low benchmark.

Figure 2.6 illustrates the achievement of Year 8 students against the international benchmarks in mathematics, for all TIMSS 2002/03 countries. Australia performed well against the international benchmarks at this level. Not only was the proportion of students achieving at the advanced and high benchmarks equivalent to or slightly higher than the international average, but the proportion of Australian students achieving the low benchmark was substantially greater than the international average.

Figure 2.6 also illustrates that there is a group of five South-East Asian countries that achieve at a very high level in TIMSS. These countries: Singapore, Chinese Taipei, Korea, Hong Kong SAR and Japan, achieve between 24 per cent and 44 per cent of their students at this highest level. As importantly, they seem to facilitate learning in mathematics for all students, because not only is the proportion of students in each of these countries reaching the advanced benchmarks substantially higher than that from any other country, but the proportions of students reaching the lower levels are also relatively high.

Year 8	Low International Benchmark (400)	Intermediate International Benchmark (475)	High International Benchmark (550)	Advanced International Benchmark (625)
	Students have some basic mathematical knowledge. Students can do basic computations with whole numbers without a calculator. They can select the two-place decimal closest to a whole number. They can multiply two-place decimal numbers by three-place decimal numbers with calculators available. They recognise some basic terminology and read information from a line on a graph.	*Students can apply basic mathematical knowledge in straightforward situations.* They can add, subtract, or multiply to solve one-step word problems involving whole numbers and decimals. They can identify representations of common fractions and relative sizes of fractions. They understand simple algebraic relationships and solve linear equations with one variable. They demonstrate understanding of properties of triangles and basic geometric concepts including symmetry and rotation. They recognise basic notions of probability. They can read and interpret graphs, tables, maps, and scales.	*Students can apply their understanding and knowledge in a wide variety of relatively complex situations.* They can order, relate, and compute with fractions and decimals to solve word problems, operate with negative integers, and solve multi-step word problems involving proportions with whole numbers. Students can solve simple algebraic problems including evaluating expressions, solving simultaneous linear equations, and using a formula to determine the value of a variable. Students can find areas and volumes of simple geometric shapes and use knowledge of geometric properties to solve problems. They can solve probability problems and interpret data in a variety of graphs and tables.	*Students can organise information, make generalisations, solve non-routine problems, and draw and justify conclusions from data.* They can compute percent change and apply their knowledge of numeric and algebraic concepts and relationships to solve problems. Students can solve simultaneous linear equations and model simple situations algebraically. They can apply their knowledge of measurement and geometry in complex problem situations. They can interpret data from a variety of tables and graphs, including interpolation and extrapolation.

Figure 2.5 Descriptors of international benchmarks in mathematics, Year 8

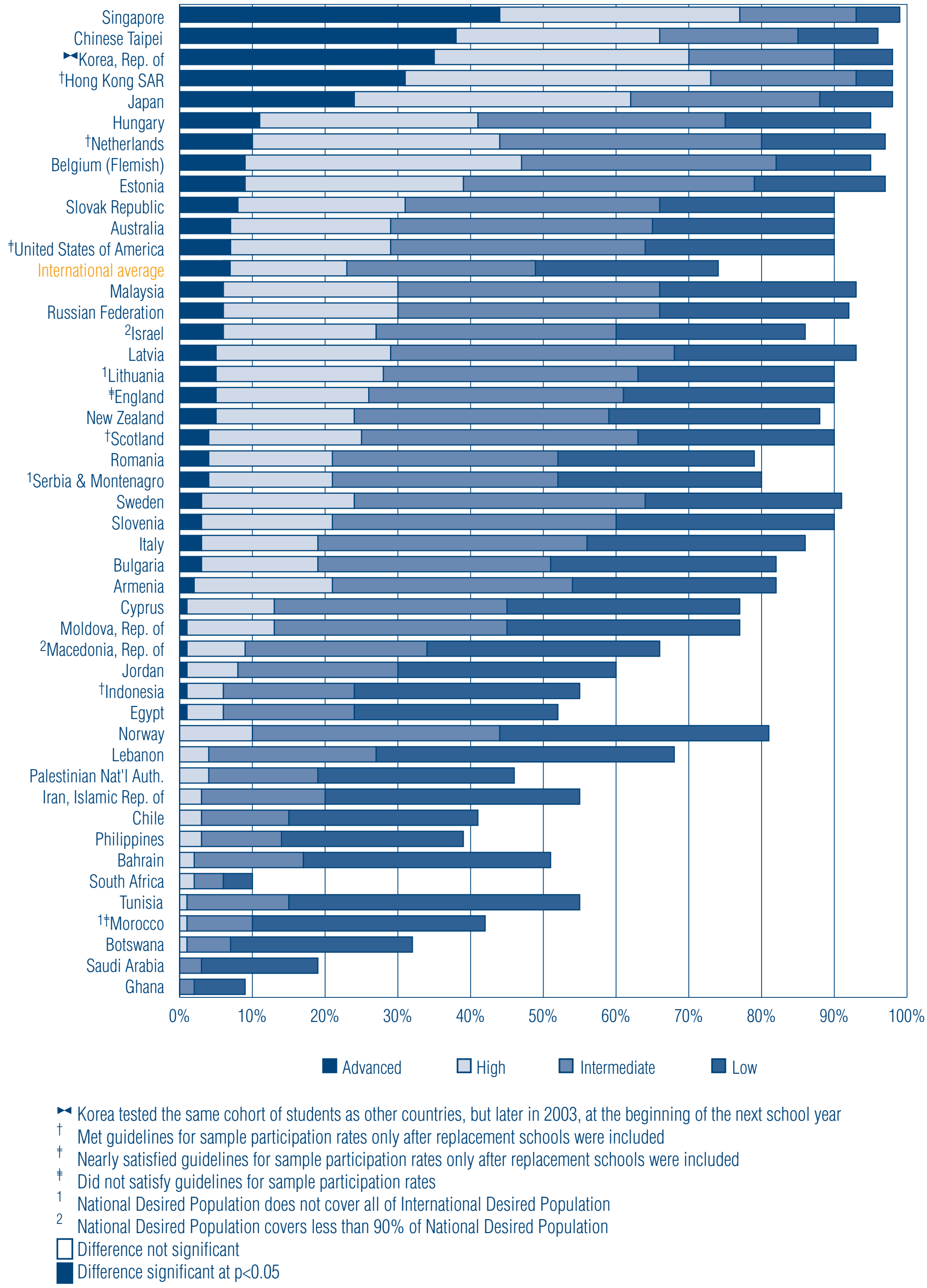


Figure 2.6 Proportion of Year 8 students reaching the mathematics international benchmarks, internationally

Table 2.4 shows the percentages of Australian students achieving each of the benchmarks, the international averages for trend countries, and the corresponding percentages for TIMSS 1994/95. The proportion of Year 8 students achieving the highest benchmarks in mathematics is similar to the international average. The proportion of Year 8 students in Australia who achieve the lowest two benchmarks is, however, significantly higher than the international average. This means that in an international context, Australia is doing a better job, on average, of getting more of its students to a basic level of understanding in mathematics. None of the proportions for Australian students are significantly different from those in 1994/95: although there was a slight decline in the proportion of Australian students reaching the high international benchmark from TIMSS 1994/95 to TIMSS 2002/03, this was not significant.

Table 2.4 Percentages of Year 8 Australian students reaching the international benchmarks of mathematics achievement in TIMSS 2002/03 and TIMSS 1994/95

	TIMSS 2002–03		TIMSS 1994–95	
	Proportion of Australian students (%)	International average for trend countries (%)	Proportion of Australian students (%)	International average for trend countries (%)
Advanced	7 (1.1)	8 (0.3)	7 (1.0)	11 (0.3)
High	29 (2.4)	27 (0.3)	33 (1.8)	37 (0.4)
Intermediate	65 (2.3)	55 (0.3)	68 (1.7)	69 (0.4)
Low	90 (1.4)	79 (0.3)	90 (1.0)	89 (0.3)

The international average of TIMSS students achieving at each of the international benchmarks has declined significantly over the eight year period, meaning that a larger proportion of students in TIMSS 2002/03 did not reach the lowest benchmark.

Gender differences in attainment of international mathematics benchmarks

Figure 2.7 shows the proportion of Australian students achieving at each of the international benchmarks, by gender, for Year 4 and Year 8. At Year 4, there is very little difference between males and females in achievement, with just a slightly higher proportion of males achieving at least at the high international benchmark than females. Slightly fewer females than males fail to reach the low international benchmark. At Year 8, the gender differences in achievement are slightly more marked – although still not significant. A larger proportion of male students reached both the advanced and high international benchmarks, while at the other end of the distribution, fewer males than females failed to achieve the low benchmark.

Benchmark examples

The remainder of this chapter provides a number of examples of the benchmarks. Two items are provided for each of the benchmarks to complement the descriptions provided, and to give the reader a more concrete notion of the skills and abilities that the students at each level could demonstrate. Each example item is described, and is accompanied by the percentage of correct responses for Australia, for the highest achieving country for that particular example, for a group of other countries, including those with whom we share language or trading ties, and the international average. All examples in this section are taken from booklets completed by Australian students, and are examples of completely correct answers.

For an item to be included in a benchmark at least 65 per cent of the students scoring at the score point corresponding to the benchmark had to have answered the item correctly and less than 50 per cent of the students at the next lowest benchmark had to have answered it correctly.

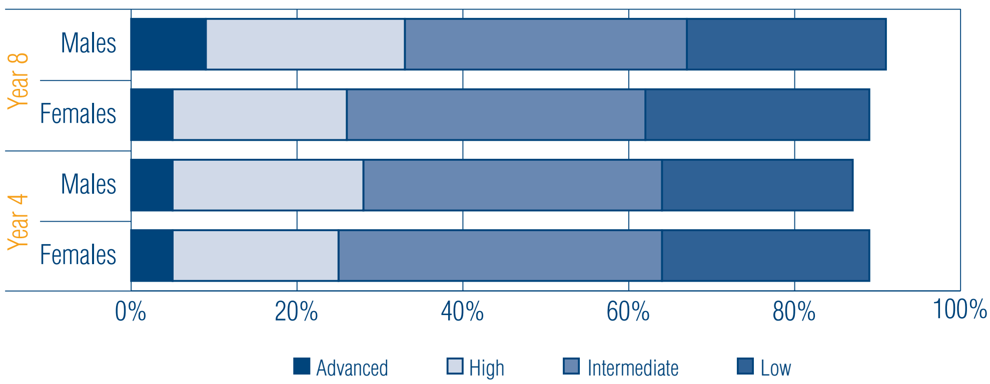


Figure 2.7 Proportion of Australian male and female students achieving at each of the international benchmarks in mathematics

In the examples the following conventions are used:

- Countries whose students achieved significantly higher scores than the international average are annotated with a ▲;
- Countries whose students performed at similar levels to the international average are annotated with a •;
- Countries whose students performed lower than the international average are annotated with a ▼.

Year 4: Performance at the advanced international benchmark

Year 4 students achieving at the advanced international benchmark demonstrated their ability to apply their understanding and knowledge in a wide variety of relatively complex situations. They typically demonstrated success on the knowledge and skills represented by this benchmark, as well as those demonstrated at the high, intermediate and low benchmarks. In the first example, students achieving at the high international benchmark were able to identify '0.7' as the decimal representation for a fraction with a denominator of 10.

Which of these means $\frac{7}{10}$?

Ⓐ 70

Ⓑ 7

Ⓒ 0.7

Ⓓ 0.07

Content area: Number

Students who reached the advanced international benchmark exhibited a developing understanding of fractions and decimals and the relationship between them.

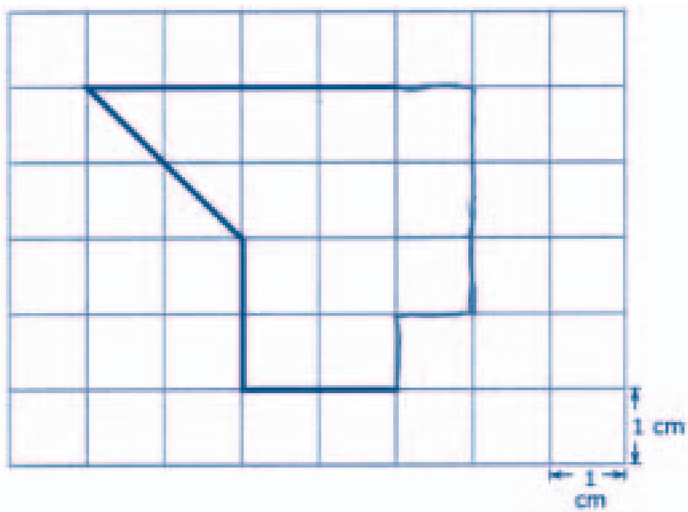
Australian students performed as well as the international average on this item, similar to English students. Students in the United States of America performed significantly better than the international average, as did students in Japan, while those in New Zealand and Scotland performed at a level significantly lower than the international average. In Singapore, by contrast, all but five percent of students correctly answered this question.

Country	Percent full credit	
Highest achieving country:		
Singapore	95 (0.8)	▲
United States of America	62 (1.8)	▲
Japan	60 (2.2)	▲
England	46 (2.5)	●
Australia	42 (3.0)	●
New Zealand	37 (2.0)	▼
Scotland	22 (2.1)	▼
International average	43 (0.4)	

Figure 2.8 Year 4 Mathematics Example 1: Advanced international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

In this item, students had to complete the irregular figure on a grid so that it had the correct area.



The squares in the grid above have areas of 1 square centimetre. Draw lines to complete the figure so that it has an area of 13 square centimetres.

Content area: Measurement

Year 4 students reaching the advanced level were able to correctly determine the area of a figure composed of squares and half squares, and correctly complete the drawing so that the figure had the correct area.

This item was relatively difficult for the Year 4 students, with less than one-third answering it correctly. Australian students' performance was equivalent to this, as was that of England and Scotland, while students in the United States of America and New Zealand had scores significantly lower than the international average. In contrast, a little more than two-thirds of the students in Japan completed this item correctly.

Country	Percent full credit	
Highest achieving country:		
Japan	68 (2.1)	▲
Singapore	43 (2.2)	▲
Australia	29 (2.2)	●
England	29 (2.3)	●
Scotland	29 (2.4)	●
United States of America	24 (1.7)	▼
New Zealand	15 (1.6)	▼
International average	29 (0.4)	

Figure 2.9 Year 4 Mathematics Example 2: Advanced international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

Year 4: Performance at the high international benchmark

Year 4 students who achieved at the high international benchmark can demonstrate their ability to apply their knowledge and understanding to solve problems. In the first of the examples selected, students were asked to select the appropriate algebraic expression to represent a situation presented to them.

$\square$ represents the number of magazines that Lina reads each week.
Which of these represents the total number of magazines that Lina reads in 6 weeks?

Ⓐ $6 + \square$

Ⓑ $6 \times \square$

Ⓒ $\square + 6$

Ⓓ $(\square + \square) \times 6$

Content area: Algebra

Students answering this item correctly demonstrated an ability to identify a number sequence for a word problem involving multiplication.

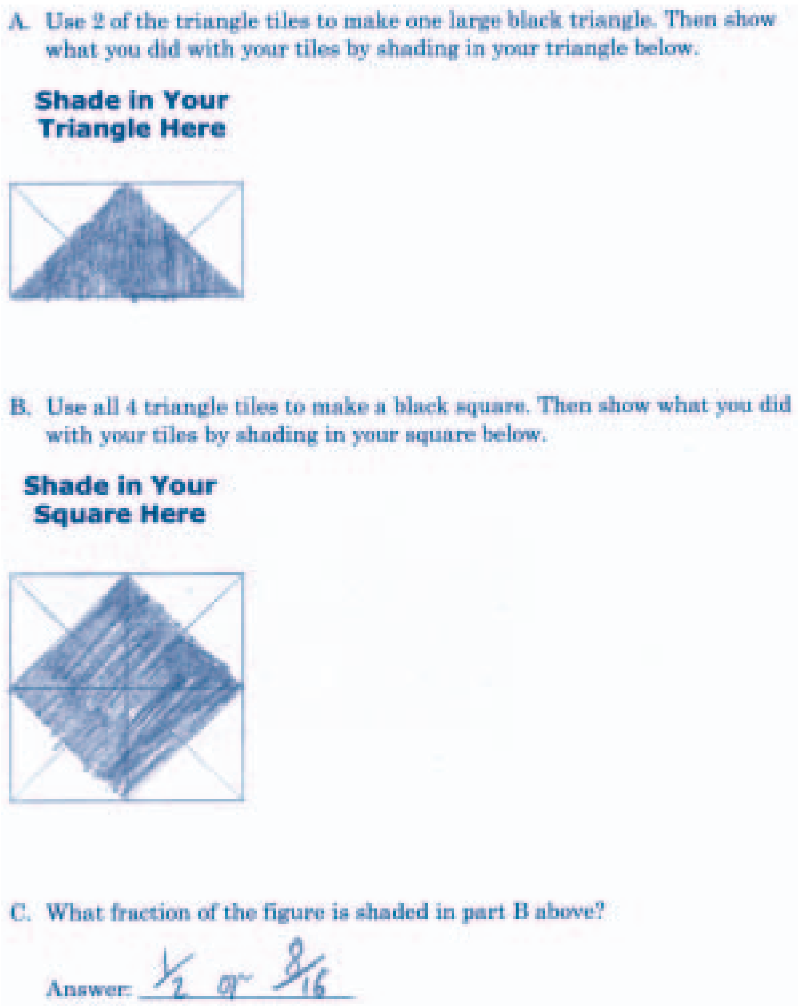
Australian students' performance on this item was around that of the international average, and similar to, although a little lower than, the achievement of Scottish students. Students in the United States of America performed well on this item, significantly higher than the international average and slightly higher than Japan. The highest achieving country was Singapore, where 86 per cent of students answered this item correctly. A little over half of the students in New Zealand answered this item correctly, significantly less than the international average.

Country	Percent full credit	
Highest achieving country:		
Singapore	86 (1.4)	▲
United States of America	72 (1.2)	▲
Japan	67 (2.0)	▲
England	66 (2.5)	▲
Scotland	60 (2.2)	•
Australia	56 (2.3)	•
New Zealand	54 (1.7)	▼
International average	58 (0.4)	

Figure 2.10 Year 4 Mathematics Example 3: High international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

The second example is part of a problem solving and inquiry question in which students were provided with square tiles divided diagonally into one white and one black triangle and asked to use the tiles to answer a number of questions. In Part A of this question students were asked to use two of the triangle tiles to make a black triangle, and in Part B to use all four triangles to make a black square. In each part of the question, a 'frame' was provided on which students could place the manipulables (that is, the square tiles). Students then shaded in their solution.


A. Use 2 of the triangle tiles to make one large black triangle. Then show what you did with your tiles by shading in your triangle below.

Shade in Your Triangle Here

B. Use all 4 triangle tiles to make a black square. Then show what you did with your tiles by shading in your square below.

Shade in Your Square Here

C. What fraction of the figure is shaded in part B above?

Answer: 1/2 or 8/16

Content area: Geometry

In answering this item, Year 4 students used simple properties of triangles and rectangles to solve problems.

Australian students performed well on this item, scoring significantly higher than the international average. England, New Zealand and Scotland also scored significantly above the international average, whilst the United States of America and Singapore showed no significant difference from the international average. Students in Japan were superior to those in any other country on this item, with more than 70 per cent answering correctly, compared with the next highest achieving country, the Netherlands, in which 60 per cent of students answered correctly.

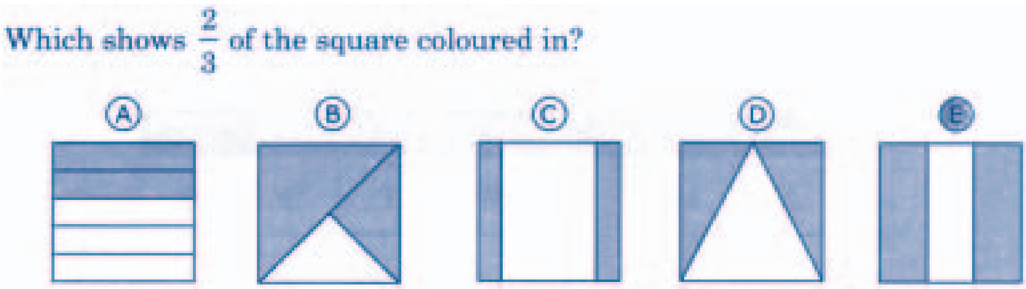
Country	Percent full credit	
Highest achieving country:		
Japan	71 (2.0)	▲
England	54 (2.4)	▲
Australia	52 (3.0)	▲
New Zealand	52 (2.3)	▲
Scotland	48 (2.9)	▲
Singapore	45 (2.3)	•
United States of America	42 (1.7)	•
International average	42 (0.5)	

Figure 2.11 Year 4 Mathematics Example 4: High international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

Year 4: Performance at the intermediate international benchmark

At this level, students are able to demonstrate the ability to apply basic mathematical knowledge in straightforward situations. Examples were chosen from the content areas of *Number* and *Data*. The first example asked students to indicate which of a series of shaded squares has a specified fractional part shaded.



Content area: Number

This example asks students to demonstrate recognition of the fractional part of an object.

Australian students performed reasonably well on this item, achieving a score significantly above the international average. Eighty-two per cent of students in the United States of America, 76 per cent of students in Japan and 93 per cent of students in Singapore also gave a correct answer. Scotland was the only country within our comparison group whose score was significantly below the international average, while scores for New Zealand students were not significantly different to the international average.

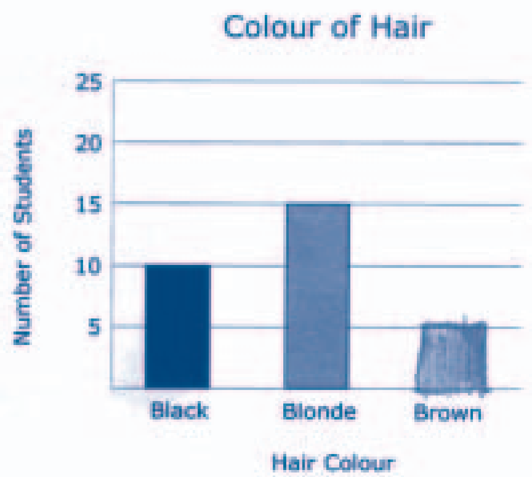
Country	Percent full credit	
Highest achieving country:		
Singapore	93 (1.0)	▲
United States of America	82 (1.1)	▲
Japan	76 (1.5)	▲
England	67 (2.2)	▲
Australia	62 (2.2)	▲
New Zealand	59 (2.2)	•
Scotland	52 (2.2)	▼
International average	57 (0.4)	

Figure 2.12 Year 4 Mathematics Example 5: Intermediate international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

In the second example students were provided with some data and asked to complete a simple bar graph using data from their solution of a word problem.

In a class of 30 students, 10 have black hair, 15 have blonde hair, and the rest have brown hair. Complete the graph below to show the number of students with brown hair.



Content area: Data

In this item, students demonstrate their ability to complete a bar graph based on the solution of a word problem.

This item was quite easy internationally. Indeed of the 25 countries participating at Year 4 level, 15 achieved 80 per cent or greater proportion of students answering correctly. Australia however, fell a little short of this mark, with 76 per cent of students answering correctly, not significantly different from the international average. All of the other countries in our comparison group achieved at a level significantly higher than the international average, and the highest scores were from students in Belgium (Flemish) and the Netherlands, where around 93 per cent of students gave the correct answer.

Country	Percent full credit	
Highest achieving countries:		
Belgium (Flemish)	93 (1.1)	▲
Netherlands	93 (1.1)	▲
Japan	90 (1.3)	▲
England	86 (1.7)	▲
Scotland	83 (1.8)	▲
United States of America	82 (1.3)	▲
New Zealand	80 (1.7)	▲
Australia	76 (2.1)	•
International average	73 (0.4)	

Figure 2.13 Year 4 Mathematics Example 6: Intermediate international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

Year 4: Performance at the low international benchmark

Year 4 students achieving at the low international benchmark have some basic mathematical language. For example they were asked to demonstrate their ability to multiply a two-digit whole number (15) by a one-digit whole number (9).

15 x 9 =

Answer: 135

Content area: Number

In this simple example of an open ended number problem, students were asked to demonstrate that they are able to multiply a two-digit whole number by a one-digit whole number.

Students in many of the participating countries answered this question correctly. The international average was 72 per cent, and at least 90 per cent of the students in Chinese Taipei, Singapore, Hong Kong SAR, and the Russian Federation answered correctly.

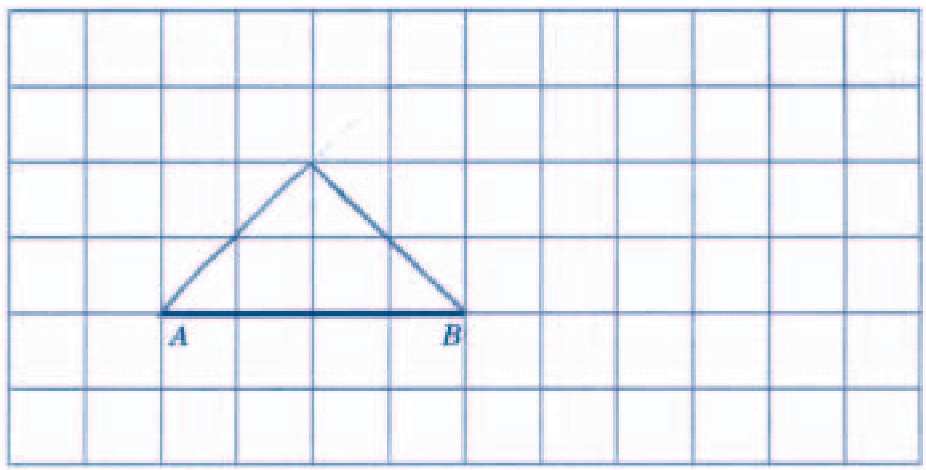
Students in the United States of America achieved at around the same level as the international average with a little fewer than three-quarters of Year 4 students answering correctly. In Australia, however, fewer than one-half of the Year 4 students could correctly complete the multiplication. While this is significantly below the international average, it is similar to the proportion of students correctly answering the item in England, New Zealand and Scotland.

Country	Percent full credit	
Highest achieving country: Chinese Taipei	94 (1.0)	▲
Japan	86 (1.6)	▲
United States of America	73 (1.2)	•
England	59 (2.7)	▼
Scotland	54 (2.2)	▼
Australia	45 (2.4)	▼
New Zealand	41 (2.0)	▼
International average	72 (0.4)	

Figure 2.14 Year 4 Mathematics Example 7: Low international benchmark

Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

The second example asked students to draw a triangle so that the line AB is the base and the two new sides are the same length as each other.



Draw a triangle in the grid so that the line *AB* is the base of the triangle and the two new sides are the same length as each other.

Content area: Measurement

In this item students were asked to draw a triangle so that the two 'new' sides were the same length. The example shown illustrates the type of student response that was given full credit.

Internationally, two-thirds of students were able to complete this question correctly. Students in Australia showed some facility with this item, with a little more than three-quarters able to complete the question correctly. This was significantly higher than the international average, and similar to the results from England, Scotland and New Zealand. In the highest achieving country on this item, Hong Kong SAR, 95 per cent of students were able to correctly complete the triangle.

Country	Percent full credit	
Highest achieving country:		
Hong Kong SAR	95 (0.9)	▲
Japan	80 (1.8)	▲
New Zealand	80 (1.8)	▲
Australia	77 (2.1)	▲
England	73 (2.1)	▲
Scotland	71 (2.2)	•
United States of America	63 (1.4)	▼
International average	67 (0.4)	

Figure 2.15 Year 4 Mathematics Example 8: Low international benchmark

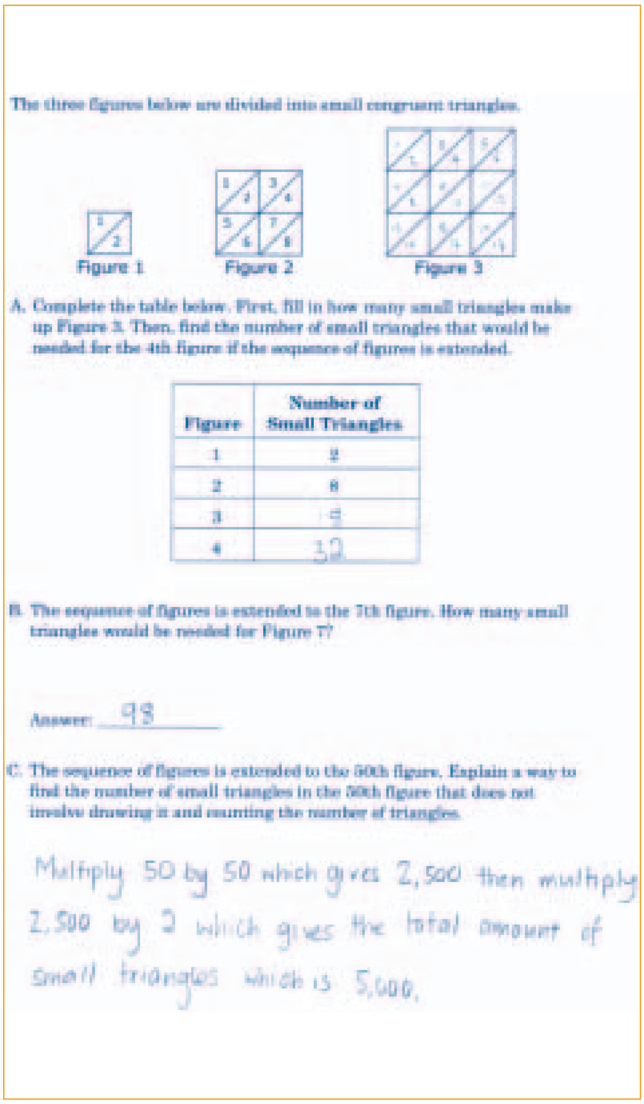
Note: United States of America, England, Scotland and Australia met sample guidelines for participation only after replacement schools were included.

Year 8: Performance at the advanced international benchmark

At the advanced international benchmark, Year 8 students are able to organise information in problem-solving situations, make generalisations, solve non-routine problems, and draw and justify conclusions from data. They typically demonstrated success on the knowledge and skills represented by this benchmark, as well as those demonstrated at the high, intermediate and low benchmarks.

In the first of the two examples chosen to illustrate the advanced international benchmarks, students were presented with an extended problem, in three parts. In the first part of the problem students were given a geometric pattern and asked to indicate how many triangles would be in the 3rd, 4th, and 7th figures if the pattern were extended. In part C of the question, students were asked to explain a way to find the number of triangles in the 50th figure that did not involve drawing or counting.

To receive full credit for part C, students had to show or explain how their answer was obtained by providing a general expression or equation and by calculating the correct number of triangles for the 50th figure.



The three figures below are divided into small congruent triangles.

Figure 1 Figure 2 Figure 3

A. Complete the table below. First, fill in how many small triangles make up Figure 3. Then, find the number of small triangles that would be needed for the 4th figure if the sequence of figures is extended.

Figure	Number of Small Triangles
1	2
2	8
3	18
4	32

B. The sequence of figures is extended to the 7th figure. How many small triangles would be needed for Figure 7?

Answer: 98

C. The sequence of figures is extended to the 50th figure. Explain a way to find the number of small triangles in the 50th figure that does not involve drawing it and counting the number of triangles.

Multiply 50 by 50 which gives 2,500 then multiply 2,500 by 2 which gives the total amount of small triangles which is 5,000.

Content area: Algebra

Students were asked to demonstrate their ability to apply a generalisation in order to solve a sequence problem. They were asked to generalise from the first of several terms of a sequence growing in two dimensions to find a specified term.

This item was one of the most difficult in the assessment. Internationally, just 14 per cent of students gained full credit for this item. In no country were the majority of Year 8 students able to gain full credit for this question, although Chinese Taipei came very close with 49 per cent. Students in Singapore and Japan also performed well on this item, with 44 per cent of students gaining full credit for their solution. A little more than one-quarter of Australian students gained full credit for this item, significantly higher than the international average, and similar to the proportion of students in the United States of America, England and Scotland.

Country	Percent full credit	
Highest achieving country:		
Chinese Taipei	49 (2.0)	▲
Japan	44 (2.1)	▲
Singapore	44 (2.0)	▲
Australia	26 (2.7)	▲
Scotland	22 (2.2)	▲
England	20 (2.2)	▲
United States of America	19 (1.5)	▲
New Zealand	16 (2.1)	•
Malaysia	10 (1.0)	▼
Indonesia	7 (0.9)	▼
International average	14 (0.2)	

Figure 2.16 Year 8 Mathematics Example 1: Advanced international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis, Martin, Gonzalez & Chrostowski, 2004).

The second example illustrating the advanced international benchmark provides an example of the multi-step word problems that were used in the TIMSS assessment. The item required students to select relevant information from a table and calculate which of two phone plans would be least expensive for a person given their usage patterns. Students needed to be able to justify their answer in terms of monthly fees and free minutes.

Phone Plans

Instructions: Questions **67, 68,** and **69** are about phone plans.

Betty, Frank, and Darlene have just moved to Zedland. They each need to get phone service. They received the following information from the telephone company about the two different phone plans it offers.

They must pay a set fee each month and there are different rates for each minute they talk. These rates depend on the time of the day or night they use the phone, and on which payment plan they choose. Both plans include time for which phone calls are free. Details of the two plans are shown in the table below.

Plan	Monthly Fee	Rate per minute		Free minutes per month
		Day (8 am – 6 pm)	Night (6 pm – 8 am)	
Plan A	20 zeds	3 zeds	1 zed	180
Plan B	15 zeds	2 zeds	2 zeds	120

Betty talks for less than 2 hours per month. Which plan would be less expensive for her?

Less expensive plan Plan B

Explain your answer in terms of both the monthly fee and free minutes.

The monthly fee is less and she gets 2 hours of free phone calls.

Content area: Data

To obtain full credit for this item, students were given a table of data, and were asked to demonstrate their ability to draw and justify conclusions from these data.

This was also a challenging item for TIMSS students. Internationally 21 per cent of students obtained full credit for this question, and again in no country did the majority of students answer the question correctly, with the highest performing country being Japan, with 49 per cent of students gaining full credit. In Australia and Singapore, between 40 and 44 per cent of students gained full credit.

Country	Percent full credit	
Highest achieving country:		
Japan	49 (2.2)	▲
England	45 (2.5)	▲
Australia	44 (2.2)	▲
Singapore	40 (1.7)	▲
United States of America	37 (1.7)	▲
Scotland	36 (2.7)	▲
New Zealand	30 (2.4)	▲
Malaysia	27 (1.7)	▲
Indonesia	12 (1.4)	▼
International average	21 (0.3)	

Figure 2.17 Year 8 Mathematics Example 2: Advanced international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis et al., 2004).

Year 8: Performance at the high international benchmark

At Year 8, students achieving the high international benchmark demonstrated that they were able to apply their understanding and knowledge in a wide variety of relatively complex situations.

In the first of the examples that demonstrate this benchmark, students were required to use their understanding of fractions to divide or reason with a unit fraction to solve a one-step word problem.

A scoop holds $\frac{1}{5}$ kg of flour. How many scoops of flour are needed to fill a bag with 6 kg of flour?

Answer: 30

Content area: Number

This item required students to solve a one-step word problem involving division of a whole number by a unit fraction.

Internationally, 38 per cent of students, on average, were able to correctly answer this question. Australian students' performance was significantly higher than the international average, with more than half of Australian students able to calculate this answer correctly. This is similar to the proportion of students in the United States of America, England, New Zealand, Scotland and Malaysia who could also answer this question correctly. The highest achieving countries were Singapore, Hong Kong SAR, Chinese Taipei and the Netherlands, in which about three-quarters of students answered the item correctly.

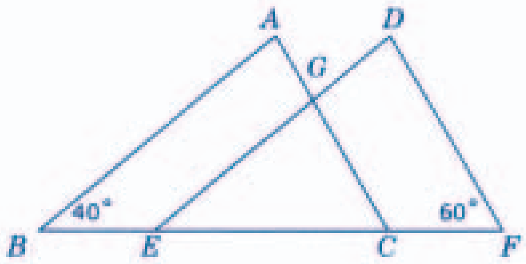
Country	Percent full credit	
Highest achieving country:		
Singapore	79 (1.9)	▲
Chinese Taipei	75 (1.9)	▲
Japan	62 (1.8)	▲
Australia	53 (2.6)	▲
United States of America	52 (1.7)	▲
Scotland	51 (2.7)	▲
England	50 (3.1)	▲
Malaysia	47 (2.2)	▲
New Zealand	46 (3.2)	▲
Indonesia	26 (1.5)	▼
International average	38 (0.3)	

Figure 2.18 Year 8 Mathematics Example 3: High international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis et al., 2004).

In the second example, students were asked to demonstrate their ability to use their knowledge of congruent triangles to find the measure of an angle.

In this figure, triangles ABC and DEF are congruent with $BC = EF$.



What is the measure of angle EGC ?

Ⓐ 20°

Ⓑ 40°

Ⓒ 60°

Ⓓ 80°

Ⓔ 100°

Content area: Geometry

This item required students to apply their knowledge of geometric properties to find an angle in a triangle.

Internationally, just under half of the students answered this item correctly. However in the highest achieving countries; Korea, Hong Kong SAR, Japan, and Singapore, around four-fifths of the students did so. Australian students performed at a level not significantly different from the international average, and at a similar level to the United States of America, England, New Zealand, Scotland, and Malaysia.

Country	Percent full credit	
Highest achieving country:		
Korea, Republic of	84 (1.4)	▲
Japan	80 (1.4)	▲
Scotland	54 (2.7)	▲
Australia	47 (2.1)	•
Malaysia	47 (2.4)	•
England	47 (2.8)	•
New Zealand	42 (3.6)	•
United States of America	36 (1.7)	▼
Indonesia	31 (1.7)	▼
International average	46 (0.3)	

Figure 2.19 Year 8 Mathematics Example 4: High international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis et al., 2004).

Year 8: Performance at the intermediate international benchmark

Year 8 students achieving at the intermediate international benchmark demonstrated the ability to apply basic mathematical knowledge in straightforward situations. The first example that illustrates this benchmark involves students subtracting one two-place decimal from another.

Alice ran a race in 49.86 seconds. Betty ran the same race in 52.30 seconds. How much longer did it take Betty to run the race than Alice?

- (A) 2.44 seconds
- (B) 2.54 seconds
- (C) 3.56 seconds
- (D) 3.76 seconds

52.30
49.86
2.44

Content area: Number

This item required students to solve a word problem involving subtraction of one two-place decimal number from another.

Almost two-thirds of Australian students answered this item correctly, which was not significantly different to the international average of 61 per cent. While this was similar to the proportion of students in England, it was lower than the proportion of students in the United States of America, Japan, Scotland and Malaysia, and much lower than that attained by Singaporean students, of whom 88 per cent answered correctly.

Country	Percent full credit	
Highest achieving country:		
Singapore	88 (1.0)	▲
Malaysia	81 (1.4)	▲
Japan	78 (1.6)	▲
United States of America	74 (1.7)	▲
Scotland	71 (2.0)	▲
Australia	63 (2.4)	•
Indonesia	55 (2.0)	▼
England	54 (2.5)	▼
New Zealand	53 (2.4)	▼
International average	61 (0.3)	

Figure 2.20 Year 8 Mathematics Example 5: Intermediate international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis et al., 2004).

The second example provides an example of students' emerging familiarity with algebraic representation, asking students to solve an algebraic expression involving fractional representation.

If $\frac{12}{n} = \frac{36}{21}$, then n equals

(A) 3

(B) 7

(C) 36

(D) 63

Content area: Algebra

This item required students at Year 8 to solve an equation for missing numbers in a proportion.

Almost two-thirds of students internationally were able to successfully answer this item. In 12 countries, including Australia, the United States of America, Japan, Scotland and Malaysia, more than three-quarters of students answered correctly, significantly higher than the international average.

Country	Percent full credit	
Highest achieving country:		
Singapore	93 (0.7)	▲
Malaysia	83 (1.5)	▲
United States of America	80 (1.1)	▲
Japan	79 (1.6)	▲
Scotland	79 (1.9)	▲
Australia	76 (1.9)	▲
England	74 (2.6)	▲
New Zealand	68 (2.3)	•
Indonesia	58 (1.9)	▼
International average	65 (0.3)	

Figure 2.21 Year 8 Mathematics Example 6: Intermediate international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis et al., 2004).

Year 8: Performance at the low international benchmark

At the low international benchmark, students have some basic mathematical knowledge. There were very few items anchoring at the low international benchmark, and only one of these has been released. This example asks students to identify which of four alternatives is closest to 10.

Which of these numbers is closest to 10?

Ⓐ 0.10

Ⓑ 9.99

Ⓒ 10.10

Ⓓ 10.90

Content area: Number

In this item students show that they are able to select a two-place decimal that is closest to a given whole number.

The international average was high, with 77 per cent of students correctly selecting 9.99 as the decimal closest to 10. Fifteen of the countries had 90 per cent or more of their students choosing the correct answer, while in the Netherlands and Singapore 95 per cent or more students answered correctly. Australian students also performed significantly better than the international average, and at a similar level to students in the United States of America, England, New Zealand, and Scotland.

Country	Percent full credit	
Highest achieving country:		
Netherlands	97 (1.0)	▲
Singapore	95 (1.1)	▲
Malaysia	93 (1.4)	▲
Japan	92 (1.4)	▲
Scotland	89 (2.0)	▲
Australia	88 (1.8)	▲
United States of America	87 (1.1)	▲
New Zealand	86 (2.0)	▲
England	82 (2.5)	▲
Indonesia	74 (2.7)	•
International average	77 (0.3)	

Figure 2.22 Year 8 Mathematics Example 7: Low international benchmark

Note: England did not satisfy guidelines for sample participation rates. United States of America nearly satisfied guidelines for sample participation rates only after replacement schools were included. Hong Kong SAR, Netherlands, and Scotland met guidelines for sample participation rates only after replacement schools were included. In Indonesia, the National Desired Population does not cover all of the International Desired Population (see International Report: Mullis et al., 2004).

Summary

This chapter has described Australia's mathematics performance in Year 4 and Year 8 in the context of international results. Australian students acquitted themselves moderately well in mathematics, with the performance of Australian students not statistically different to the international average at Year 4, and significantly higher than the international average at Year 8. At Year 4, Singapore and Hong Kong SAR outperformed all other countries, while at Year 8, Singapore outperformed all other countries.

It is not really possible to describe Australia's position in terms of 'rankings' of countries, as the participating countries have changed substantially since TIMSS 1994/95. However it is possible to outline a few changes in relative standings at each year level.

At Year 4, Latvia, England and Cyprus were significantly lower than Australia in 1994/95: in 2002/03 their achievement level was significantly higher than Australia's. New Zealand and Scotland were significantly lower than Australia in 1994/95: in 2002/03 there is no significant difference to Australia. Hungary and the United States of America had similar scores to Australia in 1994/95, but in 2002/03 their achievement was significantly higher than Australia.

In 1994/95 at Year 8 the scores of Latvia, the United States of America, Lithuania, Scotland, England and New Zealand were significantly lower than those of Australia, and their difference is now the same as that of Australia. The Netherlands and Hungary scored the same as Australia in 1994/95 and were significantly higher in 2002/03.

There were no gender differences in mathematics for either year level, either in TIMSS 1994/95 or TIMSS 2002/03.

International benchmarks were developed by the International Study Centre; these are described in this chapter and elaborated with examples of each of the benchmark levels. The proportion of Australian Year 4 students reaching the advanced international benchmark (5%) was much lower than the international average (10%), and slightly better at Year 8. At Year 4, there were five per cent of Australian students reaching the advanced benchmark, 26 per cent reaching the high benchmark, 64 per cent reaching the intermediate and 88 per cent reaching the low international benchmark. At Year 8, there were seven per cent of students reaching the advanced benchmark, 29 per cent reaching the high benchmark, 65 per cent reaching the intermediate and 90 per cent reaching the low international benchmark.

The next chapter, Chapter 3, presents results within Australia, focussing on performance in the mathematics content areas and differences in achievement between states.

Chapter 3
Australian students' achievement in mathematics

Chapter 3 Australian students' achievement in mathematics

In Chapter 2 the overall achievement results for Australia were presented in an international context, comparing the results from Australian students to results from each of the other participating countries as well as to the international average. This chapter presents results in each of the mathematics content areas for both Year 4 and Year 8, and overall achievement results for each of the Australian states.

The TIMSS 2002/03 mathematics assessments at both year levels were designed to allow comparisons between countries as much as is possible. The five content areas and the topics for each area in mathematics are:

- *Number*
  - whole numbers,
  - fractions and decimals,
  - integers, and
  - ratio, proportion and percent.

  At Year 4 , the topic of integers is not included, and the final topic includes only simple proportional reasoning.
- *Patterns and Relationships* (Y4)/*Algebra* (Y8)
  - pattern,
  - algebraic expressions,
  - equations and formulas, and
  - relationships.

  At Year 4, the topic of algebraic expressions is not included.
- *Measurement*
  - attributes and units, and
  - tools, techniques and formulas
- *Geometry*
  - lines and angles,
  - two- and three-dimensional shapes,
  - congruence and similarity,
  - locations and spatial relationships, and
  - symmetry and transformations.
- *Data*
  - data collection and organisation,
  - data representation,
  - data interpretation, and
  - uncertainty and probability.

  At Year 4, the topic of uncertainty and probability is not included.

How does achievement differ internationally across content areas?

To provide a basis of comparison for the performance of each country in each content area, the international average for each content area was scaled to be 495 for Year 4 and to 467 for Year 8 mathematics. At both year levels, countries scoring the highest in the overall mathematics assessment tended also to be the highest scoring countries in each of the major content areas, although not necessarily in the same order.

At Year 4 level, the largest difference between the highest and lowest scoring country was 285 score points in *data*, with the highest in Singapore and the lowest in Ghana. Score differences in other content areas were 260 for *measurement*, 253 for *number*, 249 for *patterns and relationships*, and 245 for *geometry*. Singapore was the highest achieving country in *number* (612), *patterns and relationships* (579), and *geometry* (570), and Japan was the highest achieving country in *measurement* (568) and *data* (593).

At Year 8 level, the differences between the highest- and lowest-performing countries were the largest for *geometry* and *measurement* (351 score points and 349 score points respectively), next for *number* (344), *algebra* (322) and least for *data* (286). Singapore was the highest achieving country in *number* (618), *measurement* (611) and *data* (579), while Korea achieved the highest scores internationally in *algebra* (597) and *geometry* (598).

How did Australian students perform in the mathematics content areas?

Australian students scored at a level significantly higher than the international average in three of the five content areas at Year 4 level and in all content areas at Year 8 level in mathematics.

Figure 3.1 shows the average and confidence intervals for each of the Year 4 mathematics content areas, and includes the confidence interval for the international average as the shaded bar on the graph. This figure shows that Australian Year 4 students' achievement in *measurement*, *geometry* and *data* was significantly higher than both the international average and their own achievement in *number* and *patterns and relationships*.

At Year 4, Australian students scored significantly higher than the international average in *measurement*, *geometry* and *data*. Their weakest area was *number*, in which Australian students scored significantly less than the international average. In *patterns and relationships*, their achievement was statistically the same as the international average.

Figure 3.2 presents the averages and confidence intervals for Year 8 students in mathetmatics content areas and shows that Australian Year 8 students' achievement level was significantly higher than the international average in all mathematics content areas. At this year level, *data* is by far the strongest achievement area for Australian students, with achievement in this area significantly higher than in any other content area. *Measurement* was another strong area, while the weakest area (although still better than the international average) was *geometry*.

Achievement in mathematics content areas by gender

There were no gender differences in TIMSS mathematics at either year level. Table 3.1 provides achievement in each of the mathematics content areas, by year level, for males and females. It is clear from this table that gender differences within Australia are quite small. At Year 4 level, the largest gender difference internationally was in the content area of *geometry*, in which the score of 498 attained by females was significantly higher than the 493 attained by males, and in the content area of *measurement*, in which the males' score of 498 was significantly higher than the females' score of 493. Females also scored significantly higher than males in *data*. Australian students' results were somewhat similar to the international results in gender differences, with a significant difference in favour of females in the area of *geometry*.

Table 3.1 also shows that gender differences at Year 8 are not large. The largest gender difference internationally was in the content areas of *algebra*, in which the females' score of 471 was significantly higher than the males' score of 462, and

Table 3.1 Average achievement in mathematics content areas, internationally and Australian, total and by gender*

Content area	Australian			International		
	Females average	Males average	All average	Females average	Males average	All average
Year 4						
Number	476 (5.1)	481 (5.0)	479 (4.3)	495 (0.8)	496 (0.8)	495 (0.7)
Patterns & relationships	493 (4.5)	497 (4.3)	495 (3.7)	496 (0.8)	495 (0.8)	495 (0.7)
Measurement	510 (4.4)	517 (4.1)	514 (3.7)	**493 (0.8)**	**498 (0.7)**	495 (0.7)
Geometry	**529 (3.6)**	**519 (4.9)**	524 (3.7)	**498 (0.8)**	**493 (0.8)**	495 (0.7)
Data	529 (4.3)	521 (4.7)	525 (3.6)	**497 (0.8)**	**494 (0.7)**	495 (0.7)
Year 8						
Number	**490 (5.5)**	**507 (5.9)**	498 (4.6)	467 (0.6)	467 (0.6)	467 (0.5)
Algebra	496 (5.5)	501 (5.4)	499 (4.4)	**471 (0.6)**	**462 (0.6)**	467 (0.5)
Measurement	**504 (5.3)**	**518 (5.7)**	511 (4.3)	**464 (0.6)**	**470 (0.6)**	467 (0.5)
Geometry	485 (5.7)	497 (6.1)	491 (4.8)	466 (0.6)	467 (0.6)	467 (0.5)
Data	527 (4.8)	536 (4.3)	531 (3.8)	467 (0.5)	467 (0.6)	467 (0.5)

*Figures in bold indicate where a significant difference exists

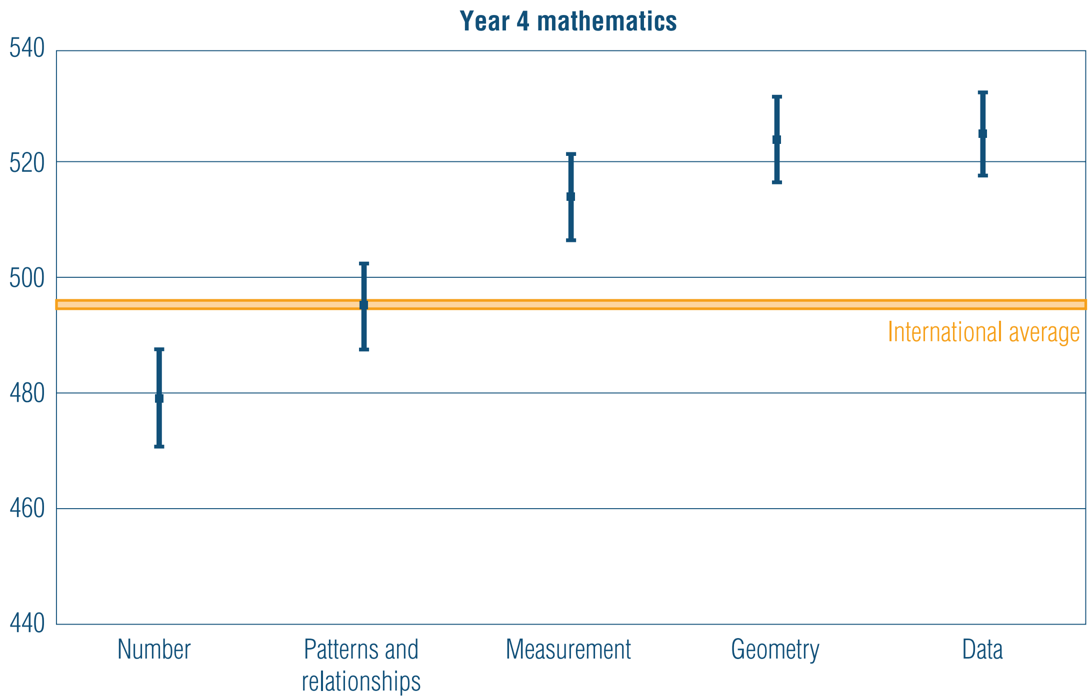


Figure 3.1 Australian Year 4 students' performance in mathematics content areas

measurement, where the males' score of 470 was significantly higher than the females' score of 464. In Australia, males scored significantly higher than females in two content areas: *measurement* and *number*. In *number*, males scored 507 and females 491, and in *measurement* males scored 518 and females 504.

Results in the Australian states

Schools were oversampled in the smaller states of Australia: South Australia, Western Australia, Northern Territory, Tasmania and the Australian Capital Territory, to enable reliable estimates of achievement to be made for each state.

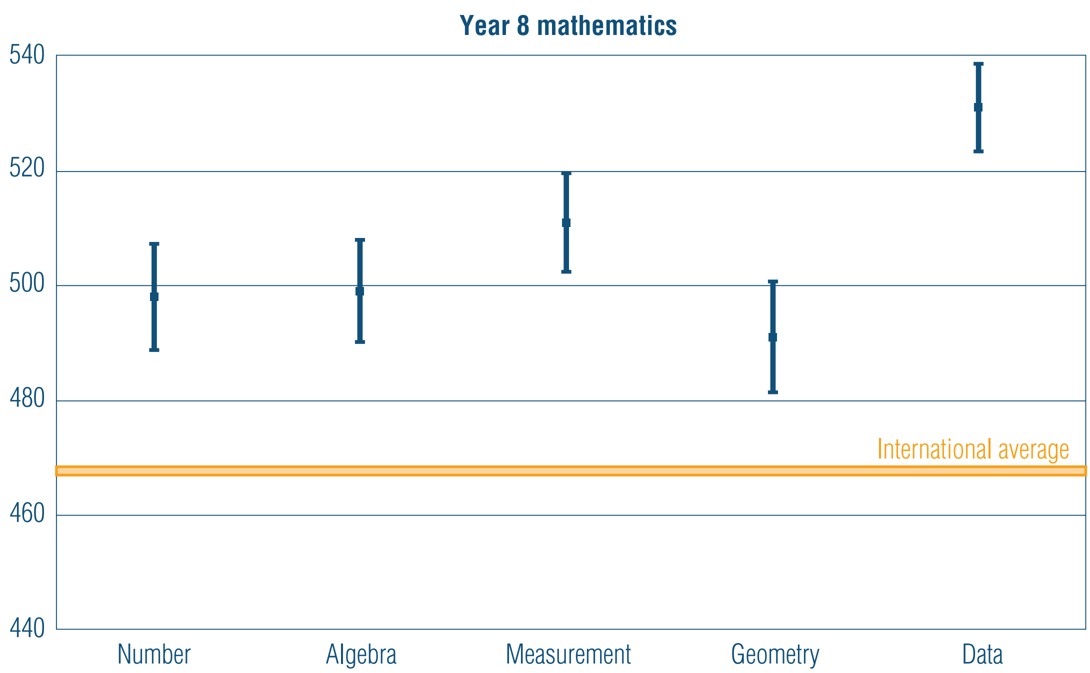


Figure 3.2 Australian Year 8 students' performance in mathematics content areas

While it is easier to compare the Australian states than to compare countries, there are still structural and curriculum differences to take into account. In Chapter 1, reference was made to the different school starting ages in each state and to the differing roles of the first year of school. In some parts of Australia, students enter school as they turn five, so may only complete one term of a preparatory year before moving on to the first year. In other parts of Australia many children enter the school system before they turn five, and have a whole year at school before entering the first year, whilst in other areas children move straight into the first year. There are also differing points of transition from primary to secondary schooling. In some states it is at the end of Year 6, others at the end of Year 7. These differences mean that by settling on one year at each population level (Year 4 for population 1 and Year 8 for population 2), as the IEA have stipulated for TIMSS 2002/03, there are some differences between states that should be borne in mind when discussing results:

- students in some states will be younger than those in other states and thus may be at different maturational stages;
- students in some states will have had more formal schooling experiences than students in other states; and
- students in some states in Year 8 will have had two years of mathematics and science with specialist teachers, whereas for those in other states, it will be their first year of specialised teaching.

However by choosing to sample Year 8 in each state, the samples have one major factor in common – all students have four years left to the completion of secondary schooling, which is Year 12 in every state.

State results – Year 4

Table 3.2 provides the average achievement for each state for Year 4 mathematics, and also presents the multiple comparisons of results in mathematics within Australia. Figure 3.3 illustrates the averages and confidence intervals for Year 4 achievement in mathematics for students in each state, and provides, for comparison, the confidence interval for Australia and also the international confidence interval.

The comparison of the results within Australia[1] presented in Table 3.2 shows that there is very little variation amongst states in mathematics achievement at Year 4. The only significant difference, given the adjustment for multiple comparisons, was that scores for students in New South Wales, the Australian Capital Territory and Victoria were significantly higher than those for Western Australia.

In comparison to TIMSS 1994/95, these results represent a change. When making comparisons with that study, it is important that comparisons are made with the Year 4 cohort only, as presented in Table A.11 of the TIMSS 1994/95 Australia population 1 report (Lokan, Ford & Greenwood, 1997). In that comparison, students in the Australian Capital Territory outperformed those in all other states, and students in the Northern Territory were outperformed by students in the Australian Capital Territory, Victoria, and New South Wales.

Table 3.2 Year 4 mathematics achievement by state

State	Average	se	ACT	NSW	VIC	TAS	SA	QLD	NT	WA
Australian Capital Territory	523	13.7		•	•	•	•	•	•	▲
New South Wales	510	9.2	•		•	•	•	•	•	▲
Victoria	508	6.8	•	•		•	•	•	•	▲
Tasmania	497	13.2	•	•	•		•	•	•	•
South Australia	485	8.3	•	•	•	•		•	•	•
Queensland	484	7.1	•	•	•	•	•		•	•
Northern Territory	479	14.9	•	•	•	•	•	•		•
Western Australia	472	7.8	▼	▼	▼	•	•	•	•	

▲ score significantly higher than that for comparison state
• score not significantly different than that of the comparison state
▼ score significantly lower than that for comparison state
Note: Read **across** the row to compare a state's performance with the performance of each state as listed in the column headings

[1] The statistical technique used adjusts for multiple comparisons, i.e. comparing results of several groups simultaneously. Tests of significance were adjusted for the number of simultaneous comparisons being made, so that the probability level remained at 0.05.

While there appear to be differences in scores between the states both in TIMSS 1994/95 and in the present study, it must be emphasised that if the differences are not statistically significant, they could well be an artefact of sampling or measurement error. It is only when there is a significant difference that we are able to say that, with 95 per cent probability, the differences reflect actual differences in the population under consideration.

Figure 3.3 shows that the confidence intervals for all of the states, other than Western Australia, overlap the confidence intervals for both the national and international averages. The scores for Western Australia were significantly lower than both the national and international averages, however none of the results of the other states could be said to be any different, statistically, than either the national or international average.

Table 3.3 shows where achievement for each state fits into the international picture of achievement in mathematics. The confidence intervals associated with the Australian states are larger than those for the country means because of the smaller number of schools in the state samples.

The best estimate of the achievement level of Year 4 students in the Australian Capital Territory (because of the large standard error) was equal to the fifth highest achieving country, with a score not significantly different to that of Belgium (Flemish). New South Wales and Victoria had similar levels of achievement to the United States of America, but not significantly higher than the international average, and South Australia, Tasmania, Queensland and the Northern Territory scored around the international average. Western Australia's score was signicantly lower than the international average.

A comparison with mathematics achievement patterns in TIMSS 1994/95 can be made. However achievement in the TIMSS 1994/95 report was derived from a combination of upper and lower year scores, hence the sample was composed of students from Year 3, Year 4 and Year 5. Given this caveat, however, the data provides a rough 'yardstick' for comparison. The highest scoring three states in TIMSS 1994/95 were Queensland, Western Australia and South Australia, and these states outperformed all countries other than Japan, Korea and Singapore. In the TIMSS 2002/03 assessment, these three states are near the bottom of the distribution, while Victoria and New South Wales have apparently improved achievement.

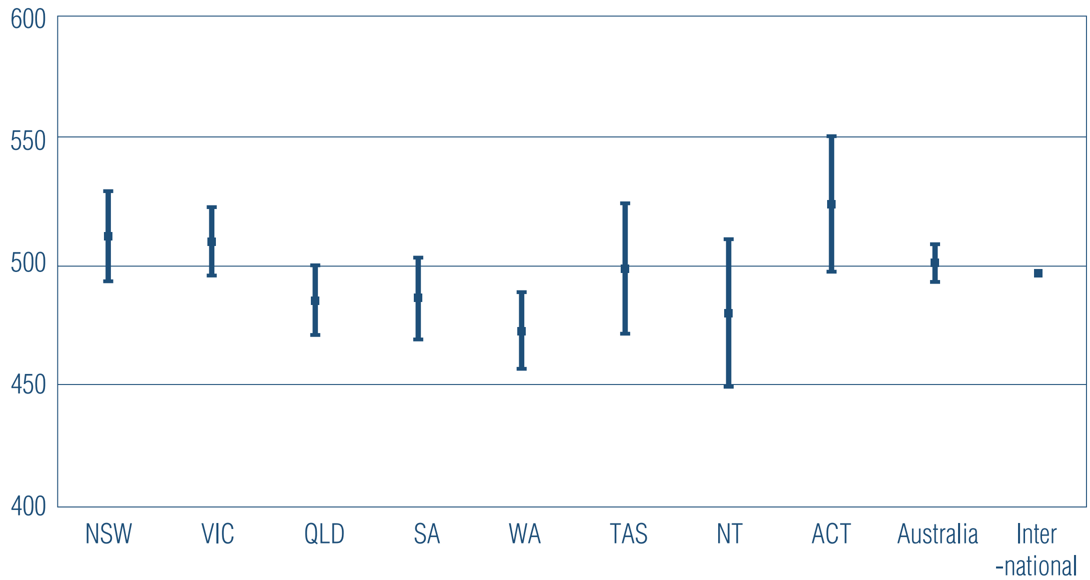


Figure 3.3 Averages and 95% confidence intervals for Year 4 mathematics achievement, by state

Table 3.3 Year 4 mathematics achievement nationally and internationally

All Year 4 TIMSS 2002/03 countries	Average scale score (se)	Average age
Singapore	594 (5.6)	10.3
[1]Hong Kong SAR	575 (3.2)	10.2
Japan	565 (1.6)	10.4
Chinese Taipei	564 (1.8)	10.2
Belgium (Flemish)	551 (1.8)	10.0
[1]Netherlands	540 (2.1)	10.2
Latvia	536 (2.8)	11.1
[1]Lithuania	534 (2.8)	10.9
Russian Federation	532 (4.7)	10.6
[1]England	531 (3.7)	10.3
Hungary	529 (3.1)	10.5
Australian Capital Territory	523 (13.7)	10.1
[1]United States of America	518 (2.4)	10.2
Cyprus	510 (2.4)	9.9
New South Wales	510 (9.2)	10.0
Victoria	508 (6.8)	10.1
Moldova, Rep. Of	504 (4.9)	11.0
Italy	503 (3.7)	9.8
[1]Australia	499 (3.9)	9.9
Tasmania	497 (13.2)	10.2
International average	*495 (0.8)*	*10.3*
New Zealand	493 (2.2)	10.0
[1]Scotland	490 (3.3)	9.7
South Australia	485 (8.3)	9.4
Queensland	484 (7.1)	9.4
Northern Territory	479 (14.9)	9.8
Slovenia	479 (2.6)	9.8
Western Australia	472 (7.8)	9.4
Armenia	456 (3.5)	10.9
Norway	451 (2.3)	9.8
Iran, Islamic Rep. of	389 (4.2)	10.4
Philippines	358 (7.9)	10.8
Morocco	347 (5.1)	11.0
Tunisia	339 (4.7)	10.4

[1] These countries did not meet all the sampling requirements

Achievement at the international benchmarks – Year 4

Figure 3.4 shows the proportion of students in each state reaching each of the international benchmarks, along with the proportions for the highest scoring country, Singapore, and the overall international proportions for comparison. Nationally, students in the Australian Capital Territory do the best at achieving both the advanced international benchmark and the lowest international benchmark. Around 11 per cent of students in the Australian Capital Territory reached the advanced international benchmark, more than one-third the high international benchmark, and 93 per cent achieved the low international benchmark. The next best achieving state was New South Wales, in which seven per cent met the advanced international benchmark, almost one-third reached the high international benchmark, and over 90 per cent achieved the low benchmark. Victorian students were only slightly below students from New South Wales in achieving each of the international benchmarks. Tasmania, Queensland and South Australia formed a group, with 2-3 per cent achieving the advanced benchmark and 85 per cent achieving the low benchmark. However, more Tasmanian students achieved the high benchmark than in Queensland or South Australia. At the bottom of the table are the Northern Territory and Western Australia. In the Northern Territory, 2 per cent met the advanced international benchmark; a little more than 20 per cent met the high international benchmark; and around 20 per cent did not meet

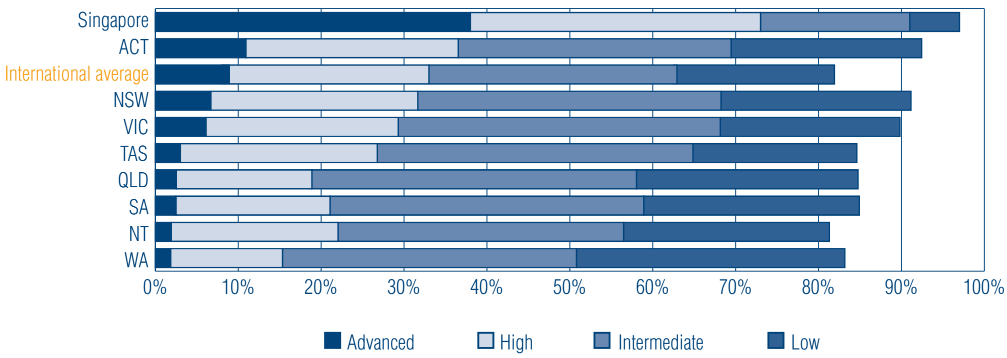


Figure 3.4 Proportion of Year 4 students reaching the international benchmarks in mathematics by state

the low international benchmark. In Western Australia the picture is similar, with 2 per cent reaching the advanced international benchmark, 15 per cent meeting the high benchmark, and 17 per cent not reaching the low benchmark. The proportion of students failing to reach either of the two lowest international benchmarks in the Northern Territory and Western Australia were both larger than the international average.

Although lower than the international average, this quite large 'tail' of students failing to reach the lowest benchmark should be of some concern to educators in all states, but particularly in those states where the proportion of students failing to achieve the low benchmark is highest.

State results – Year 8

Table 3.4 provides the average achievement for each state for Year 8 mathematics, and also presents the multiple comparisons of results in mathematics within Australia. Figure 3.5 illustrates averages and confidence intervals for Year 8 achievement in mathematics for students in each state, and provides, for comparison, the confidence interval for Australia and also the international confidence interval.

The comparison of the results within Australia presented in Table 3.4 show that as with Year 4 there were few significant differences across states. The differences can be summarised as follows:

- Scores for students in New South Wales were significantly higher than those for Queensland, Western Australia, and the Northern Territory,
- Scores for students in the Northern Territory were significantly lower than those for students in the Australian Capital Territory.

In comparison to TIMSS 1994/95, this represents a change of relative positions. When making comparisons with that study, it is important that comparisons are made with the Year 8 cohort only, as presented in Table A.10 of the TIMSS Australia population 2 report (Lokan, et al., 1996). In that comparison, students in the Australian Capital Territory and Western Australia had the strongest outcomes, with those in the Australian Capital Territory outperforming those in all states other than Western Australia and New South Wales, and those in Western Australia outperforming those in Victoria, Tasmania and the Northern Territory.

Table 3.4 Year 8 mathematics achievement by state

State	Average	se	NSW	ACT	SA	VIC	QLD	WA	TAS	NT
New South Wales	530	11.9		●	●	●	▲	▲	●	▲
Australian Capital Territory	507	9.6	●		●	●	●	●	●	▲
South Australia	501	11.3	●	●		●	●	●	●	●
Victoria	495	6 .4	●	●	●		●	●	●	●
Queensland	490	6.1	▼	●	●	●		●	●	●
Western Australia	487	7.6	▼	●	●	●	●		●	●
Tasmania	477	12.3	●	●	●	●	●	●		●
Northern Territory	449	14.1	▼	▼	●	●	●	●	●	

▲ score significantly higher than that for comparison state
● score not significantly different than that of the comparison state
▼ score significantly lower than that for comparison state
Note: Read **across** the row to compare a state's performance with the performance of each state as listed in the column headings

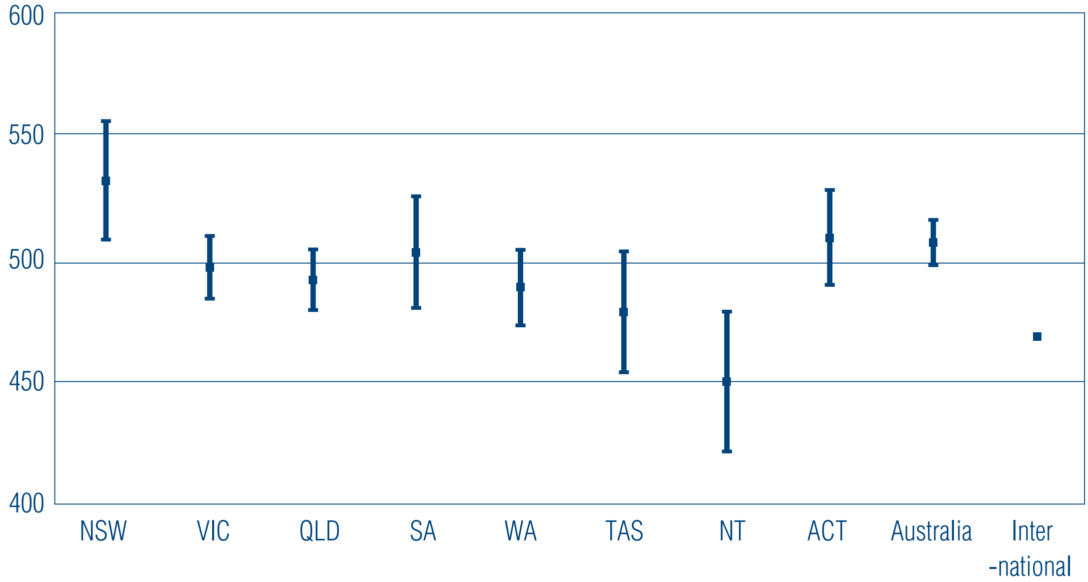


Figure 3.5 Averages and 95% confidence intervals for Year 8 mathematics achievement, by state

Figure 3.5 shows that the achievement levels of students in most states is higher than the international average. The only exceptions to this are Tasmania and the Northern Territory, where there is no significant difference between the average for the state and the international average.

Table 3.5 shows where achievement for each state fitted into the international picture of Year 8 achievement in mathematics. Again, the confidence intervals associated with the Australian states are larger than those for the country averages because of the smaller number of schools in the state samples. As there are a great many more countries participating at Year 8 level, ability groupings are more apparent in these data than in the Year 4 data.

For instance New South Wales falls into a high-achieving group which includes Belgium (Flemish), the Netherlands, Estonia and Hungary, and the achievement level of this group is significantly higher than that of the next grouping. The next grouping, which forms a 'middle band' of achievement, takes in all of the other states of Australia other than the Northern Territory, and places them in the same band of achievement as a large number of countries, including Malaysia, England, Scotland, the United States of America, and New Zealand. The scores of the Northern Territory were not different to the international average.

In comparison to mathematics achievement nationally and internationally with TIMSS 1994/95, several differences are evident. New South Wales performed a great deal better in TIMSS 2002/03 than in TIMSS 1994/95, and its ranking has moved from around the middle of the distribution to near the top of it. The achievement by students in the Australian Capital Territory has remained fairly high, although achievement in countries such as the Russian Federation, Hungary and the Netherlands has improved to the extent that they now perform on a similar level or higher than the Australian Capital Territory, instead of being outperformed by the Australian Capital Territory as in TIMSS 1994/95.

Achievement at the international benchmarks – Year 8

Figure 3.6 shows the proportion of students in each state reaching each of the Year 8 international benchmarks, along with the proportions for Australia as a whole, and for the highest scoring country, Singapore, for comparison. Year 8 students in New South Wales continued their strong performance from Year 4, having the greatest proportion of the states achieving the advanced international benchmark, while the Australian Capital Territory again had the greatest proportion of students reaching at least the lowest international benchmark.

Around 13 per cent of students in New South Wales reached the advanced international benchmark, a further 45 per cent reached the high benchmark, and 91 per cent overall reached the low international benchmark. The proportion of

Table 3.5 Year 8 mathematics achievement nationally and internationally

All Year 8 TIMSS 2002/03 countries	Average scale score (se)	Average age
Singapore	605 (3.6)	14.3
[1]Korea, Rep. of	589 (2.2)	14.6
[1]Hong Kong SAR	586 (3.3)	14.4
Chinese Taipei	585 (4.6)	14.2
Japan	570 (2.1)	14.4
Belgium (Flemish)	537 (2.8)	14.1
[1]Netherlands	536 (3.8)	14.3
Estonia	531 (3.0)	15.2
New South Wales	530 (12.0)	14.0
Hungary	529 (3.2)	14.5
Malaysia	508 (4.1)	14.3
Latvia	508 (3.2)	15.0
Russian Federation	508 (3.7)	14.2
Slovak Republic	508 (3.3)	14.3
Australian Capital Territory	507 (9.6)	14.1
Australia	505 (4.6)	13.9
[1]United States of America	504 (3.3)	14.2
[1]Lithuania	502 (2.5)	14.9
South Australia	501 (11.3)	13.8
Sweden	499 (2.6)	14.9
[1]Scotland	498 (3.7)	13.7
England	498 (4.7)	14.3
[1]Israel	496 (3.4)	14.0
Victoria	495 (6.4)	14.1
New Zealand	494 (5.3)	14.1
Slovenia	493 (2.2)	13.8
Queensland	490 (6.1)	13.4
Western Australia	487 (7.6)	13.4
Italy	484 (3.2)	13.9
Armenia	478 (3.0)	14.9
[1]Serbia & Montenegro	477 (2.6)	14.9
Tasmania	477 (12.3)	14.2
Bulgaria	476 (4.3)	14.9
Romania	475 (4.8)	15.0
International average	467 (0.5)	14.5
Norway	461 (2.5)	13.8
Moldova, Rep. Of	460 (4.0)	14.9
Cyprus	459 (1.7)	13.8
Northern Territory	449 (14.2)	13.8
[1]Macedonia, Rep. of	435 (3.5)	14.6
Lebanon	433 (3.1)	14.6
Jordan	424 (4.1)	13.9
Iran, Islamic Rep. of	411 (2.4)	14.4
[1]Indonesia	411 (4.8)	14.5
Tunisia	410 (2.2)	14.8
Egypt	406 (3.5)	14.4
Bahrain	401 (1.7)	14.1
Palestinian Nat'l Auth.	390 (3.1)	14.1
Chile	387 (3.3)	14.2
[1]Morocco	387 (2.5)	15.2
Philippines	378 (5.2)	14.8
Botswana	366 (2.6)	15.1
Saudi Arabia	332 (4.6)	14.1
Ghana	276 (4.7)	15.5
South Africa	264 (5.5)	15.1

[1] These countries did not meet all the sampling requirements

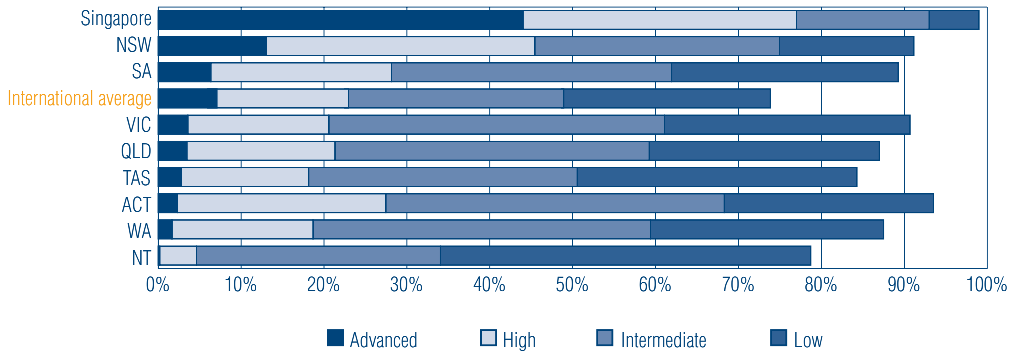


Figure 3.6 Proportion of Year 8 students achieving the mathematics international benchmarks, by state

South Australian students reaching each of the benchmarks was substantially higher in Year 8 than Year 4, with six per cent of Year 8 students reaching the advanced benchmark, and just under 90 per cent reaching the low international benchmark.

The position of the Australian Capital Territory in Figure 3.6 is of interest, as their average achievement level in mathematics is second highest of the Australian states at Year 8 level. The data on benchmarks indicate that the Australian Capital Territory education system is achieving good outcomes in mathematics education for the largest percentage of Year 8 students. Whilst not achieving the very high scores, with only two per cent attaining the advanced international benchmark, 94 per cent achieved the low benchmark.

The positions of the Northern Territory and Western Australia, as was the case for the Year 4 benchmarks, are quite low with few students achieving the advanced benchmark and, in the case of the Northern Territory, more than 20 per cent not attaining the low benchmark. However in Western Australia almost one in five students achieved the high international benchmark, which is only a little less than the international average, and 88 per cent achieved the low international benchmark, which is substantially better than the international average. In the Northern Territory, the picture is not as favourable as that at Year 4, with less than one per cent of students achieving the advanced international benchmark, around five per cent achieving the high international benchmark, and more than one in five students at Year 8 failing to reach the low international benchmark.

At Year 8, as at Year 4, there is a 'tail' which should be of concern to educators. The TIMSS 2002/03 data indicate that while there is ample room at the advanced end of the achievement distribution for growth, there is considerable need for improvement of Australia's achievement at the other end of the scale: improving the proportions of students achieving the lowest international benchmark, which is a very basic standard.

Summary

This chapter has examined Australian students' achievements in the mathematics content areas of *number*, *patterns and relationships*, *measurement*, *geometry* and *data*. In Year 4, Australian students performed above the international average in *measurement*, *geometry* and *data*. Australian students' performance in *patterns and relationships* was the same as the international average, while performance in *number* was significantly lower than the international average. In Year 8, Australian students performed significantly above the international average in all mathematics content areas.

While there were no gender differences in Year 4 in the overall mathematics scores, females significantly outperformed males in *geometry*. At Year 8, males significantly outperformed females in *number* and *measurement*.

There were very few differences in mathematics achievement between the states at either year level. Placing the states in an international context, the achievement level of Year 4 students in the Australian Capital Territory was equal to that of the fifth highest-achieving country, with a score not significantly different to that of Belgium (Flemish). New South Wales and Victoria had similar levels of achievement to the United States of America, but not significantly higher than the international average, while the average scores of South Australia, Tasmania, Queensland and the Northern Territory scored around the international average and Western Australia significantly below it. At Year 8, New South Wales falls into a high-achieving group internationally; all of the remaining states other than the Northern Territory form a 'middle band' which includes countries such as England, Scotland and the United States of America and New Zealand. The scores of the Northern Territory are not significantly different than the international average.

Nationally, students in Year 4 in the Australian Capital Territory did the best at achieving both the highest and the lowest international benchmarks, and in Year 8 had the greatest proportion of students achieving the lowest benchmark. Students in New South Wales also performed strongly at both year levels. The proportion of Australian students, particularly in South Australia, Queensland, Tasmania, Western Australia and the Northern Territory, who do not reach the lowest benchmark is of concern to educators and policy makers. While there is ample room at the advanced end of the achievement distribution for growth, a priority should be improving the proportion of students achieving at the lowest benchmark.

The next chapter, Chapter 4, utilises the information gathered from the student questionnaires to describe the Australian student population at both year levels, and to explore the relationships between these characteristics and mathematics achievement.

Chapter 4
Australian TIMSS students

Chapter 4
Australian TIMSS students

Past IEA studies have found that student achievement is related to student characteristics (Beaton, Mullis, Martin, Gonzalez, Kelly and Smith, 1996; Mullis, et al., 2000). In TIMSS 2002/03 students completed a 30-minute questionnaire as well as the test booklet. This chapter utilises the information gathered from this questionnaire to describe the Australian student population at both Year 4 and 8 and explore the relationships between some of these characteristics and mathematics achievement.

The questionnaire asked students about their home background, their self-confidence and attitudes towards learning mathematics and science, activities within mathematics and science lessons, their use of computers, their attitudes towards school, feelings of safety within school, activities outside school, extra tutoring in mathematics and science and the amount of homework given in mathematics and science. Year 8 students were also asked about their educational aspirations. Unless otherwise specified, the data given in this chapter are weighted[1], allowing inferences to be made about the Australian Year 4 and Year 8 student populations.

Student background characteristics

Gender and age

As Table 4.1 shows, there was virtually the same proportion of females and males who participated in TIMSS 2002/03. The distribution varies across states, but none of the differences in number of males and females are significant. Gender was only very weakly related to mathematics achievement at Year 8 (a correlation of 0.11) and was not related at all to mathematics achievement at Year 4 (a correlation of 0.05). As was seen in Chapter 2, males tended to score higher than females at both year levels, but this difference was not significant.

Table 1.1 illustrated that the average age of students in Year 4 and 8 varied from state to state, with Queensland and Western Australia having the youngest students. Overall the average age of Australian Year 4 students was 9.9 years and that of Australian Year 8 students 13.9 years. Interestingly, for the whole sample, age is not related to mathematics achievement (correlations of 0.09 for Year 4 and 0.04 for Year 8). Therefore, any differences in achievement between the states are unlikely to be due to differences in the average age of students.

Table 4.1 Percentage of males and females in TIMSS 2002/03 by state

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Year 4									
Females	50	50	51	49	52	54	54	47	50
Males	50	50	49	51	48	46	46	53	50
Sample N	837	617	678	546	609	453	227	294	4261
Year 8									
Females	52	50	54	47	50	50	53	54	51
Males	48	50	46	53	50	50	47	46	49
Sample N	800	774	771	633	641	551	264	346	4780

[1] Students included in the final TIMSS samples are not equally representative of the entire student population of a country, despite random sampling of schools and classes. Survey weights are thus incorporated into the analysis in order to provide accurate population estimates.

Parents' education and home education resources

Year 8 students were asked to indicate the highest level of education attained by their parents. These levels ranged from finishing primary school throught to post-graduate education. From the high proportion of students ticking 'I don't know', it would appear that this is a difficult question for students to answer, which is why it was not asked of Year 4 students (internationally, 17 countries had response rates of 85% or less on these questions).

Table 4.2 presents the distribution of parents' education for the Year 8 students in Australia. For the TIMSS 2002/03 sample of students, 16 per cent of fathers and 20 per cent of mothers did not complete secondary school. This is lower than the proportion of Australian parents who did not complete secondary schooling in TIMSS 1998/99 (almost a fifth of fathers and a quarter of mothers, Zammit, Routitsky & Greenwood, 2002) and less again than the 34 per cent of fathers and 40 per cent of mothers in TIMSS 1994/95 (Lokan et al., 1996). However, responses of 'I don't know' were not included in TIMSS 1994/95 as a valid response category, which has inflated the percentages of the other categories in comparison to the percentages in TIMSS 1998/99 and 2002/03.

The combined parents' education variable, which uses the highest level of education attained by either parent, is weakly related to mathematics achievement in Australia (a correlation of 0.19). Figure 4.1 shows the average mathematics achievement and confidence intervals for Year 8 students at each level of parents' education[2]. Figure 4.1 shows that Australian students with parents who attained higher levels of education had higher mathematics achievement scores than those with parents who reached lower levels of education (although there is no difference in achievement between students with parents whose highest education is either lower secondary or upper secondary school). Internationally, higher levels of parents' education were associated with higher levels of student achievement in most countries. This is also reflected in the international average, where students with university educated parents scored 93 points higher than students with parents with only primary schooling.

Past IEA studies have also shown a clear relationship between the educational resources available in the home and student achievement (Mullis et al., 2000). In TIMSS 1998/99, an index of home educational resources was developed, which combined parents' education, number of books in the home and the presence of study aids (computer, study desk for own use, dictionary), which was then collapsed into three categories – high, medium and low. A high level indicated more than 100 books in the home, all three study aids and either parent's highest level of education was to have at least finished university. A low level indicated 25 or fewer books in the home, not all three study aids and both parents' highest level of education was at most some secondary schooling. A medium level included all other combinations of responses.

In TIMSS 1998/99 Australia had the second highest percentage of students indicating a high level of home educational resources, with 24 per cent of students in this category and only 3 per cent in the low category (Mullis et al., 2000). In TIMSS 2002/03 this index was constructed for Australian students (at Year 8 only). Table 4.3 shows that the number of students in the high category has dropped slightly to 15 per cent but the number of students with a low level of home educational resources was still very low at 2 per cent. The skew towards the high end of this index is due to the high number of students who had all 3 educational aids (96% of Australian Year 8

Table 4.2 Percentage of students by parents' education (Year 8 only)

Education level	Mother	Father
Completed primary school	3	2
Some secondary school	17	14
Completed secondary school or apprenticeship	18	19
TAFE or college diploma	17	14
Bachelor's degree	9	9
Beyond Bachelor's degree	5	8
I don't know	33	35

[2] As this is a scale which is derived from a combination of the mother's and father's educational level, the categories are slightly broader than those given in the student's responses shown in Table 4.2.

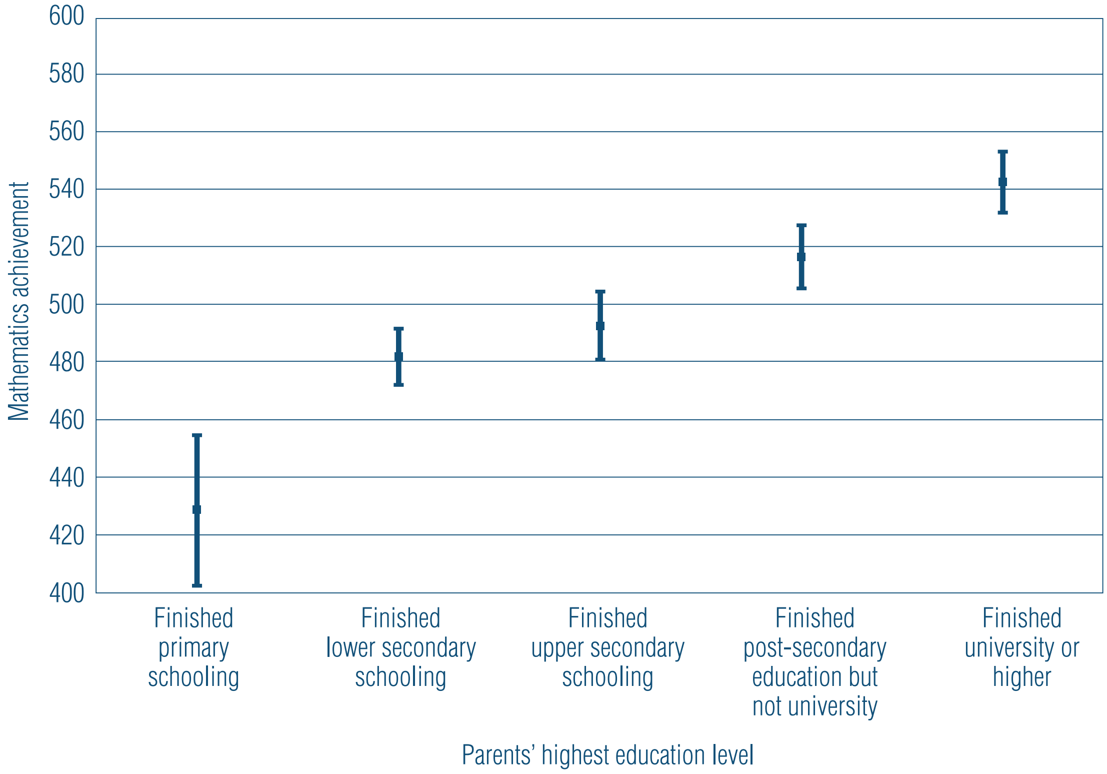


Figure 4.1 Year 8 mathematics achievement by the highest education level of either parent

students had a computer at home, 98% had a dictionary and 92% had their own study desk). Table 4.3 shows that mathematics achievement is related to educational resources in the home (a correlation of 0.24), with students in the high category having higher mathematics achievement than those in the medium category and those in the medium category scoring higher than those in the low category.

The index of home educational resources included parents' education so could not be applied to Year 4 students. However, the number of books in the home has been used by itself as an indicator of educational capital in the home in the past. In TIMSS 1994/95 and TIMSS 1998/99, there was a clear relationship between the number of books in the home and student achievement in mathematics and science. In both these studies, around 40 per cent of Australian Year 8/9 students had more than 200 books in their home (Lokan, et al., 1996; Lokan, et al., 1997; Zammit, et al., 2002). In TIMSS 2002/03, 31 per cent of Australian Year 8 students had more than 200 books in the home, exceeded or equalled only by Hungary (31%), Sweden (32%) and Estonia (45%). At Year 4, Australia had the highest proportion (23%) of students with more than 200 books in the home. At both year levels, just over one fifth of students had between 101 and 200 books, about a third had 26 to 100 books, just over 10 per cent had 11 to 25 books and about 5 per cent had less than 10 books in the home.

Figures 4.2 and 4.3 show that there is a clear relationship between the number of books in the home and mathematics achievement for Australian students. At both year levels, the correlation between the number of books in the home and mathematics achievement is 0.22. The difference in mathematics scores between students with more than 200 books and those with 10 or less books in the home was around 80 score points for both year levels. Internationally, the difference was 69 points at Year 8 (from 429 to 498) and 64 points at Year 4 (from 457 to 521).

Table 4.3 Index of home education resources – percentage of Year 8 students and achievement by category[3]

	Low	Medium	High
Per cent of Year 8 students	2	83	15
Mathematics achievement	417 (10.1)	501 (4.7)	545 (5.4)

[3] Standard errors appear in parentheses.

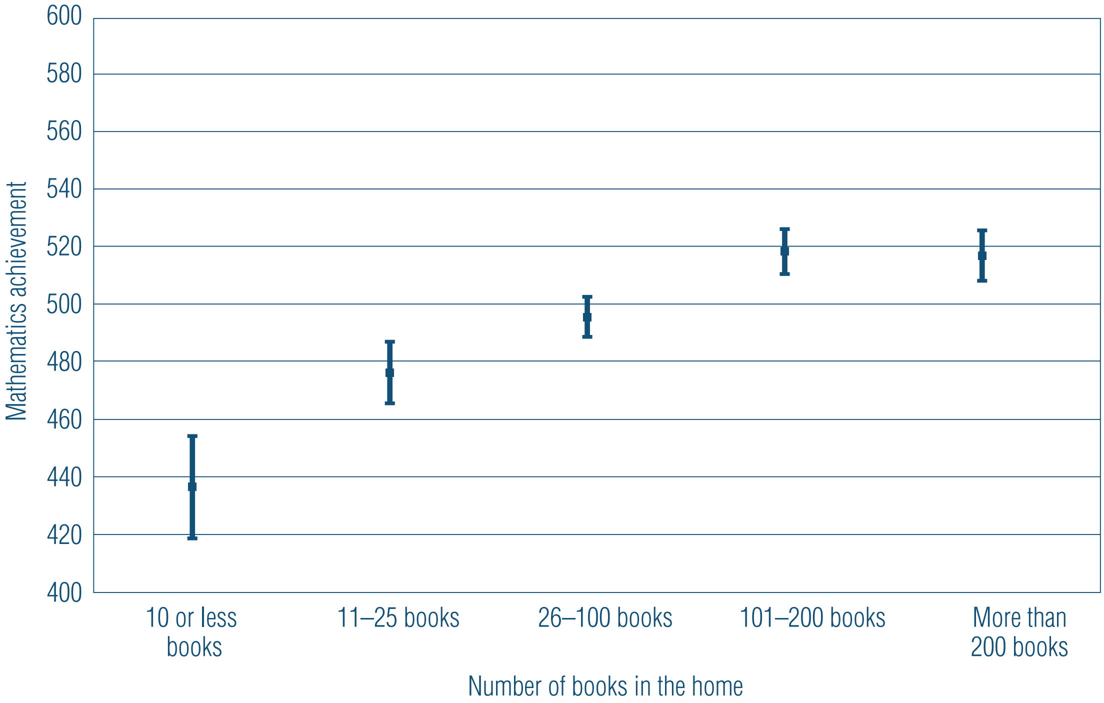


Figure 4.2 Year 4 mathematics achievement by the number of books in the home

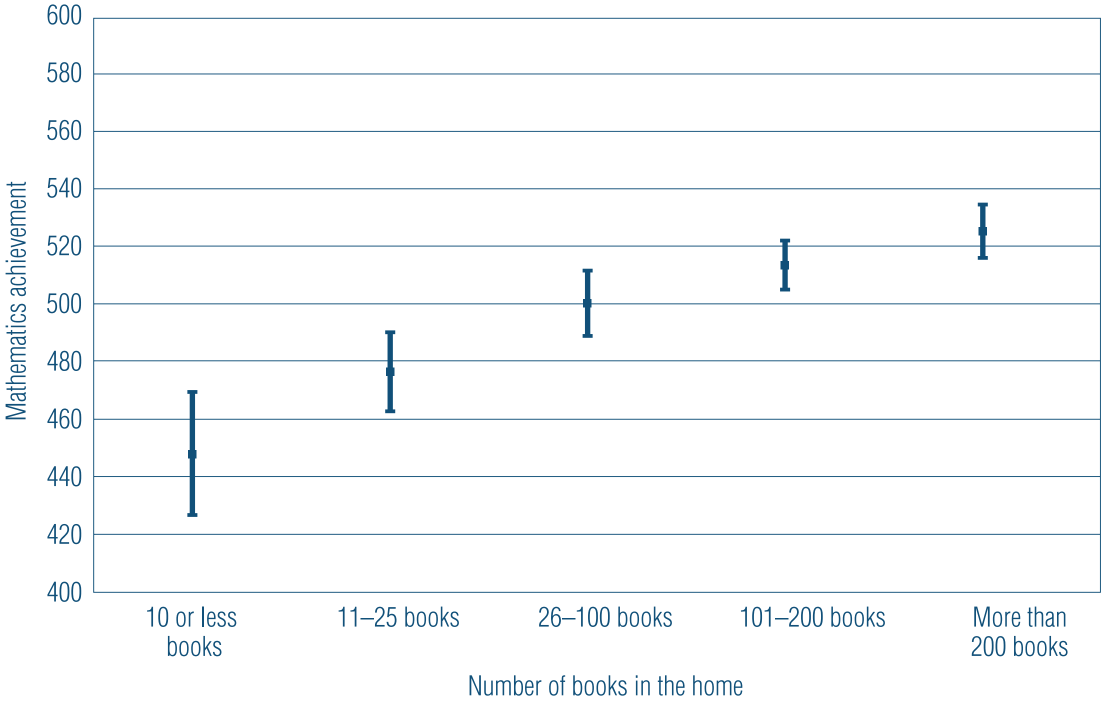


Figure 4.3 Year 8 mathematics achievement by the number of books in the home

Indigenous students

Table 4.4 shows the proportion of Indigenous students in the Australian TIMSS sample. Overall, five per cent of Year 4 students are Indigenous. This is similar to the proportion of Year 4 students the Australian Bureau of Statistics (ABS) reported in 2002 (4.2%). The proportion of Year 8 students who indicated that they were of Aboriginal or Torres Strait Islander background in TIMSS 2002/03 was three per cent, also about the same as the proportion (3.6%) reported by the ABS (2003).

Table 4.4 Percentage of Indigenous students in the TIMSS sample

	Year 4	Year 8
Australia	5	3

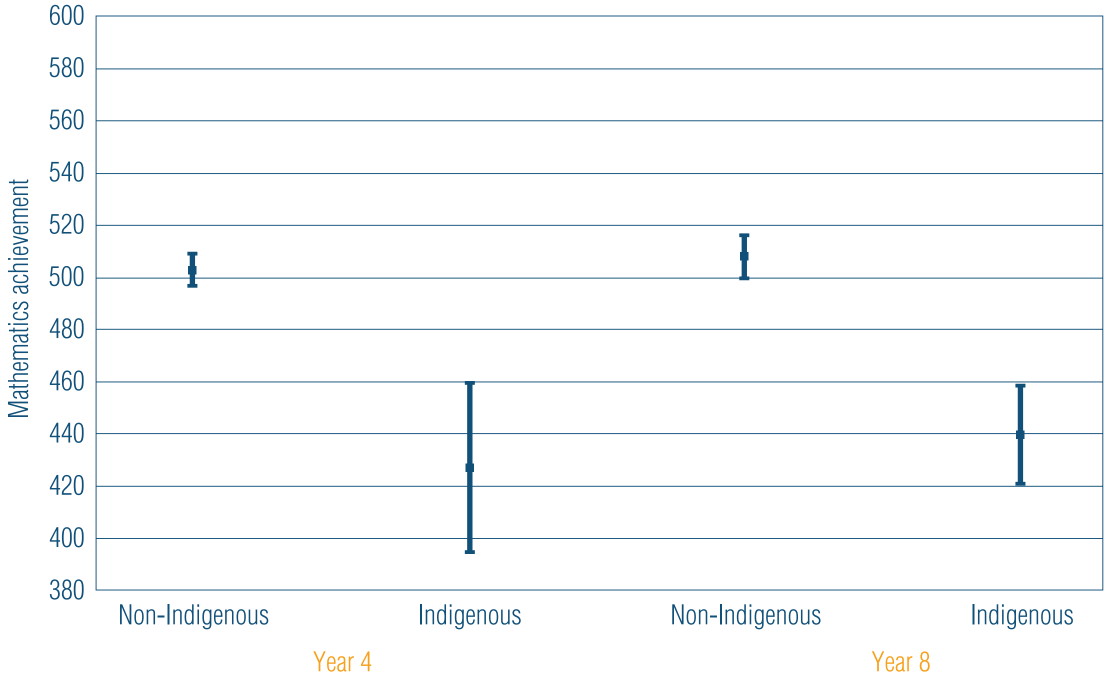


Figure 4.4 Year 4 and Year 8 mathematics achievement for Indigenous and non-Indigenous Australian students[4]

Figure 4.4 shows clearly that Indigenous students did not perform as well as non-Indigenous students in mathematics at either Year 4 or Year 8. At Year 4, Indigenous students achieved an average score of 427, which was 76 score points less than the average score of non-Indigenous students (503). At Year 8, Indigenous students achieved an average score of 440, which was 68 score points less than the average score of non-Indigenous students (508). In addition, at both year levels, when compared to the international data, Australian Indigenous students' average mathematics score was significantly below the international average (68 score points at Year 4 and 51 score points at Year 8).

Has the mathematics achievement of Indigenous students improved since TIMSS 1994/95?

The performance of Australia's Indigenous students in core subject areas continues to be an issue. The difference in scores between Indigenous students and all Australian students provides us with an idea of the magnitude of such differences in mathematics. At Year 4 the difference in TIMSS 1994/95 between Indigenous students and Australian students was 0.6 of a standard deviation (60 score points), while in TIMSS 2002/03 the situation had worsened marginally, with a difference of 0.72 of a standard deviation (72 score points). For Year 8 students, the situation had improved. In TIMSS 1994/95, the

Table 4.5 Percentage of students and their parents by place of birth

	Australia	Other English	Southern Europe	Other Europe	Asia	Middle East and North Africa	Other Africa	Central and South America	Pacific Islands
Year 4									
Students	91	4	1	1	2	1	0	0	0
Mothers	70	10	3	3	9	2	1	0	2
Fathers	67	11	5	3	8	3	1	1	2
Year 8									
Students	88	4	1	1	6	1	0	0	1
Mothers	66	11	3	3	12	2	1	1	2
Fathers	64	11	5	4	11	3	1	1	1

[4] While the Year 4 and Year 8 scores have been presented here on the same axes for the sake of expedience, the Year 4 and Year 8 tests were not scaled together and, therefore, are not comparable. That is, a score of 500 for a Year 4 student does not mean that they have the same mathematical skills as a Year 8 student who also scores 500. This holds for all Year 4 and Year 8 achievement data.

Table 4.6 Percentage of students and parents born in English speaking countries, including Australia, by state

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Year 4									
Students	94	96	96	96	94	99	97	96	95
Mothers	75	79	89	86	80	95	85	81	80
Fathers	73	76	84	86	81	95	86	78	78
Both parents	68	72	82	81	74	88	80	72	74
Neither parent	20	16	8	9	13	6	9	12	15
Year 8									
Students	87	92	94	95	95	98	95	94	92
Mothers	66	74	87	87	87	95	83	81	77
Fathers	63	73	87	82	84	94	84	85	75
Both parents	60	67	82	78	79	91	76	77	70
Neither parent	31	20	9	10	8	2	9	11	19

difference was a little more than three-quarters of a standard deviation (76 score points), while in 2002/03 it was a little less than two-thirds of a standard deviation (65 score points). While it is unlikely that either of these changes is statistically significant, this will be investigated in a further report which will examine the achievement of Indigenous Australians in more detail.

Country of birth and language background

Table 4.5 categorises the place of birth of Australian students and their parents. Around 90 per cent of students were born in Australia (91% at Year 4 and 88% at Year 8). Of those students who were not born in Australia, or whose parents were not born in Australia, most come from English-speaking countries or Asia.

As Table 4.6 shows, the majority of Year 4 and Year 8 students come from English-speaking backgrounds, with only 15 per cent of Year 4 students and 19 per cent of Year 8 students having neither parent born in an English-speaking country. Correspondingly, at both year levels, just over 90 per cent of students speak English at home always or almost always (see Table 4.7). Of the states, Tasmania had the highest proportion of students with an English speaking background with 99 per cent of Year 4 students and 98 per cent of Year 8 students from English speaking countries and 96 per cent of Year 4 students and 98 per cent of Year 8 students speaking English at home always or almost always. Of the other states, New South Wales has the greatest proportion of students coming from non-English speaking backgrounds.

Internationally, in most countries the majority of students spoke the language of the test at home always or almost always – overall 81 per cent of Year 4 students and 79 per cent of Year 8 students spoke the language of the test at home always or almost always. Most of the countries that had a large percentage of students who did not speak the language of the test at home frequently were countries that had relatively low performance. However, Singapore (the country that scored the highest in mathematics) had only 46 per cent of Year 4 students and 42 per cent of Year 8 students who spoke the language of the test at home always or almost always.

Internationally, across countries, students at both year levels who always or almost always spoke the language of the test at home achieved a higher score than those that spoke it less frequently. However, in Australia, the relationship is not so clear-cut. For Year 4 students, those who always or almost always spoke English at home had an average score of 501, whereas those who spoke English less frequently had an average score of 482 (a correlation of 0.07). However, Year 8 students who always or almost always spoke English at home had an average score of 503, less than those who spoke English less frequently who had an average score of 532 (a correlation of –0.1).

In TIMSS 1994/95, for Australia, country of birth and language spoken at home were combined to give

Table 4.7 Percentage of students speaking English at home (always or almost always) by state

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Year 4	89	90	94	92	92	96	88	93	91
Year 8	86	91	96	95	97	98	95	95	92

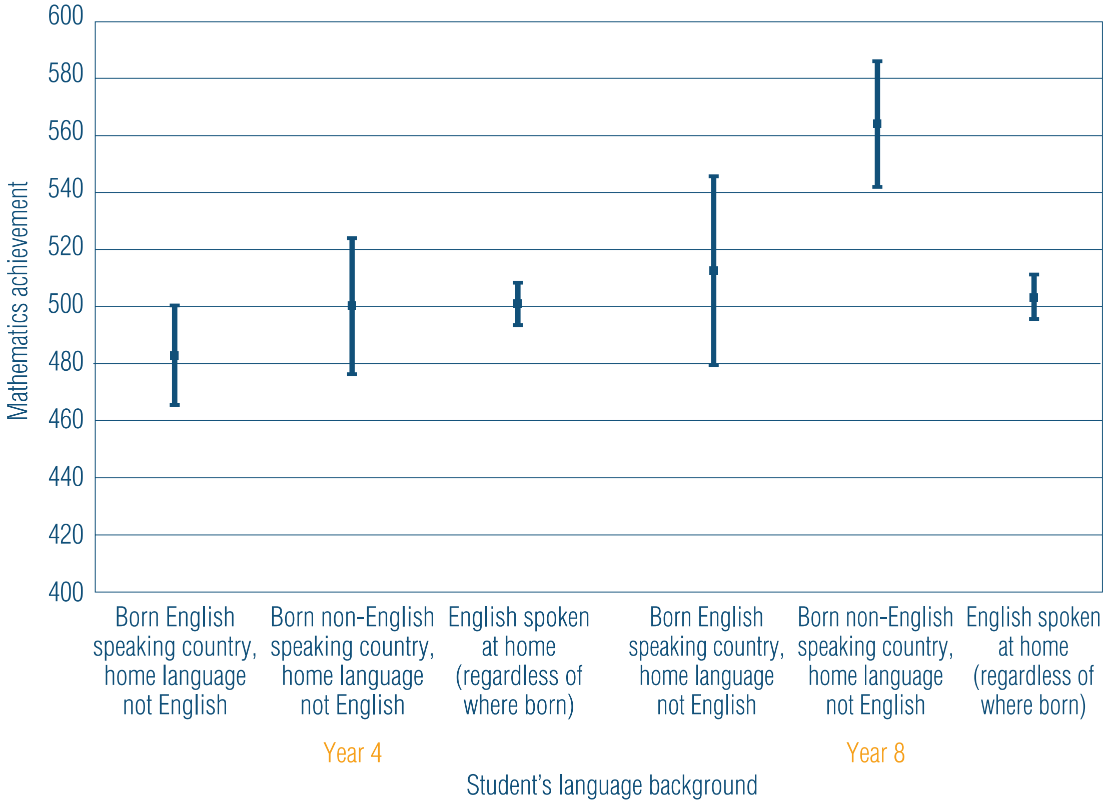


Figure 4.5 Year 4 and Year 8 mathematics achievement by students' language background

4 categories of students – those born in an English speaking country but did not speak English at home; those born in a non-English speaking country and did not speak English at home; those born in an English speaking country and spoke English at home; and those born in a non-English speaking country and spoke English at home (in Years 8 and 9 these last two categories were combined). It was found that for students in Years 4 and 5, mathematics achievement increased fairly uniformly from the first category to the last category. For Years 8 and 9, it was found that that those students who did not speak English at home, although they were born in English-speaking countries, did significantly worse in mathematics than those students who spoke English at home or were from a non-English-speaking country and did not speak English at home (Lokan, et al., 1996; Lokan, et al., 1997). In TIMSS 2002/03 this line of enquiry was replicated, however, the results were quite different. As Figure 4.5 shows, there was little difference between any of the categories for Year 4 students, although those students who spoke English at home did slightly better than those students born in an English speaking country who did not speak English at home. Year 8 students who were born in a non-English speaking country and did not speak English at home did significantly better than any other category in mathematics.

Out-of-school activities

Homework

In order to gauge how much time students were required to devote to mathematics homework, two questions were asked: 'How often does your teacher give you homework in mathematics?' and 'When your teacher gives you mathematics homework, about how many minutes are you usually given?' From the responses to these questions an index was constructed that assigned students to a high, medium or low level of required time for mathematics homework. Students in the high category reported that they were assigned more than 30 minutes of mathematics homework at least 3–4 times per week. Students in the low category reported being assigned not more than 30 minutes of mathematics homework twice a week. The middle category included all other response combinations.

The percentage of students falling into each category and the average mathematics achievement for students in that category was calculated for all countries. The international average for students in Year 4 was 18 per cent in the high category, 56 per cent in the medium category and 26 per cent in the low category.

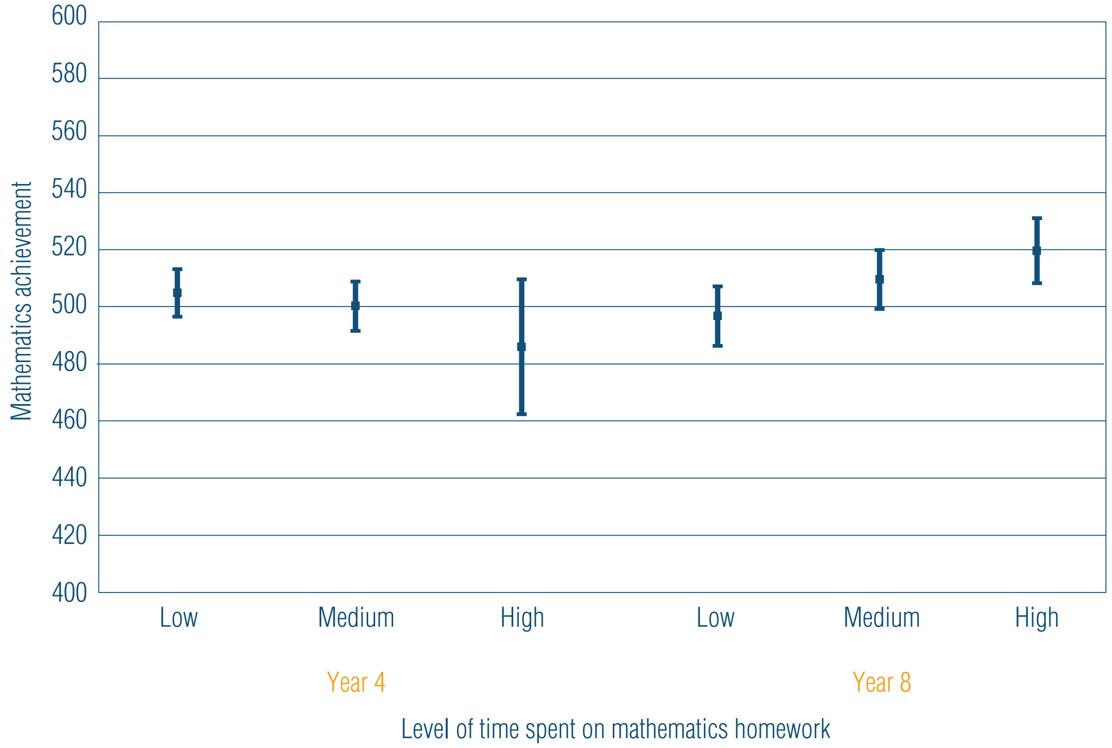


Figure 4.6 Year 4 and Year 8 mathematics achievement by level of time spent on mathematics homework

Singapore had the most students, 40 per cent, in the high category, and England and the Netherlands had less than 5 per cent of students reporting high amounts of mathematics homework. At Year 4, students in the medium category had the highest average mathematics achievement. This may be because lower achieving students are assigned more homework than higher achieving students as a remedial strategy.

In most countries, Year 8 students reported being given more mathematics homework than Year 4 students. The international average for students in Year 8 was 26 per cent in the high category, 54 per cent in the medium category and 19 per cent in the low category. Students receiving the lowest amounts of homework had lower mathematics achievement than students in the high and medium categories. This is a different pattern to that found at Year 4. It seems that at Year 8 higher achieving students do more homework, perhaps as extension work or perhaps it is simply that more homework does lead to higher achievement. Romania had the highest number of students in the high category – 68 per cent. Japan, Sweden, Scotland and England all had less than 10 per cent of students falling into the high category. Across countries, the number of students assigned high amounts of mathematics homework did not seem to be related to mathematics achievement. Japan was in the top five scoring countries yet had only six per cent of students reporting high amounts of homework while Singapore, the top scoring country, had 38 per cent of students in the high category of the index. It may be that the homework figure does not take into account extra-curricular coaching, cram schools or similar that is the norm in a number of countries.

Australian students received relatively low amounts of homework. At Year 4 Australia was in the bottom five countries in terms of numbers of students reporting receiving high amounts of homework. Only seven per cent of Year 4 students fell into the high category, 43 per cent reported a medium amount and 50 per cent reported receiving a low amount of mathematics homework. Nineteen per cent of Year 8 students reported a high amount of mathematics homework, 50 per cent reported medium levels and 31 per cent reported a low amount. Figure 4.6 shows the relationship between mathematics homework and mathematics achievement in Australia. At Year 4, there was no relationship between the amount of mathematics homework received and mathematics achievement. Year 8 students who reported doing high amounts of mathematics homework, however, had higher mathematics achievement than those students at the low level (a correlation of 0.08).

Students were also asked how much time they spent on a normal school day doing homework (all subjects, not just mathematics). The majority (56%) of Australian Year 4 students did some but less than one hour of homework on a normal school day, while another 24 per cent did between one and two hours. The remaining 20 per cent were spread equally between the categories of 'no time', 'between two and four hours' and 'more than four hours'. The amount of homework Year 8 students did on a normal school day was slightly higher than that of Year 4 students – 40 per cent did up to an hour, another 40 per cent did one to two hours, 10 per cent did two to four hours and three per cent did over four hours of homework on a school day. Figures 4.7 and 4.8 show that

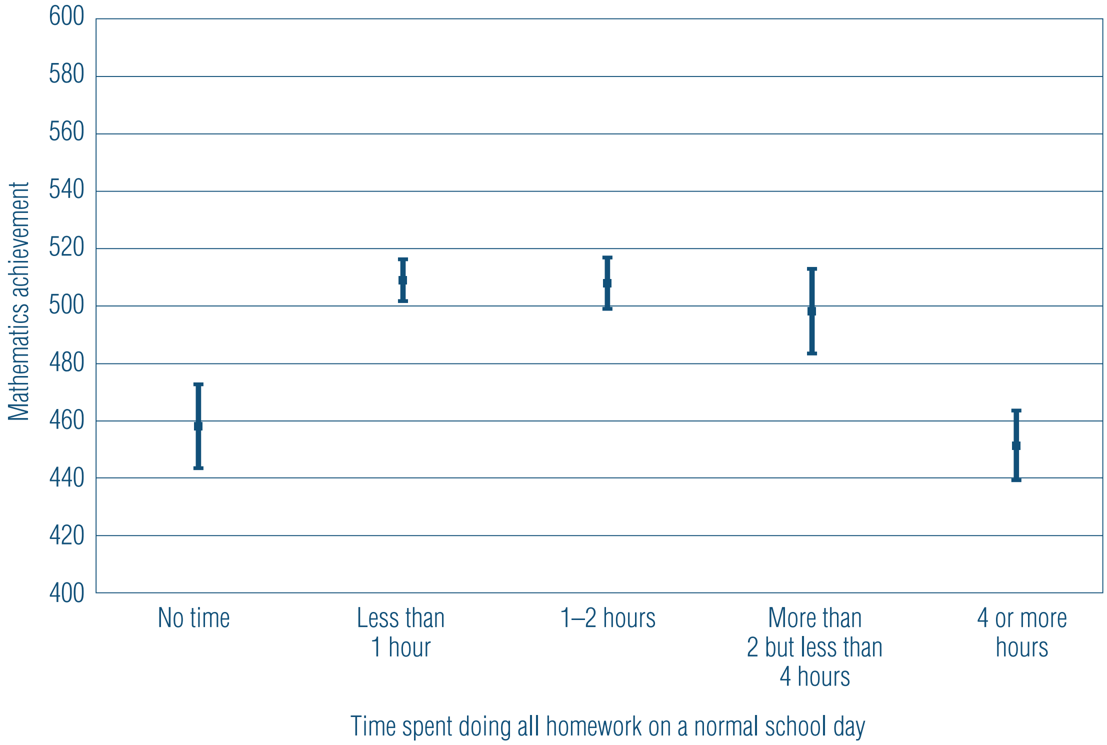


Figure 4.7 Year 4 mathematics achievement by amount of time spent on all homework

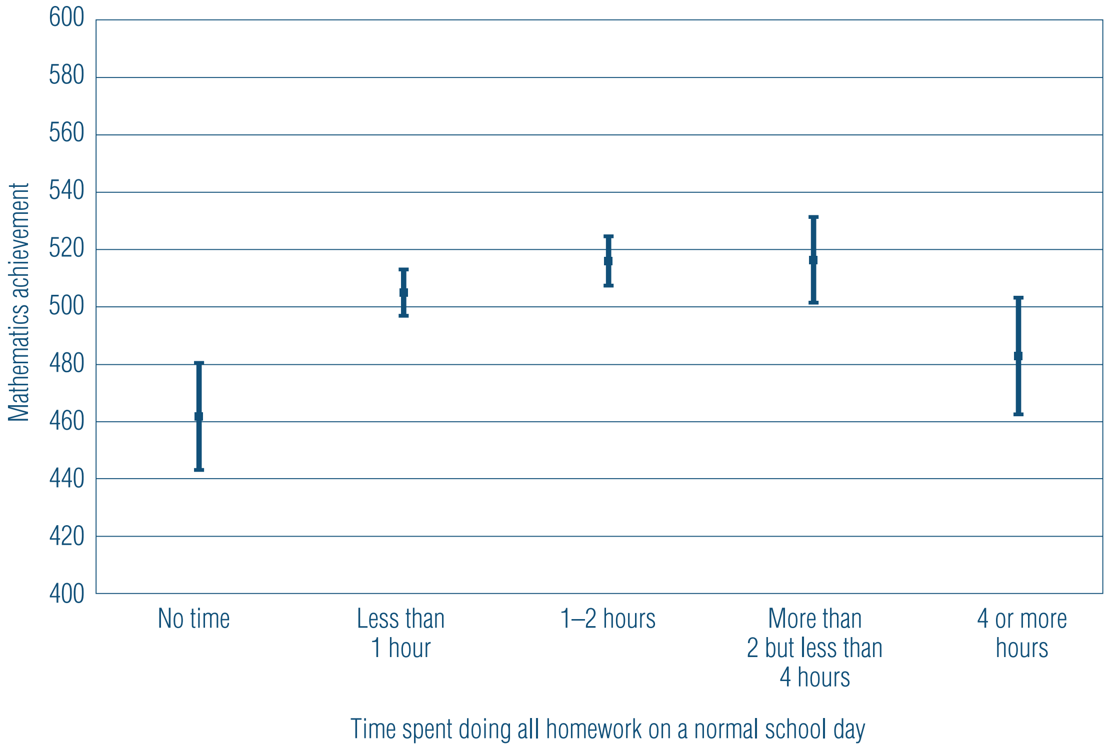


Figure 4.8 Year 8 mathematics achievement by amount of time spent on all homework

Year 4 and Year 8 students in Australia that do some homework in any subject, but less than four hours a day, have better mathematics achievement than those that do none or those that do more than four hours. What cannot be concluded from this data is the direction of the relationship. The ready conclusion to be made is that some homework, but not too much, is beneficial to achievement in mathematics. However, it could also be that those students who aren't achieving as well either do no homework because they are disengaged from schooling or do more than average amounts of homework because they are assigned more in order to 'catch-up'.

Questions about time spent on homework were also asked of students in TIMSS 1994/95 and TIMSS 1998/99 (Lokan, et al., 1996; Lokan, et al., 1997; Zammit, et al., 2002). However, the questions asked and the measures derived from these questions were not exactly the same as those asked in TIMSS 2002/03 and, therefore, are not directly comparable. However, the general trend, for students who do some but not a lot of homework in any subject, to have higher scores on the mathematics achievement scale, was also found in these prior TIMSS studies.

Leisure activities

Students were also asked about how much time they spend on a normal school day, on leisure activities such as reading for enjoyment or sport. Internationally the two most popular activities were watching television or videos and playing or talking with friends – on average, Year 4 students spend a bit less than two hours on each of these activities and Year 8 students spend about two hours. In Australia, these were also among the most popular activities, along with sport. Year 4 students spend, on average, just under two hours on each of these three activities, whereas Year 8 students spend, on average, two hours on watching television and closer to an hour and a half on playing sport and playing or talking with friends.

Figures 4.9 and 4.10 show the relationship between time spent watching television and mathematics achievement. As in previous TIMSS studies (Lokan, et al., 1996; Lokan, et al., 1997; Zammit, et al., 2002), about two thirds of Australian Year 4 and Year 8 students watched some television but less than two hours on a normal school day. Slightly more Year 8 students than Year 4 students watched more than two hours of television a day (39% compared to 33%). The relationship between time spent watching television and mathematics achievement is also similar to previous years. That is, students who watch more than four hours of television a day had significantly lower levels of mathematics achievement than students who watched less television.

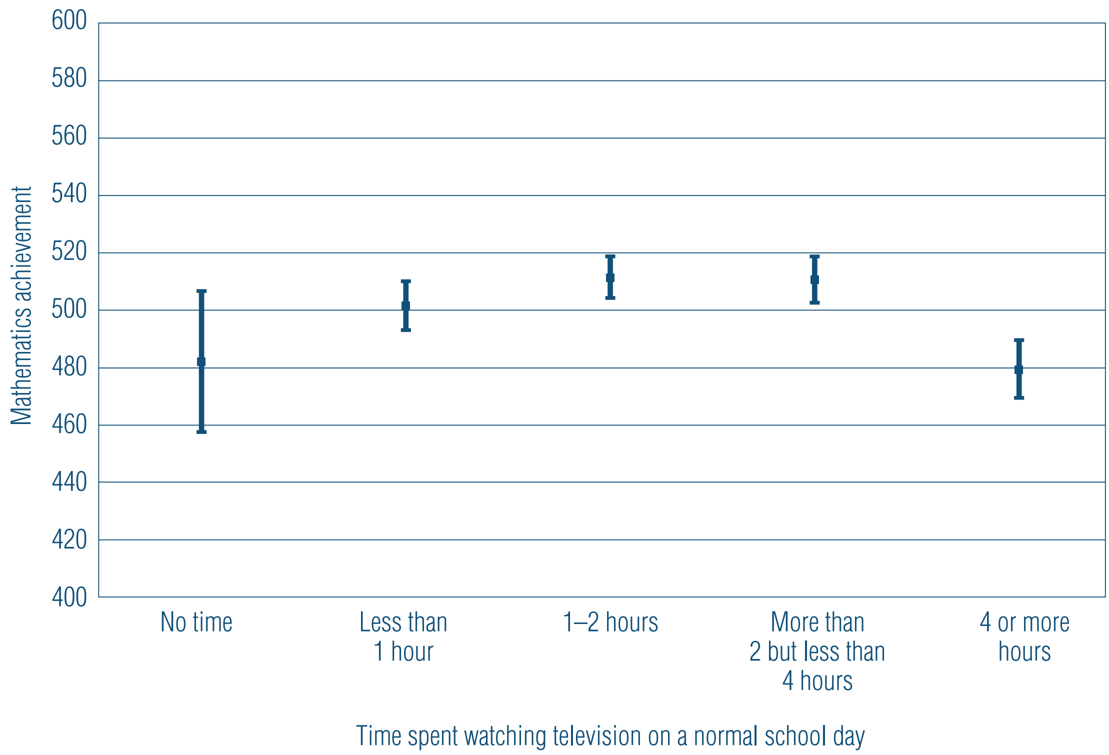


Figure 4.9 Year 4 mathematics achievement by amount of time spent watching television

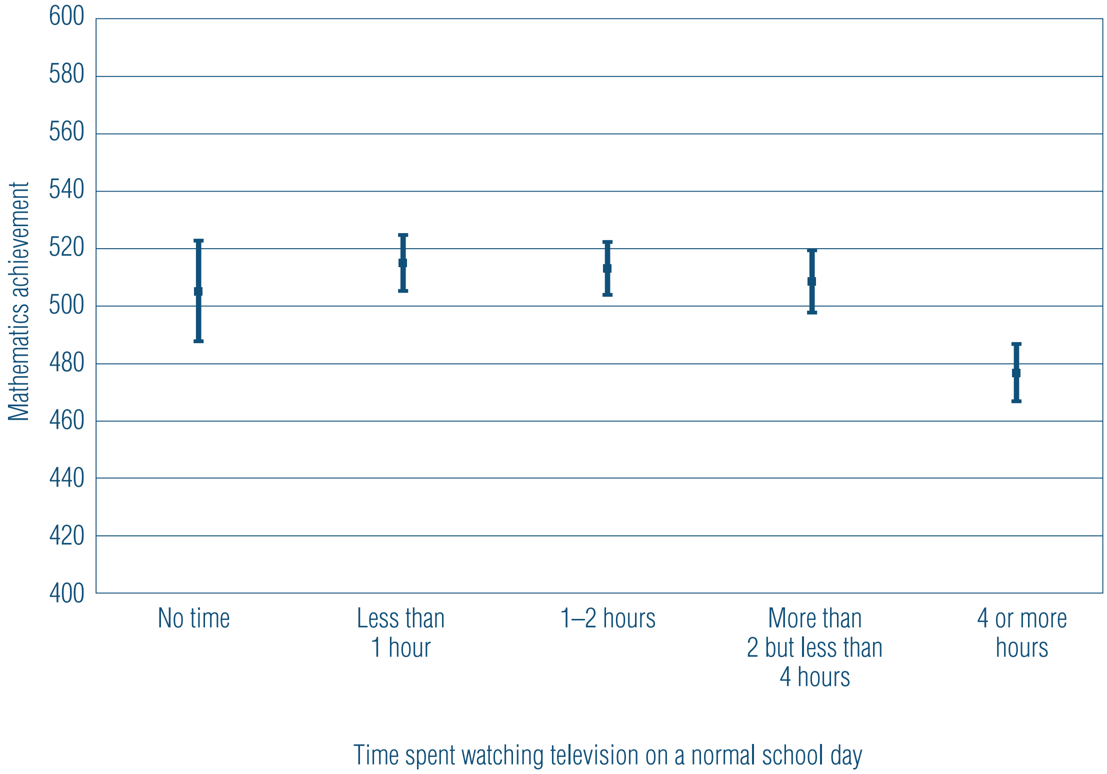


Figure 4.10 Year 8 mathematics achievement by amount of time spent watching television

Figures 4.11 and 4.12 show the relationship between time spent reading for enjoyment and mathematics achievement. Australian Year 4 students were more inclined than Year 8 students to spend some time reading for enjoyment on a normal school day – two thirds of Year 4 students spent up to two hours on a normal school day reading for enjoyment, compared to half of Year 8 students. As for the Australian Year 8 and Year 9 students in TIMSS 1998/99, 40 per cent of Year 8 students did not read for enjoyment at all (Zammit, et al., 2002). As in previous TIMSS studies

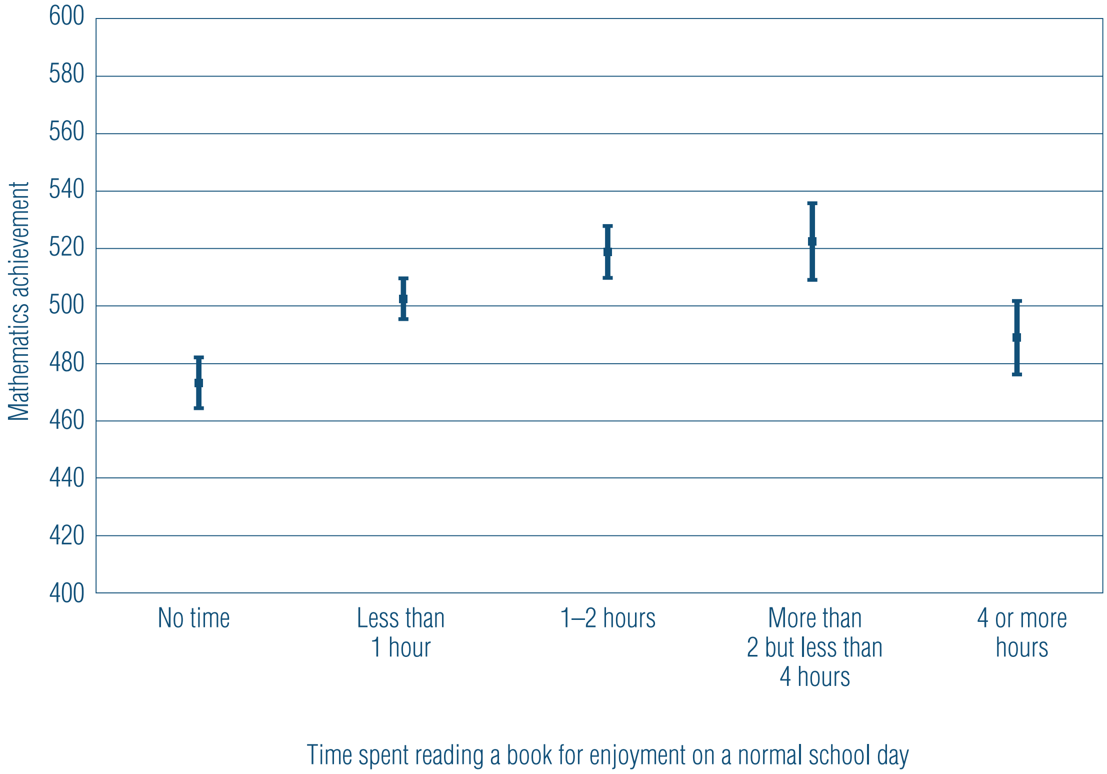


Figure 4.11 Year 4 mathematics achievement by amount of time spent reading for enjoyment

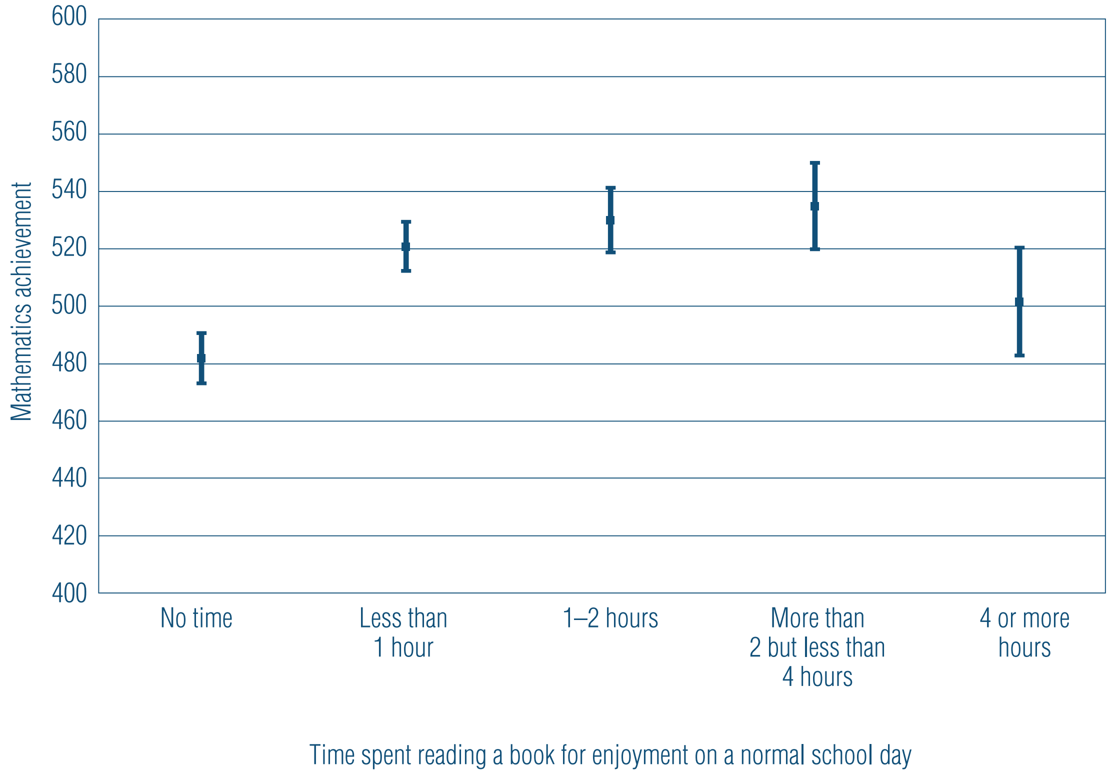


Figure 4.12 Year 8 mathematics achievement by amount of time spent reading for enjoyment

(Lokan, et al., 1996; Lokan, et al., 1997; Zammit, et al., 2002), there was a weak positive relationship (a correlation of 0.1 at Year 4 and 0.2 at Year 8) between reading for enjoyment and mathematics achievement – in both Year 4 and 8, students that read for up to four hours a day had a higher average mathematics achievement score than those that did not read at all. However, students who read for more than four hours a day had a lower average mathematics score than those students who read for between one and four hours a day.

Use of computers

Australia had one of the highest percentages of students with a computer at home. At Year 4, 92 per cent of students had a computer at home (the United States of America and the Netherlands being the only other countries to have the same or a higher percentage of students with a computer at home). At Year 8, 96 per cent of Australian students had a computer at home (Norway, Hong Kong SAR, Korea, Sweden and the Netherlands being the only other countries to have the same or a higher percentage of students with a computer at home). Interestingly, Australia is one of the few countries that actually had more Year 4 and Year 8 students reporting that they have a computer at home than have a study desk or table for their use. The other countries reporting this phenomenon are the other English speaking countries – the United States of America, New Zealand, England and Scotland – and Hong Kong SAR (for both Year 4 and Year 8), Singapore (at Year 8), and Chinese Taipei and Italy (at Year 4).

As Table 4.8 shows, there is some variation between states as to the number of students who have a computer at home. For example 84 per cent of Year 4 students in the Northern Territory have a computer at home, compared to almost all of the students in the ACT.

In Australia, 98 per cent of students (at both Year 4 and 8) use a computer at either school or home. Of those students, 80 per cent of Year 4 and 83 per cent of Year 8 students use a computer at

Table 4.8 Percentage of students who have a computer at home by state

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Year 4	92	94	91	90	93	90	84	97	92
Year 8	97	97	94	94	93	91	91	99	96

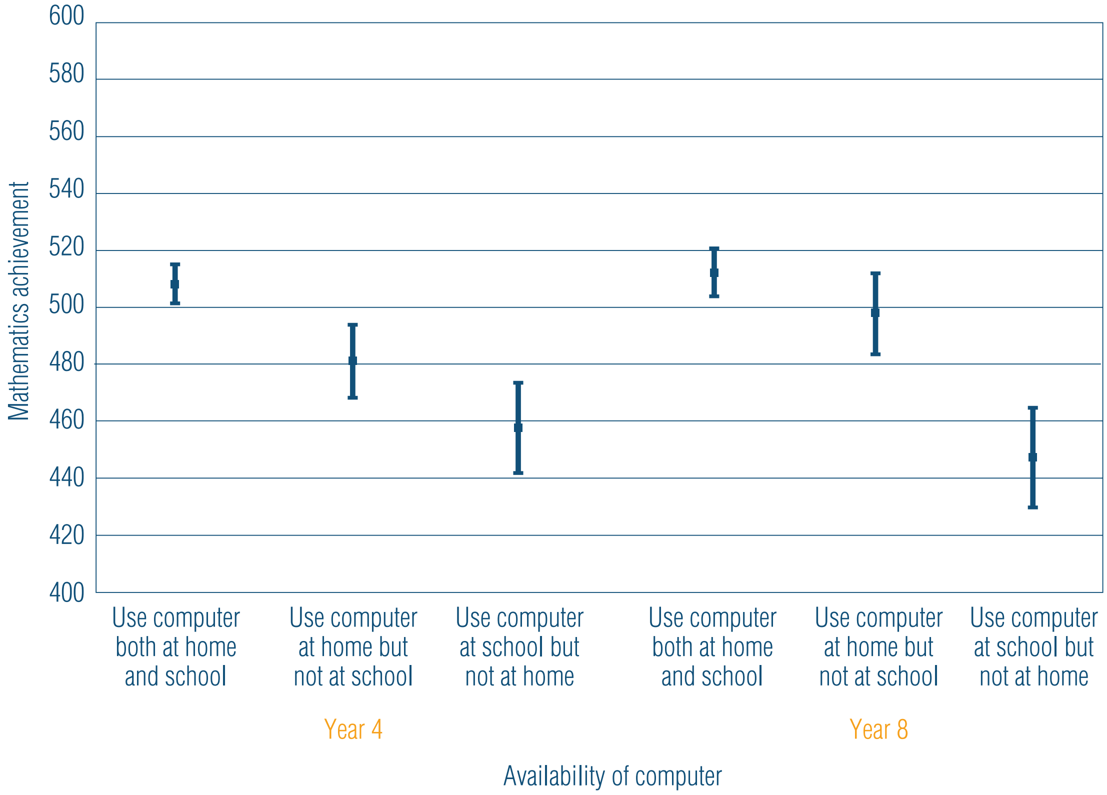


Figure 4.13 Year 4 and Year 8 mathematics achievement by the availability of computers

both home and school. In comparison, the international average is that 43 per cent of Year 4 students and 39 per cent of Year 8 students use a computer at both home and school. Hong Kong SAR, England and Chinese Taipei also had more than 80 per cent of Year 8 students using computers at home and school. At Year 4 the only other country for which this was true was Chinese Taipei.

In Australia, the availability of computers is clearly related to mathematics achievement at both Year 4 and 8, as can be seen in Figure 4.13 (a correlation of 0.22 at Year 4 and 0.21 at Year 8). Students who used computers both at home and at school had a higher average mathematics achievement than those who used computers only at home or only at school (the numbers of students who didn't use computers at all or only used them elsewhere are too small for a sensible comparison of achievement). This pattern was also present at the international level, especially at Year 8.

While the availability of computers and the general use of computers was positively related to mathematics achievement, the relationship of specific uses of the computer with mathematics achievement is less clear. Figures 4.14 and 4.15 show the relationship of mathematics achievement and the use of computers to look up ideas and information for mathematics at Years 4 and 8 in Australia. At both year levels it appears that those students who use the computer to look up ideas and information for mathematics a few times a year to once or twice a month have the highest average mathematics achievement. At first glance, this relationship is unexpected. However, it could be hypothesised that those students who have higher mathematics achievement are more targeted in their use of the computer and therefore use the computer in their study of mathematics less frequently than students who do less well in mathematics. Conversely, students who have lower mathematics achievement may be more inclined to use the computer to help them study mathematics using 'drill and practice' type programs, when more able mathematics students would not need this type of assistance.

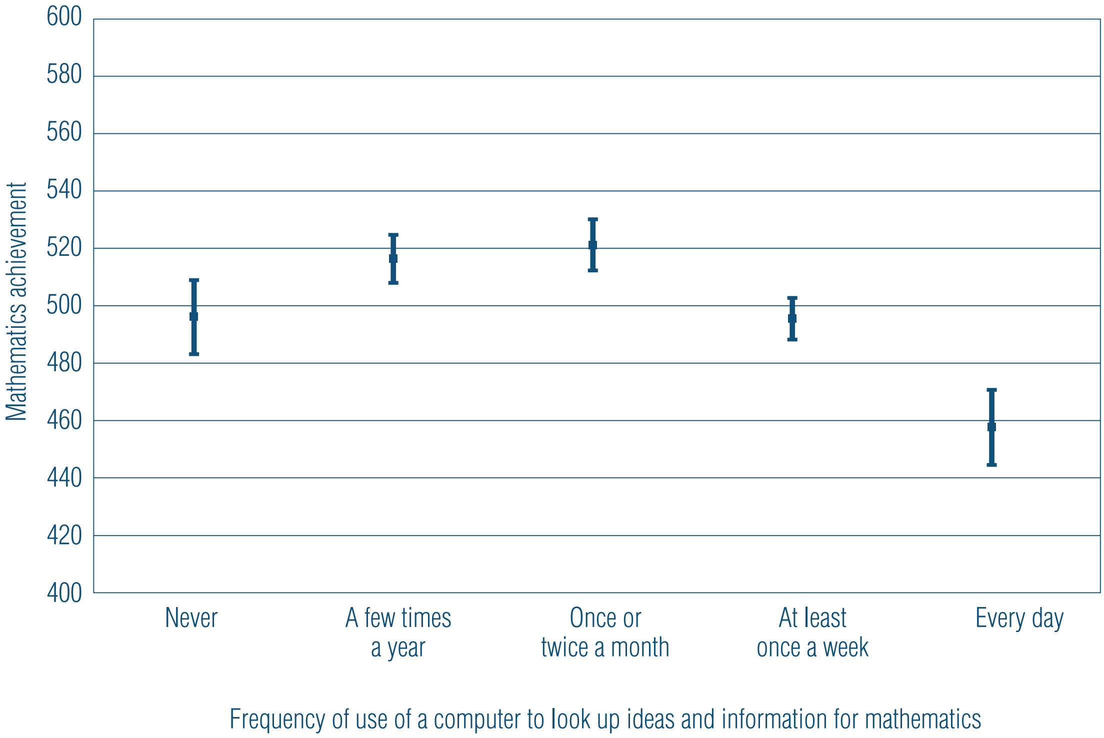


Figure 4.14 Year 4 mathematics achievement by use of computers to look up ideas and information for mathematics

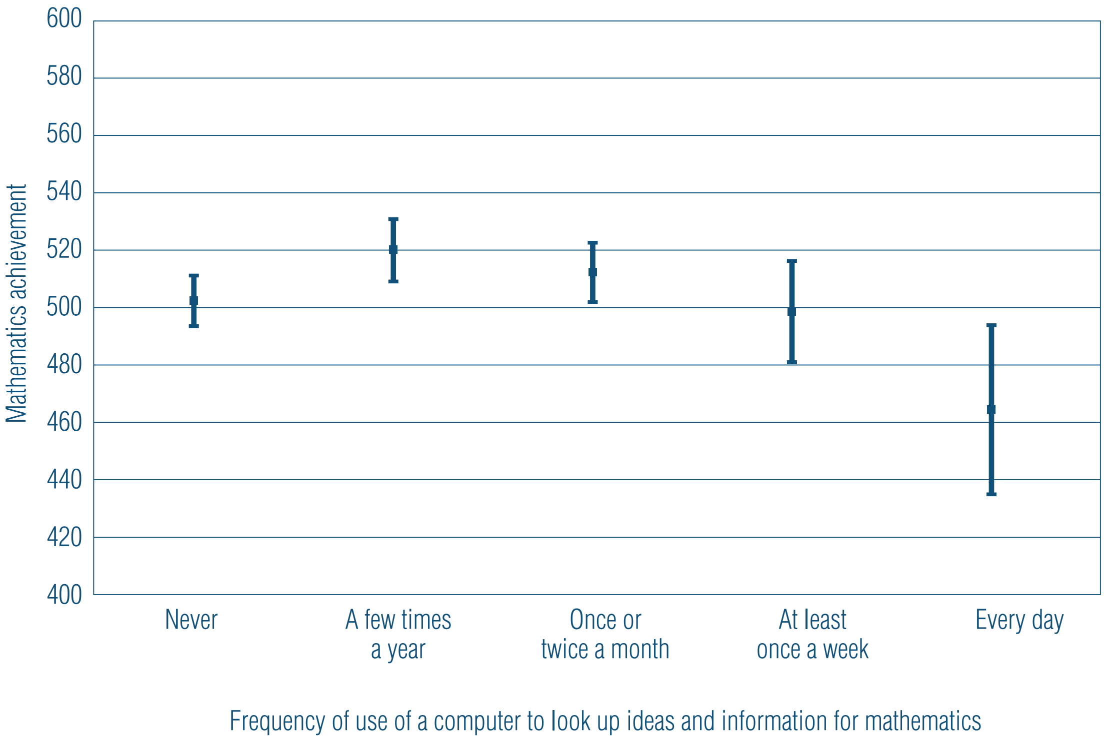


Figure 4.15 Year 8 mathematics achievement by use of computers to look up ideas and information for mathematics

Attitudes towards learning mathematics

Students were also asked a series of questions about how they felt about learning mathematics. These items consisted of questions oriented to the students' self-confidence in learning mathematics and also questions about how the students value mathematics. Those questions that focussed on the future (such as jobs or future study) were only asked of Year 8 students. Table 4.9 lists the statements and their correlation with mathematics achievement for Australian students. This table shows that the statements most strongly correlated with mathematics achievement are those about self-confidence in learning mathematics for both year levels. Of the valuing mathematics statements, enjoyment in learning mathematics has one of the higher correlations with mathematics achievement, as does wanting a job that uses mathematics (Year 8 students only).

Self-confidence in learning mathematics

The four statements about self-confidence in learning mathematics were combined (some having been reversed first) to form an index of students' self-confidence in learning mathematics. Students who agreed a little or a lot with all four statements were assigned to the high level of the index, while students who disagreed a little or a lot with all four were assigned to the low level. The medium level includes all other possible combinations of responses.

Internationally, 40 per cent of Year 8 students had high self-confidence in learning mathematics. The percentages ranged from 17 per cent in Japan to 59 per cent in Israel. At Year 4, the level of self-confidence was higher than at Year 8, with, on average, 55 per cent of students reporting high self-confidence in learning mathematics. The Year 4 percentages ranged from 34 per cent in the Philippines through to 77 per cent in Slovenia. Australian students had relatively high self-confidence, with 64 per cent of Year 4 students and 50 per cent of Year 8 students at the high level of the index. Interestingly, most of the top five countries in terms of mathematics achievement had relatively low percentages of students with high self-confidence in learning mathematics. Since these are all Asian Pacific countries, it may be that they share cultural traditions that encourage modest self-confidence.

Figures 4.16 and 4.17 show the percentages of Australian males and females at each level of the index. They show that, in Australia at least, males have higher levels of self-confidence in learning mathematics than females. At both year levels, the gender differences are significant for both the high and medium levels of the index.

While between countries there does not appear to be a clear relationship between self-confidence in learning mathematics and mathematics achievement, within countries and internationally as a whole, a positive relationship is apparent. Figure 4.18 shows the relationship between self-confidence in learning mathematics and mathematics achievement for Australian students. The index of self-confidence in learning mathematics has a strong positive association with mathematics achievement (a correlation of 0.36 at Year 4 and 0.45 at Year 8) – students with high self-confidence in learning mathematics have higher mathematics achievement than students with low self-confidence.

Table 4.9 Correlations of student attitudes with mathematics achievement

Statements about mathematics	Year 4	Year 8
Self-confidence in learning mathematics		
I usually do well in mathematics	0.34	0.40
Mathematics is more difficult/harder for me than for my classmates	–0.34	–0.36
Mathematics is not one of my strengths/I am just not good at mathematics	–0.35	–0.45
I learn things quickly in mathematics	0.25	0.39
Valuing mathematics		
I would like to take/do more mathematics in school	0.06	0.16
I enjoy learning mathematics	0.15	0.21
I think learning mathematics will help me in my daily life	-	0.04
I need mathematics to learn other school subjects	-	0.08
I need to do well in mathematics to get into the post-school course of my choice	-	0.11
I would like a job that involved using mathematics	-	0.20
I need to do well in mathematics to get the job I want	-	0.05

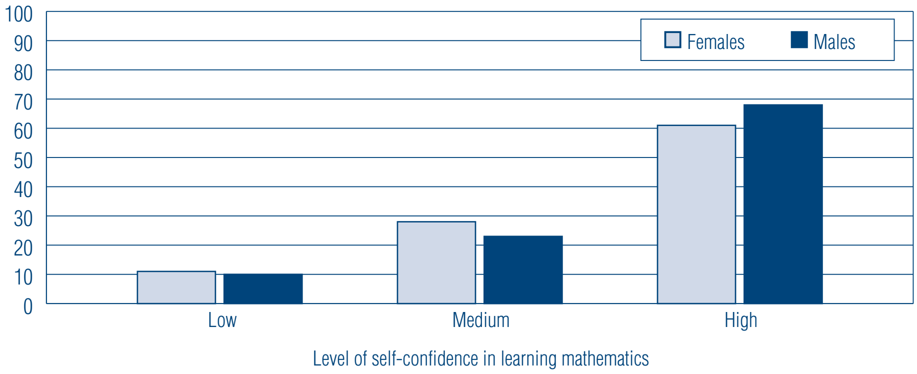


Figure 4.16 Percentage of Year 4 females and males reporting high, medium and low levels of self-confidence in learning mathematics

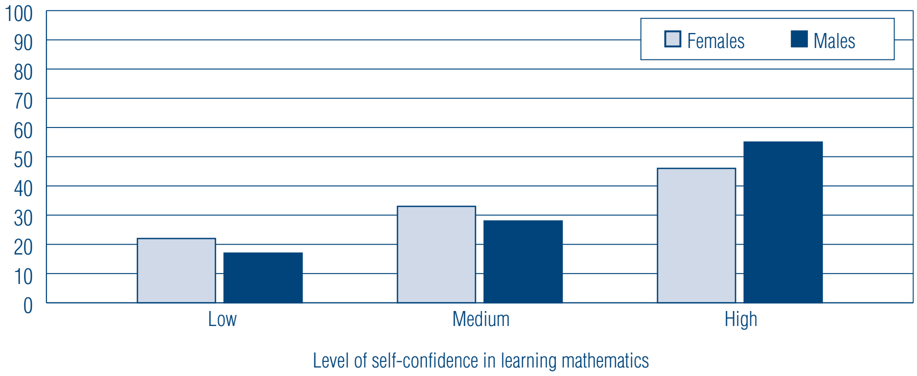


Figure 4.17 Percentage of Year 8 females and males reporting high, medium and low levels of self-confidence in learning mathematics

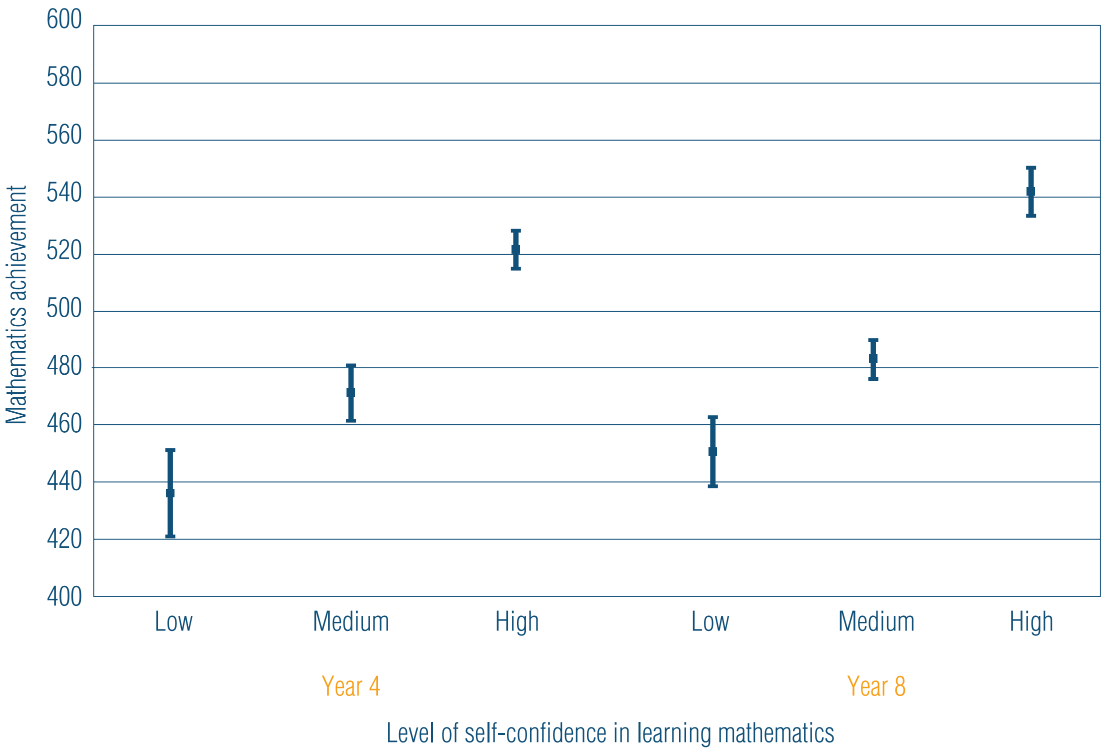


Figure 4.18 Year 4 and Year 8 mathematics achievement by level of self-confidence in learning mathematics

Table 4.10 **Enjoyment of learning mathematics – percentage of males and females by response category**

I enjoy learning mathematics	Year 4		Year 8	
	Females	Males	Females	Males
Agree a lot	48	56	17	20
Agree a little	30	25	38	40
Disagree	22	19	45	40

Enjoyment of mathematics

As one of the questions asked at both year levels in TIMSS 1994/95 and 2002/03 we are able to explore changes over time in attitudes to learning mathematics by focussing on student responses to the statement 'I enjoy learning mathematics'.

The degree to which students enjoy learning mathematics has some association with mathematics achievement (a correlation of 0.15 at Year 4 and 0.21 at Year 8). In Australia, there are more Year 4 students who agree that they enjoy learning mathematics a lot or a little (79%) than Year 8 students who agree a lot or a little (57%). Males also appear to enjoy learning mathematics more than females. Table 4.10 shows the percentages of females and males giving each response (agree a lot, agree a little, disagree) to the statement 'I enjoy learning mathematics'.

Internationally, the average percentage of students agreeing a lot that they enjoy learning mathematics has increased since 1994/95, from 46 per cent to 50 per cent at Year 4 and from 17 per cent to 29 per cent at Year 8. Australia was one of a small number of countries (including Singapore, New Zealand and the United States of America, amongst others) that showed a significant increase, at both Years 4 and 8, in the percentage of students who agreed a lot that they enjoy learning mathematics. Figures 4.19 and 4.20 show the Australian students' responses to the statement 'I enjoy learning mathematics' in TIMSS 1994/95 and TIMSS 2002/03.

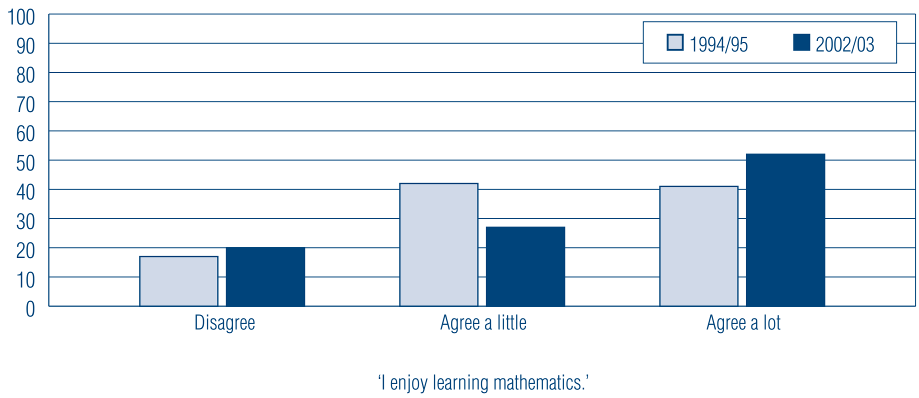


Figure 4.19 Year 4 student responses to 'I enjoy learning mathematics' in 1994/95 and 2002/03

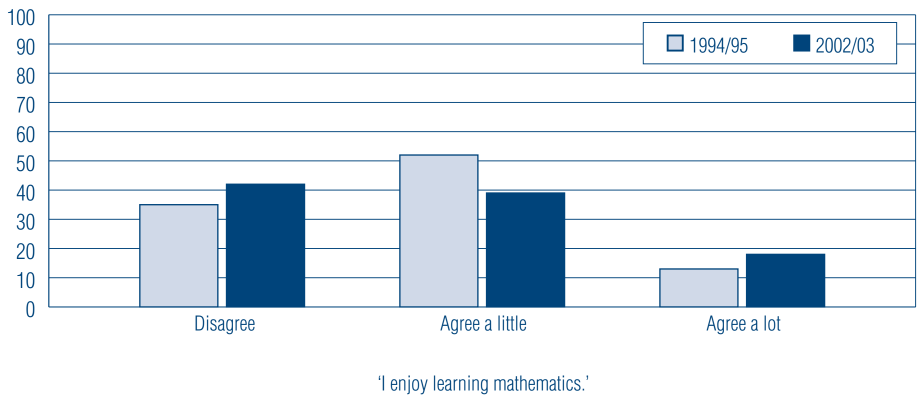


Figure 4.20 Year 8 student responses to 'I enjoy learning mathematics' in 1994/95 and 2002/03

Valuing mathematics

The seven statements about valuing mathematics were combined to form an index of students' valuing mathematics for Year 8 students. Students who agreed a little or agreed a lot with all seven statements were assigned to the high level of the index, while students who disagreed a little or disagreed a lot with all seven were assigned to the low level. The medium level includes all other possible combinations of responses.

Internationally, 55 per cent of Year 8 students were in the high category, 35 per cent in the medium category and only 10 per cent in the low category. This suggests that students generally place a high value on mathematics. However, in some countries (Morocco, Botswana, Ghana, Egypt and Jordan) over 80 per cent of students place a high value on mathematics, whereas others (Korea, Japan and the Netherlands) have fewer than 20 per cent of students in the high category.

Australian Year 8 students generally value mathematics – about half put a high value on mathematics, a third a medium value and about 10 per cent are in the low category. As Figure 4.21 shows, in Australia, valuing mathematics is positively related to mathematics achievement (a correlation of 0.15). As with the index of self-confidence in learning mathematics, between countries there does not appear to be a clear relationship between valuing mathematics and mathematics achievement. However within countries and internationally as a whole a positive relationship is apparent.

Of the statements that make up the index of students valuing mathematics, the statements 'I enjoy learning mathematics' and 'I would like a job that involved using mathematics' had the strongest correlation with achievement for Australian students. Students' responses to 'I enjoy learning mathematics' have been discussed in the previous section. Figure 4.22 shows the relationship between mathematics achievement and students' agreement with the statement 'I would like a job that involved using mathematics'. Fourteen per cent of Australian Year 8 students agreed a lot that they would like a job that involved using mathematics, 34 per cent agreed a little, 29 per cent disagreed a little and 23 per cent disagreed a lot. There was no difference in average mathematics achievement between those who agreed a lot and those who agreed a little. The pattern seen in Figure 4.22 is similar to that seen in TIMSS 1994/95 (Lokan, et al., 1996).

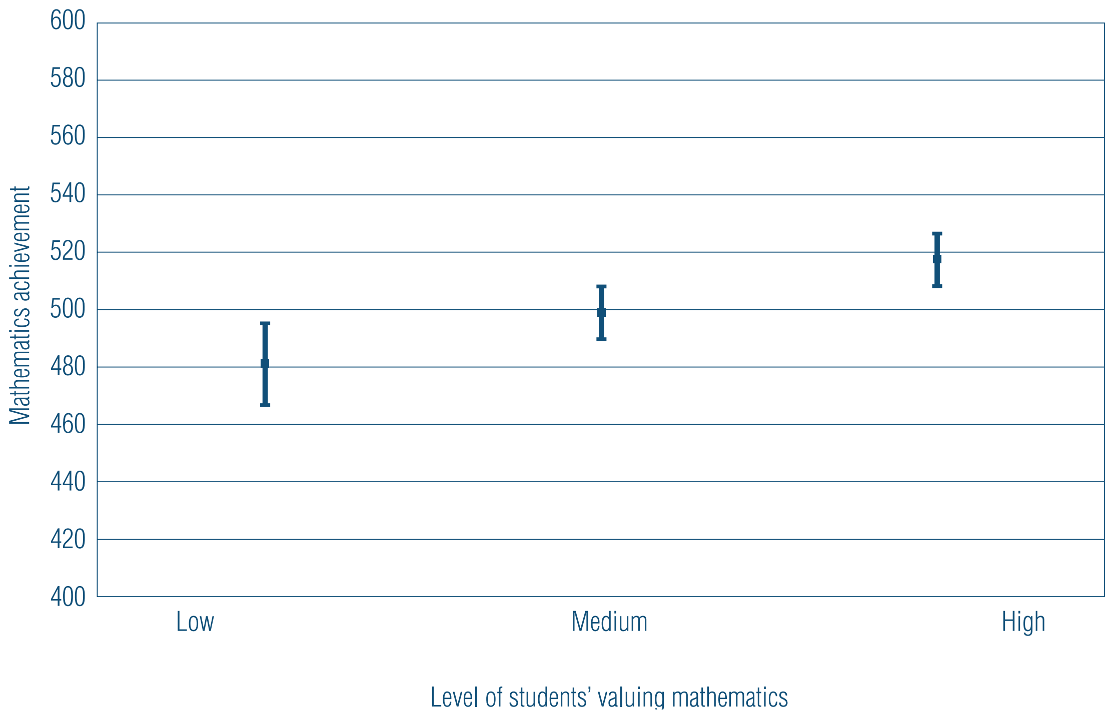


Figure 4.21 Year 8 mathematics achievement by level of students' valuing mathematics

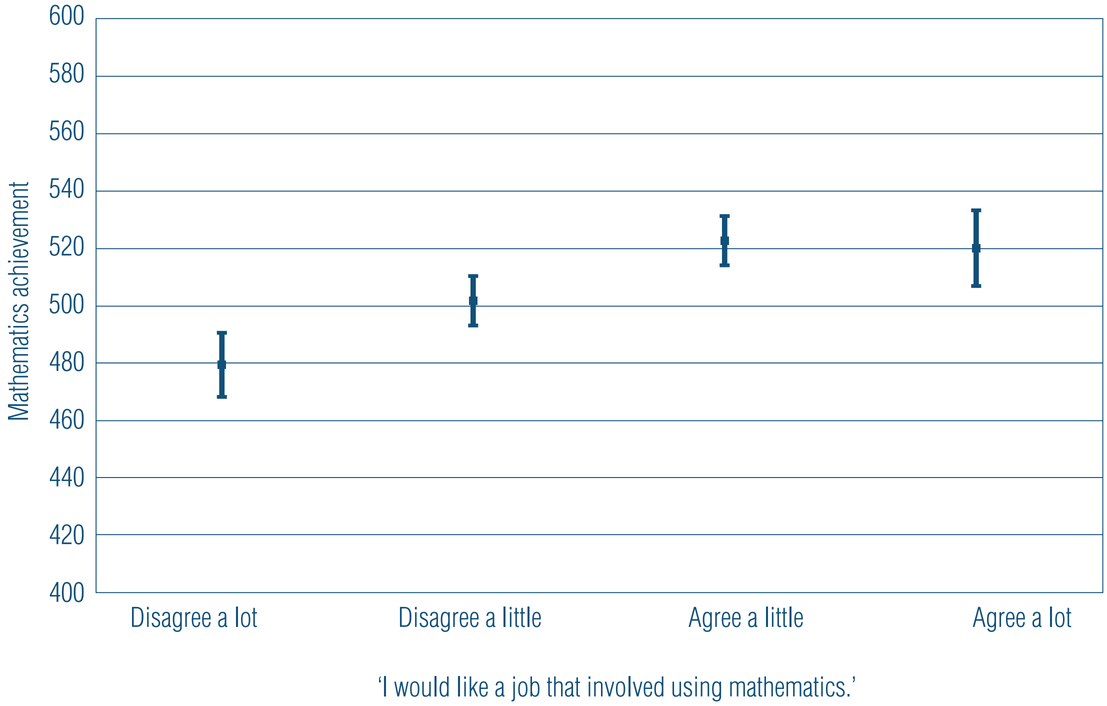


Figure 4.22 Year 8 mathematics achievement by desiring a job that involves using mathematics

Educational aspirations

Students in Year 8 were also asked about how far they expected to go in school and further education. Internationally, 54 per cent of Year 8 students reported that they expected to finish university. This is higher than the expectations of Australian Year 8 students – only about 40 per cent of Australian Year 8 students expect to complete university or higher. Table 4.11 shows the educational aspirations of Year 8 males and females in Australia.

Internationally it was found that those students who expected to finish university had substantially higher average mathematics achievement than those without university expectations. This pattern was also found in Australia. Figure 4.23 shows the positive relationship between educational aspirations and mathematics achievement (a correlation of 0.28) for Australian students.

Table 4.11 Percentage of Year 8 students by educational aspirations and gender

	Not finish secondary school	Finish secondary school or apprenticeship	TAFE or college diploma or certificate	Bachelor's degree	Post-graduate degree	I don't know
Females	2	14	30	21	19	15
Males	4	18	26	15	22	17

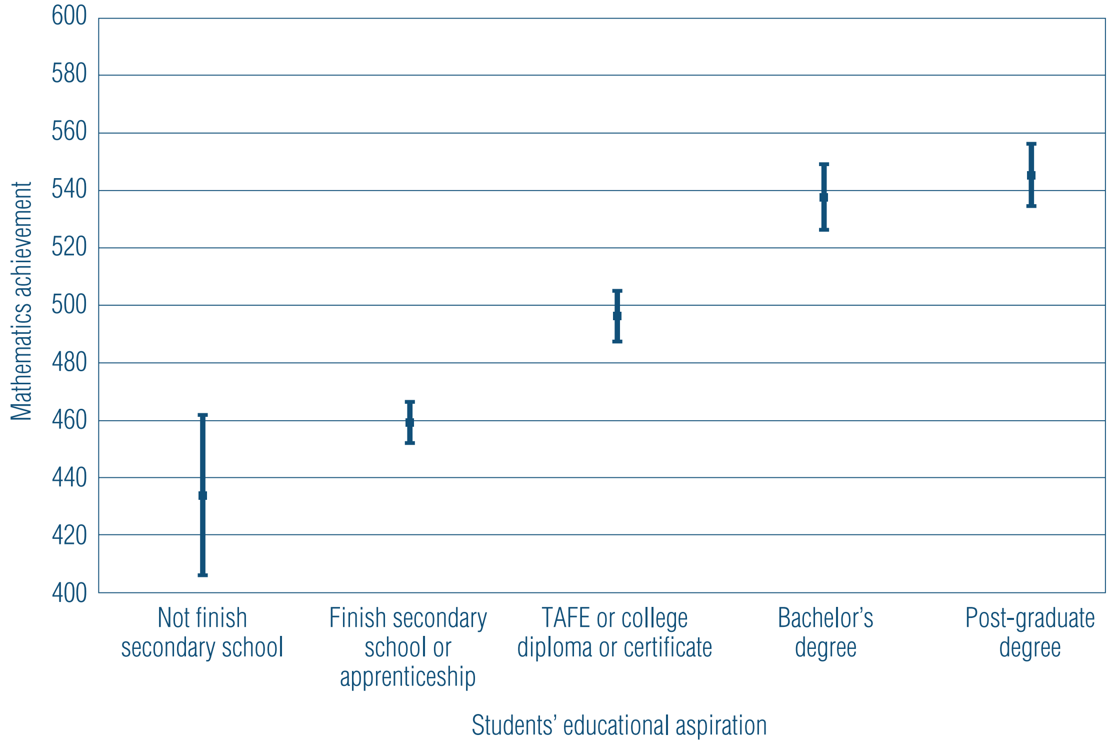


Figure 4.23 Year 8 mathematics achievement by educational aspirations

Summary

This chapter has described the characteristics of the Australian Year 4 and Year 8 student populations, and has explored the relationships between these characteristics and achievement in mathematics.

Year 8 students were asked the highest level of education reached by their mother and father. The highest of these was used as the parental education variable, and achievement in mathematics was found to be higher for students whose parents had completed a university degree or higher. An index of home educational resources was also created, which combined parents' education, number of books in the home, and the presence of study aids (a desk, a dictionary and a computer), and three categories (high, medium and low) of students were defined. There was a clear relationship found between this index and achievement in mathematics. At Year 4, parents' educational level was not determined; however there was a clear and strong relationship between books in the home and achievement in mathematics.

The scores of Indigenous students at both year levels was significantly lower than those of non-Indigenous students. For Year 4 students the difference between the scores of the two groups was slightly larger than in TIMSS 1994/95. However, for Year 8 students the difference between the scores of the two groups was slightly smaller than in TIMSS 1994/95. These differences will be explored in a follow-up report on Indigenous students.

The relationship between mathematics achievement and language background was not clear. At Year 4 there were no apparent differences between the groups, while for Year 8, students whose family background was from a non-English speaking country, but who spoke English at home, performed significantly better than those in the other two categories.

As well as student background characteristics, student attitudes towards learning mathematics were examined. Australian students generally reported quite high levels of self-confidence in mathematics, and self-confidence in mathematics was significantly higher for males than females at both Year 4 and Year 8. There was a clear positive relationship between level of self-confidence and achievement in mathematics.

Enjoyment of mathematics is an important outcome in itself. Australia was one of a small number of countries that showed a significant increase at both year levels in the percentage of students who agreed 'a lot' that they enjoy learning mathematics.

There was a wide range of student background factors, aspirations, out-of school activities and attitudes towards learning mathematics that were investigated and reported in this chapter, along with their relationships with mathematics achievement. The next chapter examines the contexts of their learning; the teachers who teach them and the schools in which they learn. Finally, a multilevel analysis is presented that draws together student, class and school factors that influence achievement in an 'other things equal' analysis.

Chapter 5
The contexts of learning mathematics in Australia: TIMSS schools and teachers

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The contexts of learning mathematics in Australia: TIMSS schools and teachers

This chapter examines the context for TIMSS students' learning – the schools that they attended and the teachers who were teaching them at the time of the testing. The aim of this examination is to describe those variables that are most likely to have an impact on or be associated in some way with achievement. Factors such as school environment, teachers' pedagogical practices, and teacher preparation are all variables that have been shown in TIMSS and other studies to be related to student achievement.

The chapter draws on data collected for TIMSS 2002/03 through questionnaires completed by teachers and principals. The unit for sampling of students within schools was their mathematics class, so that one mathematics teacher[1] per school was asked to complete a questionnaire. The mathematics teachers' responses to the questionnaire were not necessarily representative of those of Australian mathematics teachers, as these teachers were simply the teachers of a representative sample of students assessed as part of TIMSS 2002/03. The school questionnaires, however, should be representative of Australian schools as a whole because of the way the sampling was done. The information in this chapter should be thought of as indicative, and is provided for the purposes of setting achievement in context.

Just as the mathematics and science frameworks for TIMSS describe what should be assessed in those areas, the contextual framework identifies the major characteristics of the educational and social context that will be studied with a view to improving student learning. These major characteristics for the TIMSS 2002/03 study were:

Teachers and their preparation

- Academic Preparation and Certification
- Teacher Recruitment
- Teacher Assignment
- Teacher Induction
- Teacher Experience
- Teaching Styles
- Professional Development

Classroom activities and characteristics

- Curriculum Topics Taught
- Time
- Homework
- Assessment
- Classroom Climate
- Information Technology
- Calculator Use
- Emphasis on Investigation
- Class Size

The schools

- School Organisation
- School Goals
- Roles of the School Principal
- Resources to Support Mathematics and Science Learning
- Parental Involvement
- Disciplinary Environment of the School

[1] At Year 4, the unit of sampling was the Year 4 class, which in most cases was also the mathematics class. Year 4 class teachers completed a general questionnaire, which included mathematics specific questions. Where 'mathematics teachers' are referred to, this means the class teacher at the Year 4 level.

This chapter provides a broad overview of each aspect of this framework. In Australia, responses were obtained from 91 per cent of the teachers and 98 per cent of the schools of the Year 4 students, and for 83 per cent of the teachers and 91 per cent of the schools of the Year 8 students.

Australian mathematics teachers and their preparation for teaching

Age and gender

Nationally, three-quarters of Year 4 students were taught by women, and the majority were taught by teachers in the 40-49 year age group. This is around the same proportion as in TIMSS 1994/95, where 72 per cent of Year 4 teachers were women. Table 5.1 shows the gender distribution for Year 4 and Year 8 mathematics teachers by state. Table 5.2 and Table 5.3 show the age distribution by state for Year 4 teachers and Year 8 teachers respectively.

Internationally most Year 4 students were taught by women. The international average is 80 per cent female teachers at Year 4. In two countries, however, most Year 4 students were taught by men. These countries were Morocco (36% female teachers), and Tunisia (46% female teachers). In Japan and Iran, a relatively high proportion (37% and 49% respectively) of Year 4 students had male teachers, while in Italy, Latvia, Lithuania, Moldova, the Russian Federation and Slovenia, more than 95 per cent of Year 4 students were taught by women.

In Australia, in all states other than South Australia (where 63 per cent of teachers were women) more than 70 per cent of Year 4 students were taught by women.

The picture for mathematics teachers at Year 8 is somewhat different. In TIMSS 1994/95, 58 per cent of mathematics teachers were male and 42 per cent female; in TIMSS 2002/03 the national average was almost equal proportions – 49 per cent of students were taught by female teachers and 51 per cent by males. Internationally, however, Year 8 students are taught more often by women than men. In two states of Australia; Queensland and the ACT, this was also the case, with around two thirds of students taught by female teachers, while in South Australia and Western Australia, the situation was reversed, with almost two-thirds of Year 8 students taught by male teachers.

On average, Australian Year 4 teachers had almost 17 years teaching experience, and Year 8 mathematics teachers around 16 years experience. Both of these figures were very similar to the international average.

Given these years of experience, it follows that most students were taught mathematics by teachers in their 30s and 40s. This is certainly the case both in Australia and internationally, where 60 per cent of both Year 4 and Year 8 students were taught by teachers aged between 30 and 49 years of age.

If there were a regular replenishment of trained teachers, one would expect that there would be approximately equivalent percentages of students taught by teachers in each age group. Very few countries, however, had a young teaching force. At Year 4 in Singapore, four in ten students were taught by teachers in their twenties, while at Year 8 in Botswana, Ghana, the Palestinian National

Table 5.1 Percentages of Year 4 and Year 8 mathematics teachers by gender and state

State	Year 4			Year 8		
	N of teachers	% of students taught by a female teacher	% of students taught by a male teacher	*N* of teachers	% of students taught by a female teacher	% of students taught by a male teacher
NSW	55	81 (9.3)	19(9.3)	42	43 (9.2)	57 (9.2)
VIC	39	75 (7.0)	25 (7.0)	38	50 (9.5)	50 (9.5)
QLD	38	73 (8.2)	27 (8.2)	40	64 (11.0)	36 (11.0)
SA	41	63 (10.8)	37 (10.8)	30	36 (10.3)	64 (10.3)
WA	32	70 (8.8)	30 (8.8)	26	40 (9.9)	60 (9.9)
TAS	29	79 (9.5)	21 (9.5)	31	54 (12.7)	46 (12.7)
NT	22	81 (13.4)	19 (13.4)	11	53 (10.2)	47 (10.2)
ACT	16	73 (13.8)	27 (13.8)	16	69 (17.4)	31 (17.4)
Australia	272	75 (4.2)	25 (4.2)	234	49 (4.7)	51 (4.7)
International average		*80 (0.6)*	*20 (0.6)*		*58 (0.5)*	*42 (0.5)*

Table 5.2 Percentages of Year 4 mathematics teachers by age and state

State	Under 30	30–39	40–49	50 or older
NSW	21(6.2)	9 (3.6)	65 (8.7)	5 (2.5)
VIC	26 (9.1)	10 (6.1)	34 (9.8)	29 (9.1)
QLD	17 (8.2)	29 (6.5)	29 (7.8)	26 (7.0)
SA	14 (6.3)	16 (8.1)	47 (7.8)	23 (8.1)
WA	22 (8.4)	13 (3.7)	36 (7.3)	28 (8.7)
TAS	29 (10.4)	0 (0)	29 (9.9)	32 (9.2)
NT	17 (10.2)	44 (14. 7)	38 (14.3)	0 (0)
ACT	0 (0)	32 (9.5)	34 (12.7)	34 (11. 6)
Australia	21 (3.5)	14 (2.4)	46 (4.4)	19 (3.0)
International average	*19 (0.6)*	*31 (0.7)*	*29 (0.7)*	*21 (0.7)*

Authority, Saudi Arabia and Singapore, more than four in ten teachers at Year 8 were under 29 years of age. One in five Australian Year 4 students, and a little more than one in ten Year 8 students, had teachers in their twenties. The proportion of students being taught by teachers who were less than 30 years of age has remained about the same since TIMSS 1994/95 for Year 4 students, whilst it is about double that of TIMSS 1994/95 for Year 8 students.

At the other end of the age distribution, around one in five Year 4 students internationally and in Australia, and around one-quarter of Year 8 students were taught by teachers aged 50 or older. At Year 8 level, more than half of the students in Italy, Moldova, and Serbia, had teachers at last 50 years of age.

In Australia, Year 4 students in Tasmania had the largest proportion of teachers under 30, although almost two-thirds of students were taught by teachers in their forties and fifties. Around half of the Year 8 students in Queensland, South Australia and the Northern Territory had teachers in their twenties or thirties.

Qualifications and training

Almost all (91% of Year 4 teachers and 89% of Year 8 teachers) Australian mathematics teachers have full certification to teach, rather than provisional or emergency certification. This high level of certification of teachers was fairly common internationally, although in a large number of countries the level of full certification was higher than in Australia at both Year 4 and Year 8. In Singapore, for example, 97 per cent of both Year 4 and Year 8 teachers surveyed, were fully certificated.

Table 5.4 presents the highest educational level attained by Australian Year 4 and Year 8 mathematics teachers. Between one-fifth and one-quarter of Year 4 students in Australia were taught by teachers with some form of post-secondary education that was not university. For most of these teachers, this would be in the form of teachers' college training, and it is the older teachers who have this form of qualification. For the younger teachers, a university degree is the minimum qualification for being a teacher in Australia.

Table 5.3 Percentages of Year 8 mathematics teachers by age and state

State	Under 30	30–39	40–49	50 or older
NSW	5 (3.4)	30 (10.6)	43 (11.2)	22 (7.6)
VIC	19 (6.2)	18 (6.9)	29 (8.0)	34 (8.0)
QLD	22 (7.6)	29 (8.0)	40 (10.9)	9 (5.3)
SA	23 (7.9)	23 (8.0)	23 (9.6)	31 (9.7)
WA	5 (4.3)	30 (12.6)	47 (11.8)	19 (7.0)
TAS	15 (7.7)	18 (5.5)	46 (11.2)	22 (12.3)
NT	16 (15.7)	54 (23.0)	19 (14.3)	11 (9.6)
ACT	11 (11.1)	14 (10.8)	37 (12.3)	39 (17.0)
Australia	13 (2.6)	26 (4.4)	37 (5.1)	24 (3.7)
International average	*17 (0.4)*	*30 (0.6)*	*30 (0.6)*	*23 (0.5)*

Table 5.4 Percentage of Year 4 and Year 8 mathematics teachers by highest educational level

	Finished post-secondary education but not university	Finished university or equivalent	Beyond initial university degree
Year 4 teachers			
Females	24 (4.1)	52 (4.6)	23 (3.7)
Males	22 (7.4)	40 (8.9)	38 (10.3)
Australia	24 (3.4)	49 (4.4)	27 (4.1)
International average	*22 (0.5)*	*52 (0.7)*	*13 (0.4)*
Year 8 mathematics teachers			
Females	6 (2.7)	46 (5.8)	48 (5.6)
Males	7 (3.5)	40 (6.1)	52 (6.4)
Australia	7 (2.2)	43 (4.1)	50 (4.0)
International average	*20 (0.3)*	*59 (0.5)*	*17 (0.4)*

Table 5.4 shows that the Australian mathematics teaching force is well educated in comparison to the international average. Internationally, 13 per cent of Year 4 teachers have postgraduate qualifications; for Australian teachers the average is more than twice this, at 27 per cent. For Year 8 mathematics teachers, the international average is 17 per cent, and the Australian figure is almost three times this, with half of Australian mathematics teachers having postgraduate qualifications: postgraduate diploma, honours, masters or doctorate. However, 40 per cent of this is postgraduate diplomas, which in many cases is the adjunct to an initial Bachelor's degree that is required to become a teacher.

At both year levels it was more commonly men who held the higher qualifications, and this difference was particularly pronounced at the Year 4 level. An interesting note is that only three per cent of Year 4 teachers and five per cent of Year 8 teachers in Singapore held any form of postgraduate qualification. At the eighth grade, more than half of the students in Armenia, Australia, Bulgaria, the Russian Federation, Tunisia and the United States of America were taught by teachers having qualifications beyond their initial university degree, while in contrast, 72 per cent of students in Morocco were taught by teachers who had only completed secondary school.

Most teachers (72%) of Year 4 in Australia described the major area of study in their post-secondary education as primary education without a major specialisation in either mathematics or science. This is true of many countries; similar proportions of generalist teachers teach Year 4 in most Western countries. In Iran, Moldova, the Russian Federation and Singapore, around half of the students in Year 4 are taught by teachers with primary education training but with a major or specialisation in mathematics, and in Armenia, 86 per cent of Year 4 students are taught by teachers with a mathematics or science major but with no substantial primary teaching education.

Mathematics teaching at Year 8 requires well-trained teachers with a sound knowledge of their subject matter as well as teaching skills. Bodies such as the Australian Association of Mathematics Teachers (AAMT) have warned of problems associated with increased use of teachers in mathematics and science who do not have adequate knowledge of the subject area (for example Thornton, 2002). According to the responses from the Australian mathematics teachers of the TIMSS students, 58 per cent had education-mathematics as their major area of study, and 61 per cent had mathematics as their major area of study[2]. Some 30 per cent of mathematics teachers at Year 8 level did not have either mathematics or education-mathematics as their major area of study, however 13 per cent had neither mathematics nor science as their major field of study. This proportion is of some concern, and warrants further investigation.

[2] Teachers of Year 8 students answering the survey could indicate more than one area of specialisation, and so categories of education at this level are not mutually exclusive.

Readiness to teach

The TIMSS questionnaires asked teachers how ready they felt to teach the mathematics topics in the TIMSS 2002/03 mathematics framework. For most of the framework areas, all teachers at both Year 4 and Year 8 reported that they were ready to teach the topic. The lowest agreement with this was 95 per cent for the Year 4 areas of translation, reflection and rotation (*geometry*), and for the Year 8 area of sources of error in collecting and organising data (*data*).

Formal professional development

As well as having had opportunities to develop pedagogical expertise in their subject areas before they start to teach, it is important that teachers be provided with opportunities to continue to develop their expertise once they begin to teach. Teachers responding to the TIMSS surveys were asked to indicate the extent of opportunities for and participation in professional development activities. Of the Australian teachers surveyed, 85 per cent of Year 4 teachers and 90 per cent of Year 8 teachers had participated in professional development of some form during the previous two years. The area of professional development in which these teachers participated is summarised in Table 5.5. Of course teachers' participation in the particular areas of professional development is predicated on what is offered to them. As shown by the differences between the Australian and international averages, Australian teachers participate in professional development to a greater extent than in many other TIMSS countries.

Professional development in mathematics for Australian teachers of Year 4 students was mainly in the area of mathematics content, mathematics curriculum, improving critical thinking or problem solving skills and mathematics pedagogy or instruction. Professional development aimed at integrating information technology into mathematics was only undertaken by a little more than one-third of Year 4 teachers. This was similar to the pattern internationally, with slightly more emphasis on content and curriculum in relation to other areas in Australia than internationally.

For Australian mathematics teachers teaching Year 8 students, professional development is mainly in the areas of mathematics curriculum and integrating information technology into mathematics. This is quite a different pattern than seen in the international data, where the major areas of involvement in professional development were mathematics content and pedagogy. Professional development in the area of improving students' critical thinking and problem solving skills had the lowest participation amongst Year 8 teachers.

Principals were also asked about the opportunities for professional development for their staff. Their responses to these items are presented in Table 5.6. Internationally, at both year levels, schools reported that their professional development programs emphasised improving content knowledge and teaching skills. In Australia, however, the three main areas for professional development for both year levels were: designing and supporting the school's own improvement goals, improving teaching skills and integrating information and communication technology into education.

Table 5.5 Participation in areas of professional development for Year 4 and Year 8 mathematics teachers, Australia and internationally

Area of professional development	Year 4 teachers (%)		Year 8 teachers (%)	
	Australia	International average	Australia	International average
Mathematics content	63	46	68	57
Mathematics pedagogy/instruction	57	47	56	57
Mathematics curriculum	58	41	71	52
Integrating information technology into mathematics	36	33	70	43
Improving students' critical thinking or problem solving skills	57	46	47	47
Mathematics assessment	53	41	57	49

Table 5.6 **Professional development opportunities for Year 4 and Year 8 mathematics teachers**

	Supporting the implementation of the state curriculum (%)	Designing or supporting the school's own improvement goals (%)	Improving content knowledge (%)	Improving teaching skills (%)	Using information and communication technology for educational purposes (%)
Year 4					
3 or more times a year	43	46	40	44	48
1–2 times a year	34	38	37	42	39
Never	23	16	23	14	13
Year 8					
3 or more times a year	48	60	40	50	46
1–2 times a year	38	35	48	47	50
Never	14	4	12	3	4

Informal professional development

As well as participating in formal professional development sessions, a great deal of informal professional development is conducted within a school – talking to other staff about teaching strategies, preparing instructional materials, and observing others teach. Teachers were asked how often they interacted with their colleagues in such a manner.

About 50 per cent of Australian teachers at both year levels interact with their colleagues on at least a weekly basis in order to discuss the teaching of a particular concept or topic. Only about ten per cent of teachers answered that they never or almost never spent time with their colleagues on such activities.

Again, a little more than half of both Year 4 and Year 8 teachers interacted with their colleagues on at least a weekly basis to prepare instructional materials for their students. A further 40 per cent of Year 8 teachers spent some time (but not on a weekly basis) with their colleagues in such a manner, compared to about 30 per cent of Year 4 teachers.

Another important part of informal professional development is observation of other teachers, and having other teachers observe and critique your own classes. TIMSS teachers were asked about the frequency with which other teachers informally observed their teaching. Most Australian teachers said that this occurred on a very infrequent basis, however it was more common for this to occur amongst Year 4 than Year 8 teachers. Observations of another's classroom was also infrequent, with almost 90 per cent of Year 8 teachers and 70 per cent of Year 4 teachers saying that they rarely did this, but about one third of Year 4 teachers and 15 per cent of Year 8 teachers said that they did do so on at least a monthly basis.

Classroom activities and characteristics

It is largely teachers and their practices that determine the implemented curriculum – the mathematics that students are taught in their classrooms. The previous section of this chapter has examined the background of the mathematics teachers in this study; this section examines classroom practices.

Factors limiting instruction in mathematics

At Year 8 only, teachers were asked about the instructional impact of six characteristics of their students on a four-point scale – ranging from 'not at all' to 'a lot'. These six characteristics were:

- differing academic abilities,
- range in backgrounds,
- students with special needs,
- uninterested students,
- low morale, and
- disruptive students.

Teachers' responses were combined into an index called *Teaching mathematics classes with few or no limitations on instruction due to student factors*, which is abbreviated MCFL. Students were placed into one of three categories based on the level of impact on their classrooms. Students were placed in the high category if, on average, their teachers reported 'not at all' or 'a little'; in the low category if on average their teachers reported 'some' or 'a lot'; and into an 'average' category in all other

Table 5.7 Teachers' perceptions of factors limiting instruction in Year 8 mathematics by state

State	High MCFL		Medium MCFL		Low MCFL	
	% of students	Average achievement	% of students	Average achievement	% of students	Average achievement
NSW	46 (0.1)	566 (12.6)	41(0.1)	515 (18.2)	14 (0.1)	451 (46.0)
VIC	37(0.1)	518 (10.7)	44 (0.1)	493 (9.3)	19 (0.1)	453 (12.7)
QLD	44 (0.1)	523 (9.3)	42 (0.1)	473 (10.3)	14 (0.0)	450 (19.0)
SA	35 (0.1)	550 (22.5)	51 (0.1)	508 (11.3)	14 (0.1)	419 (8.7)
WA	40 (0.1)	518 (11.9)	39 (0.1)	490 (11.5)	22 (0.1)	452 (17.3)
TAS	56 (0.1)	503 (12.0)	17(0.0)	461 (4.4)	27(0.1)	433 (17.6)
NT	2 (0.0)	488 (18.2)	60 (0.2)	460 (19.9)	38 (0.2)	424 (13.4)
ACT	71 (0.1)	506 (13.2)	21 (0.1)	524 (16.5)	8 (0.0)	423 (7.9)
Australia	42 (4.1)	538 (6.0)	42 (4.4)	497 (7.5)	16 (3.2)	448 (13.4)
International average	*40 (0.6)*	*480 (1.1)*	*41 (0.6)*	*460 (0.9)*	*20 (0.5)*	*449 (1.5)*

cases. That is, a high value on the MCFL index means that a classroom is relatively unaffected by these values and a low value indicates that these factors have a large impact on a classroom.

Internationally, it is clear that there is a relationship between these factors and achievement in mathematics. Average mathematics achievement is lower in classrooms with more instructionally challenging and diverse students. On average, internationally, one-fifth of students are in such classrooms, and this figure ranges from zero in Lithuania and one per cent in Bahrain to 44 per cent in Cyprus and Morocco. In Australia there are 16 per cent of classrooms in which instruction is hampered by factors such as these, compared to the United States of America in which there were 19 per cent, New Zealand with 21 per cent, Singapore with 24 per cent, and England with just six per cent.

Within Australia there is as much variation as there is internationally. The index is shown for each state in Table 5.7. Also shown is the proportion of students in each of the three categories, and their average achievement score. While there is a cluster of states around the Australian average for the percentage of students in the High MCFL category, the Australian Capital Territory and the Northern Territory stand out as very different from each other and the rest of Australia. Given that the number of mathematics teachers surveyed in each of the Territories was small, these results should be treated with some caution, and the caveat about these results not being representative of all teachers should be noted.

According to their teachers, 71 per cent of classes in the Australian Capital Territory are barely affected by these issues. However only two per cent of the teachers in the Northern Territory make the same assertion, and almost four in ten students attend classes that are seriously affected by such issues.

Table 5.8 Teachers' perceptions of individual factors limiting Year 8 mathematics instruction by state (% of teachers)*

	Different academic abilities		Range of backgrounds		Students with special needs		Uninterested students		Low morale amongst students		Disruptive students	
	None – a little	Some – a lot	None – a little	Some – a lot	None – a little	Some – a lot	None – a little	Some – a lot	None – a little	Some – a lot	None – a little	Some – a lot
NSW	38	54	59	31	66	10	50	47	61	34	49	46
VIC	24	76	54	33	65	21	51	49	63	33	62	38
QLD	38	60	70	25	63	17	41	52	74	20	51	43
SA	27	73	58	28	69	10	46	54	39	38	62	30
WA	36	64	76	19	58	15	36	64	52	44	42	58
TAS	61	40	51	24	56	22	52	48	69	29	56	44
NT	15	85	35	65	59	10	2	98	24	54	6	95
ACT	59	34	84	11	45	16	73	27	67	19	82	18

*Pairs of cells do not add to 100 as the response category 'Not applicable' is not reported in this table

The responses on the individual items of this index are of some interest insofar as they impact on policy considerations for these states. The responses to the individual items can be seen in Table 5.8. More than three-quarters of teachers in the Northern Territory and Victoria answered that their instruction was limited by students with differing academic abilities. Only one-third of teachers in the Australian Capital Territory answered in this way.

Sixty-five per cent of teachers in the Northern Territory also believed that the wide range of their students' backgrounds limited their teaching; this was more than twice the proportion for any other state, and six times that of teachers in the Australian Capital Territory.

Having children with special needs was perceived to be somewhat of a problem for about one-fifth of teachers in Victoria and Tasmania, but not in other states, including the Northern Territory.

The last three items in this index deal with student motivation issues, and the effect these have on teachers' ability to deliver the curriculum. The first of these – uninterested students – is one of the major issues for teachers in most states but most particularly in the Northern Territory where 98 per cent of students are in classrooms where teachers feel their instruction is limited by this problem. The problem varies in magnitude for the other states and, with the exception of the Australian Capital Territory, ranges from 47 per cent of students in New South Wales to 64 per cent in Western Australia.

In comparison with the other items on this index, low morale amongst students did not seem to be generally as much of a problem. However more than half of the teachers in the Northern Territory, far more than in any other state, still believed that it limited instruction.

In Western Australia 44 per cent, in South Australia 38 per cent, in New South Wales 34 per cent, and in Victoria 33 per cent of teachers felt that low student morale impacted on their ability to teach mathematics. It is common in the classroom that uninterested students become disruptive students and this indeed appears to be the case. Disruptive students are more of a problem in the Northern Territory, where 95 per cent of students are in classrooms in which their teachers have reported this as a factor limiting instruction.

Instructional time in mathematics

On average, Australian Year 4 students spent about one-fifth of their instructional time on learning mathematics. Of this, about 40 per cent was spent on instruction in the area of *number*, 18 per cent in the area of *patterns and relationships*, 17 per cent in *measurement*, 12 in *geometry* and 11 in *data*. The percentage of timetabled mathematics class time is fifth highest of the TIMSS Year 4 countries, however it is not very different from either the international average of 16 hours or the average for the highest country, Italy, which timetables mathematics 21 per cent of their total instructional time.

Students in Year 8 on average spent 13 per cent of their instructional time on learning mathematics. This proportion was similar to the proportion of time spent on mathematics instruction in countries such as New Zealand, the United States of America and Singapore. Of the timetabled mathematics time, one-quarter was spent in the area of number, 23 per cent in the area of algebra, 18 per cent in the area of geometry, 16 per cent in the area of measurement, and 14 per cent in the area of data.

Problem solving activities

An emphasis on problem-solving activities has been an important part of the mathematics curriculum for a number of years now, and improving students' problem-solving skills continues to be a goal for educators. TIMSS asked Year 8 students and teachers how often students were asked to do the following:

- relate what was being learned in mathematics to their daily lives,
- explain their answers, and
- decide procedures for solving complex problems.

Both students and teachers were asked to nominate a percentage of time that was spent in their mathematics classes on each of these activities.

In Australia, being asked to explain answers was the most common of these activities in mathematics classes, with around two-thirds (69%) of students saying that at least half of their lessons involved this type of activity. A little less than half (45%) of the students said that they spent time in more than half their mathematics classes deciding on procedures for solving complex problems, while

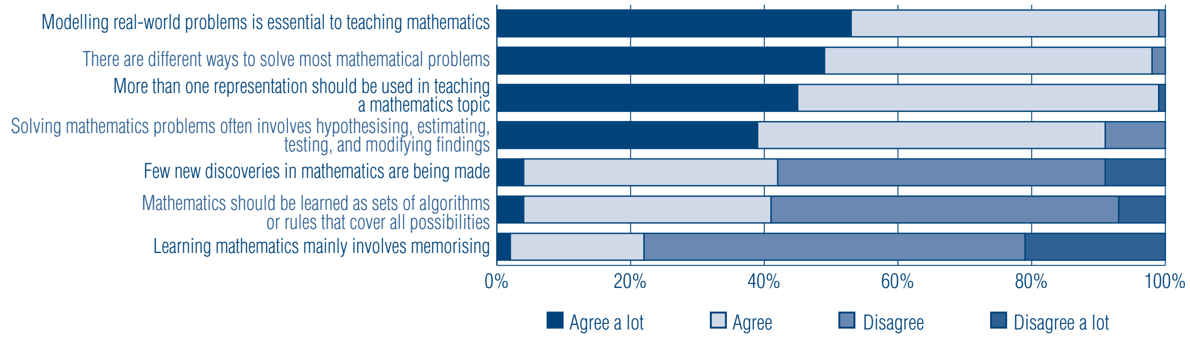

Figure 5.1 Australian Year 8 teachers' beliefs about mathematics and teaching mathematics

the area of least attention was being asked to relate classroom mathematics to their daily lives, in which 37 per cent of students reported spending time in at least half of their classes.

Teachers were also asked the same questions, and there was substantial agreement between teachers and students. Almost two-thirds of teachers said that their main emphasis was on asking students to explain their answers, and about forty per cent said that in more than half of their classes they asked students to relate their learning to their daily lives. The only area in which Australian students and teachers differed was that 23 per cent of teachers said that they set time in more than half of their classes for students to decide on procedures for solving complex problems compared to 37 per cent of students. Perhaps students feel the load of decision making more than teachers are aware.

Teachers' beliefs about mathematics and teaching mathematics

Teachers' beliefs and understandings about mathematics underpin the approach they take to teaching the subject. In TIMSS, Year 8 teachers were asked their level of agreement with seven statements about mathematics. The results of this are presented in Figure 5.1.

The vast majority of Australian teachers agreed on four things – that modelling real-world problems is essential in teaching mathematics, that there are different ways to solve most mathematical problems, that more than one representation should be used in teaching a mathematics topic, and that solving mathematics problems often involves hypothesizing, estimating, testing, and modifying findings.

On two issues, teachers were fairly evenly divided. Around 45 per cent of teachers agreed, and 55 per cent disagreed, that few new discoveries in mathematics are being made, and that mathematics should be learned as sets of algorithms or rules that cover all possibilities.

The remaining item asked teachers their level of agreement with a statement that 'learning mathematics mainly involves memorising', and it is of some concern that almost one-quarter of the Australian teachers surveyed agreed or strongly agreed with this statement, as memorisation is a learning strategy that rarely leads to deep understanding.

Instructional strategies

The mathematics textbook is the foundation of mathematics instruction in both Year 4 and Year 8 in most countries in the TIMSS study. Australia stands out amongst the countries surveyed at Year 4 as having almost 30 per cent of classes not using a textbook for mathematics. In Armenia, England, Italy, New Zealand and the United States of America, around one in ten classes do not use a textbook. In other countries there is almost universal use of a textbook, either as a primary basis for teaching or as a supplementary resource.

Of the 70 per cent of Australian teachers who say they do use a textbook, less than five per cent use it as their primary resource. Italy and New Zealand are the only countries that use a textbook as a primary resource less than Australian Year 4 teachers.

At Year 8, Australian teachers use a textbook in a similar manner to teachers in most other countries. Only five per cent do not use one at all, about one-half use it as their primary basis for lessons, and 43 per cent use it as a supplementary resource.

In Australian Year 8 classes, depth of content knowledge was found to be related to the purpose for which teachers used the textbook. For example, teachers who had a mathematics major in their undergraduate degree were significantly more likely to use the textbook as a supplementary rather than as a primary resource than those who did not have such a qualification. Forty-seven per cent of teachers with a mathematics major in their undergraduate degree used the textbook as their primary resource compared to 64 per cent of teachers without such a qualification.

Activities in mathematics classes

Year 4 students in Australia spend about half (52%) of their class time working on problems with and without teacher guidance. This is slightly more than the international average (45%), the United States of America (45%) and Singapore (34%), but around the same as England (51%) and Scotland (51%). A further quarter of Australian Year 4 students' class time is spent listening to teachers: that is, listening to lecture style presentations and listening to teachers re-teach and clarify content and procedures. The remaining quarter of class time was spent reviewing homework (6%), taking tests and quizzes (7%), participating in classroom management tasks unrelated to the lesson (5%) and other student activities (5%).

Australian students in Year 8 spend their time in a very similar manner to students in Year 4. About half of their time was taken up with working on problems with and without the teacher's help, which is substantially more than the international average (40%), the United States of America (39%), Japan (39%) and Singapore (34%). Another quarter of class time was spent listening to teachers, and the remaining time reviewing homework (8%), taking tests (7%), participating in classroom management tasks unrelated to the lesson (7%) and other student activities (3%).

Calculators and computers

Calculator use is widespread in Australian schools. At Year 4, 94 per cent of teachers allow calculator use in the classroom, and the primary use is checking answers, solving complex problems, and exploring number concepts. On average internationally, only 43 per cent of classes use calculators, and use is particularly restricted in Singapore (3%), Tunisia (3%), the Philippines (4%) and Slovenia (5%).

Calculator use is similarly widespread in Year 8, where 96 per cent of Australian teachers allow the use of calculators and they are mostly used for routine computations, checking answers and solving complex problems. More than 95 per cent of the students in Year 8 in other countries such as Belgium (Flemish), Hong Kong SAR, Lithuania and Morocco are allowed the use of calculators, while in Egypt, the Netherlands, Norway, Singapore and England, all students are permitted to use calculators.

Seventy six per cent of Year 4 students in Australia also have access to a computer in their classroom. However for mathematics at this year level there is moderate usage, with the majority of time on the computer being spent practising skills and procedures, which occurs in about half of the lessons in about eight per cent of Australian classrooms. Internationally, on average, 42 per cent of Year 4 students have access to a computer in the classroom. Students in Japan have the highest access, with 84 per cent having access to a computer in the classroom, compared to only 2 per cent in Iran. In most countries, less than 5 per cent of students use a computer frequently in mathematics classes. An exception is the Netherlands where 31 per cent of students had a teacher who reported using a computer in half their classes to practice skills and procedures.

With mathematics at Year 8 level being more often taught in general classrooms, only 54 per cent of Australian teachers have access to a computer, and even given this moderate level of availability, only in one per cent of classrooms is there any use of computers for more than half of the mathematics lessons. Internationally, on average, 32 per cent of Year 8 students have access to a computer in the classroom. Like in Year 4, students in Japan have the highest access – 84 per cent computers in the classroom – and Iran reported the least access, with only 2 per cent having access to a computer in the mathematics classroom. Use of a computer in mathematics classes is low – across countries most reported less than 5 per cent of students have teachers that use computers frequently in class. Korean teachers report the highest use of computers in class – 17 per cent of Korean Year 8 students have teachers who use computers in more than half their mathematics classes to discover principles and concepts.

Homework and assessment

The amount of time students spend on homework, and the types of homework that teachers set, is an important consideration when examining opportunity to learn. TIMSS calculates a summary measure, an index of teacher's emphasis on mathematics homework (EMH). The teachers of students in the high category gave longer homework assignments on a relatively frequent basis (in half the lessons or more). Teachers of students in the low category gave short assignments (less than 30 minutes) relatively infrequently (in less than half the lessons). The medium level includes all other possible combinations.

Internationally, 14 per cent of Year 4 students were in the high category, almost one-half had teachers that reported giving a medium amount of homework, and 37 per cent of students had teachers that reported having a low emphasis on mathematics homework. This varied enormously between countries, from 46 per cent of students in Armenia having teachers with a high emphasis on mathematics homework, through to the Netherlands, in which no students are apparently in the high EMH category. In Australia, there were few teachers with a high emphasis on homework, with the vast majority assigning little homework infrequently. In many countries, there appears to be a negative relationship between achievement and emphasis on mathematics homework, in that the students in the high category had the lowest achievement – suggesting that often homework is used for the purposes of remediation.

At Year 8 level the international average was 30 per cent of students having teachers with a high emphasis on mathematics homework, while about half of the students were in the medium category. The range, however, was extremely wide, from 78 per cent in the high category in Romania and 71 per cent in Italy, through to three per cent in Scotland and five per cent in the Slovak Republic. More than half of the students were in the low category in Sweden, Belgium (Flemish), Korea, Japan, England and Scotland. It should be noted that students in Japan and perhaps also Korea may be more likely to spend extra time in tutoring and special schools than in doing homework (Robitaille, 1997).

In Australia, ten per cent of Year 8 students had teachers with a high emphasis on mathematics homework (well below the international average), 56 per cent in the average category, and 34 per cent in the low category. There was a slight positive relationship between achievement and EMH (a correlation of 0.26).

School contexts for mathematics learning

There is a number of factors at the school level that influence the way that teachers are able to prepare and deliver the curriculum, and the way in which students are able to learn what is taught. This section describes the school level contexts in which children learn mathematics, internationally and within Australia.

School size and location

In Australia, the average school size for TIMSS Year 4 students was around 300 students, and for the Year 8 students it was around 630 students. The smallest school in the Year 4 assessment was 25 students, and the largest 1173 students, while for the Year 8 students the smallest school was 94 students and the largest 1970 students.

Figure 5.2 shows the location of schools in the TIMSS study. While the largest proportion of students are in urban regions of more than 500 000 people, there is a wide range, and almost the same proportion live in locations of between

Table 5.9 Percentage of Australian students who attend schools in metropolitan, regional or remote areas and their average mathematics achievement

Location of school	Year 4		Year 8	
	% of Australian students	Average mathematics score	% of Australian students	Average mathematics score
Metropolitan	61	504 (4.8)	63	509 (7.2)
Regional	36	492 (7.7)	34	500 (8.2)
Remote	3	479 (16.9)	3	457 (12.0)

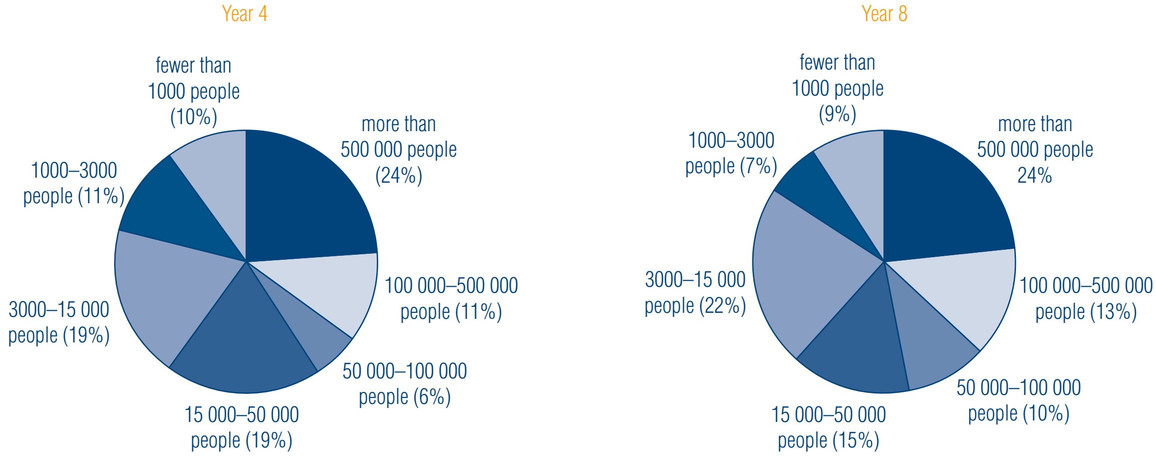

Figure 5.2 Location of schools for Year 4 and Year 8 students, in Australia

3000 and 15 000 people. Around one in 10 Year 4 students and eight per cent of Year 8 students live in rural areas where the population is fewer than 1000 people.

Each school was located on the MCEETYA Schools Geographic Location Classification. Table 5.9 shows that just under two thirds of Australian students attend schools in a metropolitan location, another third attend schools in regional areas and only 3 per cent attend schools in remote areas. At Year 4 there is no significant difference in average mathematics score for students in each category. However, in Year 8, students in remote schools scored significantly lower than students in either metropolitan or regional schools.

School's socioeconomic composition

As well as examining student-level socio-educational background by asking students about their parents' educational level, TIMSS asked principals to report on the economic composition of their school, in particular by asking the approximate percentage of students in the school who come from economically disadvantaged homes. Principals were asked to assign a percentage from the following ranges: 0–10%, 11–25%, 26–50%, or more than 50%. A summary of the responses to this question for schools from both Australian populations is shown in Table 5.10. Clearly schools with a low proportion of students from disadvantaged backgrounds will have greater resources and educational capital than schools with more than one-quarter of students from disadvantaged backgrounds.

Table 5.10 Principals' reports on the percentages of students in their schools coming from economically disadvantaged backgrounds, Year 4 and Year 8, Australia and selected countries

	Schools with few (0–10%) economically disadvantaged students		Schools with between 11% and 25% economically disadvantaged students		Schools with between 26% and 50% economically disadvantaged students		Schools with more than 50% economically disadvantaged students	
	Year 4	Year 8	Year 4	Year 8	Year 4	Year 8	Year 4	Year 8
Australia	34 (4.4)	32 (4.6)	30 (4.0)	35 (4.2)	21 (3.6)	23 (3.3)	15 (4.0)	9 (2.3)
England	38 (4.4)	32 (5.3)	25 (4.5)	33 (6.0)	11 (3.0)	22 (6.2)	25 (4.2)	13 (4.2)
United States of America	19 (2.8)	28 (2.9)	23 (2.6)	23 (3.1)	20 (2.9)	25 (3.1)	38 (2.6)	24 (2.8)
New Zealand	44 (3.2)	36 (4.2)	22 (3.5)	30 (5.6)	12 (2.3)	16 (3.2)	22 (2.5)	18 (2.3)
Singapore	64 (3.7)	57 (0.0)	25 (3.2)	28 (0.0)	6 (1.7)	10 (0.0)	4 (1.6)	5 (0.0)
Hong Kong SAR	23 (4.4)	14 (3.5)	26 (3.5)	27 (4.0)	25 (4.9)	24 (3.9)	25 (4.4)	35 (4.6)
International average	*34 (0.7)*	*22 (0.5)*	*25 (0.8)*	*26 (0.5)*	*18 (0.7)*	*21 (0.5)*	*24 (0.7)*	*31 (0.5)*

About one-third of both Year 4 and Year 8 Australian students attend schools in which there are fewer than 10 per cent of the students who come from economically disadvantaged homes. This is the same as the international average for Year 4 students, but substantially greater than the international average for Year 8 students. At the other end of the scale, around 15 per cent of Australian Year 4 students and fewer than one in ten Australian Year 8 students attend schools in which the principal believes that more than half of the students are from economically disadvantaged homes. At both year levels, but particularly at Year 8 level, these are much lower than the international averages.

This latter finding is to be expected given the much larger and more diverse range of countries that participated in TIMSS at Year 8. Indeed the range at Year 8 is very large. There was a number of countries where more than half of the students attended schools in which there were few disadvantaged students: Belgium (Flemish), Chinese Taipei, Japan, the Netherlands, and Singapore. There were also countries in which more than half of the students (50%–85%) attended schools in which more than half of the students were from economically disadvantaged homes: Chile, Ghana, Indonesia, Lebanon, Malaysia, Morocco, the Palestinian National Authority, the Philippines, Romania, South Africa and Tunisia.

In Figure 5.3 and Figure 5.4 the mathematics achievement averages for Australia and the international average are plotted for each of the levels of reported economic disadvantage for Year 4 students and Year 8 students respectively. Figure 5.3 shows that the Australian and international averages for Year 4 are almost identical, and both show distinct advantages for students in schools with few students from economically disadvantaged homes. Figure 5.4 shows that the Australian scores at Year 8 are substantially higher than the international average,

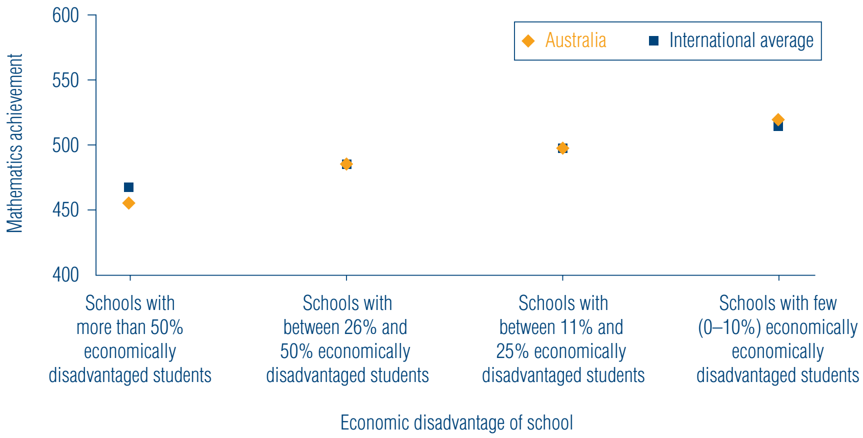

Figure 5.3 Relationship between economic disadvantage and mathematics achievement for Year 4, Australia and the international average

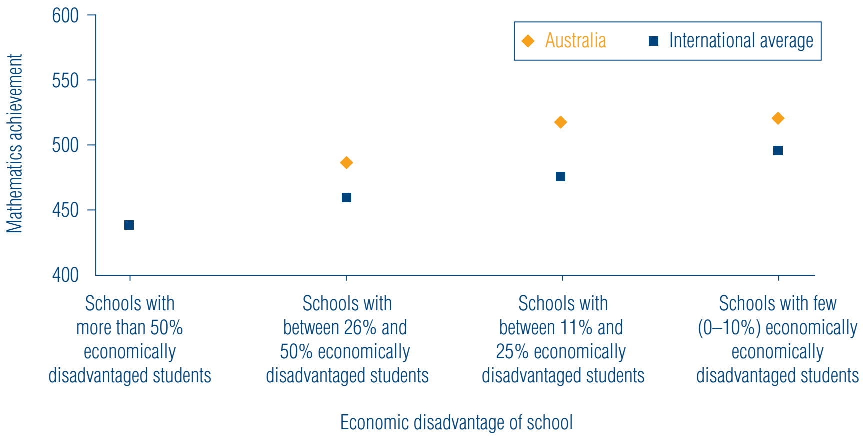

Figure 5.4 Relationship between economic disadvantage and mathematics achievement for Year 8, Australia and the international average

the same advantages for students in schools with low percentages of poorer students exist. The difference in mathematics achievement between the highest and lowest categories of economic disadvantage at Year 4 level is 64 score points; while for Year 8 students the difference is 48 score points. The international differences were 47 score points for Year 4 and 57 score points for Year 8.

In some countries, there is less of a gap between the average mathematics achievements for schools with a low proportion of disadvantaged students and schools with a high proportion of disadvantaged students. In Singapore, for example, the difference at Year 4 in the average mathematics score for students in schools with few economically disadvantaged students and those in schools with more than 50 per cent economically disadvantaged students was half that of Australia: 33 score points. The ideal situation is that despite their social advantage or disadvantage, all students have the opportunity to succeed at school. While Figure 5.3 and Figure 5.4 provide some evidence that this is not the case in Australia, it is less marked than in countries such as Belgium (Flemish) where the difference in average achievement for Year 8 students in mathematics between these two categories of schools was 155 score points.

Perceptions of school climate

If we are trying to identify influences on student achievement, it is important to investigate the environment in which students learn. TIMSS 2002/03 created two new indices that indicate the extent to which schools offer a positive school climate, and this section relates these indices to student achievement. The indices were created from questions asked of both teachers and principals. Teachers and principals were asked to characterise, on a scale from very high to very low, each of the following within their school:

- teachers' job satisfaction,
- teachers' understanding of the schools' curricular goals,
- teachers' degree of success in implementing the schools' curriculum,
- teachers' expectations for students' achievement,
- parental support for students' achievement,
- parental involvement in schools' activities,
- students' regard for school property, and
- students' desire to do well in school.

A high rating on the principals index (PPSC) indicated that principals averaged high or very high reports for each aspect of school climate. Students whose principals characterised school climate as medium were placed in the medium category and students whose principals characterised each aspect of the school climate as low or very low were placed in the low category. Similar categorisations were made for the teachers' responses to the items, forming the teachers' perception of school climate scale (TPSC). The averages on each of the indices, together with the international average, are shown in Table 5.11 for principals' perceptions and Table 5.12 for teachers' perceptions.

There is a clear relationship between principals' perceptions of school climate and mathematics achievement at both year levels (a correlation of 0.2 at both year levels). On average, students in Australian schools that rated high on principal's perception of school climate scored about 60 score points higher than those students in the low PPSC category at Year 4, and about 76 score points higher at Year 8.

Table 5.11 Index of principals' perception of school climate (PPSC) at Year 4 and Year 8, Australia and the international average

	High PPSC		**Medium PPSC**		**Low PPSC**	
	% of students	Average achievement	% of students	Average achievement	% of students	Average achievement
Year 4						
Australia	38 (4.6)	517 (5.6)	55 (5.1)	492 (4.7)	7 (3.6)	457 (20.3)
International average	*23 (0.7)*	*515 (2.2)*	*66 (0.8)*	*492 (0.9)*	*11 (0.5)*	*468 (3.4)*
Year 8						
Australia	31 (4.3)	520 (9.4)	61 (4.8)	506 (6.3)	8 (2.7)	444 (20.6)
International average	*15 (0.4)*	*495 (2.1)*	*67 (0.6)*	*466 (0.8)*	*18 (0.4)*	*446 (2.0)*

Table 5.12 Index of teachers' perception of school climate (TPSC) at Year 4 and Year 8, Australia and the international average

	High TPSC		Medium TPSC		Low TPSC	
	% of students	Average achievement	% of students	Average achievement	% of students	Average achievement
Year 4						
Australia	31 (3.6)	508 (8.5)	59 (3.7)	504 (3.7)	11 (2.5)	452 (15.9)
International average	*20 (0.6)*	*512 (2.6)*	*67 (0.8)*	*494 (1.1)*	*13 (0.5)*	*473 (2.3)*
Year 8						
Australia	16 (2.6)	530 (9.1)	58 (4.4)	514 (7.6)	27 (4.0)	462 (7.9)
International average	*10 (0.4)*	*486 (3.3)*	*60 (0.6)*	*471 (0.8)*	*30 (0.5)*	*450 (1.1)*

In general, principals were more positive about the climate of their school than teachers, although there was a reasonable level of agreement between the two. At Year 4, almost four in ten principals, and at Year 8 almost one-third of principals believed that their school had a very supportive and involved school climate (high PPSC), in which teachers were satisfied with their jobs, had a degree of success in implementing the curriculum, high parental support and involvement, and high levels of student engagement. This was a great deal higher than the international average for Year 4, and more than twice the international average for Year 8. In contrast, fewer than one in ten Australian principals rated their school as low on this index.

At Year 4 there was strong agreement between principals and teachers, with a little less than one-third of teachers rating their schools as having a good school climate and only one in ten rating it as low. Year 8 principals were, in general, far more optimistic about their school climate than the teachers in their schools. At Year 8, 16 per cent of teachers rated their schools as high on the school climate scale, whilst more than one in four rated it as low. Australian teachers were still, in general, more positive about their school climate than the international average.

There was also a relationship between teachers' perceptions of school climate (TPSC) and achievement (a correlation of 0.15 at Year 4 and 0.28 at Year 8). On average, those students whose teachers rated their schools as high on this index achieved 56 scale score points higher than those in low TPSC schools at Year 4, and 68 scale score points higher at Year 8.

Absenteeism and other school discipline problems

In some countries, student absenteeism is a serious problem. Schools that deal with high levels of absenteeism also confront problems of instructional continuity and reduced time for learning. To examine this issue, TIMSS developed an index of good school and class attendance that is based on schools' responses to three items about the seriousness of student absenteeism, arriving late at school, and skipping class. Research has suggested that higher levels of truancy are related to less serious attitudes to school and lower academic achievement. High scores on this index indicate that none of these behaviours are a problem, while low scores on the index indicate that either two or more behaviours are a serious problem, or two a minor and the third a serious problem. The medium category includes all other possible combinations of responses.

Table 5.13 shows the proportions of Year 4 and Year 8 students in Australia attending schools reported by their principals to be in each category, and also the average achievement score for each category. At Year 4, internationally 47 per cent of principals rated their schools as having few if any attendance problems, compared to 41 per cent of Australian principals. Only five per cent of principals internationally compared with four per cent of Australian principals believed that school and class attendance was a serious problem. However this ranged a great deal. More than three-quarters of the principals in Slovenia and Chinese Taipei judged their schools as having few problems with attendance, while one fifth of those in Morocco and Moldova, almost one in seven of those in the Philippines and one in ten of those in Armenia thought that attendance was a serious problem.

Table 5.13 Index of principals' perception of good school and class attendance (GSCA), at Year 4 and Year 8, in Australia

	Australia	
GSCA	% of students	Mathematics achievement
Year 4		
High	41	510
Medium	55	491
Low	4	463
Year 8		
High	26	523
Medium	61	508
Low	13	475

At Year 8, as would be expected, the picture was not as good. Internationally, less than one-quarter of principals rated their school as having little or no problems with school or class attendance rates, whereas almost one in five admitted to this being a serious problem. The Australian proportions were similar to this, as can be seen in Table 5.13, with the main difference being fewer students in the 'low' category and more in the 'medium' category. The range internationally was not quite as large as with the Year 4 students. In Lebanon, Italy, Republic of Korea and Chinese Taipei, more than half of the students were in schools categorised as having no serious problems with issues around absenteeism. In contrast, around four in ten of the students in Japan, Estonia, South Africa, Lithuania, Latvia and Bulgaria attended schools where the principal believed that attendance was a serious issue for their school. As would be expected, achievement levels are higher in those schools with high levels of good school and class attendance, and lower in those schools with low levels of school and class attendance (a correlation of 0.15 at Year 4 and 0.17 at Year 8).

Organisation of mathematics instruction

There are many ways in which mathematics instruction in a school can be organised, and the way in which it is organised may have repercussions for the students at the school. Principals were asked how their school organises mathematics instruction for Year 8 students with different levels of ability. In 17 per cent of Australian schools, principals said that all students study the same curriculum, regardless of ability, and a further 21 per cent of principals said that students study different mathematics curricula according to their ability. In most schools (62%), principals said that students studied the same mathematics curriculum, but at different levels of difficulty. Principals were asked explicitly whether Year 8 students were grouped by ability for mathematics, and 52 per cent answered yes. In almost half of these schools, as seen in Figure 5.5[3], all students are streamed or grouped according to ability. The next most popular manner of dealing with students of varying abilities is to take the highest ability and lowest ability students and teach them separately, and to leave the rest of the students in more

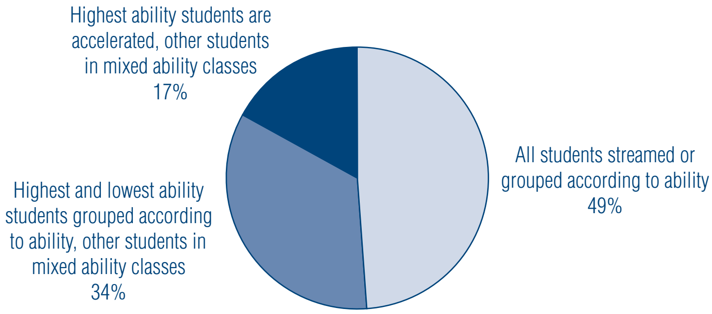

Figure 5.5 Manner of grouping students if the school streams for mathematics at Year 8, in Australia

[3] Comparative international data were not available for this item.

homogeneous classes. The least often used strategy is to simply deal with the highest ability students by accelerating them, and leaving all other students in attenuated mixed ability classes.

Availability of school resources for mathematics instruction

While there are some resources in a school specific to mathematics, many are general resources that improve learning across the curriculum. TIMSS has in previous studies calculated an index of the availability of school resources for mathematics instruction (ASRMI) in each of the participating countries[4]. In TIMSS 1994/95 and TIMSS 1998/99 it was found that schools that were generally well resourced had higher average mathematics achievement than those in which shortages in resources affected instruction capacity in some manner. The index is based on principals' average response to five questions about shortages that affect the school's general capacity to provide instruction, and five questions that target the provision of instruction in mathematics specifically. Students were placed in a high category if principals reported that shortages had little or no effect on mathematics instruction, the medium level if one shortage affects instruction to some extent, and low if both shortages affect instruction some or a lot. The proportion of students in each of the groups both for TIMSS 1994/95 and for the current study, are shown in Table 5.14.

At Year 4, there has been a significant increase between 1994/95 and 2002/03 in the proportion of students in schools with few shortages that affect instruction. This is similar to the trend internationally, where the proportion of students in schools with few shortages has increased from just over one–quarter to one-third. In Australian primary schools, this proportional increase has reflected a decline in the proportion of schools with medium ASRMI – those with shortages in one area or another. The same decline can be seen internationally. However, of some concern internationally is the increased proportion of students in schools with shortages in both areas. This is not a real concern in Australia, with very few schools teaching Year 4 students reporting such levels of shortages.

While the proportion of Australian students in the high ASRMI group is substantially above the international average, it is a great deal lower than for countries such as Singapore (86%), Scotland (62%), Slovenia (58%) and Japan (57%).

More than half of the Year 8 students in Australia are in schools with high ASMRI, and this has significantly increased since TIMSS 1994/95. The proportion of students in both medium and low ASRMI has declined since TIMSS 1994/95. The highest achieving country, Singapore had 88 per cent in the highest category. The Australian proportion of students in this category was equivalent to that of Hong Kong SAR, Belgium (Flemish), Japan and a number of other countries.

Table 5.14 Trends in the index of availability of school resources for mathematics instruction (ASRMI), Australia and the international average

	High ASRMI		Medium ASRMI		Low ASRMI	
	1994/95	2002/03	1994/95	2002/03	1994/95	2002/03
	% of students	% of students	% of students	% of students	% of students	% of students
Year 4						
Australia	27 (4.7)	**46 (4.1)**	**71 (5.0)**	53 (4.1)	2 (1.4)	1 (0.8)
International average	*26 (1.1)*	***33 (0.7)***	***68 (1.2)***	*58 (0.9)*	*6 (0.6)*	***10 (0.5)***
Year 8						
Australia	42 (5.0)	**56 (3.8)**	52 (5.2)	43 (3.9)	**6 (2.3)**	1 (0.7)
International average	*23 (0.8)*	***26 (0.5)***	***67 (1.0)***	*64 (0.6)*	*10 (0.6)*	*11 (0.4)*

Figures in bold indicate that the proportion is significantly higher than the proportion for the other group of students

[4] The index is based on principals' average response to items about shortages affecting general capacity to provide instruction (such as instructional materials, budget for supplies, school buildings and grounds, heating, cooling and lighting, and instructional space) and shortages affecting mathematics instruction (such as computers and computer software for mathematics instruction, calculators, library resources and audio-visual resources).

Student perceptions of school safety

TIMSS asked students five questions that examined their perceptions of how safe they were in their school. These questions tapped into students' perceptions of whether they were subjected to a level of bullying in their schools. Students were asked to answer 'yes' or 'no' to whether each of the following things had happened in the last month:

- Something of mine was stolen
- I was hit or hurt by other students
- I was made to do things that I didn't want to do by other students
- I was made fun of or called names
- I was left out of activities by other students.

The responses to these items were used to create the index of students' perception of being safe in school. Students who reported being in a safe environment (i.e. those who felt a low level of bullying), answering 'no' to all five statements, were placed into the high category on this index. Students who reported being in a less safe environment (those who were bullied on a regular basis) by answering 'yes' to all of these statements were placed in the low category. All other response patterns were included in the medium category. Table 5.15 provides the percentage of students in Australia and the international average for each of the categories.

The percentage of Australian students in the high category, that is those students who answered 'no' to all of the items listed, was lower than the international average, while the percentage of students in the 'low' category was higher than the international average, particularly at Year 4. For both Year 4 and Year 8 students, there was a direct positive relationship between students' reporting being in safer schools and higher mathematics achievement.

The countries with the lowest proportion of students who feel bullied at school in Year 4 were Armenia (5%), Norway (13%) and Lithuania (13%), and in Year 8 were Sweden (3%), Serbia, the Netherlands and Belgium (5%). The countries with high proportions of students who feel as though they are bullied at school in Year 4 were the Philippines (50%) and Chinese Taipei (35%). The next highest proportions were for New Zealand and Australia, both with 32 per cent of students who feel they are bullied on a regular basis. In Year 8, the countries with the highest proportion of students in the 'low' perception of safety category were Jordan (61%), South Africa (40%) and the Philippines and Ghana (38%).

Table 5.15 Index of students' perceptions of being safe at school at Year 4 and Year 8, Australia and the international average

	Students' perception of school safety					
	High		Medium		Low	
	% of students	Average score	% of students	Average score	% of students	Average score
Year 4						
Australia	29 (1.0)	516 (3.6)	39 (1.0)	504 (4.7)	32 (1.4)	482 (4.8)
International average	*35 (0.3)*	*510 (1.2)*	*42 (0.2)*	*496 (0.9)*	*23 (0.2)*	*477 (4.8)*
Year 8						
Australia	43 (1.2)	510 (4.7)	40 (1.0)	507 (5.3)	18 (0.9)	499 (5.0)
International average	*48 (0.2)*	*478 (0.7)*	*37 (0.1)*	*465 (0.6)*	*15 (0.1)*	*447 (0.9)*

Multilevel analyses

Over the past two chapters we have looked at the student, teacher and school level factors that have an influence on mathematics learning and achievement for Australian students. Some of these factors may have a direct influence on achievement; others may have influences that are mediated through other variables. This section examines the effect of these factors, taking into account the concomitant influences of other related factors and the multilevel structure of the data – that is, students grouped or 'nested' within classes.

Hierarchical linear modeling was used to examine the net effects of factors at the student and class levels. This procedure provides an indication of the influence of one factor under the condition that the influence of the other factors was equal. It also allows modeling of outcomes at two levels (e.g. student level, classroom level), partitioning separately the variance and effects at each level while controlling for the variance across levels. In this sense it allows for the fact that students within a classroom will be more similar to each other than to students in other classes or schools.

The analyses were conducted separately for Year 4 and Year 8. Because only one class per school was sampled in Australia, a two-level analysis (classroom and student) was conducted. All independent variables were normalised to a mean of zero and a standard deviation of one.

Variables included in the analyses

Table 5.16 provides details of the variables that were used in the analyses. In the table, variables are organised in groups as student-level and classroom-level variables.

Table 5.16 Student and class variables used for multilevel mathematics analyses

Student-level	
Student background variables	
Sex	Student's gender
Possessions	Number of possessions relating to family wealth
Books	Number of books in the home
Age	Student's age
Indigenous	Indigenous status
Language background	Whether the student speaks English at home or not
Parents' education	Highest of parents' educational level
Aspirations	Student's aspirations to higher education
Student mediating variables	
Mathematics homework	Amount of homework the student does regularly
Computer usage	Breadth of use of computers
Self-confidence in mathematics	Student's level of confidence in mathematics
Perceptions of safety	Student's perceptions of their level of safety in the school
Self-confidence	Student's self-confidence in mathematics
Classroom-level variables	
Years taught	Number of years teacher has been teaching
Education	Level of education of teacher
Training	Level of teacher training of teacher
Informal PD	Level of informal professional development of teacher
Formal PD	Level of formal professional development of teacher
TPSC	Teacher's perception of school climate
EMH	Teacher's emphasis on mathematics homework
Mathematics time	Amount of time allocated to mathematics
Stream	Whether school streams in mathematics
PPSC	Principal's perception of school climate
GSCA	Principal's perception of good school and class attendance
Disadvantage	Proportion of students from disadvantaged backgrounds
ASRMI	Availability of school resources for mathematics instruction
Location	Area in which school is located, based on MCEETYA index

Influences on mathematics achievement – Year 4

A two-step analysis was conducted (using MlWiN) to investigate which factors were significant influences on mathematics achievement at Year 4 in Australia. The initial model (null model) was used to estimate the amount of between-class and within-class variance. This indicated that 26 per cent of the variance in students' mathematics achievement was attributable to differences between classrooms (between-class) and 74 per cent of the variance in mathematics achievement was attributable to differences between individuals (within-class). It should be noted that because TIMSS 2002/03 only sampled one class per school, the variance at the second level of the multilevel analysis combines what would normally be school-level and class-level variance. In other words, because we only have one classroom per school, we are unable to determine how much of the variance that we are describing at the second level of the model is variance that occurs between classes in the school, or variance that occurs between schools.

In the second analysis a range of school/classroom and student level variables were included. The model was then tested iteratively. At each iteration any variables that were not statistically significant were removed until the model only contained variables with a significant influence. Results are presented in Table 5.17.

The final model of influences on Year 4 students' mathematics achievement includes 11 factors – nine at the student level and two at the school/classroom level. Together, these 11 factors explain 34 per cent of the variance in mathematics achievement scores. Of the remaining unexplained variance, 9 per cent is the result of differences between schools/classrooms and 57 per cent is attributable to differences between students.

The role of self-confidence is important, as it is one of the variables in the analysis that is amenable to change. Other things equal, self-confidence in learning mathematics has the strongest association with mathematics achievement for Year 4 students. That is, students who fall into the medium category of the self-confidence in learning mathematics index achieve, on average, 34 points higher than students in the low category. Students in the high category achieve another 34 points (on average) on top of that. However, as we have not been able to control for either prior mathematics achievement or earlier self-confidence in learning mathematics, it is not possible to determine whether it is the self-confidence in learning mathematics that influences mathematics achievement or vice versa, or indeed if it is a reciprocal relationship.

The next strongest influence is Indigenous status, in a negative direction. Indigenous students achieved, on average, 21 points below their non-Indigenous counterparts. Speaking English at

Table 5.17 Estimates of influences on mathematics achievement in schools, Year 4

	Coefficient (standard error)
Intercept	**490.8 (7.4)**
Student level variables	
Self-confidence	33.7 (1.5)
Indigenous	–21.3 (4.4)
Language background	13.2 (4.1)
Gender	–10.2 (2.2)
Books	10.0 (1.3)
Computer usage	7.1 (1.8)
Perceptions of safety	6.9 (1.4)
Possessions	6.6 (1.4)
Mathematics homework	–6.2 (1.5)
School and classroom level variables	
Disadvantage	–13.6 (2.8)
GSCA	6.7 (3.1)
Variance	
Explained by the model	34%
Unexplained school level (between-schools)	9%
Unexplained student level (within-schools)	57%

home most of the time was the next strongest positive influence on mathematics achievement. Predominantly English-speaking students achieved, on average, 13 points higher than those students who did not speak English at home often. The strength of this relationship indicates that some further investigation is needed.

Gender was a moderately strong influence on mathematics achievement; being female was associated with about 10 less score points in mathematics achievement than being male. The number of books in the home was also a positive influence of similar strength, with students gaining 10 points in mathematics achievement per step of the index.

Similarly, number of possessions in the home was positively related to mathematics achievement, with each extra possession associated with almost 7 extra points on the scale. Students who had access to computers at both home and school did better than students who did not have access to a computer in one or both of these locations, with an increase of 7 points for each additional place in which a computer was used. Students' perception of safety at school also had an impact on mathematics achievement – the safer a child felt (or the less they feel bullied), the higher their level of mathematics achievement (about 7 points for each step increase on the index).

Amount of mathematics homework (that is being in either the medium or high categories of the homework index) was similarly associated with mathematics achievement, although the influence was in a negative direction. Students who received medium amounts of mathematics homework scored 6 points below those receiving low amounts and those in the high category lost another 6 points again. It is likely that this reflects the usual assignment of homework to weaker students, that weaker students spend more time on homework than higher achieving students or that weaker students take longer to do the same amount of homework.

Two school and classroom level variables were significant; the principal's assessment of the proportion of students in their school from disadvantaged backgrounds, and their report of good school and class attendance (GSCA). Students' score would be expected to be about 14 points lower for each level on this scale, so those students in a school with more than 50 per cent of economically disadvantaged students would score, on average, 42 points less, all other things equal, than a school with less than 10 per cent economically disadvantaged students. Students attending schools that scored higher on this index had higher achievement (7 points per category on the index) than those students whose principal reported problems in the area of school and class attendance.

This analysis provides some valuable information for schools and policy makers. A number of the factors that have a significant effect on student achievement in mathematics at Year 4 reflect socioeconomic background, language background or Indigenous status, and while none of these can be altered, provision can be made to support learning for each of these groups. However there are other factors that are amenable to change – student self-confidence, perceptions of safety, and good school and class attendance. These last two in particular suggest particular strategies that primary schools can use to improve learning in mathematics – they need to provide an environment in which children feel safe, and they need to deal with problems of absenteeism to ensure instructional continuity and to provide ample time for learning to occur.

Influences on mathematics achievement – Year 8

As at Year 4, a two-step analysis was conducted to investigate which factors were significant influences on mathematics achievement at Year 8. The initial model (null model) was used to estimate the amount of between-class and within-class variance. This indicated that 48 per cent was attributable to differences between schools/classrooms (between-class) and 52 per cent of the variance in mathematics achievement was attributable to differences between individuals (within-class).

In the subsequent analysis the school/classroom and student level variables were included. The model was then tested iteratively. At each iteration any variables that were not statistically significant were removed until the model only contained variables with a significant influence.

The final model of influences on Year 8 students' mathematics achievement includes nine factors – six at the student level and three at the school/classroom level. Together, these nine factors explain 46 per cent of the variance in mathematics achievement scores. Of the remaining variance, 19 per cent is the result of differences between schools/classrooms and 36 per cent is attributable to differences between students.

As with Year 4 students, self-confidence in learning mathematics has the strongest association with mathematics achievement for Year 8 Australian students. That is, students who fall into the medium category of the self-confidence in learning mathematics index achieve, on average, 33 points higher than students in the low category. Students in the high category achieve another 33 points (on average) on top of that. However, as mentioned above, we have not been able to control for either prior mathematics achievement or earlier self-confidence in learning mathematics, so it is not possible to determine whether it is the self-confidence in learning mathematics that influences mathematics achievement or vice versa, or indeed if it is a reciprocal relationship.

Indigenous status has the next strongest, although negative, influence. Indigenous students at Year 8 achieved, on average, 21 points below their non-Indigenous counterparts. These two factors have a much larger effect than any of the other factors at Year 8.

The next largest influence on Year 8 mathematics achievement was the educational aspirations of the student, with students achieving an extra 10 points for each increase in educational aspirations. Computer usage had a significant positive effect on mathematics achievement, with an increase of almost 8 score points for each increase in level of computer usage. Number of books in the home, reflecting socio-educational level of the home, also had a significant positive effect, with students gaining about 6.5 points extra for each step up on the level of books in the home. The education level of parents, reflecting the amount of educational support available in the home, had a small but still significant positive influence on mathematics achievement, with an increase of about 4.5 points per step of level of education of the parents.

School and classroom level variables have a greater influence on mathematics achievement at Year 8 than at Year 4. The degree to which a teacher emphasises homework was the strongest school level variable to have a significant influence – students whose teacher had a medium emphasis on homework scored 18 points higher than those whose teacher had a low emphasis on homework, and students whose teacher had a high emphasis on homework scored another 18 points higher again.

As with Year 4 students, the principal's report of good school and class attendance was significant. Students attending schools that scored higher on this index had higher achievement (10 points per category on the index) than those students whose principal reported problems in the area of school and class attendance. In addition, the principal's perception of school climate was positively associated with mathematics homework. Students whose principal rated their school as medium on the principal's perception of school climate index scored 17 points higher than those whose principal scored the school climate as low; with students whose school fell in the high category gaining a further 17 points.

Table 5.18 Estimates of influences on mathematics achievement in schools, Year 8

	Coefficient (standard error)
Intercept	**490.8 (7.4)**
Student level variables	
Self-confidence in mathematics	33.3 (1.4)
Indigenous	–21.3 (5.6)
Aspirations	10.1 (1.4)
Computers usage	7.6 (1.6)
Books	6.5 (1.3)
Parents' education	4.5 (1.3)
School and classroom level variables	
EMH	18.4 (4.0)
PPSC	16.5 (3.9)
GSCA	10.2 (3.8)
Variance	
Explained by the model	46%
Unexplained school level (between-schools)	19%
Unexplained student level (within-schools)	36%

Summary

This chapter has examined a wide range of the contextual factors that may have an impact, either directly or indirectly, on the mathematics learning of TIMSS students. This information was primarily obtained from the teacher and school questionnaires; however an item from the student questionnaire is also reported in this section as it pertains directly to the classroom or school environment.

The chapter profiled the mathematics teachers of the TIMSS students: their age, qualifications, training and experience, readiness to teach, and use of professional development. The surveys showed that 75 per cent of Year 4 students and 49 per cent of Year 8 students were taught by women, and that most teachers were in the 30–49 years age group. Most teachers felt prepared to teach most subjects, and participated in some form of professional development throughout the year.

The chapter also reviewed teachers' and principals' views about classroom characteristics that were hypothesised to impact on learning. These included factors limiting instruction in mathematics (students with differing abilities, students with special needs, uninterested students, low morale and disruptive students), time on instruction, use of problem-solving activities, teachers' beliefs about mathematics and teaching mathematics, instructional strategies, computer use, and homework and assessment usage.

In some states, there appear to be factors limiting instruction that are not apparent in other states. In the Northern Territory in particular, there appeared to be problems with children with a wide range of abilities, the wide range of student backgrounds, uninterested students, low levels of student morale and disruptive students. The majority of Year 8 mathematics teachers surveyed agreed with statements reflecting a constructivist way of teaching mathematics, although around 25 per cent supported the use of learning strategies such as memorisation.

The use of textbooks in mathematics is lower in Australia than in most other countries in TIMSS. Thirty per cent teachers of Year 4 do not use a textbook as their primary resource in mathematics lessons. Of the 70 per cent of Australian Year 8 teachers who say that they do use a textbook, fewer than one in twenty use it as their primary resource. Computer use was low in most schools despite high availability, and at both year levels, teachers did not assign their classes a great deal of homework.

An examination was conducted of the influence of various aspects of school contexts on mathematics learning. This examination included factors such as school size and geographic location, school socioeconomic composition, perceptions of school climate, absenteeism and other school discipline problems, availability of resources for instruction, and students' perceptions of school safety.

Geographic location did not have an effect on mathematics achievement, other than Year 8 students in remote schools scoring at a significantly lower level than students in metropolitan schools. Socioeconomic composition did have an effect on mathematics achievement, with achievement levels higher in schools with low proportions of students from disadvantaged economic backgrounds. Not surprisingly perhaps, student achievement was also higher in schools in which principals reported high levels of teacher satisfaction and cohesion, where teachers had high expectations of their students, parents were supportive and involved, and students were engaged and had high expectations of themselves. Again, and not surprisingly, achievement was lower in schools where absenteeism, truancy and late arrivals were a problem.

Finally, this chapter examined a range of variables at student, class and school level in separate two-level multilevel models for Year 4 and Year 8 mathematics achievement. All factors were included and then removed in an iterative process that left only the significant net effects on mathematics achievement.

At Year 4 and Year 8, the largest influence on mathematics achievement was self-confidence in learning mathematics. This is a very positive finding, as students' self-confidence can be encouraged not only by the classroom teacher but by the school climate. Students with an Indigenous background did not do as well as other Australian students, and this was the second largest effect on achievement at both year levels. Language background had an effect at Year 4; students with an English-speaking background outperforming those with a language background other than English. At Year 4, achievement of students in schools with high proportions of economically disadvantaged students was also lower than those in schools with low proportions of economically disadvantaged students. This suggests that policy makers and schools should continue to provide the resources to support learning for Indigenous students and students with a language background other than English, and that further attention should be paid to improving equity for schools with large proportions of disadvantaged students.

Gender had a moderate effect at Year 4, with females scoring less than males, but this was not significant at Year 8. Books in the home had a similar influence for Year 4 students, but the influence was not as strong for Year 8 students. Educational intentions were a moderate influence on achievement for Year 8 students, with achievement higher for those with high aspirations.

The other relatively strong influences on achievement at Year 8 were school/classroom level variables: teachers' emphasis on mathematics homework (with higher emphasis on assigning homework related to higher achievement in mathematics); and principals' perception that the school's climate is positive, and that students attend classes regularly and on time.

In summary, this chapter has identified some of the factors at the class and school level which are related to student learning in mathematics. However some of these factors have stronger influences than others. Indigenous students, students whose language background is other than English, and students in schools with high levels of economically disadvantaged students, may need to have greater support with their learning in mathematics than other groups. Students with high levels of self-confidence tend to achieve well in mathematics, and this can be nurtured within the classroom. Lastly, a school climate which is supportive, and which encourages attendance and high aspirations, will almost certainly lead to higher mathematics achievement.

The final chapter of this report provides a summary of the findings from the TIMSS mathematics study, and suggests some policy matters that result from these findings.

Chapter 6
Summary and policy considerations

Chapter 6 Summary and policy considerations

This report describes the achievements in mathematics of Australian students in the Trends in International Mathematics and Science Study (TIMSS) conducted in Australia and other southern hemisphere countries in late 2002 and in northern hemisphere countries in early 2003. Just over 10,000 Australian students participated in TIMSS, as did students in 45 other countries, from both developed and developing parts of the world. A parallel report focussing on achievement in science is published concurrently to this report (Thomson & Fleming, 2004).

TIMSS 2002/03 is the latest in a series of international tests in mathematics and science, going back to the mid 1960s. It is the third combined mathematics and science study in which Australia has participated; others being the Third International Mathematics and Science Study (TIMSS 1994/95), and the partial repeat of TIMSS at Year 8 level only (TIMSS 1998/99). Australia's participation in TIMSS provides an opportunity to continue to build a comprehensive picture of trends in achievement in mathematics and science for students in Year 4 and Year 8. Although Australia participated in TIMSS 1998/99, the results from this study are not used to provide detailed trend analyses in the current reports because there have been changes in the definition of populations. These trends will be examined in detail in a later report. The current report uses Population 1 (Year 4) and Population 2 (Year 8) data from TIMSS 1994/95 for comparison with TIMSS 2002/03 data, and can thus look at changes in mathematics achievement over an eight-year span.

This report details the achievement in mathematics of Australian students in Year 4 and Year 8 both in an international context and for the six Australian states and two territories. The samples of schools and students in TIMSS were large and representative, and smaller states were oversampled so that accurate estimates can be made for those jurisdictions. Response rates were high, and quality control methods were strictly applied. Australia reached the required participation rates for the Year 8 sample, and for the Year 4 sample with replacement schools.

To complement the achievement data, TIMSS also collected contextual information from a range of sources, including school systems, and the principals, teachers and students in the schools selected for participation in TIMSS. This allows analysis and interpretation of achievement results in relation to many of the contextual variables that are suggested by other research to improve performance.

Achievement in mathematics in an international context

In TIMSS 2002/03, Australian Year 4 students' performance was around the same as the international average in mathematics. This is a relative decline since TIMSS 1994/95, in which Australian Year 4 students scored significantly above the international average. While the average scale score for Australia has not changed significantly over that time, a number of other countries showed an improvement over this period, raising their position relative to that of Australia.

Australian students acquitted themselves well in mathematics at Year 8, scoring significantly higher than the international average. Australian students also scored at this level in TIMSS 1994/95; however as with Year 4, a number of other countries have improved their levels of achievement over this period of time so that their level of achievement in TIMSS 2002/03 was significantly better than that of Australia.

In TIMSS 1994/95 there were gender differences in a small proportion of the TIMSS countries at both year levels, and in all of these countries males outperformed females. In TIMSS 2002/03 there was a larger proportion of significant differences, but these gender differences were not all in favour of males. Almost half of the gender differences at Year 4 and half of the gender differences at Year 8 internationally were in favour of females. There were no significant gender differences in the overall mathematics score in Australia at either year level.

International benchmarks were developed by the International Study Centre to describe performance at four levels: *advanced*, *high*, *intermediate* and *low*.

Only five per cent of Year 4 students and seven per cent of Year 8 students in Australia achieved the advanced international benchmark. For Year 4 students this was lower than the international average of eight per cent, while for Year 8 students it was around the same as the international average. At Year 4, 88 per cent of Australian students reached at least the low international benchmark, higher than the international average of 82 per cent. As well, the proportion of Year 8 students (90 per cent) achieving at least the low international benchmark was well above that of the international average of 74 per cent. The proportions of Australian Year 4 and Year 8 students at the advanced and low international benchmarks have remained the same since TIMSS 1994/95.

At Year 4 in Australia, there were no gender differences in achievement of the benchmarks, and in Year 8, although the gender differences were not significant, there was a propensity for a larger proportion of males to attain both the advanced and low benchmarks.

The highest achieving country at Year 4, Singapore, achieved 38 per cent of students at the advanced international benchmark, and 97 per cent at or above the lowest benchmark. More than half of the countries at Year 4 in TIMSS 2002/03 had a larger proportion of Year 4 students achieving the lowest international benchmark than Australia, including four countries with 99 per cent of their Year 4 students achieving this level.

Singapore was also the highest scoring country at Year 8, with 44 per cent of their students attaining the advanced benchmark and 99 per cent the lowest international benchmark. Thirteen other countries at Year 8 level achieved a higher proportion of students achieving the low international benchmark than Australia.

Achievement was also examined in the separate mathematics content areas. Year 4 students in Australia scored significantly higher than the international average in three of the five content areas (*data*, *geometry* and *measurement*), equivalent to the international average in one (*patterns* and *relationships*) and lower than the international average in one content area (*number*). Year 8 students scored significantly higher than the international average in all five content areas; however their strongest area, relatively, was *data* and their weakest area *geometry*.

There were few gender differences in achievement across the mathematics content areas: in Australia females outperformed males in Year 4 in *geometry*, and males outperformed females in Year 8 in *number* and *measurement*.

Comparisons can also be made across the states of Australia, although there are some structural differences in school starting ages that mean comparisons have to be made with some caution. Students start school at various ages across the states, and some students start directly into Year 1 while others complete a preparatory year before Year 1, meaning that students in two states (Queensland and Western Australia) may be younger than their counterparts in other states and have up to a year less formal schooling.

For Year 4 students in TIMSS 2002/03, the Australian Capital Territory was the highest scoring state, with an average score around the same as that of Belgium (Flemish). At the state level, the only significant difference in Year 4 mathematics was that Western Australia scored significantly lower than the international average, and significantly lower than the Australian Capital Territory, New South Wales and Victoria. All other states performed at the international average and had scores that were not significantly different from one another. This is quite a different picture from Year 4 mathematics in TIMSS 1994/95, in which all states performed at or above the international average and Western Australia significantly outperformed New South Wales and Victoria, and achieved at the same level as the Australian Capital Territory.

In Year 8 mathematics in TIMSS 2002/03, there were again few differences. New South Wales achieved at the highest level, scoring internationally at about the same level as Belgium (Flemish), and nationally the same as all states other than Queensland, Western Australia and the Northern Territory. In TIMSS 1994/95, Western Australia, the Australian Capital Territory, South Australia and Queensland outperformed New South Wales, Victoria, Tasmania and the Northern Territory, so achievement across the states has ‘evened out' over the eight years.

Students in all states other than the Northern Territory achieved an average score that was higher than the international average. The Northern Territory's score was at the international average level. This is a better situation than that for Year 8 in TIMSS 1994/95, in which the scores for New South Wales, Victoria, Tasmania and the Northern Territory all achieved a score similar to the international average.

States also varied in the achievement of the international benchmarks in mathematics. At Year 4, the Australian Capital Territory had the greatest proportion of its students reaching each of the international benchmarks, while the Northern Territory had the lowest proportion reaching either the advanced or low benchmarks. At Year 8, New South Wales had the highest proportion of students reaching the advanced international benchmark, and the Australian Capital Territory had the highest proportion reaching, or exceeding, the low international benchmark. The Northern Territory again had the lowest proportion reaching either the advanced or low international benchmarks.

Achievement in mathematics of Indigenous students continues to be a matter for concern. Overall, Indigenous students scored well below the Australian average and therefore well below the international average at both year levels; however there does seem to have been a small decrease in the gap between the scores of Indigenous students and all Australian students between TIMSS 1994/95 and TIMSS 2002/03 at Year 8. Further analysis will be conducted with the Indigenous sample obtained from TIMSS 2002/03.

Gender differences were apparent in some aspects of attitudes towards mathematics. Males at both Year 4 and Year 8 were found to be more self-confident in learning mathematics, and they professed to enjoy mathematics to a greater degree than females did.

A large number of student, class and school variables were examined individually in relation to achievement, and then many were examined in multivariate analyses that attempted to explain the variation in mathematics achievement at both grade levels, holding other things equal. The findings from these models were that the most significant factors for both Year 4 and Year 8 mathematics were self-confidence and Indigenous status.

Policy issues arising from TIMSS

Mathematics is regarded as one of the foundation areas of learning in the compulsory years of schooling. Studies in other curriculum areas, and many occupations in modern society, require a broad base of mathematical literacy. A recent national review of teaching and teacher education in science, technology and mathematics argued that changing social and economic conditions provides an imperative to strengthen and broaden the base of knowledge and skills in mathematics and science developed through Australia's school systems (Committee for the Review of Teaching and Teacher Education, 2003).

The results from TIMSS 2002/03 indicate that achievement in mathematics at both Year 4 and Year 8 in Australia has remained virtually the same since TIMSS 1994/95, while the achievement levels of a number of other countries, including neighbours, trading partners and countries with which we have traditional ties, have improved. Australia's achievement in *number*, which is a core aspect of the Year 4 curriculum, is below the international average.

The results obtainable from large, comparative international studies such as TIMSS demonstrate that over a relatively short period of time, large improvements can be made in mathematics achievement. This report provides a broad overview of student achievement and the factors that are related to it; however there are many ways in which this rich database can be used to gain further insight as to why there has been little change in Australia's performance in mathematics relative to other countries in eight years.

While there were no gender differences in mathematics, there are areas in which males outperformed females and areas in which females outperformed males. Males tend to be over-represented at the advanced benchmark and a larger proportion of males achieved the low benchmark, and males were also more self-confident and enjoyed mathematics more than females did.

The achievement levels of Indigenous students in core learning areas such as mathematics are another concern. There is no indication that levels of achievement in mathematics have improved for Indigenous Australians since TIMSS 1994/95; however this will be investigated in depth in a further report arising from these data.

From other studies there are indications of areas that might provide a focus for improvement. The review of teaching and teacher education pointed to the uncertainties regarding how best to teach science and mathematics in primary schools, a need to strengthen the development of content and pedagogical knowledge in mathematics and science during initial education and continuing professional development, and a need to attract to, and retain in, the teaching profession graduates with strong backgrounds in mathematics (Committee for the Review of Teaching and Teacher Education, 2003). A video-based study of mathematics teaching in Year 8 classrooms in 1999 suggested that mathematics lessons in Australia involved a greater use of short, repetitive problems of low complexity than was evident in other countries (Hollingsworth et al, 2003). These perspectives from other studies are neither comprehensive nor definitive but they are consistent with the findings of TIMSS 2002/03. The results from TIMSS 2002/03 suggest that further investigation and thoughtful responses in policy and practice will be important to sustain and enhance mathematics learning in Australian schools.

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Appendix 1
Multiple comparisons of average mathematics achievement for all countries

Year 8

	Singapore	Korea, Rep. of	Hong Kong SAR	Chinese Taipei	Japan	Belgium (Flemish)	Netherlands	Estonia	Hungary	Malaysia	Latvia	Russian Federation	Slovak Republic	Australia	United States of America	Lithuania	Sweden	England	Scotland	Israel	New Zealand	Slovenia	Italy	Armenia	Serbia
Singapore		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea, Rep. of	▼		–	–	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong SAR	▼	–		–	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	▼	–	–		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	▼	▼	▼	▼		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium (Flemish)	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	▼	▼	▼	▼	▼	–				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	▼	▼	▼	▼	▼	–	–			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	▼	▼	▼	▼	▼	–	–	–		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Malaysia	▼	▼	▼	▼	▼	▼	▼	▼	▼		–	–	–	–	–	–	–	–	–	▲	▲	▲	▲	▲	▲
Latvia	▼	▼	▼	▼	▼	▼	▼	▼	▼	–		–	–	–	–	–	▲	–	▲	▲	▲	▲	▲	▲	▲
Russian Federation	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–		–	–	–	–	▲	–	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–		–	–	–	▲	–	▲	▲	▲	▲	▲	▲	▲
Australia	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–		–	–	–	–	–	–	–	▲	▲	▲	▲
United States of America	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–	–		–	–	–	–	–	–	▲	▲	▲	▲
Lithuania	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–	–	–		–	–	–	–	–	▲	▲	▲	▲
Sweden	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	▼	▼	▼	–	–			–	–	–	–	–	▲	▲	▲
England	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–	–	–	–	–		–	–	–	–	▲	▲	▲
Scotland	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	▼	▼	▼	–	–	–	–	–		–	–	–	▲	▲	▲
Israel	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–	–	–		–	–	▲	▲	▲
New Zealand	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–	–	–	–		–	–	▲	▲
Slovenia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–	–	–		▲	▲	▲
Italy	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	▼		–	–
Armenia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–		–
Serbia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	
Bulgaria	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–
Romania	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	–	–	–
Norway	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Moldova, Rep. of	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Cyprus	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Macedonia, Rep. of	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Lebanon	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Jordan	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Iran, Islamic Rep. of	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Indonesia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Tunisia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Egypt	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Bahrain	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Palestinian Nat'l Auth.	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Chile	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Morocco	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Philippines	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Botswana	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Saudi Arabia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Ghana	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
South Africa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼

▲ Average achievement significantly higher than comparison country
▼ Average achievement significantly lower than comparison country

Instructions: Read across the row for a country to compare performance with the countries listed along the top of the chart. The symbols indicate whether the average achievement of the country in the row is significantly lower than that of the comparison country, significantly higher than that of the comparison country, or if there is no statistically significant difference between the average achievement of the two countries.

	Bulgaria	Romania	Norway	Moldova, Rep. of	Cyprus	Macedonia, Rep. of	Lebanon	Jordan	Iran, Islamic Rep. of	Indonesia	Tunisia	Egypt	Bahrain	Palestinian Nat'l Auth.	Chile	Morocco	Philippines	Botswana	Saudi Arabia	Ghana	South Africa
Singapore	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea, Rep. of	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong SAR	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium (Flemish)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Malaysia	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States of America	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
England	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Scotland	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Armenia	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria		-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Romania	-		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	▼	▼		-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Moldova, Rep. of	▼	▼	-		-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Cyprus	▼	▼	-	-		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macedonia, Rep. of	▼	▼	▼	▼	▼		-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lebanon	▼	▼	▼	▼	▼	-		-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Jordan	▼	▼	▼	▼	▼	▼	-		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iran, Islamic Rep. of	▼	▼	▼	▼	▼	▼	▼	▼		-	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲
Indonesia	▼	▼	▼	▼	▼	▼	▼	▼	-		-	-	-	▲	▲	▲	▲	▲	▲	▲	▲
Tunisia	▼	▼	▼	▼	▼	▼	▼	▼	-	-		-	▲	▲	▲	▲	▲	▲	▲	▲	▲
Egypt	▼	▼	▼	▼	▼	▼	▼	▼	-	-	-		-	▲	▲	▲	▲	▲	▲	▲	▲
Bahrain	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	▼	-		▲	▲	▲	▲	▲	▲	▲	▲
Palestinian Nat'l Auth.	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		-	-	▲	▲	▲	▲	▲
Chile	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-		-	-	▲	▲	▲	▲
Morocco	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	-		-	▲	▲	▲	▲
Philippines	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	-		-	▲	▲	▲
Botswana	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-		▲	▲	▲
Saudi Arabia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲
Ghana	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		-
South Africa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	

Note: 5% of these comparisons would be statistically significant by chance alone.
SOURCE: IEA Trends in International Mathematics and Science Study (TIMSS) 2003

Year 4

Instructions: Read across the row for a country to compare performance with the countries listed along the top of the chart. The symbols indicate whether the average achievement of the country in the row is significantly lower than that of the comparison country, significantly higher than that of the comparison country, or if there is no statistically significant difference between the average achievement of the two countries.

	Singapore	Hong Kong SAR	Japan	Chinese Taipei	Belgium (Flemish)	Netherlands	Latvia	Lithuania	Russian Federation	England	Hungary	United States of America	Cyprus	Moldova, Rep. of	Italy	Australia	New Zealand	Scotland	Slovenia	Armenia	Norway	Iran, Islamic Rep. of	Philippines	Morocco	Tunisia
Singapore		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong, SAR	▼		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	▼	▼		-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	▼	▼	-		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium (Flemish)	▼	▼	▼	▼		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	▼	▼	▼	▼	▼		-	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	▼	▼	▼	▼	▼	-		-	-	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	▼	▼	▼	▼	▼	-	-		-	-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	▼	▼	▼	▼	▼	-	-	-		-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
England	▼	▼	▼	▼	▼	▼	-	-	-		-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	▼	▼	▼	▼	▼	▼	-	-	-	-		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Cyprus	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		-	-	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Moldova, Rep. of	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-		-		▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	-			▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	-		-	-	▲	▲	▲	▲	▲	▲	▲
New Zealand	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			-	▲	▲	▲	▲	▲	▲	▲
Scotland	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		-		▲	▲	▲	▲	▲	▲	▲
Slovenia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲	▲	▲	▲	▲
Armenia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		-	▲	▲	▲	▲
Norway	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-		▲	▲	▲	▲
Iran, Islamic Rep. of	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲	▲
Philippines	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		-	▲
Morocco	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-		-
Tunisia	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	-	

▲ Average achievement significantly higher than comparison country
▼ Average achievement significantly lower than comparison country

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