

Student achievement in maths and science

A population with a high level of maths and scientific literacy helps to maximise scientific and technological innovation, enhance our standard of living, and allows us to be internationally competitive.¹

Educational systems play an important role in developing students' knowledge and skills in maths and science. In recent years, however, there has been a declining proportion of Australian students who have elected to study maths and science subjects in the senior years of secondary school, and the proportion of tertiary students pursuing a Bachelor Degree in maths or science has also declined.² Recently, maths and science have been identified as key learning areas for national, state and territory curriculum programs.³

This article uses data from the Trends in International Mathematics and Science Study (TIMSS) 2007. It examines the achievement of Year 4 and Year 8 students in maths and science, and provides information on teaching practices and approaches.

Trends in maths and science

According to TIMSS 2007, Australian students performed at or significantly above the TIMSS scale average for both subject and year levels.

Between 2003 and 2007, the Year 4 maths students score increased by 17 points to 516. This score was well above the TIMSS scale average (500).

Australian Year 4 science students also achieved a score which was significantly higher than the TIMSS scale average. The 2007 score of 527 showed little change from 2003.

In contrast, the Year 8 maths score fell by 8 points to 496 over the same period. This was not significantly different to the TIMSS scale average.

Australian maths and science scores – 1995-2007(a)

TIMSS years	Year 4		Year 8	
	Maths	Science	Maths	Science
1995	494	521	509	514
2003	499	520	504	527
2007	516	527	496	515

(a) Results for Year 4 and Year 8 are not directly comparable to each other, nor are the results for maths and science.

Source: The Trends in International Mathematics and Science Study, 2007

Data and definitions

The data in this article are sourced from the 2007 Trends in International Mathematics and Science Study (TIMSS). The Australian Council for Educational Research (ACER) is responsible for conducting the Australian component of TIMSS.

In TIMSS 2007, 36 countries participated at the Year 4 level and 49 countries at the Year 8 level. In Australia, 229 primary schools and 228 secondary schools, and approximately 4,000 students from each year level, participated in the study. The minimum participation rate for TIMSS is set at 85% of sample schools and 85% of sampled students (or a combined school and student participation rate of 75%). Australia achieved the participation rate for both Year 4 and Year 8.

Results for Year 4 and Year 8 are not directly comparable to each other, nor are the results for maths and science. Also, there are differences in the number of years of schooling, and the ages of students, in certain countries and at each year level.

The *TIMSS scale average* for each of Year 4 maths, Year 4 science, Year 8 maths and Year 8 science, is the average of the scales established in 1995, calibrated to be 500, with a standard deviation of 100 score points.

The *international average* is the average score or percentage of all countries participating in TIMSS 2007 at the particular year level, for the given subject.

The *international median* is the midpoint in a ranking of countries by score or percentage. By definition, half the countries will have a score or percentage above the median and half below.

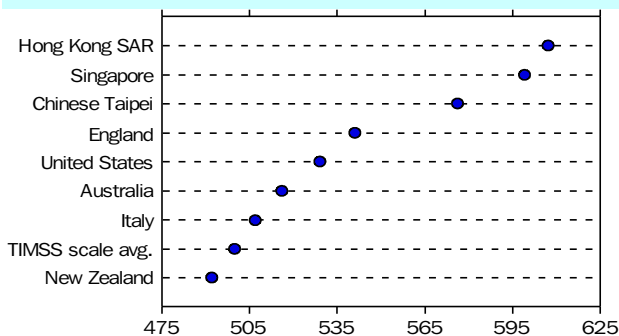
Between 2003 and 2007, achievement in science for Australian students at the Year 8 level declined, with a 12 point reduction in the TIMSS score. However, the score of 515 was still above the TIMSS scale average.

How does Australia compare?

Australian students performed well in 2007 when compared with other participating countries, but were outperformed by England, the United States and most of the Asian countries, especially Singapore and Chinese Taipei. Australian students achieved an international ranking of 14th for Years 4 and 8 maths and 13th for Years 4 and 8 science, similar to the levels of performance attained in 2003.

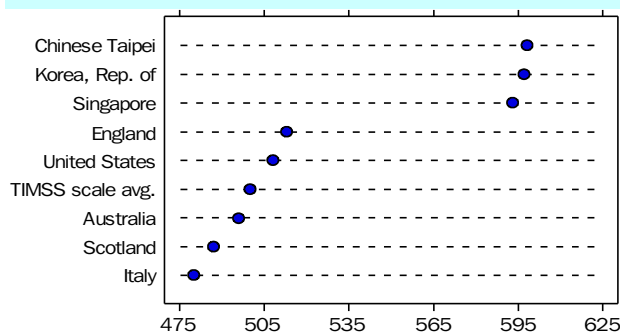
The largest disparity of scores in TIMSS 2007 was in Year 4 science, where a 390 point difference separated the highest scoring country Singapore (587) and the lowest scoring country Yemen (197). Australia's score of 527 was similar to the scores achieved by students in Germany and Italy.

Selected countries: Year 4 maths scores – 2007



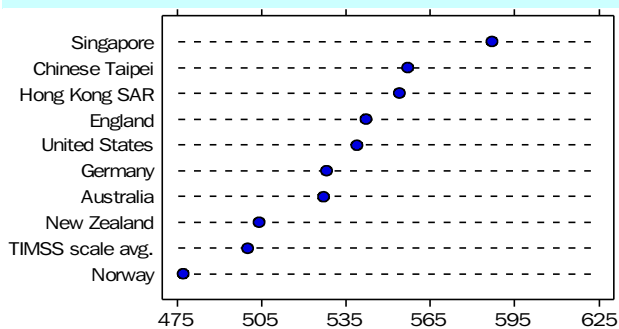
Source: The Trends in International Mathematics and Science Study, 2007

Selected countries: Year 8 maths scores – 2007



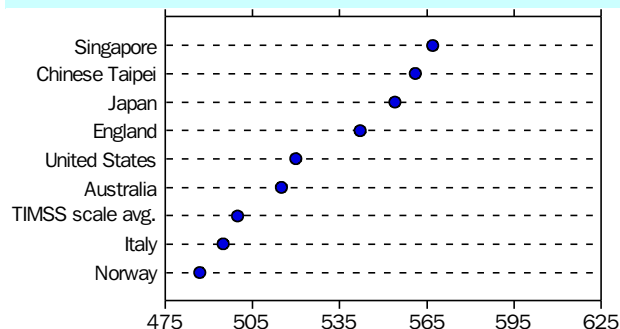
Source: The Trends in International Mathematics and Science Study, 2007

Selected countries: Year 4 science scores – 2007



Source: The Trends in International Mathematics and Science Study, 2007

Selected countries: Year 8 science scores – 2007



Source: The Trends in International Mathematics and Science Study, 2007

In contrast, the smallest disparity of scores among countries was for Year 8 science where a difference of 264 points separated Singapore (567) and Ghana (303). Australia's score of 515 was similar to Lithuania and Sweden.

International benchmarks

The international benchmarks in TIMSS 2007 describe the capacity and ability of students in maths and science, and make it possible to compare results among countries.

At the higher benchmark levels, a student has demonstrated the ability to apply their maths and science knowledge to a variety of complex situations and provide reasoning. Students at the lower benchmark levels have demonstrated only a basic level of maths and science knowledge. The international benchmark levels for Year 4 and Year 8 maths and science are: advanced (625 points), high (550 points), intermediate (475 points) and low (400 points).

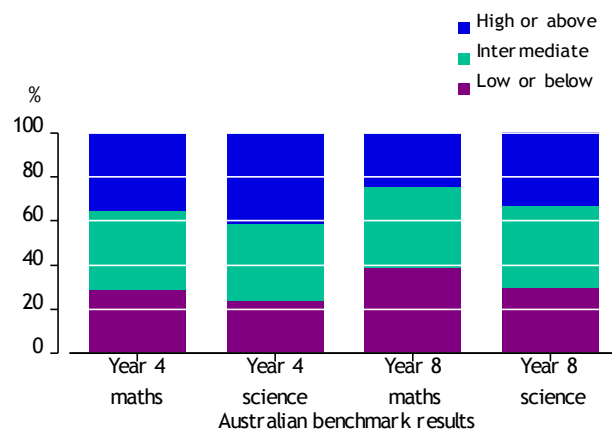
...Australian benchmark results

In TIMSS 2007, at least seven out of ten Australian students achieved the intermediate international benchmark or better, across both maths and science at Years 4 and 8 (with the exception of Year 8 maths students, where six out of ten students achieved this benchmark). This included a third or more of students who reached the advanced or high benchmark for

Year 4 maths and Year 4 and 8 science. Year 4 science had the largest proportion of students who reached the advanced (10%) and high (31%) international benchmarks.

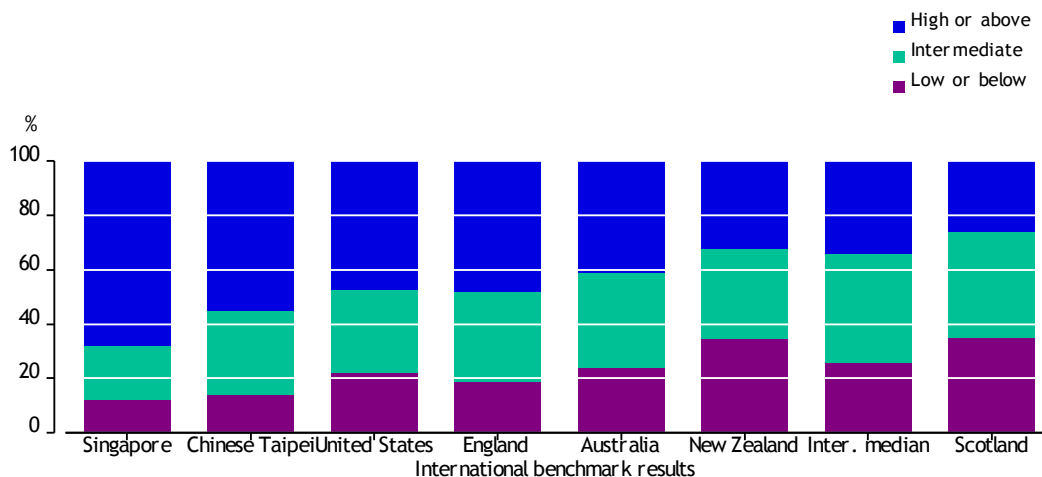
In contrast, at least one in four Australian students were at the low benchmark, with a further one in ten students unable to achieve the low benchmark. Year 8 maths had the highest proportion of students (39%) performing at the low benchmark level or below in TIMSS 2007.

Australian student achievement against International benchmarks – 2007



Source: The Trends in International Mathematics and Science Study, 2007

Year 4 science benchmarks: selected countries – 2007



Source: The Trends in International Mathematics and Science Study, 2007

State and territory scores

In 2007, Year 4 maths students in New South Wales and Victoria achieved significantly higher scores than other states and territories. A larger proportion of students in New South Wales (44%) and Victoria (41%) reached the high benchmark level or above compared with other states and territories. Nationally, an average of 36% of students reached the intermediate benchmark for Year 4 maths, while around 40% of students in Western Australia, South Australia, Queensland and the Northern Territory were at the low benchmark level or below.

For Year 4 science, students in Victoria and New South Wales had similar scores to Tasmania and the Australian Capital Territory, and significantly better scores than the remaining states and territories.

For Year 8 maths and science, there was little or no significant score differences among the states and territories in 2007, however the Australian Capital Territory and New South Wales had a higher proportion of students

reaching the high benchmark level or above compared to students in other states and territories.

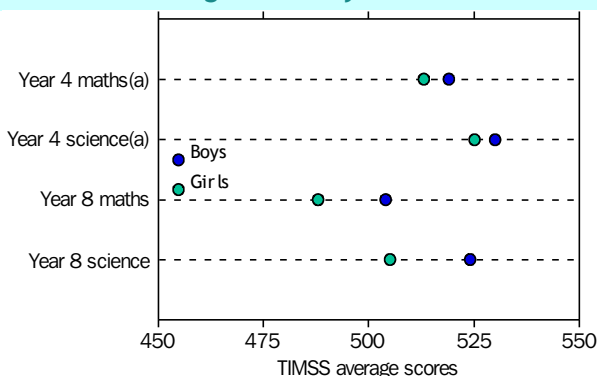
Who are the higher achievers, boys or girls?

Compared with earlier cycles of TIMSS, there are fewer countries with significant gender differences in achievement in maths and science.⁴

In 2007, there was no significant difference in achievement in maths and science between boys and girls in Year 4 in Australia. However, boys in Year 8 outperformed girls in both maths and science. These results are in contrast to the international trend for Year 8 students, as girls tended to outperform boys.

In addition, a higher proportion of boys than girls in both Year 4 and Year 8 attained the advanced benchmark level for maths and science, while the proportion not able to achieve the low benchmark was much the same across both subjects and year levels.

Australian average scores by sex – 2007



(a) Differences between boys and girls are not statistically significant.

Source: The Trends in International Mathematics and Science Study, 2007

What factors influence student achievement in Australia?

One of the main goals of TIMSS is to compare educational achievement across countries. TIMSS also provides information on teaching and learning methods for the improvement of maths and science programs.

The presence of learning resources in the home can reflect the economic capacity of parents to provide these resources as well as practical and psychological support for educational achievement. Students' access to books, computers and Internet connections at home were also measured by TIMSS.

...books, computers and the Internet

Earlier cycles of TIMSS have shown that students from homes with access to books, computers and the Internet at home have higher achievement in maths and science than students from less well-resourced homes.⁴

In 2007, Australia was one of a small number of countries with over 30% of students reporting that they had over 100 books in the home. Year 4 and Year 8 students from homes with more than 100 books had significantly higher levels of maths and science achievement than those students with fewer books in the home.

Increasingly, computers are becoming commonplace in the home and school environment, and the Internet is providing access to information in a way not previously available to students. In 2007, almost all Australian Year 4 (95%) and Year 8 students (97%) reported having a computer at home, while 84% of Year 4 students and almost 90% in Year 8 reported having an Internet connection at home. Australian students were also more likely than students from most other countries participating in TIMSS to use computers both at home and at school.

...homework

Homework may provide an opportunity for students to extend and consolidate what they have learned in school. Australian students tend to receive less maths and science homework at both Year 4 and Year 8 levels than students in other countries.

The amount of homework set for Australian students does not necessarily translate into higher achievements. Year 4 maths and science students who reported low amounts of homework had higher levels of achievement than those students who received high amounts of homework, suggesting that Year 4 homework had a stronger remedial focus.

Students in Year 8 maths and science who had high amounts of homework set had higher levels of achievement, reflecting that homework at this year level can act as an extension, as well as remediation.

...student backgrounds

Parental education is also strongly linked to student achievement. Higher levels of parental education are associated with higher levels of achievement. Students with at least one parent with a Bachelor Degree had significantly higher maths and science achievement than those students whose parents did not complete secondary school.

Content and cognitive dimensions

TIMSS 2007 assessed students in maths and science, across a content and a cognitive dimension. The content dimension specified the subject matter to be assessed, while the cognitive dimension specified the types of thinking processes and sets of behaviours expected of students. Content areas for maths included: numbers, geometric shapes and measures/geometry, data display/data chance and algebra. For science, the content included: life science/biology, physical science/physics, Earth science and chemistry. The three cognitive domains for both maths and science were knowing, applying and reasoning.

For maths, Australian Year 4 students performed less well in numbers, and better in geometric shapes and measures. Year 4 students were stronger in the knowing domain and weaker in applying. Year 8 maths students were better able to perform in data display and chance than algebra, and performed equally well in all cognitive domains.

For science, Australian Year 4 students performed less well in physical science and life science, and better in Earth science. Year 8 students performed less well in chemistry and physics and had stronger performance in biology and Earth science. In the cognitive domains, both Year 4 and Year 8 students showed stronger performance in the reasoning domain than all others.

Students who come from homes where English is not spoken frequently have less exposure to the language of instruction in the test, which could disadvantage them. Most Australian students spoke English in the home (90%) and these students had higher average scores, for both maths and science (average scores between 498 and 533), than those who spoke a language other than English at home (average scores between 478 and 489).

...student attitudes

Developing positive attitudes toward maths and science and valuing them highly is not only an important goal of the curriculum, but also a factor associated with student self-confidence and achievement.

The TIMSS 2007 measured a student's feelings towards maths and science, and how those feelings related to student achievement. In the TIMSS report they referred to this as a student's positive affect towards mathematics and science. In this article, it is referred to as a student's attitude.

Students with a high positive attitude and value towards maths and science, as well as high self-confidence levels in their capacity to learn these subjects, had higher average achievements than those students who had lower values, self-confidence and attitudes.

A greater proportion of Australian Year 4 students had a highly positive attitude towards science (78%) than Year 4 maths students (66%). In both cases this was similar to the international average.

For Year 8, a significantly lower proportion of Australian students had a positive attitude towards maths and science than was the case, on average, internationally. Around a third of Year 8 maths students had a positive attitude towards maths, compared with 54% internationally, while 47% of Year 8 students had a positive attitude towards science, compared with the international average of 65%.

In 2007, most Australian students in both Year 4 and Year 8 (80% and 75% respectively) agreed that they liked being at school. Students who liked school had higher average TIMSS scores than those students who did not like school.

Australian students in Year 4 and Year 8 generally had higher self-confidence levels than the international average, with the only exception being Year 8 science students, where 41% of students had high self-confidence in learning science, compared with 48% internationally. In addition, male students in Australia were more likely than female students to have high self-confidence levels at both year levels and for both subjects, with the exception of Year 4 science.

...teachers

Australian maths and science teachers were, on the whole, highly qualified, with only a very small proportion of teachers not having obtained at least a Bachelor Degree. While most teachers held at least a Bachelor Degree, a much smaller proportion had a qualification with a maths or science specialisation.

This was particularly so for Year 4 where only a small proportion of students in 2007 were taught by a teacher with a specific qualification in maths (7%) and science (12%). A much higher proportion of Year 8 students had a teacher with a maths or science specific qualification (49% and 85% respectively),

Classroom characteristics

The implementation of the maths and science curriculum and especially the way in which these subjects are taught is largely determined by the teacher and their classroom activities and practices.⁴ Differing academic abilities, a wide range of backgrounds, students with special needs, uninterested students and disruptive students are factors that can limit a teacher's capacity to successfully teach.

In TIMSS 2007, a higher percentage of Australian students were taught by teachers who reported few limitations on instruction compared with the international averages, especially for Year 4 science. Being taught in a class with few or no limitations on instruction was associated with higher levels of achievement in maths and science.

Australia differs from other countries participating in TIMSS both in the use of textbooks as a lesson resource, and the use of calculators in Year 4. Most countries use textbooks in both Year 4 maths and science, where over 85% of teachers use textbooks either as a primary or supplementary source. In Australia, around 76% of Year 4 maths classes and 18% of Year 4 science classes use textbooks as a primary or supplementary source. The use of calculators in the classroom is allowed by 95% of Year 4 teachers in Australia, much higher than 46% on average internationally.

The use of textbooks and calculators at the Year 8 level is similar to other countries, with most Australian maths (94%) and science (84%) teachers using textbooks as a primary or secondary source, and virtually all Year 8 students using calculators (99%).

reflecting the requirements of the different teaching levels.

A relatively high proportion of maths teachers in both Year 4 and Year 8 participated in professional development, most commonly in the areas of maths content (71% of Year 4 and 69% of Year 8 teachers) and maths curriculum (73% of Year 4 and 69% of Year 8 teachers).

Science teachers were less likely to have participated in professional development activities, with over one-third of Year 4 teachers participating in activities concerning improving students' critical thinking or problem solving skills, and over half of Year 8 teachers participating in a variety of professional activities.

In terms of preparedness to teach, most maths teachers reported feeling very well prepared to teach maths topics to students in Years 4 and 8, while around half of Year 4 science teachers and around three quarters of Year 8 science teachers felt very well prepared.

Australian student attitudes and related achievement: average scores—2007(a)

	Year 4		Year 8	
	Maths	Science	Maths	Science
High positive attitude	525	534	521	535
Low positive attitude	494	505	476	494
High value(b)	502	531
Low value(b)	470	496
High self-confidence	542	543	539	549
Low self-confidence	457	483	445	483

.. not applicable

(a) Student attributes (including positive attitudes, values and self-confidence) relate to students in Year 4 and Year 8 for maths and science only.

(b) High value of maths and science was asked of Year 8 students only.

Source: The Trends in Mathematics and Science Study, 2007

...school environment

Achievement in maths and science was highest in schools where the principal reported that the schools were well resourced. In 2007, over half of Australian Year 4 (57%) and Year 8 (55%) students attended schools well resourced for the teaching of maths, while 39% of Year 4 and 57% of Year 8 students attended schools with a high level of science teaching resources.

Looking forward

The results of TIMSS enable countries to review and develop their maths and science curriculum, in both content and implementation, as well as broader educational policies. TIMSS assessments are conducted on a four-year cycle. The next TIMSS study will be carried out in 2011.

Endnotes

- 1 The Federation of Australian Scientific and Technological Societies, *Science and Technology for the Social, Environmental and Economic Benefit of Australia*, viewed 6 May 2009, <www.usyd.edu.au>.
- 2 The Australian Association for Research in Education, *Engaging Pedagogies in Maths and Science Education: Some Key Ideas, Issues and Implications for Research and Teaching in South Australia*, Carol Aldous, Flinders University 2006, viewed 6 May 2009, <www.aare.edu.au>.
- 3 Ministerial Council on Education, Employment, Training and Youth Affairs, *Melbourne Declaration on Educational Goals for Young Australians*, December 2008, viewed 23 April 2009, <www.mceetya.edu.au>.
- 4 Trends in International Mathematics and Science Study (TIMSS) 2007, *Taking a Closer Look at Mathematics and Science in Australia*, Australian Council for Educational Research, Melbourne 2008.