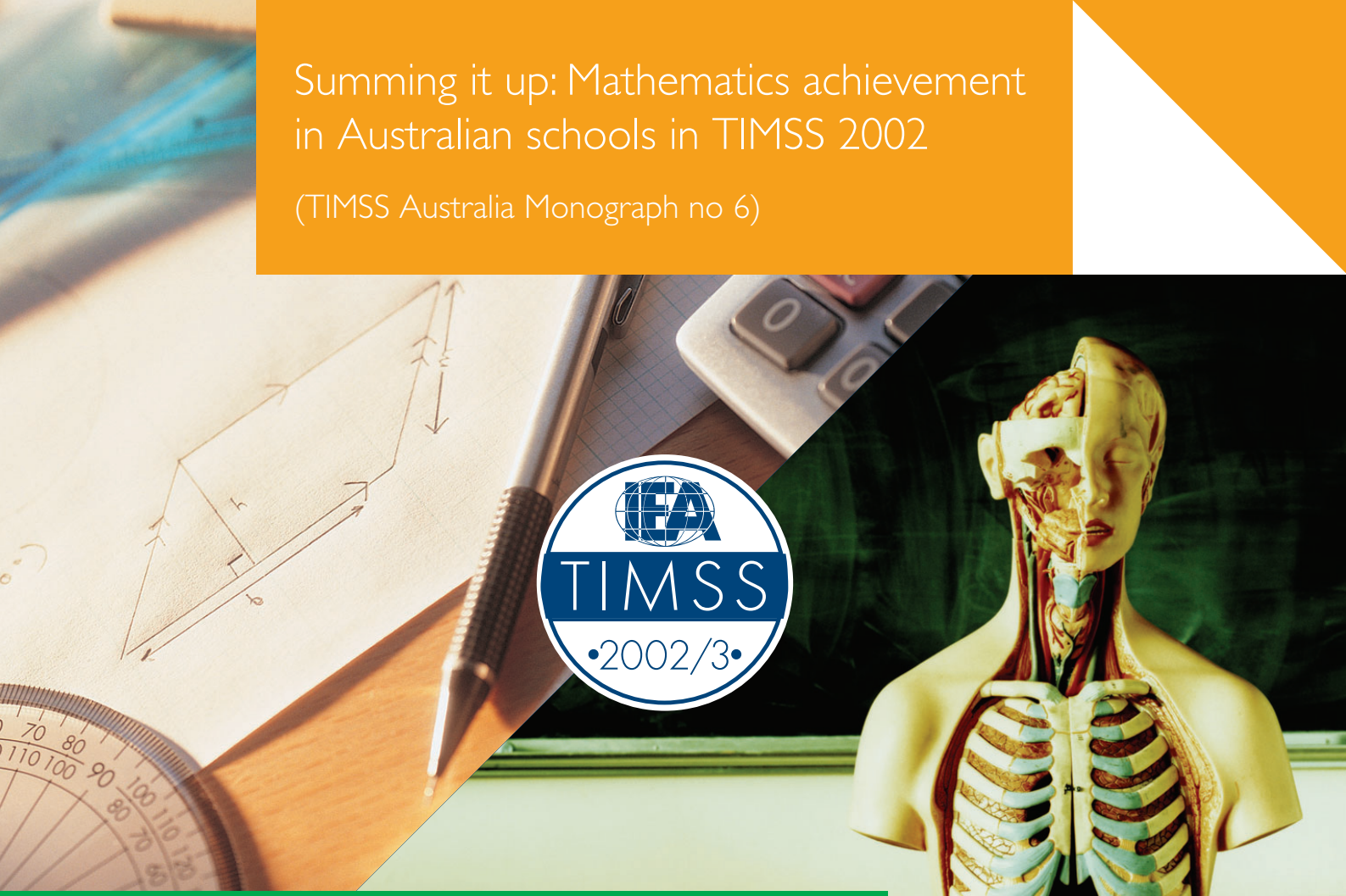
Summing it up: Mathematics achievement in Australian schools in TIMSS 2002

(TIMSS Australia Monograph no 6)



Examining the evidence: Science achievement in Australian schools in TIMSS 2002

(TIMSS Australia Monograph no 7)

Highlights from TIMSS

from Australia's perspective

Highlights from the full Australian reports from the Trends in International Mathematics and Science Study 2002/03

Australian Council *for* Educational Research

ACER

What is TIMSS?

- The *Trends in 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 the First International Mathematics Study (FIMS, 1964), the First International Science Study (FISS, 1970/71, and the Second International Science Study (SISS, 1983/84). This is the third combined mathematics and science study in which Australia has participated; others being the Third International Mathematics and Science Study (TIMSS 1994/95), and the partial repeat of TIMSS at Year 8 in 1998/99 (TIMSS 1998/99).
- TIMSS 2002/03 focuses on two populations: Population 1 - students in Year 4, and Population 2 - students in Year 8.
- As well as the TIMSS test, students completed a short background questionnaire. This sought information on students and their family background, resources in the home, educational aspirations and attitudes toward mathematics and science.
- The students' mathematics and science teachers also completed a questionnaire which asked about their preparation and professional development, instructional practices and beliefs about teaching mathematics and science.
- The school questionnaire was answered by the school principal and asked for information about school organisation, teaching resources and time allocation.

What is the focus of TIMSS?

TIMSS has a curriculum focus. The three levels of the curriculum, which have been defined in previous studies, and considered in relation to the context in which they occur, are:

The *intended* curriculum – defined as the curriculum as specified at national or system level.

- *What are mathematics and science students around the world expected to learn?*
- *How do countries vary in their intended goals? and*
- *What characteristics of education systems, schools and students influence the development of these goals?*

The *implemented* curriculum – defined as the curriculum as interpreted and delivered by classroom teachers.

- *What opportunities are provided for students to learn mathematics and science?*
- *How do instructional practices vary among countries? and*
- *What factors influence these variations?*

The *attained* curriculum – which is that part of the curriculum that is learned by students, as demonstrated by their attitudes and achievements.

- *What mathematics and science concepts, processes and attitudes have students learned?*
- *What factors are linked to students' opportunity to learn? and*
- *How do these factors influence students' achievements?*

Who participated in TIMSS 2002/03?

Testing for TIMSS 2002/03 was carried out in 46 countries. Two provinces of Canada, one state of the US and Basque Country, Spain were also in the study as benchmarking participants. The countries and regions and the year levels at which they participated are shown in this figure:

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

Benchmarking participants

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

Legend

4 Year 4
8 Year 8

*Benchmarking participants are those provinces or regions that participated in TIMSS for their own internal benchmarking. Data from these provinces are not included in the international average and are not included in the discussion in the national reports.

In Australia, just over 10,000 students participated in TIMSS. This shows where in Australia they were from:

State/Territory	Population 1			Population 2		
	N schools	N students	Weighted per cent	N schools	N students	Weighted per cent
New South Wales	35	912	35.3	34	880	32.8
Victoria	32	675	24.4	34	860	25.4
Queensland	31	759	16.9	33	881	18.8
South Australia	27	600	8.1	28	703	7.3
Western Australia	27	661	10.2	26	702	10.7
Tasmania	25	501	2.5	26	625	2.5
Northern Territory	13	251	.9	14	321	.6
Australia Capital Territory	14	316	1.6	15	383	1.8
Total	204	4675	100.0	210	5355	100.0

Australia achieved the required participation rate for Year 8 students, but for Year 4 the participation rate was met only after replacement schools were included. Nevertheless results for Year 4 are sufficient to be representative of the Year 4 population in Australia.

What does TIMSS tell us about Year 4 mathematics achievement?

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

Legend

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

Achievement is reported as the average scale score for a country, with its standard error.

- Singapore and Hong Kong SAR significantly outscored all other countries.
- There was a large group of countries which significantly outscored Australia in mathematics at Year 4.
- Australia's average score at Year 4 in mathematics was not different to the average internationally. In TIMSS 1994/95 the Year 4 average for Australia was significantly higher than the international average.
- Australia's performance has remained the same since TIMSS 1994/95, however the performance of other countries has improved so that Australia's score is relatively lower.
- There was no significant gender difference in overall mathematics achievement at Year 4 in Australia.

Achievement can also be reported in terms of benchmarks. These benchmarks were derived by the International Study Centre.

Advanced benchmark: Students can apply their understanding and knowledge in a wide variety of relatively complex situations.

- demonstrate a developing understanding of fractions and decimals and the relationship between them
- can select appropriate information to solve multi-step word problems involving proportions
- can formulate or select a rule for a relationship
- show understanding of area and can use measurement concepts to solve a variety of problems
- show some understanding of rotation
- can organise, interpret, and represent data to solve problems.

High benchmark: Students can apply their knowledge and understanding to solve problems.

- can solve multi-step word problems involving addition, multiplication, and division
- can use their understanding of place value and simple fractions to solve problems
- can identify a number sentence that represents situations
- show understanding of three-dimensional objects, how shapes can make other shapes, and simple transformation in a plane
- demonstrate a variety of measurement skills
- interpret and use data in tables and graphs to solve problems.

Intermediate benchmark: Students can apply basic mathematical knowledge in straightforward situations.

- can read, interpret, and use different representations of numbers
- can perform operations with three- and four-digit numbers and decimals
- can extend simple patterns
- are familiar with a range of two-dimensional shapes
- can read and interpret different representations of the same data.

Low benchmark: Students have some basic mathematical knowledge.

- demonstrate an understanding of whole numbers and can do simple computations with them
- demonstrate familiarity with the basic properties of triangles and rectangles
- can read information from simple bar graphs.

What does TIMSS tell us about Year 8 mathematics achievement?

- Singapore scored significantly higher than all other countries.
- In Year 8 mathematics, Australia scored significantly higher than the international average.
- Achievement in the United States, England, Scotland, New Zealand and Malaysia was similar to that of Australian students.
- Australia's performance in mathematics in Year 8 has remained the same since TIMSS 1994/95, however the performance of other countries has improved so that half of the countries outscored by Australia in TIMSS 1994/95 performed at a similar level to Australia in TIMSS 2002/03.
- There was no significant gender difference in mathematics achievement at Year 8 in Australia. Internationally, there were some substantial gender differences in favour of males and some in favour of females.

The descriptors for the international benchmarks for Year 8 mathematics are:

All Year 8 TIMSS 2002/03 countries	Average scale score (se)	2002/03	1994/95	Average Age	Years of schooling	Human Development Index*
Singapore	605 (3.6)	▲	▲	14.3	8	0.884
[3,4]Korea, Rep. of	589 (2.2)	▲	▲	14.6	8	0.879
[1]Hong Kong SAR	586 (3.3)	▲	▲	14.4	8	0.889
Chinese Taipei	585 (4.6)	▲	-	14.2	8	–
Japan	570 (2.1)	▲	▲	14.4	8	0.932
Belgium (Flemish)	537 (2.8)	▲	▲	14.1	8	0.937
[1]Netherlands	536 (3.8)	▲	•	14.3	8	0.938
Estonia	531 (3.0)	▲	-	15.2	8	0.833
Hungary	529 (3.2)	▲	•	14.5	8	0.837
Malaysia	508 (4.1)	•	-	14.3	8	0.790
Latvia	508 (3.2)	•	▼	15.0	8	0.811
Russian Federation	508 (3.7)	•	•	14.2	7 or 8	0.779
Slovak Republic	508 (3.3)	•	▲	14.3	8	0.836
Australia	505 (4.6)			13.9	8 or 9	0.939
[4]United States of America	504 (3.3)	•	▼	14.2	8	0.937
[1]Lithuania	502 (2.5)	•	▼	14.9	8	0.824
Sweden	499 (2.6)	•	•	14.9	8	0.941
[1]Scotland	498 (3.7)	•	▼	13.7	9	0.930
[4]England	498 (4.7)	•	▼	14.3	9	0.930
[2]Israel	496 (3.4)	•	•	14.0	8	0.905
New Zealand	494 (5.3)	•	▼	14.1	8.5 or 9.5	0.917
Slovenia	493 (2.2)	▼	•	13.8	7 or 8	0.881
Italy	484 (3.2)	▼	-	13.9	8	0.916
Armenia	478 (3.0)	▼	-	14.9	8	0.729
[1]Serbia & Montenegro	477 (2.6)	▼	-	14.9	8	–
Bulgaria	476 (4.3)	▼	•	14.9	8	0.795
Romania	475 (4.8)	▼	▼	15.0	8	0.773
International average	**467 (0.5)**			**14.5**	**8**	**-**
Norway	461 (2.5)	▼	▼	13.8	7	0.944
Moldova, Rep. of	460 (4.0)	▼	-	14.9	8	0.700
Cyprus	459 (1.7)	▼	▼	13.8	8	0.891
[2]Macedonia, Rep. of	435 (3.5)	▼	-	14.6	8	0.784
Lebanon	433 (3.1)	▼	-	14.6	8	0.752
Jordan	424 (4.1)	▼	-	13.9	8	0.743
Iran, Islamic Rep. of	411 (2.4)	▼	▼	14.4	8	0.719
[1]Indonesia	411 (4.8)	▼	▼	14.5	8	0.682
Tunisia	410 (2.2)	▼	-	14.8	8	0.740
Egypt	406 (3.5)	▼	-	14.4	8	0.648
Bahrain	401 (1.7)	▼	-	14.1	8	0.839
Palestinian Nat'l Auth.	390 (3.1)	▼	-	14.1	8	0.731
Chile	387 (3.3)	▼	-	14.2	8	0.831
[1,4]Morocco	387 (2.5)	▼	-	15.2	8	0.606
Philippines	378 (5.2)	▼	-	14.8	8	0.751
Botswana	366 (2.6)	▼	-	15.1	8	0.614
Saudi Arabia	332 (4.6)	▼	-	14.1	8	0.769
Ghana	276 (4.7)	▼	-	15.5	8	0.567
South Africa	264 (5.5)	▼	▼	15.1	8	0.684

Advanced benchmark: Students can organise information, make generalisations, solve non-routine problems, and draw and justify conclusions from data.

- can compute percent change and apply their knowledge of numeric and algebraic concepts and relationships to solve problems
- can solve simultaneous linear equations and model simple situations algebraically
- can apply their knowledge of measurement and geometry in complex problem situations
- can interpret data from a variety of tables and graphs, including interpolation and extrapolation.

High benchmark: Students can apply their understanding and knowledge in a wide variety of relatively complex situations.

- can order, relate, and compute with fractions and decimals to solve word problems,
- operate with negative integers, and solve multi-step word problems involving proportions with whole numbers
- can solve simple algebraic problems including evaluating expressions, solving simultaneous linear equations, and using a formula to determine the value of a variable
- can find areas and volumes of simple geometric shapes and use knowledge of geometric properties to solve problems
- can solve probability problems and interpret data in a variety of graphs and tables.

Intermediate benchmark: Students can apply basic mathematical knowledge in straightforward situations.

- can add, subtract, or multiply to solve one-step word problems involving whole numbers and decimals
- can identify representations of common fractions and relative sizes of fractions
- understand simple algebraic relationships and solve linear equations with one variable
- demonstrate understanding of properties of triangles and basic geometric concepts including symmetry and rotation
- recognise basic notions of probability
- can read and interpret graphs, tables, maps, and scales.

Low benchmark: Students have some basic mathematical knowledge. Students

- can do basic computations with whole numbers without a calculator
- can select the two-place decimal closest to a whole number
- can multiply two-place decimal numbers by three-place decimal numbers with calculators available
- recognise some basic terminology and read information from a line on a graph.

What does TIMSS tell us about Year 4 science achievement?

All Year 4 TIMSS 2002/03 countries	Average scale score (se)	2002/03	1994/95	Average age	Years of schooling	Human Development Index*
Singapore	565 (5.5)	▲	•	10.3	4	0.884
Chinese Taipei	551 (1.7)	▲	-	10.2	4	–
Japan	543 (1.5)	▲	▲	10.4	4	0.932
†Hong Kong SAR	542 (3.1)	▲	▼	10.2	4	0.889
†England	540 (3.6)	▲	•	10.3	5	0.930
†United States of America	536 (2.5)	▲	•	10.2	4	0.937
Latvia	532 (2.5)	▲	▼	11.1	4	0.811
Hungary	530 (3.0)	•	▼	10.5	4	0.837
Russian Federation	526 (5.2)	•	-	10.6	3 or 4	0.779
†Netherlands	525 (2.0)	•	•	10.2	4	0.938
†Australia	521 (4.2)			9.9	4 or 5	0.939
New Zealand	520 (2.5)	•	▼	10.0	4.5 – 5.5	0.917
Belgium (Flemish)	518 (1. 8)	•	-	10.0	4	0.937
Italy	516 (3.8)	•	-	9.8	4	0.916
†Lithuania	512 (2.6)	•	-	10.9	4	0.824
†Scotland	502 (2.9)	▼	▼	9.7	5	0.930
Moldova, Rep. of	496 (4.6)	▼	-	11.0	4	0.700
Slovenia	490 (2.5)	▼	-	9.8	3 or 4	0.881
International average	**489 (0.9)**			**10.3**	**4**	**–**
Cyprus	480 (2.4)	▼	▼	9.9	4	0.891
Norway	466 (2.6)	▼	▼	9.8	4	0.944
Armenia	437 (4.3)	▼	-	10.9	4	0.729
Iran, Islamic Rep. of	414 (4.1)	▼	▼	10.4	4	0.719
Philippines	332 (9.4)	▼	-	10.8	4	0.751
Tunisia	314 (5.7)	▼	-	10.4	4	0.740
Morocco	304 (6.7)	▼	-	11.0	4	0.606

Legend

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

- Singapore scored significantly higher than any other country in Year 4 science.
- Australia's score in Year 4 science was significantly higher than the international average.
- Australia's performance in science in Year 4 has remained the same since TIMSS 1994/95, however the performance of other countries has improved so that of the countries that participated in TIMSS 1994/95 and TIMSS 2002/03, half now have an average score that is significantly higher than that of Australia, compared to only one in TIMSS 1994/95.
- There was no gender difference in Year 4 science in Australia. Internationally, there were significant differences in about one-third of the countries, evenly split between advantage for females and advantage for males.

The descriptors for the international benchmarks for Year 4 science are:

Advanced benchmark: Students can apply knowledge and understanding in beginning scientific inquiry.

- demonstrate some understanding of Earth's features and processes and the solar system
- can communicate their understanding of structure, function, and life processes in organisms and
- classify organisms according to major physical and behavioural features
- demonstrate some understanding of physical phenomena and properties of common materials.
- demonstrate beginning scientific inquiry knowledge and skills.

High benchmark: Students can apply knowledge and understanding to explain everyday phenomena.

- demonstrate some knowledge of Earth structure and processes and the solar system
- demonstrate some understanding of plant structure, life processes, and human biology
- demonstrate some knowledge of physical states, common physical phenomena, and chemical changes.
- provide brief descriptions and explanations of some everyday phenomena
- compare, contrast, and draw conclusions.

Intermediate benchmark: Students can apply basic knowledge and understanding to practical situations in the sciences.

- demonstrate knowledge of some basic facts about Earth's features and processes and the solar system.
- recognise some basic information about human biology and health
- show some understanding of development and life cycles of organisms
- know some basic facts about familiar physical phenomena, states, and changes.
- apply factual knowledge to practical situations, interpret pictorial diagrams, and combine information to draw conclusions.

Low benchmark: Students have some elementary knowledge of the earth, life, and physical sciences.

- recognise simple facts presented in everyday language and context about Earth's physical features, the seasons, the solar system, human biology, and the development and characteristics of animals and plants
- recognise facts about a range of familiar physical phenomena – rainbows, magnets, electricity, boiling, floating, and dissolving
- interpret labelled pictures and simple pictorial diagrams and provide short written responses to questions requiring factual information.

What does TIMSS tell us about Year 8 science achievement?

- Singapore and Chinese Taipei significantly outscored all other countries.
- Australia's score was significantly higher than the international average.
- Australia's performance was not significantly different to that of a number of countries including the Netherlands, the United States and New Zealand.
- Australia's score in Year 8 science significantly increased between TIMSS 1994/95 and TIMSS 2002/03. As a result, the performance of some countries that were statistically similar to Australia is now significantly lower than that for Australia.
- There were significant gender differences in achievement in science in many countries, and almost all were in favour of males. Australia was one of these countries, with males outscoring females on average by 20 score points.

The descriptors for the international benchmarks for Year 8 science are:

All Year 8 TIMSS 2002/03 countries	Average scale score (se)	2002/03	1994/95	Average age	Years of schooling Index*	Human development
Singapore	578 (4.3)	▲	▲	14.3	8	0.884
Chinese Taipei	571 (3.5)	▲	-	14.2	8	–
▸◂Korea, Rep. of	558 (1.6)	▲	▲	14.6	8	0.879
[1]Hong Kong SAR	556 (3.0)	▲	▼	14.4	8	0.889
Estonia	552 (2.5)	▲	-	15.2	8	0.833
Japan	552 (1.7)	▲	▲	14.4	8	0.932
*England	544 (4.1)	▲	•	14.3	9	0.930
Hungary	543 (2.8)	▲	•	14.5	8	0.837
[1]Netherlands	536 (3.1)	•	•	14.3	8	0.938
[4]United States of America	527 (3.1)	•	•	14.2	8	0.937
Australia	527 (3.8)			13.9	8 or 9	0.939
Sweden	524 (2.7)	•	•	14.9	8	0.941
Slovenia	520 (1.8)	•	•	13.8	7 or 8	0.881
New Zealand	520 (5.0)	•	▼	14.1	8.5 – 9.5	0.917
[1]Lithuania	519 (2.1)	•	▼	14.9	8	0.824
Slovak Republic	517 (3.2)	▼	-	14.3	8	0.836
Belgium (Flemish)	516 (2.5)	▼	•	14.1	8	0.937
Russian Federation	514 (3.7)	▼	•	14.2	7 or 8	0.779
Latvia	512 (2.6)	▼	▼	15.0	8	0.811
[1]Scotland	512 (3.4)	▼	▼	13.7	9	0.930
Malaysia	510 (3.7)	▼	-	14.3	8	0.790
Norway	494 (2.2)	▼	▼	13.8	7	0.944
Italy	491 (3.1)	▼	-	13.9	8	0.916
[2]Israel	488 (3.1)	▼	▼	14.0	8	0.905
Bulgaria	479 (5.2)	▼	•	14.9	8	0.795
Jordan	475 (3.8)	▼	-	13.9	8	0.743
International average	**474 (0.6)**	▼		**14.5**	**8**	**–**
Moldova, Rep. of	472 (3.4)	▼	-	14.9	8	0.700
Romania	470 (4.9)	▼	▼	15.0	8	0.773
[1]Serbia and Montenegro	468 (2.5)	▼	-	14.9	8	–
Armenia	461 (3.5)	▼	-	14.9	8	0.729
Iran, Islamic Rep. of	453 (2.3)	▼	▼	14.4	8	0.719
[1]Macedonia, Rep. of	449 (3.6)	▼	-	14.6	8	0.784
Cyprus	441 (2.0)	▼	▼	13.8	8	0.891
Bahrain	438 (1.8)	▼	-	14.1	8	0.839
Palestinian Nat'l Auth.	435 (3.2)	▼	-	14.1	8	0.731
Egypt	421 (3.9)	▼	-	14.4	8	0.648
[1]Indonesia	420 (4.1)	▼	-	14.5	8	0.682
Chile	413 (2.9)	▼	-	14.2	8	0.831
Tunisia	404 (2.1)	▼	-	14.8	8	0.740
Saudi Arabia	398 (4.0)	▼	-	14.1	8	0.769
[1+]Morocco	396 (2.5)	▼	-	15.2	8	0.606
Lebanon	393 (4.3)	▼	-	14.6	8	0.752
Philippines	377 (5.8)	▼	-	14.8	8	0.751
Botswana	365 (2.8)	▼	-	15.1	8	0.614
Ghana	255 (5.9)	▼	-	15.5	8	0.567
South Africa	244 (6.7)	▼	▼	15.1	8	0.684

Advanced benchmark: Students demonstrate a grasp of some complex and abstract science concepts.

- can apply knowledge of the solar system and of Earth features, processes, and conditions
- apply understanding of the complexity of living organisms and how they relate to their environment
- show understanding of electricity, thermal expansion, and sound, as well as the structure of matter and physical and chemical properties and changes
- show understanding of environmental and resource issues
- understand some fundamentals of scientific investigation and can apply basic physical principles to solve some quantitative problems
- can provide written explanations to communicate scientific knowledge.

High benchmark: Students demonstrate conceptual understanding of some science cycles, systems, and principles.

- have some understanding of Earth's processes and the solar system, biological systems, populations, reproduction and heredity, and structure and function of organisms
- show some understanding of physical and chemical changes, and the structure of matter
- solve some basic physics problems related to light, heat, electricity, and magnetism
- demonstrate basic knowledge of major environmental issues
- demonstrate some scientific inquiry skills
- can combine information to draw conclusions; interpret information in diagrams, graphs and tables to solve problems; and provide short explanations conveying scientific knowledge and cause/effect relationships.

Intermediate benchmark: Students can recognise and communicate basic scientific knowledge across a range of topics.

- recognise some characteristics of the solar system, water cycle, animals, and human health
- are acquainted with some aspects of energy, force and motion, light reflection, and sound
- demonstrate elementary knowledge of human impact on and changes in the environment
- can apply and briefly communicate knowledge, extract tabular information, extrapolate from data presented in a simple linear graph, and interpret pictorial diagrams.

Low benchmark: Students recognise some basic facts from the life and physical sciences.

- have some knowledge of the human body and heredity, and demonstrate familiarity with some everyday physical phenomena.
- can interpret some pictorial diagrams and apply knowledge of simple physical concepts to practical situations.

Australia's performance at the international benchmarks – Mathematics

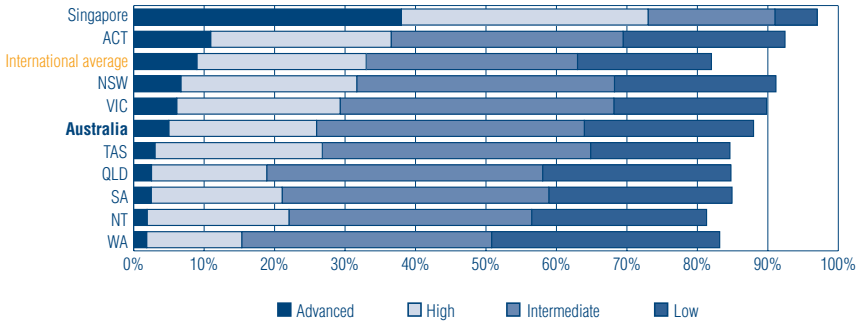
Year 4

- At Year 4, only five per cent of Australian Year 4 students reached the advanced international benchmark compared to the international average of 8 per cent, and a further 26 per cent reached the high international benchmark, compared to 33 per cent internationally. Sixty-four per cent of Australian Year 4 students reached at least the intermediate international benchmark and 88 per cent reached the low international benchmark. The equivalent proportions for the international average are 63 and 82 per cent.
- The Australian Capital Territory had the highest proportion of Year 4 students attaining each of the international benchmarks in mathematics. The Northern Territory had the lowest proportion of students reaching either the advanced international benchmark or the low international benchmark.
- There has been no significant change from TIMSS 1994/95 in the proportion of Australian Year 4 students who achieve at each of the international benchmarks in mathematics.

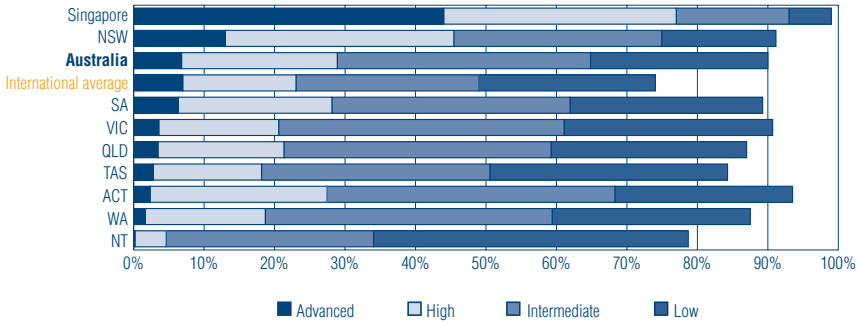
Year 8

- 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 at least the intermediate international benchmark and 90 per cent reached the low international benchmark. An equal or greater proportion of Australian Year 8 students reached each of the international benchmarks than the international average. However, the proportion of Australian students reaching each of the international benchmarks in mathematics was far less than that of the highest achieving country, Singapore.
- New South Wales had the highest proportion of Year 8 students reaching the advanced international benchmark, whereas the Australian Capital Territory had the highest proportion reaching the low international benchmark. The Northern Territory had the lowest proportion of students reaching either the advanced international benchmark or the low international benchmark.
- There has been no significant change from TIMSS 1994/95 in the proportion of Australian Year 8 students who achieve at each of the international benchmarks in mathematics.

Year 4



Year 8



The proportion of students reaching the international benchmarks in mathematics, Australia, the highest achieving country, the international average and by state.

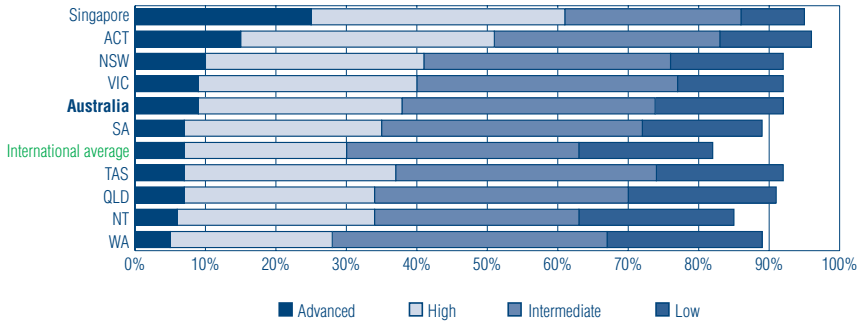
Australia's performance at the international benchmarks – Science

Year 4

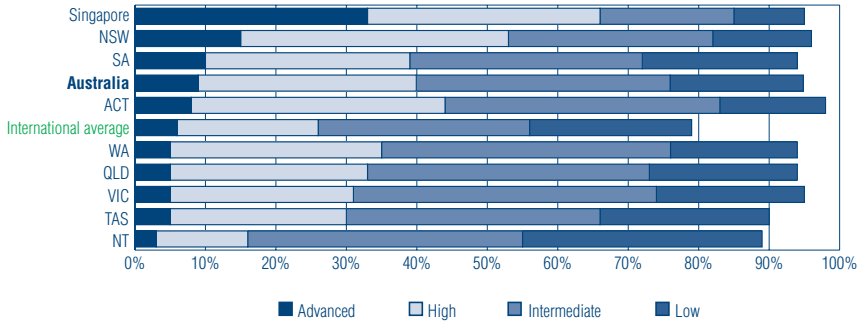
- The proportion of Australian Year 4 students at each international benchmark is higher than the international average. Nine per cent of Australian students reached the advanced international benchmark, 38 per cent reached the high international benchmark, 74 per cent reached the intermediate international benchmark and 92 per cent reached the low international benchmark. The proportion of Australian students reaching the low international benchmark is not much lower than that of Singapore, the highest achieving country. However, the percentage reaching the advanced benchmark is much less than that of Singapore.
- The Australian Capital Territory had the highest proportion of Year 4 students attaining each of the international benchmarks in science. The Northern Territory had the lowest proportion of students reaching at least the low international benchmark.
- There has been a significant decline from TIMSS 1994/95 in the proportion of Australian Year 4 students who achieve the advanced international benchmark in science. The proportion achieving the other benchmarks has not changed significantly.

Year 8

- The proportion of Australian Year 8 students achieving each international benchmark in science is higher than the international average. Nine per cent of Australian Year 8 students reached the advanced international benchmark, 40 per cent reached the high international benchmark, 76 per cent reached the intermediate international benchmark and 95 per cent reached the low international benchmark. Australian students are nevertheless far behind the highest achieving country, Singapore in the proportion achieving the advanced international benchmark.
- New South Wales had the greatest proportion of Year 8 students reaching the advanced international benchmark in science, whereas the Australian Capital Territory had the largest proportion reaching the low international benchmark. The Northern Territory had the lowest proportion of students reaching either the advanced international benchmark or the low international benchmark, but the average score was still the same as the international average.
- The proportion of Australian Year 8 students reaching the low and intermediate international benchmarks increased significantly from TIMSS 1994/95, meaning that Australian schools are doing a better job of increasing science achievement for all young Australians.



Year 4



Year 8

The proportion of students reaching the international benchmarks in science, Australia, the highest achieving country, the international average and by state.

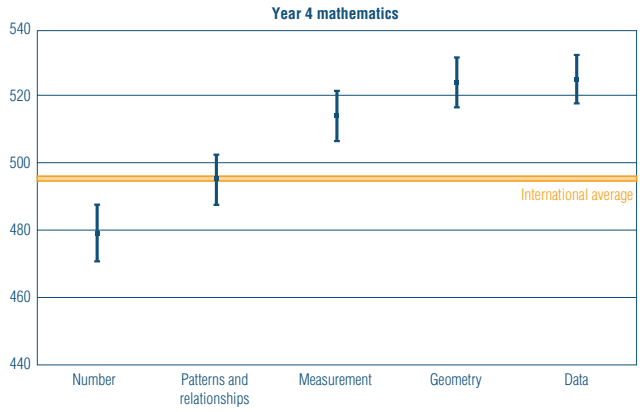
What does TIMSS tell us about achievement in the mathematics content areas?

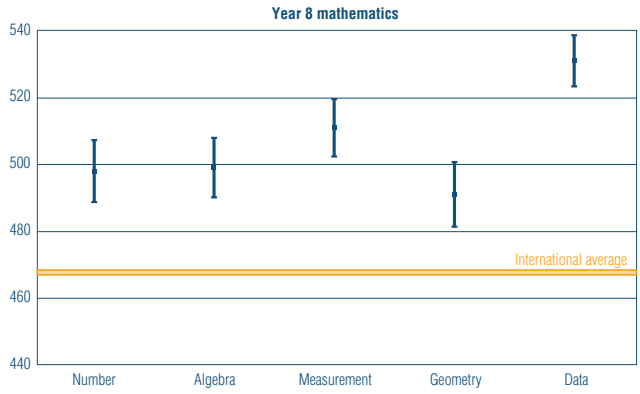
The TIMSS mathematics tests were organised along two domains – a cognitive domain and a content domain. The content domain included the areas of *number, algebra, measurement, geometry* and *data*. These tables show the balance of items across the content and cognitive domains:

Mathematics content domains	Year 4	Year 8
Number	40%	30%
Algebra/Patterns & relationships	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%

The following graphs show the performance of Australian Year 4 and Year 8 students in each of the mathematics content domains.





- The largest differences between highest and lowest scores in Year 4 internationally were in the area of *data*.
- Australia's average score was significantly higher than the international average in Year 4 in *measurement, geometry* and *data*.
- Australia's score was similar to the international average in *patterns* and *relationships*, and lower than the international average in *number*.
- In Year 8, the largest difference between highest and lowest performing countries was in *geometry*.
- Australia's average score in Year 8 was significantly higher than the international average in all mathematics content areas.
- Australia's score was significantly higher in *data* than in any other content areas.
- Performance in *geometry* was weaker than in the other content areas, although still higher than the international average.

What does TIMSS tell us about achievement in the science content areas?

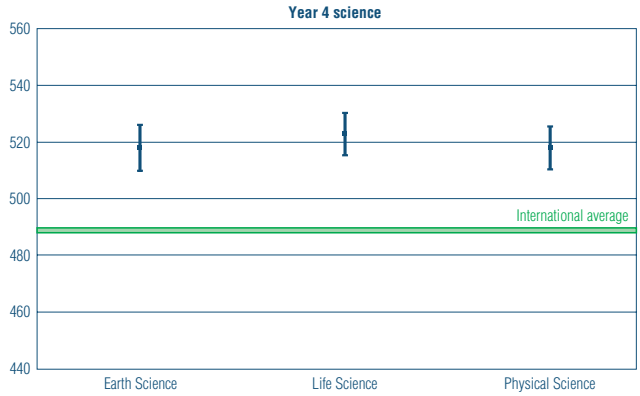
The TIMSS science tests were also organised along a cognitive domain and a content domain. The content domain included the areas of life *science*, *chemistry* and *physics* (*physical science* at Year 4), *earth science* and *environmental science* (Year 8 only). These tables show the balance of items across the content and cognitive domains:

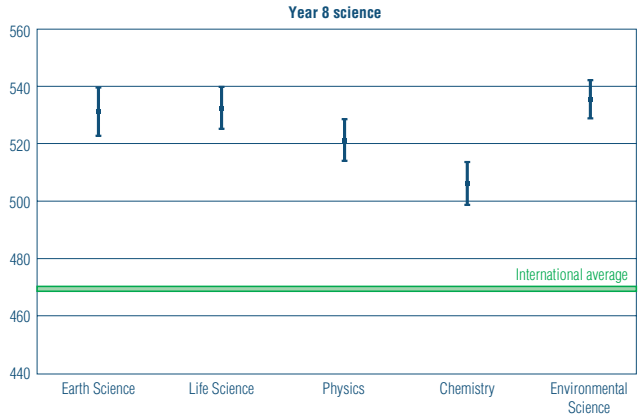
Science content domains	Year 4	Year 8
Earth science	20%	15%
Life science	45%	30%
Physical science (Year 4)	35%	
Chemistry (Year 8)		15%
Physics (Year 8)		25%
Environmental science (Year 8)		15%

Science cognitive domains	Year 4	Year 8
Factual knowledge	40%	30%
Conceptual understanding	35%	35%
Reasoning & analysis	25%	35%

The following graphs show the performance of Australian Year 4 and Year 8 students in each of the mathematics content domains.

- Australian students scored significantly higher than the international average in all content areas in both Year 4 and Year 8 science.
- Australia's performance in Year 4 science was consistent across content areas.
- In Year 8 science, students scored higher in *environmental science*, while the weakest area was *chemistry*, although achievement in this domain was still higher than the international average.
- The largest difference in average scores between highest and lowest scoring countries was in *physical science* at Year 4 and *physics* at Year 8.





Mathematics examples

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

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

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

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

Less expensive plan Plan B

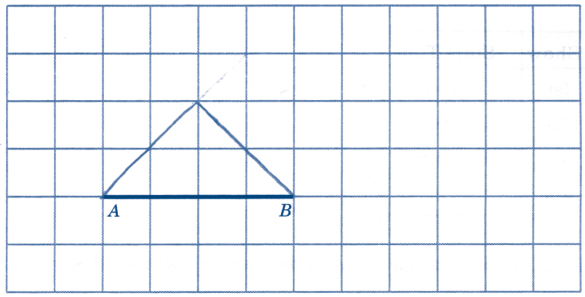
Explain your answer in terms of both the monthly fee and free minutes.

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

This example illustrates the advanced international benchmark at Year 8 and provides an example of multi-step word problems that are used in the TIMSS assessment. The item requires students to select relevant information from a table and calculate which of two phone plans would be least expensive for a person given their usage patterns. Students needed to be able to justify their answer in terms of monthly fees and free minutes. To obtain full credit for this item, students were given a table of data, and were asked to demonstrate their ability to draw and justify conclusions from these data. This was a challenging item for TIMSS students. Internationally 21 per cent of students obtained full credit for this question, and in no country did the majority of students answer the question correctly, with the highest performing country being Japan, with 49 per cent of students gaining full credit. In Australia, Estonia, Republic of Korea and Singapore, between 40 and 44 per cent of students gained full credit.

This item illustrates the low international benchmark at Year 4. This example asks students to draw a triangle so that the line AB is the base, and the two new sides are the same length as each other.

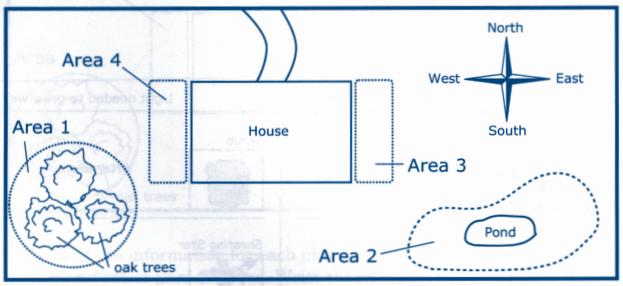
Students in Australia showed some facility with this item, with a little more than three-quarters able to complete the question correctly. This was significantly higher than the international average (67%), and similar to the results from England, Scotland and New Zealand. In the highest achieving country on this item, Hong Kong SAR, 95 per cent of students were able to correctly complete the triangle.



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

Science examples

A plan of Rebecca's house and garden is shown below. There are four areas in the garden where she would like to grow some plants (Areas 1, 2, 3, and 4).



Which side of Rebecca's house will receive the most sun in the morning?

(Tick one box.)

- [x] East side (Area 3)
- [ ] West side (Area 4)

Explain your answer.

East because the sun rises in the east and sets in the west

The first example illustrates the advanced international benchmark at Year 4. This item is part of an extended problem-solving and inquiry task, in which students were provided with a plan of a house and garden showing the points of a compass, and were asked to explain which part of the garden would receive the most sunlight in the morning. To be awarded credit, students needed to be able to explain that the East side of the house would receive the most sun and be able to explain this in terms of the sun rising in the East.

This item was relatively difficult for the Year 4 students, with a little more than one-quarter answering it correctly internationally. Australian students' performance was equivalent to this, as was that of England, New Zealand, and the United States of America. The highest scoring country was Chinese Taipei, where a little more than half of the students completed this item correctly.

The second example illustrates the low international benchmark at Year 8. Students were asked to identify the diagram showing the correct arrangement of batteries in a torch.

This item was quite easy for most students to answer correctly, with 85 per cent doing so internationally. Australia's results were exactly this, and were similar to those of Scotland, New Zealand and Indonesia. Students in Singapore, Japan, England and Malaysia all achieved at a level higher than this, with more than 90 per cent answering correctly.

The diagrams show a torch and three ways to put batteries in it.

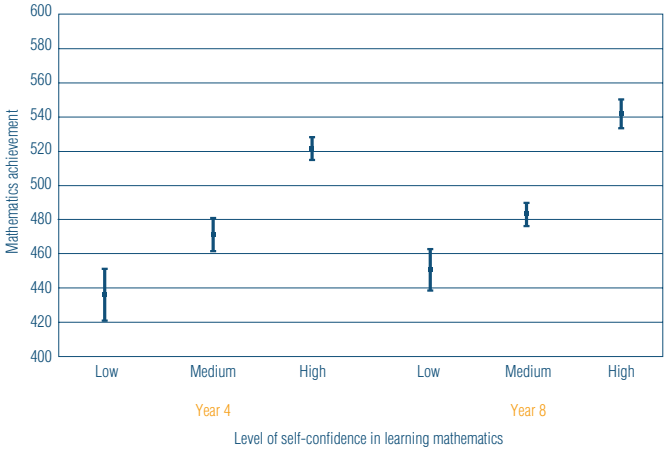
In order to make the torch work, which way must the batteries be placed?

- (A) Only as in K
- (B) Only as in L
- (C) Only as in M
- (D) None of these ways would work.

The Australian TIMSS students

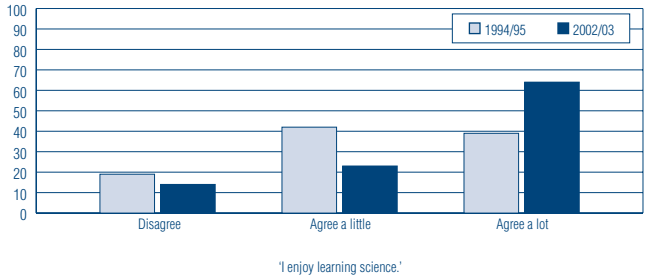
Mathematics

- *Gender* – 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*.
- *Parental education* – For Year 8 students achievement in mathematics was found to be higher for students whose parents had completed a university degree.
- *Home education resources* – At both year levels there was a clear and positive relationship between books in the home and achievement in mathematics.
- *Indigenous students* – Overall, the mathematics achievement of Indigenous students at both year levels was significantly lower than that of non-Indigenous students. For Year 4 students the difference between the scores of the two groups was slightly larger than in TIMSS 1994/95. However, for Year 8 students the difference between the scores of the two groups was slightly smaller than in TIMSS 1994/95.
- *Language background* – The relationship between mathematics achievement and language background was not clear. At Year 4 there were no apparent differences, while Year 8 students from a non-English speaking background, but who spoke English at home, performed significantly better than other students.
- *Students' attitudes and beliefs* – Students were asked a series of questions about how they felt about learning mathematics. These items consisted of questions oriented to the students' self-confidence in learning mathematics, how much the students valued mathematics, and their enjoyment of learning mathematics.
- Australian students had relatively high self-confidence in learning mathematics, and males had higher self-confidence in learning mathematics than females in both year levels.
- Students' self-confidence in learning mathematics had a clear positive relationship with mathematics achievement in Australia (see figure below) and internationally.
- Students' enjoyment of learning mathematics was also related to mathematics achievement. Australia was one of a small number of countries that showed a significant increase from TIMSS 1994/95 in the percentage of students at both year levels who agreed 'a lot' that they enjoy learning mathematics.
- At both year levels, males enjoy learning mathematics more than females.

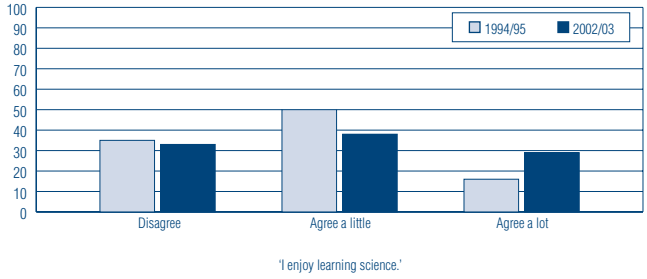


Science

- *Gender* – There were no significant gender differences in overall science achievement in Australia at Year 4. However, in Year 8, males scored a significant 20 scale points higher than females. Year 4 females outperformed males in *life science*. At Year 8, males significantly outperformed females in *chemistry*, *physics*, *earth science* and *environmental science*.
- *Parental education* – For Year 8 students achievement in science was found to be higher for students whose parents had completed a university degree.
- *Home education resources* – At both year levels there was a clear and positive relationship between books in the home and achievement in science.
- *Indigenous students* – Overall, the science achievement of Indigenous students at both year levels was significantly lower than that of non-Indigenous students. For Year 4 students the difference between the scores of the two groups was slightly larger than in TIMSS 1994/95. However, at Year 8, the difference between the scores of the two groups was less than in TIMSS 1994/95.
- *Language background* – The relationship between science achievement and language background differed across year levels. At Year 4, students who spoke English at home achieved at a significantly higher level than those who did not, while for Year 8 this difference was not apparent.
- *Students' attitudes and beliefs* – Students were asked a series of questions about how they felt about learning science. These items consisted of questions oriented to the students' self-confidence in learning science and also questions about how the students value science, including enjoyment of learning science.
- Australian students had relatively high self-confidence in learning science.
- In Australia, there was no gender difference at Year 4. However, self-confidence in learning science was higher for males than females at Year 8.
- There was a clear positive relationship between level of self-confidence and achievement in science.
- Students' enjoyment of learning science is also related to science achievement. Internationally, the average percentage of students agreeing a lot that they enjoy learning science has increased since 1994/95, from 44 per cent to 55 per cent at Year 4 and from 23 per cent to 44 per cent for Year 8 science.
- Australia was one of a small number of countries (including Singapore, New Zealand and the United States, amongst others) that showed a significant increase, at both Years 4 and 8, in the percentage of students who agreed a lot that they enjoy learning science.
- There was no difference in Australia between males and females in enjoyment of learning science in Year 4. However, at Year 8, males appear to enjoy learning science more than females.



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



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

TIMSS Trends in International Mathematics and Science Study 2002/03

- *What are mathematics and science students around the world expected to learn?*
- *What opportunities are provided for students to learn mathematics and science?*
- *What mathematics and science concepts, processes and attitudes have students learned?*
- *What factors are linked to students opportunity to learn?*
- *How do these factors influence students' achievements?*

These two reports summarise the findings from the most recent cycle of TIMSS, carried out in 2002 and 2003.

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

(TIMSS Australia Monograph no 6)

Sue Thomson and Nicole Fleming

Australian Council *for* Educational Research

Examining the evidence: Science achievement in Australian schools in TIMSS 2002

(TIMSS Australia Monograph no 7)

Sue Thomson and Nicole Fleming

Australian Council *for* Educational Research

More than 10 000 Australian students took part in TIMSS at Year 4 and Year 8. Internationally, students in 45 other countries also participated at either Year 8 or at both Year 4 and Year 8.

This is the third time Australia has participated in a combined International Mathematics and Science Study. Results for 2002/03 in mathematics and science, for both Year 4 and Year 8, are presented in these reports, for Australia and in relation to the other TIMSS countries. Results for 2002/03 are also compared, where possible, to the results from TIMSS 1994/95.

The full reports are available from ACER Press (www.acerpress.edu.au), or can be downloaded from the ACER web site (www.acer.edu.au)