International Lessons

Photo Walter Collalto

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achievement studies: from PISA and TIMSS

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In early December 2004, the results of two international studies were released providing the most recent evidence we have on how levels of school achievement in Australia compare with international standards. ACER's chief executive ***Geoff Masters*** *compares the results and outlines lessons we can learn from the findings.*

The OECD Programme for International Student Assessment (PISA) surveys reading, mathematical and scientific literacy levels every three years. The Trends in International Mathematics and Science Study (TIMSS), conducted by the International Association for the Evaluation of Educational Achievement (IEA), surveys student achievement in mathematics and science every four years. Every 12 years PISA and TIMSS align, and their results are released more or less simultaneously, as was the case in 2004 when only a week separated the release of the two studies.

PISA and TIMSS allow students' performances to be compared across countries and over time. The latest TIMSS results compare performances in 2002/03 with performances in 1994/95; the latest PISA results compare performances in 2003 with performances in 2000.

Both surveys were conducted in 2002/03 in more than 40 countries. In Australia, samples of students were drawn from all states and territories and included government, Catholic and independent schools. As well as providing information about overall levels of achievement, PISA and TIMSS provide details of the performances of girls, boys, students in each State/Territory, Indigenous students, students living in cities/regional/rural areas, students with non-English language backgrounds, and students from various socioeconomic backgrounds. The Australian samples were large and there were strict international

The picture shows the footprints of a man walking. The pacelength *P* is the distance between the rear of two consecutive footprints.

For men, the formula, $\frac{n}{P} = 140$, gives an approximate relationship between *n* and *P* where,

n = number of steps per minute, and

P = pacelength in metres.

Bernard knows his pacelength is 0.80 metres. The formula applies to Bernard's walking.

Calculate Bernard's walking speed in metres per minute and in kilometres per hour. Show your working out.

$\frac{n}{0.8} = 140$ ×0.8 ×0.8

$n = 112$ steps

$112 \times 0.8 = 89.6\text{m}$

∴ walking speed per minute: 89.6 m / min

89.6 m / min ×60

5376 m / h ÷1000

∴ 5.376 km / h

A question from the PISA test of mathematical literacy.

Source: OECD PISA

procedures that ensured the samples were representative. In PISA more than 12500 students from over 300 schools took part. In TIMSS there were approximately 10000 students from more than 400 schools.

Results from PISA

The PISA assessment focuses on young people's ability to apply their knowledge and skills to real-life problems and situations rather than on how much curriculum-based knowledge they have. Assessments are conducted across three core domains – reading literacy, mathematical literacy and scientific literacy.

The latest results showed that Australia's 15-year-old students have a level of reading, mathematical and scientific literacy among the best in the world. Australia's results were above the OECD average in mathematical, scientific and reading literacy as well as in problem solving and in each of four mathematical literacy subscales: quantity, space and shape, change and relationships and uncertainty.

Four countries (Hong Kong-China, Finland, Korea and the Netherlands) performed significantly better than Australia in mathematical literacy. In reading literacy only Finland achieved significantly better results than Australia while three countries (Finland, Japan and Korea) outperformed Australia in scientific literacy.

Although Australia's results in PISA on average were very encouraging, when results for specific sections of the population are examined, areas of concern are revealed such as the low level of performance by our Indigenous students and students in remote communities. While there are no significant gender differences overall in mathematical literacy, boys tended to be over-represented in the upper levels of achievement while girls appeared to be less engaged, more anxious and less confident in mathematics than boys.

Results from TIMSS

The results from the Trends in International Mathematics and Science Study (TIMSS) painted a less positive picture of Australian students' achievement in mathematics and science.

TIMSS 2002/03 was the third combined mathematics and science study that Australia has participated in since 1994. TIMSS 2002/03 tested achievement in mathematics and science of students in Year 4 and Year 8. The testing took place in late 2002.

Australian students performed moderately well in TIMSS 2002/03 mathematics with the average scores achieved by Australian students about the same as the international average for Year 4 and significantly higher than the international average for Year 8. In science, Australian students achieved above the international average at both year levels.

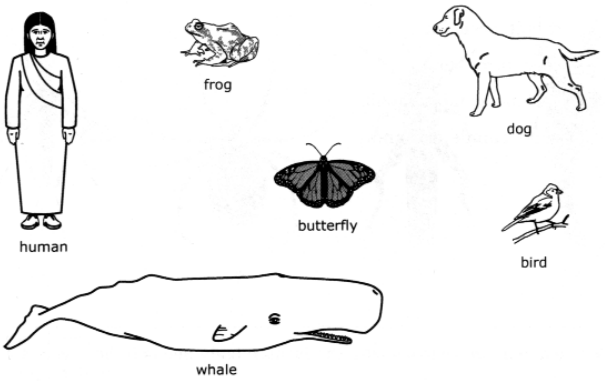
Although Australian students acquitted themselves quite well overall in TIMSS 2002/03 a relative lack of improvement in comparison to other countries was disappointing. When the performance of Australian students in 2002/03 is compared to the results in TIMSS 1994/95 their performance has not gone backwards; it has actually improved in some areas, namely in Year 8 science. However, Australia's overall results remained statistically similar since the previous round of testing. In contrast, the achievement of some other countries improved, in some cases substantially, giving the appearance that Australia has been standing still while other countries have been moving forward.

Comparing the studies

While PISA and TIMSS have much in common, they provide different, but complementary, information about levels of student achievement. In both studies there are carefully developed assessment frameworks that define what is assessed. The tests are sound, reliable instruments that measure accurately what they were designed to measure.

PISA looks at 15-year-olds – who in most countries are approaching the end of compulsory schooling – and asks how well they are able to apply understandings and skills in reading, mathematics and science to everyday situations. Are they able to perform currency conversions? read tables and graphs in newspapers? use basic understandings of science to make sense of magazine articles about topics such as genetically modified foods and animal cloning?

One of the more difficult PISA questions in 2003 asked 15-year-olds to calculate the average speed in kilometres per hour of a person who walks 89.6 metres in a minute.



Some of the organisms shown above give birth to young that develop inside the mother. Some of the organisms have young that hatch from eggs that are laid outside the mother.

In the table below, write down the names of the organisms that belong to each group.

Organisms that give birth
human dog whale

Organisms that lay eggs
bird butterfly frog

A sample question from the TIMSS Year 4 science assessment.

Source: IEA TIMSS

This task does not require high-level mathematical knowledge (students need to know that there are 60 minutes in an hour and 1000 metres in a kilometre), but it does require a level of mathematical *skill*: the ability to think logically, to multiply and divide accurately, and to apply steps in sequence.

TIMSS, on the other hand, looks at how well Year 4 and Year 8 students have mastered the factual and procedural knowledge taught in school mathematics and science curricula. Do students know how many legs an insect has? which animals lay eggs? what happens when light passes through a prism? what the angles of a triangle sum to? how to convert 7/10 to a decimal? what congruent triangles are? TIMSS begins with a detailed analysis of Year 4 and Year 8 mathematics and science curricula and then tests curriculum content common across participating countries.

What lessons did we learn from these observations?

So what did we learn? It will take some time to sift through the results in detail, but there are some clear and immediate conclusions.

From PISA we learn that Australian 15-year-olds perform well (on average) when it comes to careful reading, logical thinking, and the application of reading skills and mathematical and scientific understandings to everyday problems. In fact, Australian students are among the best in the world on tasks of this kind.

The conclusion from PISA is that, on average, Australian 15-year-olds have relatively high levels of reading, mathematical and scientific 'literacy', defined as the ability to apply skills in reading and basic mathematical and scientific principles and processes to everyday problems.

PISA also reveals that many students in Australia—as in other countries—complete the compulsory years of school with only minimal levels of reading, mathematical and scientific literacy. For example, among Australian 15-year-olds, 7 per cent of girls and 17 per cent of boys perform at or below the lowest international reading benchmark. Many of these students are able to locate specific detail in a piece of text, but are unable to connect ideas or to draw conclusions from a piece of writing.

From TIMSS we learn that Australian students perform less well on tests of mathematical and scientific *knowledge*. Among the 25 countries testing at Year 4 in 2002/03, Australia ranked 16th in mathematics and 11th in science. Countries significantly outperforming Australia in either Year 4 mathematics or science included England, USA, Latvia, Lithuania, Russian Federation, Hungary and Cyprus. Worse, over the past decade, achievement levels in Australia remained largely static while achievement levels in many other countries increased. The result is that some countries which were below or equal to Australia a decade ago in school science achievement (eg, Hong Kong SAR, England) and school mathematics (eg, England, Hungary) now outrank us.

Among the 46 countries testing at Year 8, Australia ranked 14th in mathematics and 11th in science. Countries significantly outperforming Australia in either Year 8 mathematics or science included England, Belgium, Netherlands, Estonia and Hungary. And while our performance in Year 8 science improved over the past decade, half the countries we outscored in Year 8 mathematics in 1994/5 improved to perform at the same level as Australia in 2002/03.

PISA and TIMSS provide information about different aspects of students' mathematics and science learning. PISA assesses careful reading, logical thinking and the application of general mathematical and scientific processes and principles to everyday problems. TIMSS assesses mastery of the factual and procedural knowledge taught in school mathematics and science curricula. While students in some countries—such as Hong Kong SAR and Korea—perform very well in both these areas, students in some other countries perform better in one area than the other.

In Australia and New Zealand students perform better (on average) in applying general mathematical and scientific principles and skills to everyday problems than in recalling and using curriculum-based factual and procedural knowledge. As an illustration, Australian high school students significantly outperform students in the United States in the first of these two areas, but perform no better than US students in the second.

ACER's work on PISA

ACER leads an international consortium of research and other educational institutions and eminent individuals to deliver the International PISA project on behalf of the OECD. ACER's work on PISA includes:

- leading the development of the methodology and procedures required to implement the PISA survey in all 59 participating countries;
- developing and implementing sampling procedures and assisting with monitoring sampling outcomes across participating countries;
- leading the development of all assessment instruments in Reading, Mathematics, Science, Problem Solving, Computer-based testing, background and contextual questionnaires;
- developing purpose-built software to assist in sampling and in data capture; and
- analysing all data and assisting the OECD in preparation of the international report.

An obvious question that follows from these observations is whether Australian schools are placing sufficient emphasis on the teaching of factual and procedural knowledge in mathematics and science, particularly at Year 4. While 73 per cent of Year 4 students in Singapore reach the high international mathematics benchmark, only 26 per cent of Australian students reach this benchmark. The corresponding percentages for Year 4 science are 61 per cent and 38 per cent. And, relative to other countries, Australian Year 4 students now perform less well in school mathematics and science than they did a decade ago.

During the 1990s, considerable effort went into the reform of curricula for the primary and middle years of schooling in Australia, resulting in new state curriculum and standards frameworks. In the same period, education systems introduced system wide testing programs to monitor student and school achievement. It is not clear that these efforts have improved levels of mathematics and science performance in Australian primary schools.

If Australia is to lift its performance in mathematics and science over the next decade, then greater attention will need to be given to the teaching of basic factual and procedural knowledge and the development of teachers' confidence and competence in teaching primary school mathematics and science. The focus of the past decade on *what* is taught (the curriculum) needs to be accompanied by a greater focus on *how* subject matter is taught (research-based pedagogy). Testing programs for accountability and monitoring need to be complemented by assessments more capable of diagnosing individuals' learning difficulties and providing guidance to classroom teaching and learning. More effort may be required in attracting people with strong mathematics and science backgrounds into the teaching profession.

Australia should not be satisfied with maintaining existing levels of achievement and must strive for continual improvement and to see Australian students ranked among the best in the world in all achievement studies.

Further information

The full international PISA report is available from the OECD website at *www.pisa.oecd.org.*

The Australian national PISA report is, *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

The TIMSS 2003 international reports are available from the IEA website at *http://timss.bc.edu*

The Australian national TIMSS report is published in two volumes, *Summing it up: Mathematics achievement in Australian schools in TIMSS 2002* and *Examining the evidence: Science achievement in Australian schools in TIMSS 2002* both by Sue Thomson and Nicole Fleming

Both Australian PISA and TIMSS reports are available for download from the ACER website at *www.acer.edu.au*