



# 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.

