



SCHOOLING ISSUES DIGEST

Performance of Australian School Students in International Studies in Mathematics

About the Digests

The Australian Government Department of Education, Employment and Workplace Relations (DEEWR) is publishing a series of brief reports titled "Schooling Issues Digests" which summarise existing research material on selected topics relevant to schooling in Australia. The purpose of these Digests is to provide status reports on the results of recent international and national research on selected topics, in a non-technical, easy to read format, which brings together and demystifies complicated research and statistical data. Contact Roger Wright on (02) 6240 7897 or email address roger.wright@deewr.gov.au for more information on this series.

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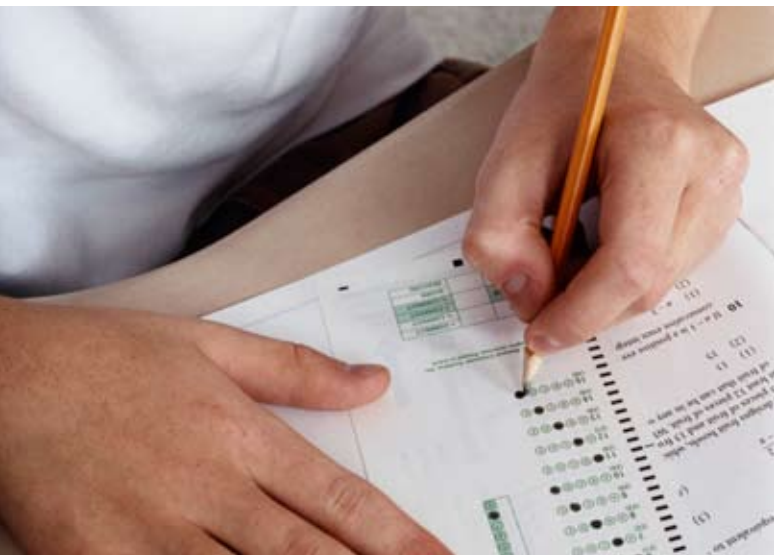
OVERVIEW

Australia participates on an ongoing basis in two international assessments that examine the mathematical skills and understanding of students. These are the Programme for International Student Assessment (PISA) which is conducted by the Organisation for Economic Cooperation and Development (OECD) and the Trends in International Mathematics and Science Study (TIMSS) which is conducted by the International Association for the Evaluation of Educational Achievement (IEA).

Participation in these studies enables us to benchmark the performance of Australian students against students in other countries, to assess Australian students' relative strengths and weaknesses and to monitor our achievement levels over time. It also provides information on how well Australian schools are providing for the educational needs of students from different backgrounds and in different locations.

TIMSS assesses Year 4 and Year 8 students in mathematics and science on a four year cycle. The most recent TIMSS results are from the TIMSS 2003 cycle. This was the third TIMSS cycle in recent years, following TIMSS 1995 and TIMSS 1999¹. The assessments for these cycles were conducted in Australian schools in 1994, 1998 and 2002 due to differences in the timing of the school year between southern and northern hemisphere countries. Testing for the next cycle, TIMSS 2007, was conducted in Australian schools in 2006 and the results will be released in December 2008.

¹ Year 8 only in 1998.



Participating countries

More than 40 countries participated in each of TIMSS 2003 and PISA 2003; however the countries were not all the same. All 30 OECD countries participated in PISA along with non-OECD countries such as Hong Kong – China, the Russian Federation, Thailand and Brazil. Thirteen OECD countries participated in TIMSS 2003 at Year 8 and nine OECD countries participated at Year 4 level. The United Kingdom participated as one country in PISA, whereas England and Scotland participated individually in TIMSS. In TIMSS 2003, Australia participated in both Year 8 and Year 4, but many countries only participated in Year 8. All 30 OECD countries and 27 non-OECD countries participated in PISA 2006.

The TIMSS 1995 cycle also included an assessment of final year students; however as these results are now over ten years old and the assessment has not been repeated, these results will not be discussed.

The PISA study assesses 15-year-old students in three core assessment domains: reading literacy, mathematical literacy and scientific literacy. The most recent PISA results are from the PISA 2006 cycle. PISA was first conducted in 2000, and is held every three years. One of the core assessment domains is the major focus for assessment and analysis in each cycle on a rotational basis. Mathematical literacy was the major focus in 2003 and a minor focus in 2000 and 2006.

Since mathematical literacy was only assessed as a minor domain in PISA 2006, the PISA 2006 results provide updated information on Australian student performance in mathematical literacy, but do not provide the extensive data on performance by content areas or on factors influencing student performance in mathematical literacy that was available from PISA 2003. This Digest will therefore provide updated information from PISA 2006 on overall mathematical literacy performance levels, but will focus on the PISA 2003 results to provide more detailed information about the strengths and weaknesses of Australian students in mathematical literacy and their attitudes towards mathematics.

Two important differences between TIMSS and PISA

PISA and TIMSS differ in two major ways: how students are sampled to participate, and the focus of the assessment. PISA uses a sample based on 15-year-old students, whilst TIMSS samples whole classes at Year 4 and Year 8. In Australia, students taking PISA, being 15 years old, are spread over several school year levels, while for TIMSS the age of Australian students, at either Year 4 or Year 8, can vary by several months. Australian students in Year 4 and Year 8 are younger than students in most other participating countries in TIMSS even though they have had at least as many years of formal schooling. The sampling procedures for TIMSS also changed from 1995 to 2003. The effects of these changes on the interpretation of results are discussed below.

The two studies focus on different aspects of mathematics. School curriculum is the focus of TIMSS, which aims to examine the attained curriculum, that is, how well the intended and implemented curriculum have been learned by students. TIMSS analyses the curriculum documents of participating countries and constructs its assessments to reflect *core* elements of the curricula of all participating countries. TIMSS can therefore provide answers to questions such as: “What mathematics are students expected to learn in all countries?” (intended curriculum); “What opportunities are provided for young people to learn mathematics?” (implemented curriculum); and “What mathematical skills and concepts have students learned?” or “What factors appear to influence students’ learning?” (achieved curriculum).

On the other hand, PISA assesses “literacy”, drawing attention to a broad range of competencies that are expected to equip young people to cope effectively with adult life in a rapidly changing society. It asks how well 15-year-olds, close to completing compulsory schooling in many countries, can apply mathematics to real-life problems. PISA defines mathematical literacy as “an individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned and reflective citizen”¹.

Sampling methods and populations

Rigorous sampling methods (outlined in the relevant reports) ensure that reliable and unbiased data are obtained. In Australia, more than 12,000 15-year-olds participated in PISA 2003, more than 14,000 participated in PISA 2006, and around 5,000 students in each of Years 4 and 8 participated in TIMSS 2003. First, schools were randomly selected from all school sectors in Australia, in proportion to their enrolments. Then, for TIMSS, a class was randomly chosen from the appropriate year level, whilst for PISA, a further random sample of the school’s 15-year-olds was drawn.

Scope of the data

The data obtained from TIMSS and PISA provide a rich source of information about overall levels of achievement, and also about the achievement of males and females, of students in each State and Territory, of Indigenous students, of those students who do not have English as their home language, of students living in urban, regional and rural areas, and of students from different socioeconomic backgrounds. There is also information that relates attitudes to achievement, and the impact of school resources on achievement.

Australian students’ performance

Performance measured by mean scores

In all three cycles of PISA to date, Australia’s performance in mathematical literacy was higher than the OECD mean. In 2003, when mathematical literacy was the major focus of assessment, Australia’s mean score was 524 compared with the OECD average of 500. Australia was significantly outperformed by seven countries (Hong Kong – China, Finland, Korea, Netherlands, Liechtenstein, Japan and Canada). In PISA 2006, Australia’s mean score was 520 compared with the OECD average of 498 and Australia was significantly outperformed by eight countries (Chinese Taipei, Finland, Hong Kong – China, Korea, Netherlands, Switzerland, Canada and Macao-China). The small decline in Australia’s mean score from 524 in PISA 2003 to 520 in PISA 2006 was not statistically significant.

Australia’s TIMSS 2003 Year 8 mean score (505) was significantly higher than the international mean (467), but there was no significant difference between the Australian Year 4 mean (499) and the international mean (495). Australian students were significantly outperformed by students in nine of the other 45 participating countries at Year 8 and by 13 of the other 24 participating countries at Year 4 level.



2 OECD, 2004, p. 24

Table 1: Australia’s performance in mathematics compared with other countries – TIMSS 2003, PISA 2003 and PISA 2006

| | Year 4 Mathematics (TIMSS 2003) | Year 8 Mathematics (TIMSS 2003) | 15-year-old Mathematical Literacy (PISA 2003) | 15-year-old Mathematical Literacy (PISA 2006) |
|--|---|---|---|---|
| Countries that outperformed Australia | 13 Singapore, Hong Kong SAR, Japan, Chinese Taipei, Belgium (Flemish), Netherlands, Latvia, Lithuania, Russian Federation, England, Hungary, USA, Cyprus | 9 Singapore, Korea, Hong Kong SAR, Chinese Taipei, Japan, Belgium (Flemish), Netherlands, Estonia, Hungary | 7 Hong Kong-China, Finland, Korea, Netherlands, Liechtenstein, Japan, Canada | 8 Chinese Taipei, Finland, Hong Kong-China, Korea, Netherlands, Switzerland, Canada, Macao-China |
| Countries that performed at an equivalent level with Australia | 4 Moldova, Italy, New Zealand, Scotland | 11 Malaysia, Latvia, Russian Federation, Slovak Republic, USA, Lithuania, Sweden, Scotland, England, Israel, New Zealand | 5 Belgium, Macao-China, Switzerland, New Zealand, Czech Republic | 5 Liechtenstein, Japan, New Zealand, Belgium, Estonia |
| Countries that were outperformed by Australia | 7 Slovenia, Armenia, Norway, Iran, Philippines, Morocco, Tunisia | 25 Slovenia, Italy, Armenia, Serbia & Montenegro, Bulgaria, Romania, Norway, Moldova, Cyprus, Macedonia, Lebanon, Jordan, Iran, Indonesia, Tunisia, Egypt, Bahrain, Palestinian National Authority, Chile, Morocco, Philippines, Botswana, Saudi Arabia, Ghana, South Africa | 27 Iceland, Denmark, France, Sweden, Austria, Germany, Ireland, Slovak Republic, Norway, Luxembourg, Poland, Hungary, Spain, Latvia, United States, Russian Federation, Portugal, Italy, Greece, Serbia, Turkey, Uruguay, Thailand, Mexico, Indonesia, Tunisia, Brazil | 43 Denmark, Czech Republic, Iceland, Austria, Slovenia, Germany, Sweden, Ireland, France, United Kingdom, Poland, Slovak Republic, Hungary, Luxembourg, Norway, Lithuania, Latvia, Spain, Azerbaijan, Russian Federation, USA, Croatia, Portugal, Italy, Greece, Israel, Serbia, Uruguay, Turkey, Thailand, Romania, Bulgaria, Chile Mexico and nine more non-OECD countries |

There is evidence from the latest TIMSS assessments, that some other countries are raising their performance while Australian performance remained static over the period from TIMSS 1995 to TIMSS 2003. At Year 4, 15 countries took part in both TIMSS 1995 and 2003. Four were statistically above Australia on both occasions, and five were above in 2003 but not 1995. At Year 8, 26 countries participated in both assessments. Australia was outperformed by five of these on both occasions, and by an additional two in 2003. Possibly this is because new sampling rules since 1995 result in the Australian students being younger than those in countries that outperform us, although they have had at least as long at school.

There were some shifts in country positions relative to Australia between PISA 2003 and PISA 2006, but there were as many countries whose positions declined relative to Australia as countries whose positions improved relative to Australia.

Performance against benchmarks

Another way of examining achievement is to look at the proportions of students achieving at each of the international benchmark levels used in TIMSS and at each of the proficiency levels used in PISA.

TIMSS defines four international benchmark levels (Advanced, High, Intermediate and Low) which divide students into five groups. For example, at the ‘Low’

level are those students whose score is between the Low and Intermediate benchmarks. These students demonstrate only very rudimentary knowledge of mathematics. There are also students who do not even achieve the Low benchmark and these are described as being below the Low benchmark.

PISA defines six proficiency levels (and hence seven groups) with Level 6 as the highest level of achievement and 'Below Level 1' as the lowest. The percentages of students achieving at each of these levels are given in Figure 1 and Figure 2 below.

Figure 1: Percentages of students reaching benchmarks of mathematics achievement in TIMSS 2003

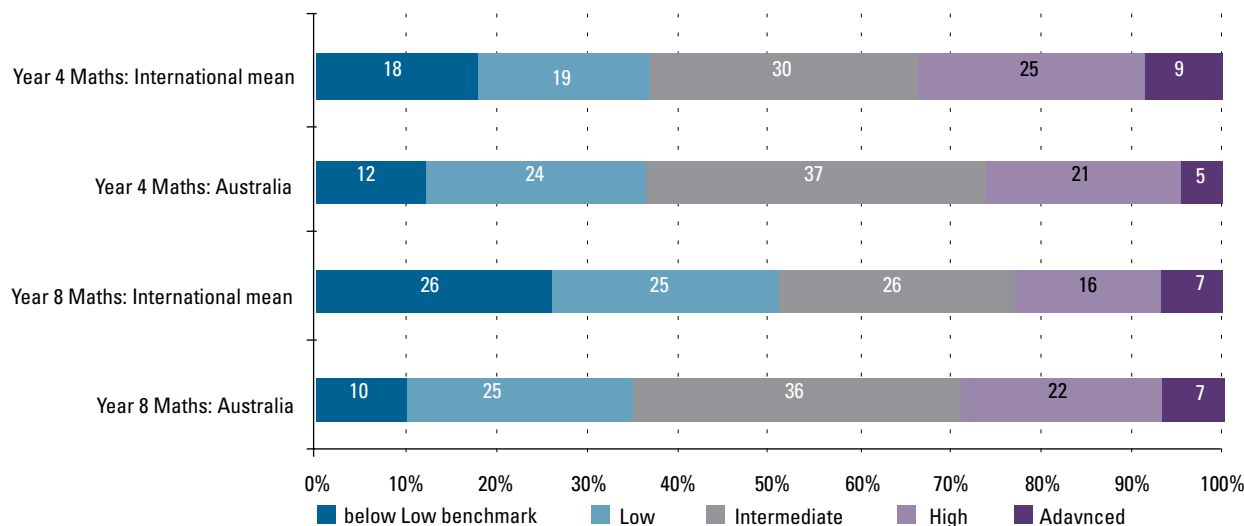
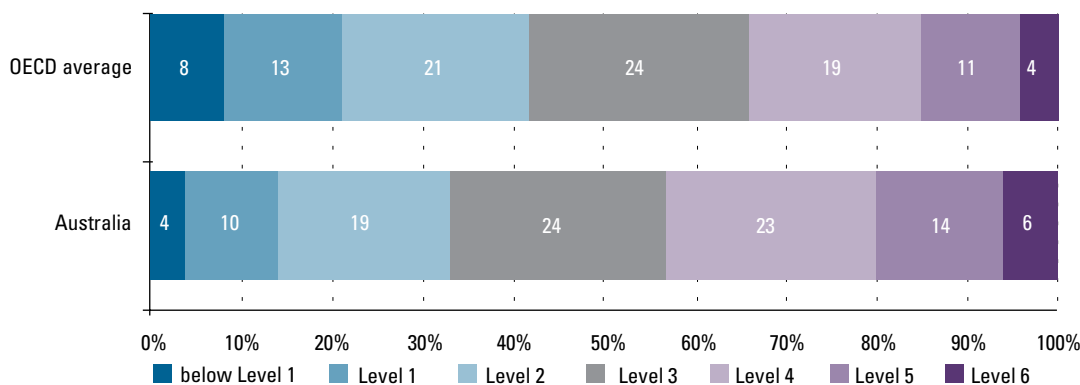


Figure 2: Percentages of students reaching proficiency levels in PISA 2003 mathematical literacy



Figures 1 and 2 show that more Australian students achieved at the highest two levels than the international averages for PISA 2003 and the Year 8 population of TIMSS 2003. This was also the case for Year 4 students in TIMSS 1995, but was not the case for TIMSS 2003. It is important to note, however, that the highest performing countries have considerably more students achieving at the highest levels. For example, at both Year 4 and Year 8 in TIMSS 2003 over 70 per cent of Singaporean students were in the Advanced or High levels compared with less than 30 per cent of Australian students. The effect is less

marked for PISA. In PISA 2003, the highest scoring countries, Finland and Korea, had about 24 per cent of students in the highest two levels compared to 20 per cent of Australian students. In PISA 2006, however, the proportion of Australian students in the highest two levels dropped to 16 per cent, with Chinese Taipei having 32 per cent of students in these levels, and the other high achieving countries, Finland, Hong Kong-China and Korea with 24 per cent, 28 per cent and 27 per cent of students respectively in the highest proficiency levels.

The OECD has described PISA Proficiency Level 2 as representing “a baseline level of proficiency at which students begin to demonstrate skills that enable them to actively use mathematics”². In Figure 2, it can be seen that 14 per cent of the PISA 2003 Australian cohort failed to reach Level 2, compared to the OECD average of 21 per cent. In PISA 2006, 13 per cent of Australian students compared to the OECD average of 21 per cent failed to reach Level 2.

Figure 1 shows that the percentages of Australian students achieving at or below the Low Benchmark in TIMSS 2003 was 35 per cent at Year 8 and 36 per cent at Year 4. By contrast, the highest performing country, Singapore, has less than 10 per cent of students at or below the Low Benchmark at both Year 4 and Year 8.

Performance by content areas

The TIMSS mathematics assessments and the PISA 2003 major domain assessment of mathematical literacy also provide student results by mathematics content areas. The PISA 2006 minor domain assessment of mathematical literacy did not provide results by content areas.

In TIMSS 2003 Australian Year 4 students performed significantly higher than the international average in three of the five mathematics content areas: *Measurement, Geometry* and *Data*. Their performance in *Patterns* and *Relationships* was comparable to the international average, whereas in *Number*, they performed below the international average.

Australian Year 8 students performed consistently above the international average in all five content



areas (*Number, Algebra, Measurement, Geometry* and *Data*), with Australian students performing best in *Data* and weakest in *Geometry*.

PISA 2003 mathematical literacy results were reported in four content areas: *Space and Shape, Change and Relationships, Quantity* and *Uncertainty*. Australian students’ performance on the *Uncertainty* subscale was slightly better than their performance on the other three subscales; performance on the *Quantity* subscale was not as strong as on the other three. These good results on *Data* in TIMSS and *Uncertainty* in PISA are probably due to these topics receiving relatively more attention here than in many other countries through the *Chance and Data* strand of Australian mathematics curricula.

Australia has shown a relative weakness in the important area of *Number* at Year 4 level in both TIMSS 1995 and TIMSS 2003. In TIMSS 1995, Australia had an average of 67 per cent correct on the *Number* items (equal to the international average), whereas Singapore, Korea and Japan all averaged over 80 per cent correct. In TIMSS 2003, on a conceptual item asking students to identify which square had $\frac{2}{3}$ shaded, Australia had 62 per cent correct (above the international average of 57 per cent) but Singapore had 93 per cent correct. On the computation ‘ 15×9 ’, Australia had 45 per cent correct (below the international average of 72 per cent) but four countries had over 90 per cent correct. On both conceptual and computational number items, Australia performs around the international average (a little higher usually) but the highest performing countries have very much better results. Many Australian mathematics educators would trade computational expertise (which is sometimes achieved by rote learning that alienates the learner and provides little of lasting benefit) for conceptual understanding, so Australian curricula often delay



³ Education at a Glance, p. 82

or de-emphasise calculation. This may explain the low results for computation, but to date this has not been compensated for by large gains in conceptual items. This has important implications for improving teaching.

Some studies (e.g. PISA 2000) have noted that Australia does relatively better on short unambiguous questions than those requiring constructed responses.

Performance by cognitive domain

TIMSS 2003 classified all items in three cognitive domains of increasing complexity: (i) Knowing facts, procedures and concepts, (ii) Applying knowledge and conceptual understanding and (iii) Reasoning, which encompasses items displaying unfamiliar situations, complex contexts and multi-step problems. At Year 8, Australia performed lower than its overall performance in *Knowing*, about the same in the *Applying*, and a little better in *Reasoning*. At Year 4, *Applying* was a relative weakness, *Knowing* was on the Australian average, and *Reasoning* was again a little above. However, these differences were not large.



State and Territory comparisons

The Australian samples for both TIMSS and PISA are designed so as to provide reliable estimates of performance for students in each State and Territory.

Caution is needed, however, in interpreting these results as an indication of the underlying effectiveness of schools and curricula across the States and Territories, without further analysis. States and Territories differ in the structure of their schooling systems which means that the tested students in some states are older than in other states, or have had more formal schooling, and some Year 8 students have had more specialist mathematics teaching in secondary school. These factors can also influence the comparison of individual States and Territories across the two different studies. States and Territories also differ in the characteristics of their populations and where they live.

The following tables provide the mean scores with standard errors for each State and Territory in TIMSS 2003 and PISA 2006, and indicate where there are statistically significant differences between the States and Territories. The tables also include, for PISA, the proportions of students tested that were in Year 10 or above, and for TIMSS, the average age of the students tested, to illustrate how the differences in schooling structures impacts on the populations of students tested.

Table 2: Year 4 Mathematics Achievement by State and Territory, TIMSS 2003

| | Average Age of Students | | ACT | NSW | VIC | TAS | SA | QLD | NT | WA |
|-----|-------------------------|------|------|-----|-----|-----|----|-----|----|----|
| | Mean | SE | | | | | | | | |
| ACT | 523 | 13.7 | 10.1 | ● | ● | ● | ● | ● | ● | ▲ |
| NSW | 510 | 9.2 | 10.0 | ● | ● | ● | ● | ● | ● | ▲ |
| VIC | 508 | 6.8 | 10.1 | ● | ● | ● | ● | ● | ● | ▲ |
| TAS | 497 | 13.2 | 10.2 | ● | ● | ● | ● | ● | ● | ● |
| SA | 485 | 8.3 | 9.9 | ● | ● | ● | ● | ● | ● | ● |
| QLD | 484 | 7.1 | 9.4 | ● | ● | ● | ● | ● | ● | ● |
| NT | 479 | 14.9 | 9.8 | ● | ● | ● | ● | ● | ● | ● |
| WA | 472 | 7.8 | 9.4 | ▼ | ▼ | ▼ | ● | ● | ● | ● |

Table 3: Year 8 Mathematics Achievement by State and Territory, TIMSS 2003

| | | | Average Age of Students | | | | | | | | |
|-----|------|------|-------------------------|-----|-----|----|-----|-----|----|-----|----|
| | Mean | SE | | NSW | ACT | SA | VIC | QLD | WA | TAS | NT |
| NSW | 530 | 11.9 | 14.0 | | ● | ● | ● | ▲ | ▲ | ● | ▲ |
| ACT | 507 | 9.6 | 14.1 | ● | | ● | ● | ● | ● | ● | ▲ |
| SA | 501 | 11.3 | 13.8 | ● | ● | | ● | ● | ● | ● | ● |
| VIC | 495 | 6.4 | 14.1 | ● | ● | ● | | ● | ● | ● | ● |
| QLD | 490 | 6.1 | 13.4 | ▼ | ● | ● | ● | | ● | ● | ● |
| WA | 487 | 7.6 | 13.4 | ▼ | ● | ● | ● | ● | | ● | ● |
| TAS | 477 | 12.3 | 14.2 | ● | ● | ● | ● | ● | ● | | ● |
| NT | 449 | 14.1 | 13.8 | ▼ | ▼ | ● | ● | ● | ● | ● | |

Table 4: 15-year-old Mathematical Literacy Achievement by State and Territory, PISA 2006

| | | | | Percentage of students in Year 10 or above | | | | | | | |
|-----|------|-----|----|--|----|-----|----|-----|-----|-----|----|
| | Mean | SE | | ACT | WA | NSW | SA | QLD | VIC | TAS | NT |
| ACT | 539 | 5.6 | 91 | | ● | ▲ | ▲ | ▲ | ▲ | ▲ | ▲ |
| WA | 531 | 6.5 | 99 | ● | | ● | ● | ● | ▲ | ▲ | ▲ |
| NSW | 523 | 5.0 | 82 | ▼ | ● | | ● | ● | ● | ▲ | ▲ |
| SA | 520 | 4.3 | 96 | ▼ | ● | ● | | ● | ● | ▲ | ▲ |
| QLD | 519 | 4.4 | 98 | ▼ | ● | ● | ● | | ● | ▲ | ▲ |
| VIC | 513 | 4.0 | 90 | ▼ | ▼ | ● | ● | ● | | ▲ | ▲ |
| TAS | 502 | 3.8 | 72 | ▼ | ▼ | ▼ | ▼ | ▼ | ▼ | | ▲ |
| NT | 481 | 6.2 | 92 | ▼ | ▼ | ▼ | ▼ | ▼ | ▼ | ▼ | |

- ▲ Average performance is statistically significantly higher than comparison state.
- No statistically significant difference from comparison state.
- ▼ Average performance is statistically significantly lower than in comparison state.

Note: Read across the row to compare a State or Territory’s performance with the performance of each State and Territory as listed in the column headings.

Student characteristics

Gender differences

It is also not a simple matter at this stage to compare the performance within individual States and Territories over time. There have only been two cycles of PISA to date with comparable data on mathematical literacy performance, and the populations assessed in TIMSS changed between 1994 and 2003. Furthermore, the above statistical differences between states are reduced when the effects of age and home background are taken into account.

Since the First International Mathematics Study (FIMS) in 1965, gender differences favouring males have been common in international results. However, no statistically significant differences had been evident in the overall performances of Australian males and females in the TIMSS³ and PISA assessments up until PISA 2006. For example, in TIMSS 1995, Australia was one of only five countries where no significant gender differences in achievement were found. There were gender differences in some content areas in Australia

⁴ The only exception is the TIMSS 1995 assessment of the general population of Year 12 students, where males performed better.



in TIMSS 2003 (Year 4 geometry favouring females, Year 8 number and Year 8 measurement favouring males) but these differences did not form a consistent pattern across assessments within Australia and there was no statistically significant overall difference in Australia. In PISA 2003, males performed better than females in 27 out of 50 countries, but there was no significant gender difference in Australia. This changed with the release of the PISA 2006 results. These showed a significant gender difference in favour of males in Australia for the first time in either TIMSS or PISA, resulting from a significant decline in the performance of females between PISA 2003 and PISA 2006.

Despite the lack of statistically significant differences in the *average* scores of males and females up until PISA 2006, there are three aspects to note. Firstly, the distribution of scores of males and females is different. In nearly all assessments males have a higher average score than females at both the item and whole test level. Generally more males than females score very highly. For example, in PISA 2003, when there was no significant difference in male and female mean scores, there were seven per cent of males compared to four per cent of females at the highest level of proficiency (Level 6). In PISA 2006, six per cent of males compared to three per cent of females achieved at Level 6. Secondly, more males than females choose to participate in the highest levels of mathematics in senior secondary years in Australia. Thirdly, there are significant differences in attitudes towards mathematics between males and females in Australia, which may explain the second factor (these are discussed in a later section).

Home language and migration background

In Australia, New Zealand and Canada, when socioeconomic background is taken into account, there appears to be almost no disadvantage in mathematics performance for students who come from immigrant backgrounds or from language backgrounds other than English, unlike the situation in the USA and in many European countries.

Internationally, being an immigrant student or speaking a language at home that is not the language of the test tends to have a negative impact on mathematical literacy. In TIMSS 2003, this was evident for Australian Year 4 students, but for Australia's Year 8 students the trend was reversed. The average score of the 80 per cent of Year 8 students who reported *always* speaking English at home was actually lower than the average score of the 19 per cent who *sometimes* or *almost always* spoke English at home.

In PISA 2003, again against the international trend, Australia had no significant differences in mean scores between students with different migration status, although students speaking English at home scored significantly higher than students who spoke a language other than English at home. In PISA 2006, students with both parents born in Australia actually scored significantly below first generation and foreign-born students, and there was no significant difference in performance between speakers of English and speakers of languages other than English at home.

Rural and remote location

The results of PISA and the TIMSS Year 8 assessments indicate that secondary students attending schools in remote and very remote areas achieve less well than other students in Australia. No statistically significant effect has been observed in TIMSS at the Year 4 level.

But is school location itself the critical factor? The impact of school location on student performance was isolated statistically from the PISA 2000 reading literacy results (this analysis has not been undertaken in relation to mathematical literacy). When the effect of home background factors, language and socioeconomic status were taken into account, the negative impact of location on performance was found to be much less significant.



Whilst teachers in remote and very remote schools were as well qualified as other teachers in Australia, remote and very remote schools reported more teacher shortages and were much more likely to report that education was hindered by a lack of resources than were other Australian schools or OECD schools overall. On the other hand, remote and very remote schools had a student-teacher ratio of only 11.6, compared to 15.4 in the major cities. It is pleasing that from TIMSS 1995 to TIMSS 2003 there was a general reduction in the percentage of schools reporting lack of school resources for instruction, in Australia and internationally.

Indigenous students

There is a wide, persistent and troubling gap between the mathematics achievement of Australia's Indigenous students and non-Indigenous students identified by both TIMSS and PISA. In TIMSS 2003 Year 8, for example, the average score of Australian Indigenous students in every location was below the international average. In addition, 38 per cent (compared to nine per cent of non-Indigenous students) failed to achieve the Low benchmark and less than one per cent (compared to nine per cent) achieved the Advanced benchmark. The achievement of female Indigenous students is of particular concern with 45 per cent not reaching the Low benchmark. It therefore seems likely that many Indigenous school leavers are ill-equipped to participate in further education or other than low-skill employment.

There was no significant closing of the gap in performance between Indigenous and non-Indigenous students in the eight years between the TIMSS 1995 and 2003 assessments, or between PISA 2003 and

PISA 2006. Improving the mathematical achievement of Indigenous students must therefore continue to be a national priority.

Socioeconomic background

Both PISA and TIMSS find that there is a significant relationship between student socioeconomic background and performance. This relationship is evident in Australia and all countries, although the strength of the relationship differs among countries. By examining the comparative impact of socioeconomic background on achievement, one can see how equitably the benefits of schooling are being shared among students of different socioeconomic backgrounds.

In PISA 2003, two measures were used to compare the impact of socioeconomic background on mathematical literacy performance. One was the strength of the relationship between socioeconomic status of students and mathematical performance. Using this measure, 14 per cent of the variation in performance was explained by socioeconomic background. This was significantly lower than the OECD average of 20 per cent of the variation explained. A second measure used the slope of the 'social gradient': the average increase in students' scores for a unit increase in the measure of socioeconomic background. The slope was less for Australia than in many other countries and lower than the OECD average, although not significantly so.

In its PISA 2003 reporting, the OECD used the strength of the relationship between socioeconomic background and performance to categorise countries on the equity of mathematical literacy outcomes achieved. On this basis, and Australia's higher than OECD average performance, Australia was categorised by



the OECD as a “High Quality/High Equity” country in relation to our mathematical literacy outcomes. Other “High Quality/High Equity” countries included Hong Kong – China, Finland, Canada and Japan. In all of these countries the percentage of variation in student performance explained by socioeconomic background was lower than in Australia.

By contrast, PISA 2000 reading literacy results showed that socioeconomic background explained 17 per cent per cent of the variation in student reading literacy performance in Australia, and the slope of the social gradient was higher in Australia than the OECD average. This could suggest that in Australia, mathematics is somewhat more impacted by school experiences whereas reading is somewhat more impacted by home experiences.

Using different measures of student socioeconomic background, TIMSS 2003 found the impact of socioeconomic background in Australia at Year 4 was almost identical with the international TIMSS 2003 average, but for Year 8 the impact of socioeconomic background was significantly higher than the international average. The TIMSS measures included the extent of social disadvantage in the whole school, and student-level measures of social capital such as number of books in the home.

While on average students from higher socioeconomic backgrounds in Australia are more likely to achieve at higher performance levels than students from lower socioeconomic backgrounds, the correlations in Australia, between socioeconomic background and performance have never been particularly strong when compared internationally. This means that socioeconomic background is not a particularly strong predictor of performance at the level of the individual student in Australia with students from both high and low socioeconomic backgrounds achieving across the spectrum of performance.

Based on this evidence, it seems reasonable to conclude that efforts to improve students’ performance in Australia need to be targeted at low performing students and low performing schools wherever they are located and whatever their social background. Relying on other indicators to guide where programs should be targeted would run the risk of dissipating the effectiveness of additional resources by including a sizeable proportion of students who already have acceptable performance levels.

School, Classroom and Learning Influences

School environment and student attitudes

The PISA 2003 student questionnaire asked students about their school and classroom environments, their attitudes and motivations and their learning strategies and preferences. Australian students generally reported more positively on their school environment and reported more positive attitudes to mathematics than the OECD average. On each of these measures, some of the highest performing countries were well below the OECD average. For example, students from the high performing Asian countries reported very low self-concept with respect to mathematics, a result that has created considerable disquiet in these countries. Australia shows significant gender differences in attitudes in line with OECD trends with male students reporting higher levels of interest and enjoyment of mathematics, higher levels of mathematics self-efficacy and self-concept, higher levels of instrumental motivation and lower levels of anxiety about doing mathematics than female students.

PISA 2003 found that students’ educational intentions, self-concept and self-efficacy were the most influential of the variables included to explain differences between students within a school. This might be expected since these variables relate to the students’ view of their own proficiency which would have been influenced by their mathematical achievements to date. Beyond this, individual student socioeconomic background factors, student-teacher relations and disciplinary climate make a positive contribution.





From the international perspective, enjoyment of learning mathematics is not a significant factor predicting performance. Within Australia, enjoyment has a small but positive correlation with achievement. This indicates that students do not need strong interest or enjoyment to do well, and conversely, that students who do not do well can find the subject interesting and enjoyable. In Japan, where students have high mathematics achievement but extremely low interest and enjoyment, there is a major national effort to improve this aspect of student quality of life.

Students' learning strategies

PISA 2003 also asked questions about how students learned mathematics. While, on the whole, the PISA measures of learning strategies have not been shown to be important indicators of performance, Australia had the 8th highest score on students' reporting a preference for a competitive approach to learning, especially boys. On the other hand, the preference for co-operative learning, which is strongly favoured by many Australian teachers and educational systems, is about at the OECD average with no gender difference. TIMSS 1995 found that students who worked in small groups had lower achievement at both Year 4 and Year 8. This association is not simply causal, as the TIMSS video study (described on the back page) showed that teachers more often chose this strategy for low achieving classes.

Teachers and classes

Because the sampling for TIMSS is based on intact classrooms, TIMSS studies can relate performance data to information from the students and their current teacher about teaching practices and the implemented curriculum.

All the TIMSS studies show Australian teachers are well qualified by international comparisons. The one area of concern is that at least 30 per cent of the Australian Year 8 students were being taught mathematics by teachers who did not have mathematics as their major area of study.

In TIMSS 2003, Year 8 teachers were asked about factors which are known to limit the overall effectiveness of lessons, such as having students with diverse needs or disruptive students. In Australia, 16 per cent of teachers reported a large impact from such factors. This is a little lower than the international average of 20 per cent (US and NZ were near this), and much higher than the UK's six per cent. In nearly all states, over half of teachers report that different academic backgrounds and uninterested students have a large effect on their lessons.

Good school and class attendance was found in TIMSS to correlate with achievement at the school level. This was not examined at the level of the individual student. Fifty-nine per cent of Australian Year 4 principals and 74 per cent of Australian Year 8 principals reported having at least some problems with student absenteeism, and/or students arriving late or skipping classes. These were near the international averages.

Instruction

Amongst variables related to instruction studied in TIMSS 2003, strong correlations with achievement



come from items closely related to content, such as whether solving equations is a frequent activity. Amongst items tapping into more generic practices, the picture is usually mixed. For example, the frequency and amount of homework set is a predictor of achievement. For Year 8 students it was positively correlated with achievement, whereas for Year 4 the impact was negative, possibly indicating that homework for younger students was differentially targeted at students needing more help, or that those students having more difficulty with mathematics felt more burdened by a given amount of homework.

This observation on homework gives a clue to why attempts to identify those teaching practices which impact on achievement have been generally disappointing in the international comparative studies. Teaching practices are hard to define in the span of a questionnaire item, as it is hard to measure the extent to which they are used, and in different situations (e.g. age levels, schools, countries, student groups) one teaching practice can function in different ways.

Even when the trend is clear, the reasons are generally not clear. For example, working on mathematics projects was negatively correlated with achievement at both Year 8 and Year 4 in TIMSS 1995. Well chosen project work can deepen students' views of mathematics and expand their knowledge of its history and uses, but it is possible that the overuse of projects detracts from the focused teaching that correlates most with high achievement.

Future Directions

Australia has, since 1965 but mainly in recent years, participated in thirteen international comparative studies of mathematics. Consistent with its position as a stable democracy with a concern for equity, Australia generally achieves very good performance, with socioeconomic disparities in relation to mathematics performance that are modest on the international scale. The Australian curriculum covers areas regarded internationally as important, and students achieve well across the curriculum and in mathematical literacy more broadly. On the other hand, the studies demonstrate that there is ample room for improvement in raising the achievement of the lowest performing students (especially Indigenous students) and bringing more students up to the highest achievement levels.

Mathematics is an enabling science, which forms the basis for innovation and a competitive economy, so that mathematical literacy is now required at all levels of the workforce.

As the TIMSS and PISA series mature, and data collection procedures and Australian additional analyses become more routine, they should:

- enable more direct analysis of trends over time, by using stable definitions of target populations, social measures and classifications;
- facilitate more multi-level and multi-variate analyses so that an underlying picture can be more easily seen through the myriad of inter-related variables and correlations;
- provide more informative data and more subtle analyses on the effect of certain learning strategies and classroom practices on achievement;
- supplement the basic results with analyses that take account for the effect of 'obvious' factors such as age, years at school, time spent on mathematics etc.

It is important to know how well our schools and young people are performing in national and international contexts. Australia has a commendable record of participation in international student assessments but this should not be taken for granted. Participation is time-consuming and expensive, and depends on support from principals, teachers, parents and students. This in turn depends on stakeholders being well-informed about the benefits that these studies offer and what they can tell us. This Digest aims to contribute to that flow of information.



Bibliography

- Achievement of Australia's Early Secondary Indigenous Students: Findings from TIMSS 2003. TIMSS Australia Monograph No 10, by Sue Thomson, Pippa McKelvie and Hannah Murnane. ACER, Melbourne 2006. Retrieved January 17, 2007.
http://www.acer.edu.au/documents/TIMSS_AustMono10Indigenousreport.pdf
- Australia's Indigenous Students in PISA 2000: Results from an International Study. ACER Research Monograph No. 59, by Lisa De Bortoli and John Cresswell. ACER, Melbourne 2004.
http://www.acer.edu.au/documents/INDEDU_RM59IndigScreen.pdf
- Australian Students Achievement in the TIMSS 2002. Mathematics Cognitive Domains. TIMSS Australia Monograph No. 9, by Sue Thomson. ACER, Melbourne 2004.
http://www.acer.edu.au/documents/TIMSS_Mono9STOct06.pdf
- Education at a Glance. Organisation for Economic Cooperation and Development (OECD), Paris 2006. Retrieved January 17, 2007.
www.oecd.org/edu/eag2006
- Exploring Scientific Literacy: How Australia measures up, The PISA 2006 survey of students' scientific, reading and mathematical literacy skills, by Sue Thomson and Lisa De Bortoli. ACER, Melbourne, 2008.
http://www.acer.edu.au/documents/PISA2006_Report.pdf
- Facing the Future: A focus on mathematical Literacy among Australian 15-year-old Students in PISA 2003, by Sue Thomson, John Cresswell and Lisa De Bortoli. ACER, Melbourne 2004. Retrieved August 18, 2006.
http://www.acer.edu.au/documents/PISA_screen.pdf
- IEA's TIMSS 2003 International Report on Achievement in the Mathematics Cognitive Domains. Findings from a Developmental Project, by I.V.S. Mullis, M.O. Martin & P. Foy. Retrieved February 12, 2007.
<http://timss.bc.edu/timss2003i/mcgm.html>
- Immigrant Status and Home Language Background: Implications for Australian Student Performance in PISA 2000, by John Cresswell. ACER, Melbourne 2004. Retrieved August 16, 2006.
http://www.acer.edu.au/documents/PISA_2000Immigrants.pdf
- Learning for Tomorrow's World: First Results from PISA 2000. Organisation for Economic Cooperation and Development (OECD), Paris 2004. Retrieved August 22, 2006.
<http://www.pisa.oecd.org/dataoecd/1/60/34002216.pdf>
- Location, Location, Location: Implications of Geographic Situation on Australian Student Performance in PISA 2000, by John Cresswell and Catherine Underwood. ACER, Melbourne 2004.
http://www.acer.edu.au/documents/PISA_RM58PISALocation.pdf
- Maths and Science on the Line: Australian Junior Secondary Students' Performance in the Third International Mathematics and Science Study, by Jan Lokan, Peter Ford and Lisa Greenwood. ACER, Melbourne 1997.
- Maths and Science on the Line: Australian Middle Primary Students' Performance in the Third International Mathematics and Science Study, by Jan Lokan, Peter Ford and Lisa Greenwood. ACER, Melbourne 1997.
- Summing it up: Mathematics Achievement in Australian Schools in TIMSS 2002, by Sue Thomson and Nicola Fleming. ACER, Melbourne 2004. Retrieved August 16, 2006.
http://www.timss.acer.edu.au/documents/TIMSS_02_Mathsreport.pdf
- Teaching Mathematics in Australia: Results from the TIMSS 1999 Video Study, by H. Hollingsworth, J. Lokan & B. McCrae. ACER, Melbourne 2003.
- Teaching Mathematics in Seven Countries: Results from the TIMSS 1999 Video Study (NCES 2003-013), by J. Hiebert, R. Gallimore, H. Garnier, K.B. Givvin, H. Hollingsworth et al. U.S. Department of Education. National Center for Education Statistics, Washington DC 2003.
- TIMSS Video Study of Mathematics Teaching. Retrieved January 17, 2007.
<http://timss.bc.edu/timss2003i/mcgm.html>

The TIMSS 1999 Video Study of Eighth-Grade Mathematics Teaching

The TIMSS Video Study described mathematics teaching practices at Year 8 in Australia, the Czech Republic, Hong Kong - China, Japan, the Netherlands, Switzerland, and the United States. In Australia, one randomly selected mathematics lesson was videotaped from 87 randomly selected schools. The teachers and students completed questionnaires, and the students did a 'mini TIMSS' test.

The overall conclusion drawn by the study is that different methods of teaching can lead to high achievement, so there is no 'silver bullet' to improve mathematical performance across societies. Japanese teachers developed lesson plans around a small number of rich problems, with deep cognitive content and careful attention to lesson objectives and mathematical connections. In Hong Kong, another high achieving country, teaching was procedurally oriented, as it was in Australia, but compared with Australia, they had more complex problems, less repetition, and more emphasis on mathematical connections.

In Australia, a typical lesson began with a review, then introduced new content, after which students usually worked individually on problems which required them to repeat the new procedures introduced in the lesson. This lesson structure provided a variety of opportunities for learning. On many measures, Australian lessons were very similar to most of the other countries.

There were some differences between the way Australian teachers taught higher and lower ability classes. For example, the lower achieving classes had less algebra, more collaborative work, and more

interaction between the teacher and the student. However, there was no difference in the complexity of problems undertaken or in the relative sophistication of the skills needed to solve them. Higher-level processes such as mathematical reasoning or making reference to mathematical relationships were hardly ever used for problems solved publicly in the Australian lessons, regardless of the skill level of the class. The Australian report notes a widespread 'shallow teaching syndrome' where the focus is on carrying out procedures without reasons, and recommends that Australian performance in mathematics may improve if time spent on short, repetitive problems is diverted to varied, more challenging problems with class discussion emphasising reasons and connections between ideas.

The emphasis on procedures without reasons that is evident in the video study links to some findings from the student and teacher questionnaires in the main studies. PISA 2003 asked questions about how students learned mathematics. Students in the highest performing countries tended to reject memorisation as a key way of learning mathematics, but many Australian students accepted this. Indeed, Australia was the 8th highest on this measure out of 40 countries. Research shows that students who try to memorise mathematics rather than trying to understand the underlying principles, can solve routine problems but do not equip themselves for high achievement or deep understanding. TIMSS 1995 showed a negative correlation (- 0.14) between students' achievement and tendency to memorise rules and procedures. A disturbing result from TIMSS 2003 is that 22 per cent of Australian teachers agreed that "Learning mathematics mainly involves memorising".

