OECD PISA

Exploring Scientific Literacy: How Australia measures up

The PISA 2006 survey of students' scientific, reading and mathematical literacy skills

Sue Thomson
Lisa De Bortoli

ACER

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www.acerpress.com.au

sales@acer.edu.au

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Executive Summary

The Programme for International Student Assessment (PISA) is an initiative of the Organisation for Economic Cooperation and Development (OECD) in Paris. PISA is part of an ongoing OECD program of reporting on indicators in education, which first appeared in the annual OECD publication *Education at a Glance* more than a decade ago. Over this period, the OECD has successfully developed indicators of human and monetary resources invested in education and how education systems operate. PISA arose because there was a need for regular and reliable information on educational outcomes across countries, particularly a measure of students´ skills. Because it is part of an ongoing program of reporting, an aim of PISA is to monitor trends in performance over time.

What does PISA assess?

The primary focus of PISA is on public policy issues related to education provision, with the aim of helping the governments of OECD member countries (and others) to have the best possible education systems. Questions guiding the development of PISA are the following:

- How well are young adults prepared to meet the challenges of the future? What skills do they possess that will facilitate their capacity to adapt to rapid societal change?
- Are some ways of organising schools and school learning more effective than others?
- What influence does the quality of school resources have on student outcomes?
- What educational structures and practices maximise the opportunities of students from disadvantaged backgrounds? How equitable is education provision for students from all backgrounds?

Who is assessed?

The student population chosen for PISA is students aged 15 years, who are thus assessed as they approach the end of their secondary schooling. National random samples of at least 4,500 15-year-old students are chosen from 150 or more schools in each country to participate in the assessment.

The first assessment of 15-year-old students in 28 OECD member countries (including Australia) and four non-OECD (or partner) countries took place in 2000. The second assessment was undertaken in 2003, and involved more than one-quarter of a million students in 41 countries (all 30 OECD member countries and 11 non-OECD countries)[1]. In 2006, 57 countries participated; all OECD countries and 27 partner countries in regions spanning all inhabited continents. In total, almost 400,000 students worldwide participated in PISA 2006.

In Australia, 356 schools and 14,170 students participated in PISA. The larger sample was taken in Australia for a number of reasons:

- Smaller states and Indigenous students were oversampled so that reliable estimates could be inferred for those populations; and
- The PISA 2006 sample was designed to become a cohort of the Longitudinal Surveys of Australian Youth (LSAY). These students will be contacted in future years to trace their progress through school and entry into further education and the work force. A large sample is needed to allow for attrition: over time contact is lost with a proportion of the original sample.

1 Although the Netherlands participated in PISA 2000, and the United Kingdom in PISA 2003, neither countries´ results are reported as they were unable to meet sampling requirements.

What is assessed?

The goal of PISA is to measure competencies that will equip students to participate productively and adaptively in their life beyond school education. The PISA assessment focuses on young people´s ability to apply their knowledge and skills to real-life problems and situations. The emphasis is on whether students, faced with problem situations that might occur in real life, are able to analyse, reason and communicate their ideas effectively. In addition, how well do they make use of technological advances? Do they have the capacity and are they equipped with strategies to continue learning throughout their lives? The term *literacy* is attached to each domain to reflect the focus on these broader skills. The way in which it is used is a great deal broader than in the traditional sense of being able to read and write. The OECD considers that mathematics, science and technology are so pervasive in modern life that it is important for students to be `literate´ in these areas as well.

The relevant skills are measured with assessment tasks that typically contain some text describing a real-life situation and a series of two or more questions for students to answer about the text. For the mathematical and scientific components of the assessment, the text typically presents situations in which mathematical or scientific problems are posed or mathematical or scientific concepts need to be understood. In all domains, the `text´ is not necessarily prose text, but can be a diagram, table, or chart, for example. Some of the PISA 2006 items were multiple choice, but for others, students had to construct and write their own answers.

There are many more skills in which PISA is interested than could be measured in each survey. As the surveys are planned every three years a different domain is chosen to be the focus for each assessment. Reading literacy was the major domain in PISA 2000, mathematical literacy in PISA 2003, and scientific literacy was the major focus of the PISA 2006 assessment.

With the focus on scientific literacy as a major domain for PISA 2006, the framework describing PISA science was developed in depth. The PISA 2006 assessment more clearly separates *knowledge about science* from *knowledge of science*. *Knowledge of science* refers to knowledge of the natural world across the major fields of physics, chemistry, biological science, Earth and space science, and science-based technology. *Knowledge about science* refers to knowledge of the means (scientific enquiry) and the goals (scientific explanations) of science. The PISA framework further elaborates on, and gives greater emphasis to, *knowledge about science* as an aspect of science performance, through the addition of elements that underscore students´ knowledge about the characteristic features of science.

The PISA scientific competencies can be thought of as a sequence of strategies students use when solving a problem. First they identify the problem, then apply their *knowledge of science* to find a solution, and finally interpret and use the results. The three competencies defined in PISA 2006 for science are identifying scientific issues, explaining phenomena scientifically and using scientific evidence. The term `scientific literacy´ used in this report refers collectively to both *knowledge about science* and *knowledge of science*.

What did participants need to do?

Students who participated in PISA completed an assessment booklet that contained questions from the major domain and one or more of the minor domains being tested – in PISA 2006 they were assessed on scientific literacy (the major domain), reading literacy, and mathematical literacy. Students also answered a short questionnaire, which included scales to measure their attitudes as well as questions to collect information on their backgrounds. School principals completed a short questionnaire which collected information about their schools.

How are results reported?

Results are reported for scientific, reading and mathematical literacy, for the PISA scientific literacy knowledge domains and scientific competencies, and for attitudes towards science and science learning. For each of the major domains, a scale was defined that had a mean of 500 and a standard deviation of 100.

Results from countries are reported as average scores, as distributions of scores, and as percentages of students who attain each of a set of defined levels of proficiency. The science proficiency scales contain descriptions of the skills typically shown by students achieving at each level, and were defined especially for PISA 2006 by international science experts.

How is PISA managed?

PISA 2006 was implemented internationally by a consortium led by the Australian Council for Educational Research (ACER). Other members of the consortium were the Netherlands National Institute for Educational Measurement (CITO), Westat Inc. in the United States, and the National Institute for Educational Policy Research (NIER) in Japan.

There is a high emphasis in PISA on collaboration between countries, and between countries and the consortium. Input is sought from countries by the consortium at all stages of the development of the PISA instruments and the frameworks that establish what is to be assessed.

PISA 2006 in Australia

- Just over 14,000 students from 356 schools participated, from all States and Territories and all sectors of schooling.
- Data were gathered between late-July and early September 2006.
- Teachers who were not on the staff of any of the selected schools, and who were not currently teaching, travelled throughout Australia to administer the assessment sessions. These Test Administrators were all required to attend a training session about PISA procedures in order to ensure that testing occurred in a standard way.
- A group of teachers coded the students´ answers to questions where the answers had to be written in. These teachers attended training sessions for several days to become familiar with the wide range of items in PISA and the criteria that were set up as the basis for decisions about the correctness of students´ answers.
- Students´ results were sent back to their own schools. Apart from that, all information in PISA at student and school levels is strictly confidential at all times.

Australia´s performance in PISA 2006

Overall, Australia´s students acquitted themselves very well in PISA 2006. The following are some highlights. Differences are only mentioned if tests of statistical significance showed that the differences were highly likely to indicate real differences.

In terms of country averages:

- Australia´s results were above the OECD average in each of scientific, reading and mathematical literacy.
- Australia was significantly outperformed in scientific literacy by three countries – Finland, Hong Kong-China and Canada. Australia´s performance was not significantly different from that of Japan or Korea or to that of five other countries. In 2003, four countries also achieved better results than Australia in scientific literacy – Finland, Japan, Korea and Hong Kong-China. In PISA 2000, only Korea and Japan outperformed Australia.

- Eight countries outperformed Australia in mathematical literacy in PISA 2006, compared with seven countries in PISA 2003 and one in PISA 2000.
- In reading literacy in PISA 2006 Australia was outperformed by five countries: Korea, Finland, Hong Kong-China, Canada and New Zealand. In PISA 2003 Finland and Korea achieved significantly better results than Australia and in PISA 2000 only Finland achieved significantly better results than Australia in reading literacy. The change in Australia´s position has occurred because of a combination of Australia´s decline in score, improvements for Korea and Hong Kong-China, and the scores for Canada, Finland and New Zealand remaining the same.
- Australian students scored significantly higher than the OECD average in both science knowledge domains, scoring 533 points for *knowledge about science* and 528 points for *knowledge of science*, compared to the OECD averages of 500.
- Australia performed at a level higher than the OECD average in all three of the content areas within the PISA *knowledge of science* domain: Earth and space systems, living systems, and physical systems. Physical systems was a relative weakness nationally, with achievement in this domain a significant 12 points lower than the average overall science performance score for Australia. The score in living systems was also relatively lower than the overall average score for scientific literacy, while the score for Earth and space systems was slightly higher than the overall average score.
- Australian students performed well in the *identifying scientific issues* competency, scoring second only to Finland. This was also a strength nationally, with an average score eight points higher than the overall Australian science average. As was the case in almost all participating countries, Australian females scored significantly higher than males in this competency.
- Australian students demonstrated a relative weakness in the *explaining phenomena scientifically* competency. The average score was seven score points lower than the overall average for science, and Australian students were outperformed by five other countries. Gender differences internationally were almost all in favour of males, and Australian males outscored their female counterparts by a significant 14 score points.
- In *using scientific evidence*, Australian students performed moderately well. The average score was four points higher than the overall science average, and Australian students were outperformed by four other countries. There were fewer gender differences in this competency than in the other two, and most were in favour of females. In Australia the gender difference was not significant.

In terms of distribution of scores:

- In Australia, the ranges of scores between the 5th and 95th percentile are wider than the OECD average for scientific literacy, and narrower than the OECD average for reading literacy and mathematical literacy. A lower spread in scores means that there is a smaller gap in performance between the highest- and lowest-achieving students.

In terms of proficiency levels in scientific literacy:

- Three per cent of Australia´s students achieved the highest scientific literacy proficiency level (Level 6), which was above the OECD average of one per cent. The country with the highest proportion of students achieving proficiency level 6 was Finland, with four per cent of its students at Level 6.
- In Australia, three per cent of students reached proficiency level 6 in *identifying scientific issues* (highest was New Zealand with 4%), three per cent in *explaining phenomena scientifically* (highest was Finland with 5%), and four per cent in *using scientific evidence* (highest were New Zealand and Finland with 7%).
- At Level 6, students can consistently identify, explain and apply scientific knowledge and *knowledge about science* in a variety of complex life situations. They can link different

information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they are willing to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social, or global situations.

- Fifteen per cent of Australian students were placed at Level 5 or higher in scientific literacy, 40 per cent at Level 4 or higher, and two-thirds at Level 3 or higher. Corresponding figures for the OECD as a whole were nine per cent at Level 5 or higher, 29 per cent at Level 4 or higher, and 56 per cent at Level 3 or higher.
- Only 13 per cent of Australian students did not reach at least Level 2 in scientific literacy, compared with the OECD average of 19 per cent. Ten per cent of Australian students in *identifying scientific issues*, 14 per cent in *explaining phenomena scientifically*, and 14 per cent in *using scientific evidence* did not reach Level 2.
- Four per cent of Australia´s students were not achieving at the basic PISA proficiency level, Level 1, in scientific literacy compared with eight per cent in the OECD as a whole. Students performing below the lower boundary of Level 1 were not necessarily incapable of performing any scientific tasks but were unable to utilise these skills in a given situation, as required by the easiest PISA tasks.

In terms of proficiency levels in reading literacy and mathematical literacy:

- Eleven per cent of Australian students were achieving at the highest level of reading literacy, Level 5, which was higher than the OECD average of nine per cent. The country with the highest proportion of students achieving at this level was Korea, with 22 per cent of students achieving at Level 5.
- About 14 per cent of Australian students were performing below proficiency level 2 in reading, lower than the OECD average (21%), but higher than that of the highest performing country, Korea (5%).
- Four per cent of Australian students were achieving at the highest level of mathematical literacy, Level 6, which was just higher than the OECD average of three per cent. Finland, one of the other highest scoring countries, achieved six per cent at Level 6, while Chinese Taipei, the other highest-scoring country achieved 12 per cent at level 6.
- Sixteen per cent of Australian students, compared with 13 per cent for the OECD on average and 32 per cent for Chinese Taipei, scored at Level 5 or 6 in mathematics.
- Thirteen per cent of Australian students, compared with 22 per cent of students on average in the OECD and 12 per cent in Chinese Taipei, failed to achieve Level 2 on the mathematical literacy scale. In Finland, just six per cent of students failed to achieve Level 2.

Between 2000, 2003 and 2006:

- Australia´s performance significantly declined in reading literacy, and remained statistically the same in mathematical literacy. As the first major assessment of science, the PISA 2006 assessment establishes the basis for analysis of trends in science performance in the future and it is therefore not possible to compare science learning outcomes from PISA 2006 with those of earlier PISA assessments as is done for reading and mathematics.
- Data on reading literacy achievement by state and gender over the period from 2000 to 2006 show that there was a statistically significant decline in the reading literacy performance of females in the Northern Territory and Western Australia between PISA 2003 and PISA 2006 and for Tasmania between PISA 2000 and PISA 2006. There were also significant declines for males between 2003 and 2006 in South Australia and the Northern Territory and in the Northern Territory, New South Wales and South Australia between 2000 and 2006. Overall for

Australia, mean reading scores for both males and females declined significantly between 2003 and 2006.

- While the mean scores in mathematical literacy for Australia as a whole and for most of the states declined between PISA 2003 and PISA 2006, the decreases were not significant for Australia overall and were significant for only two states – Western Australia (by 17 score points) and South Australia (by 15 score points). However, there was a significant decline in the mean score of female students between 2003 and 2006 for Australia as a whole.

In terms of results for the Australian states and territories:

- In scientific literacy, the Australian states and territories all performed, on average, at a level in each domain that was either at or above the OECD average.
- In scientific literacy, the average performance of students in the Australian Capital Territory was significantly higher than that of all states other than Western Australia. The scores of students in Western Australia were statistically similar to those of students in New South Wales and South Australia but higher than those of the other states. These findings were similar to those reported for PISA 2000 and PISA 2003.
- In reading literacy, the Australian Capital Territory and Western Australia achieved the highest means (which were not statistically different from one another) while Western Australia also performed on a par with New South Wales and South Australia.
- In mathematical literacy the score for the Australian Capital Territory was not significantly different to that of Chinese Taipei, the highest scoring country. The score for Western Australia was not significantly different to that of the Australian Capital Territory, and was also significantly higher than the Australian average.
- In both the Australian Capital Territory and Western Australia, around 20 per cent of students were performing at the highest two proficiency levels in scientific literacy, 40 per cent of students were performing at the highest two proficiency levels in reading literacy, and more than 20 per cent were performing above Level 5 in mathematical literacy.

In terms of the results for males and females:

- Internationally there were gender differences in scientific literacy in 20 countries: 12 in favour of females and eight in favour of males. In Australia there was no significant gender difference on the overall scientific literacy scale.
- There were, however, some gender differences in scores at the level of content areas and competencies. Australian female students performed at a significantly lower level than Australian male students in both Earth and space systems and physical systems but at a similar level in living systems. In Earth and space systems and living systems the average scores for Australian females were significantly higher than the OECD average, but in physical systems the average score for females was not significantly different to the OECD average. In the science competencies, Australian males outscored females in *explaining phenomena scientifically,* and females outscored males in *identifying scientific issues*.
- As in PISA 2000 and PISA 2003, the gender difference in favour of females in reading literacy was large, about 0.4 of a standard deviation, and this was about the same as the OECD average.
- Males significantly outscored females in mathematical literacy in Australia in 2006, in contrast to the position in the previous cycle when there was no significant gender difference.
- There were no gender differences shown in overall scientific literacy within the states of Australia.
- In reading literacy the gender difference in each state was in favour of females, and was largest in New South Wales, where the difference was 46 score points or half a proficiency level. In

terms of proficiency levels, there were more than twice as many females as males achieving at Level 5 in the Northern Territory and South Australia, and almost twice as many females as males in New South Wales, Queensland, and Tasmania. The smallest gender differences at Level 5 were found in the Australian Capital Territory, where 4% more females than males achieved Level 5, Western Australia, with a 5% gap between the proportion of females and males, and Victoria, with a 3% gap between the proportion of females and males.

- In mathematical literacy the largest gender differences were found in Victoria (23 points) and Western Australia (19 points). In the Australian Capital Territory, 29 per cent of males but only 18 per cent of females were found to be achieving at or above Level 5, and in Victoria and Western Australia there was a gap of some eight percentage points between the percentage of males and females achieving at this high level. The smallest gender difference at high proficiency levels was found in the Northern Territory, where 10 per cent of females and 12 per cent of males achieved at Level 5 or higher.

In terms of Indigenous students´ results:

- Altogether, 1,080 Indigenous students were assessed in PISA 2006. On average, the performance of Indigenous Australians in scientific literacy was 88 score points lower than that of non-Indigenous students. That is, Indigenous students scored around one proficiency level lower than non-Indigenous students.
- Similar results were evident for reading and mathematical literacy.
- Indigenous students were over-represented in the lowest categories of science proficiency and under-represented in the highest category. Only three per cent of Indigenous students demonstrated skills at proficiency level 5 or higher, and 40 per cent failed to achieve proficiency level 2.
- Similarly, Indigenous students were over-represented in the lowest categories of reading and mathematical literacy, and under represented in the highest categories. In reading, 12 per cent of Indigenous students were found in the highest two proficiency levels along with 36 per cent of non-Indigenous students. In mathematical literacy, two per cent of Indigenous students and 16 per cent of non-Indigenous students were found in the higher levels. In reading, 38 per cent of Indigenous and 12 per cent of non-Indigenous students did not achieve Level 2, and in mathematical literacy 39 per cent of Indigenous and 12 per cent of non-Indigenous students did not achieve Level 2.
- The scores for Indigenous students on the three scientific competencies were also significantly lower than the scores for non-Indigenous students and also than the OECD averages. Indigenous students performed relatively better in the *identifying scientific issues* competency, scoring an average of 12 points more than the Indigenous overall scientific literacy score. Their performance in *explaining phenomena scientifically* and *using scientific evidence* was close to the Indigenous overall average for scientific literacy.

For other student groups:

- The average scientific literacy score of students attending schools in remote areas was significantly lower than that of students attending schools in either provincial areas (by 47 score points) or metropolitan areas (by 57 score points). More than one-quarter of students in remote schools were not achieving at Level 2, compared with around 12 per cent of the cohort in metropolitan or provincial areas. At the higher end of the achievement scale, only seven per cent of students in remote areas achieved Level 5 or higher, compared with 13 and 15 per cent of students in provincial and metropolitan schools respectively.
- In reading literacy, the average score of students attending remote schools was about 30 score points lower than that of students attending schools in provincial areas, and about 50 score points lower than that of students attending schools in metropolitan areas. Twenty-four per cent

of the students in remote areas did not achieve the baseline proficiency level, compared to 17 per cent of students in provincial areas and 12 per cent in metropolitan areas. Around 12 per cent of students attending metropolitan schools were achieving at Level 5, compared to eight per cent of those in provincial schools and seven per cent of those in remote schools.

- In mathematical literacy the average score of students who attended schools in remote areas was 40 score points lower than that of students attending schools in provincial areas, and 58 score points lower than that of students attending schools in metropolitan areas. Twenty-eight per cent of the students in remote areas did not achieve proficiency level 2, compared to 20 per cent of students in provincial areas and 12 per cent in metropolitan areas. Around 18 per cent of students attending metropolitan schools were achieving at Level 5, compared to 12 per cent of those in provincial schools and seven per cent of those in remote schools.
- The average scientific literacy score of students in the lowest socioeconomic quartile was significantly lower than that of students in the highest socioeconomic quartile (by 87 score points). Twenty-three per cent of students in the lowest socioeconomic quartile were not achieving at Level 2, compared with five per cent of the cohort in the highest socioeconomic quartile. Only six per cent of students in the lowest socioeconomic quartile achieved Level 5 or higher, compared with 26 per cent of students in the highest socioeconomic quartile.
- In reading literacy the difference in average scores between students in the highest and lowest socioeconomic quartiles was 84 score points. Five per cent of students in the highest socioeconomic quartile were not achieving at Level 2, compared with 23 per cent of the cohort in the lowest socioeconomic quartile. Only four per cent of students in the lowest socioeconomic quartile achieved Level 5, compared with 21 per cent of students in the highest socioeconomic quartile.
- In mathematical literacy, students in the lowest socioeconomic quartile scored on average 78 score points lower than those of students in the highest socioeconomic quartile. Twenty-two per cent of students in the lowest socioeconomic quartile were not achieving at Level 2, compared with five per cent of the cohort in the highest socioeconomic quartile. Only six per cent of students in the lowest socioeconomic quartile achieved Level 5 or higher, compared with 29 per cent of students in the highest socioeconomic quartile.
- To examine the effects of immigrant status on scientific literacy two indicators were used: immigrant status (based on country of birth of students and their parents) and language background. Language background is of interest because unfamiliarity with the language of testing could possibly be a factor in student performance in scientific, reading or mathematical literacy. Students´ immigrant status is categorised in the Australian context as either Australian-born, first-generation, or foreign-born. Language background is dichotomised as `English-speaking´ or `language background other than English´.
- In scientific literacy there were no significant differences between the scores of the three immigrant groups, but students with a language background other than English scored significantly lower than those who spoke English. Slightly more foreign-born students than Australian-born students and substantially more students with a language background other than English (20% compared to 11% of English-speaking students) were not achieving proficiency level 2.
- In reading literacy, first-generation students achieved significantly higher scores than Australian-born students. In the proficiency levels, English-speaking students scored at a significantly higher level than those students with a language background other than English, and 20 per cent of students with a language background other than English failed to achieve Level 2, compared with 12 per cent of English-speaking students.
- In mathematical literacy, both first-generation and foreign-born students significantly outperformed Australian-born students. There was no significant difference in the average scores of English-speaking students and those with a language background other than English. Similar proportions of students in each of the immigrant and language categories achieved at the lower proficiency levels. However, a higher proportion of foreign-born (23%) than first-

generation (18%) and Australian-born (15%) students and a higher proportion of students with a language background other than English (22%) than English-speaking (16%) students were achieving at Level 5 or higher.

In relation to socioeconomic background:

- The primary measure of a student´s family and home background in PISA is the index of economic, social and cultural status (ESCS). PISA collected detailed information from students including information on the occupations of the student´s parents or guardians, the level of education of the parents or guardians, and an index of home possessions, which included access to educational and cultural resources at home. The composite socioeconomic background index, ESCS, was based on the occupations of the parents or guardians, the highest level of education of the parents converted into years of education, an index of the home educational resources, an index of cultural possessions in the home, and an index of family wealth.
- As for all the other indices used in PISA, the ESCS index was standardised to have a mean of zero and a standard deviation of 1 for all OECD countries combined. Australia´s mean value on the ESCS was 0.21, which was higher than the OECD average. This is similar to the ESCS score for OECD countries Austria (0.20), Finland (0.26), the Netherlands (0.25), and Sweden (0.24), is lower than that of Canada (0.37) and Iceland (0.77), and higher than that of countries such as New Zealand (0.10) and the United States (0.14). Within Australia, the mean values for the ESCS were 0.58 in the Australian Capital Territory, 0.28 in New South Wales, 0.21 in Victoria and Western Australia, 0.16 in South Australia, 0.10 in Queensland, 0.07 in the Northern Territory, and -0.04 in Tasmania.
- The terms `socioeconomic gradient´ or `social gradient´ refer in PISA to the relationship between students´ performance and ESCS, which is evident in all countries but the strength varies between countries. Four types of information are useful in a discussion of this relationship.
  - The *strength* of the relationship between science achievement and socioeconomic background – represented by the percentage of the variation in performance that can be explained by the ESCS index. If the percentage is large it indicates that performance is relatively highly determined by ESCS whereas if it is small it indicates that performance is not highly determined by ESCS.
  - The *slope* of the gradient line is an indication of the extent of inequality in the relationship between students´ results and their socioeconomic background (as measured by ESCS). A steeper slope indicates a greater difference in performance between low socioeconomic background students and high socioeconomic background students. Greater equity would be indicated by a flatter gradient.
  - The average *level* of the line in the graph gives an indication of how well the overall population has achieved on the given assessment. Lines at higher levels indicate higher mean performance by the students.
  - The *length* of the line indicates the range of ESCS. The graphs in this report are plotted between the 5^{th} percentile of ESCS and the 95^{th} percentile of ESCS. A smaller range indicates less difference in socioeconomic background between students from the highest and lowest socioeconomic backgrounds in the country.
- The strength of the relationship between ESCS and performance in science in Australia is significantly lower than for the OECD overall, meaning that the relationship is not as deterministic.
- The slope of the socioeconomic gradient for Australia was 43, significantly higher than the slope of 40 for the OECD. This means that in Australia every additional unit increase on the index of socioeconomic background translates into an additional 43 score points on the scientific literacy scale, significantly more than the 40 score points on average over the OECD.

- On the basis of Australia´s lower than (OECD) average strength of relationship between socioeconomic background and performance and higher than (OECD) average performance, Australia is categorised as a high quality and high equity country in relation to science literacy performance in PISA 2006. Other countries categorised as high quality/high equity in science in 2006 were Finland, Hong-Kong China, Japan and Canada. New South Wales, Western Australia, South Australia, Queensland and Victoria are similarly characterised. Countries such as New Zealand, the Netherlands and Germany, as well as the Australian Capital Territory and Tasmania, are classed as high quality/low equity. The United States and France, as well as the Northern Territory, are classed as low quality/low equity, and countries such as Italy and Norway are classed as low quality/high equity.
- Level of the lines: The Australian gradient line is higher than that of the OECD, reflecting the fact that Australian students performed at a higher level than on average in the OECD.
- Length of the lines: The range of ESCS scores between the 5th and 95th percentiles is smaller in Australia than over the OECD as a whole, as would be expected given the range of countries contributing to the OECD average score.
- There is less difference in performance, generally, between countries at high levels of ESCS than there is at low levels. This means that students with high levels of socioeconomic background tend to vary less in their scientific literacy performance, from country to country, than students with relatively low levels of socioeconomic background. That is, the impact of educational experiences on student performance is greatest for students from lower socioeconomic backgrounds.
- The slopes for each of the three domains are very similar in Australia. There is a slightly lower impact of socioeconomic background on mathematics achievement than either scientific or reading literacy achievement. The slope for reading scores has declined significantly from that measured in PISA 2000, meaning that Australia´s reading literacy score, although significantly lower than in PISA 2000, is also more equitably distributed in terms of socioeconomic background. The strength of the relationship has also decreased over the time period.
- In scientific literacy, the gradient for the Northern Territory is the steepest, with the Australian Capital Territory almost as steep, and Victoria has the flattest slope. The graphs for Tasmania and the Australian Capital Territory have a negative curvilinearity (the curvature of the line), indicating that there is a decreasing return on achievement for socioeconomic background past a certain point. South Australia´s slope on the other hand shows a positive curvilinearity, indicating a higher rate of increase in science scores for students in high socioeconomic backgrounds than for students with low socioeconomic backgrounds. The average socioeconomic background for the Australian Capital Territory is generally higher than that of other states. Performance is also generally higher than that of students in other states. Performance across the states at the lower levels of ESCS has a wider range than at the higher levels; as was found internationally, the range of the states´ performance converges at higher levels of ESCS.
- In most OECD countries, including Australia, the effect of the average ESCS of students in a school outweighs the effects of the student´s own socioeconomic background.

In terms of students´ attitudes and motivation:

- A number of measures used in PISA reflect indices that summarise responses from students to a series of related questions. The questions were selected on the basis of theoretical considerations and previous research. Values on the index were standardised so that the mean value for the OECD student population was zero and the standard deviation was one. The highest correlations between constructs discussed in this report and Australian scientific literacy performance were for self-efficacy in science, awareness of environmental issues, self-concept in science and enjoyment of science.

- Australian students had higher levels of self-efficacy in science than the OECD average. There was a significant gender difference in Australia in relation to self-efficacy in science, with males scoring significantly higher than females; however, both were higher than the OECD average.
- Students from New South Wales had the highest levels of self-efficacy in science. Students in the Australian Capital Territory, Western Australia, South Australia and the Northern Territory had higher mean levels of self-efficacy in science than the OECD average, while students in Victoria, Tasmania and Queensland had means that were slightly lower than the OECD average. Males from all states showed higher levels on the self-efficacy in science index than females. The largest gender differences were found in Western Australia and Victoria, with differences of approximately 0.25 points. There was a large positive relationship between self-efficacy in science and scientific literacy performance for Australian students. Students in the highest quartile scored 130 points on average higher than students in the lowest quartile on the self-efficacy in science index, which is equivalent to almost four years of schooling or almost two proficiency levels on the scientific literacy scale.
- The average for Australia for self-concept in science was -0.03, which was not significantly different to the OECD average. There was a significant gender difference in Australia, with males generally more confident in science than the OECD mean for males, and females less confident than the OECD mean for females. Western Australia had a mean score for self-concept in science that was just higher than the OECD mean; all other states scored below the OECD average, indicating lower levels of self-concept in science than students on average in OECD countries. The largest gender differences in relation to self-concept in science were in the Northern Territory and Western Australia. Self-concept in science has a moderately strong positive relationship with scientific literacy performance in Australia. There were 113 points on average between students in the highest quartile of the self-concept in science index and students in the lowest quartile.
- In general there was a positive association in Australia between scientific literacy performance and most of the constructs. An exception to this was optimism regarding environmental issues, where students with high levels of optimism about future environmental issues scored lower than students with low levels of optimism.
- Significant gender differences were found for all indices in Australia except in the index of general interest in learning science and the index of instrumental motivation in science, where no significant gender differences were found. All but two of the significant gender differences were in favour of males, the exceptions being the indices related to responsibility for sustainable development and concern for environmental issues, where they were in favour of females.

Policy Issues

Australia is well placed to continue its tradition of producing high quality scientists. The average score in scientific literacy is significantly higher than the OECD average, and either statistically similar to, or significantly higher than, most trading partners and other countries to which we would usually compare ourselves. Fifteen per cent of our young people scored in the top two proficiency levels, comparing favourably internationally.

The `gap´ in achievement between the best and the weakest students varies by subject domain. In science, there is a relatively wide gap, narrower than that of the United States and the United Kingdom, but wider than the OECD average and that of most other countries. In reading and mathematical literacy, however, it is narrower than the OECD average and also narrower than the spread for between 60 per cent of other countries (for reading) and 70 per cent of other countries (for mathematics).

Analysis of Australia´s performance in terms of equity and achievement places us in the category of above-average level of student performance and below-average impact of socioeconomic background in scientific literacy; in other words, high quality and high equity. In terms of the slope and strength of the association between socioeconomic background and achievement in science, both have decreased significantly since PISA 2003. Australia´s outcomes have become more equitable, as shown by a flatter gradient, and less deterministic, as shown by the smaller proportion of variance explained by socioeconomic background. In reading literacy the slope and strength have also significantly declined, while in mathematics only the strength of the relationship has decreased. However, the increase in equity in reading literacy may be an artefact of declining achievement in the higher levels rather than because achievement at the bottom end has improved.

Australia´s results in scientific, reading and mathematical literacy are laudable. However average scores do not paint the complete picture of a country´s performance, and that has been the primary aim of this report. There are a number of areas in which Australia´s performance is not as good as would be hoped.

Decline in reading achievement

The results from the first three cycles of PISA indicate that the performance levels of Australian students, while comparing reasonably well internationally, are generally not improving. TIMSS 2003 found that scores in science at Year 8 had improved significantly; however, this improvement in scores has not really translated to an improvement in scientific literacy in the manner in which it is presented in PISA. There had also been no evidence previously of any decline in performance, but the PISA 2006 results now point to a significant decrease in performance in reading literacy since PISA 2000. While some caution should be exercised in interpreting these results, as PISA 2006 is comparing the results from the assessment of a minor domain to the assessment of a major domain, there is evidence of a decline, and it seems to be occurring primarily at the upper end of the achievement scale without any compensatory improvement at the lower end. The decline was found for both male and female students. While there is no evidence of any decrease in the average achievement levels in mathematical or scientific literacy, there was a significant decline in the mathematics achievement of Australian females.

Gender

In terms of gender, there was no difference overall in scientific literacy; however, males performed significantly better than females in both Earth and space systems and physical systems, and the performance of females in the latter was at the OECD average. In reading literacy, the gender gap continued to favour females, and it is of a similar size to the gap found in PISA 2000. In PISA 2006 mathematics there is evidence of a decline in the scores of 15-year-old females and no associated decline in the score for males, resulting in a significant gender difference and one that is higher than the OECD average. The decline in scores for females appears to have come from the higher end of achievement.

The performance of males in reading relative to females has not improved, and there is now a gender difference in mathematics, in favour of males, that has not existed for many years. Perhaps gender needs to be reconsidered as an issue for Australian education.

Indigenous students

The achievement of Australia´s Indigenous students continues to be a concern. Average scores for Indigenous students place them on a par with students in a low-performing country such as Chile, and two and a half years behind the average for their non-Indigenous contemporaries. While some individual Indigenous students performed very well on the PISA assessment many more performed extremely poorly. There is no doubt that many Indigenous students will continue to need extra support.

Students attending schools in remote locations

The relatively poor performance of students attending schools in remote areas is also evident from these analyses, and requires attention. Students attending schools in remote areas were found to be achieving at a level about a year and a half lower than their counterparts in metropolitan schools in all of the assessment areas. It is recognised that schools in remote areas face problems such as attracting and retaining qualified teachers, maintaining services and providing resources, and in their capacity to send staff to participate in professional development, which may impinge on the quality of student outcomes.

Students and schools with low socioeconomic levels

This report has also examined differences in achievement by quartiles of socioeconomic background. Students in the lowest socioeconomic quartile, on average, were achieving at a level two and a half years lower than students in the highest socioeconomic quartile across all three domains. Of the students in the lowest socioeconomic quartile around one-quarter failed to achieve the baseline proficiency levels in scientific, reading or mathematical literacy. Few achieved the highest levels in any domain.

Achievement differences in Australia are much larger within schools than they are between schools. However, the discussion of the PISA findings in scientific literacy indicates that the average socioeconomic background of a school outweighs a student´s own socioeconomic background, and that the impact of schooling is greatest for students from disadvantaged backgrounds or attending schools with a low average socioeconomic background.

However, students from low socioeconomic backgrounds are a diverse group encompassing the full range of learning abilities, evidenced by the relatively low strength of the relationship between socioeconomic background and performance. They can and do achieve high standards.

Students who are confident in their own abilities and well motivated tend to do better at school. Positive approaches not only help to explain student performance but also are themselves important outcomes of education. Students who have become effective learners by the time they leave school, and particularly those who have learned to regulate their own learning, are often considered more likely to learn throughout life.

Australia remains committed to the principle of equity and social justice in education and to the goal of allowing and encouraging all children to fulfil their full educational potential. To a large extent, these goals are realised; evidenced by the high average achievement levels in all three assessment domains in PISA. However, there is some evidence from this cycle that Australia appears to be standing still while other countries improve their levels of performance. This report has also shown that behind the higher than average scores, significant levels of educational disadvantage exist in Australia, and that the gap between students of the same age can be equivalent to several years of schooling. This gap places an unacceptable proportion of 15-year-old students at serious risk of not achieving levels sufficient for them to participate fully in the 21st century work force and to contribute to Australia as productive citizens.

Educational inequality is not a given. Some schools, some school systems, and some countries do more to mitigate inequality than others. Using PISA to monitor national outcomes on a regular basis provides Australian educators at all levels with the opportunity to step back and see how we measure up in terms of educational outcomes.

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Acknowledgements

The funding for the Australian component of PISA 2006 was provided jointly by the Australian Government and the state and territory governments. All of Australia's share of the international overheads and half of the basic funding for PISA within Australia was contributed by the Australian Government Department of Education, Science and Training, while each state and territory government school system provided funding in proportion to the numbers of 15-year-olds enrolled in their schools. The Australian government also met the additional cost of increasing the size of the sample to enable PISA 2006 to become the basis for a cohort of the Longitudinal Surveys of Australian Youth.

In Australia, PISA is managed by a team from the Australian Council for Educational Research (ACER) and guided by a National Advisory Committee (NAC). ACER wishes to thank the NAC members, who are listed in a separate section of the report, for their continued interest and commitment throughout every phase of the project. Their involvement included reviewing assessment items, assisting with the implementation of PISA in schools in their state or territory and providing valuable information to ensure the continued success of PISA in Australia.

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The undertaking of PISA 2006 was a collaborative effort. A national survey such as PISA could not be successful without the cooperation of school systems, principals, teachers, parents and of course, students. For high quality data a high participation rate of the randomly selected schools and students is essential. Australia was able to satisfy the internationally set response criteria completely for PISA 2006. ACER gratefully acknowledges the assistance of education system officials Australia-wide, and the principals, teachers and students in the participating schools who so generously gave of their time and support to the project.

Membership of National Advisory Committee

Note: members are listed with their affiliation at the time of membership.

Names in italics denote previous members of the National Advisory Committee.

Chair

Dr Michele Bruniges
ACT Deptartment of Education and Training, Canberra
Mr Ken Smith

Commonwealth representative

Ms Robyn Versegi
Educational Accountability Section, Schools Funding and Reporting Group, Department of Education, Science and Training, Canberra
Ms Wendy Whitham

State and Territory representatives

Mr David Wasson
Educational Measurement, NSW Department of Education and Training, Sydney

Ms Susan Dennett
Standards and Accountability, Victorian Department of Education and Early Childhood, Melbourne

Ms Margo Bampton
Office of Strategic and Executive Services, Queensland Department of Education and the Arts, Brisbane

Dr Tilahun Afrassa
Data Management and Accountability, SA Department of Education and Children's Services, Adelaide
Mr Barry Schmitt

Ms Perette Price
Educational Measurement Office, WA Department of Education and Training, Perth
Ms Jocelyn Cook
Ms Marilyn McKee

Ms Meriloy Horsham
Educational Performance Services, Tasmanian Department of Education, Hobart
Ms Sharyn Lidster
Ms Jennifer Gale

Mrs Ellen Herden
Curriculum Services Branch, NT Department of Employment, Education and Training, Darwin
Mr Ronald Bibby
Mrs Beverley O'Connell

Mr Matthew Hardy
Measurement, Monitoring and Reporting Branch, ACT Department of Education and Training, Canberra
Ms Helen Strauch

Peak non-government representatives

Mr Paul Sedunary
    Curriculum and Innovation, Catholic Education Office, Melbourne
Mr Garry McLean

Mr Andrew Smith
    Strategy and Operations, Independent Schools Council of Australia, Victoria

Indigenous Education representative

Ms Penny Tripcony
    Independent Consultant, Brisbane

Professional association representatives

Mr Paul Carnemolla
    Australian Science Teachers Association, Canberra
Ms Deborah Crossing

Dr Jo O'Mara
    Australian Association for the Teaching of English, Melbourne
Ms Debbie de Laps
Mr Terry Hayes

Dr Christine Stocks
    Australian Association of Mathematics Teachers, Adelaide
Mr Steve Thornton

Academic representatives

Professor Trevor Cairney
    New College, University of New South Wales, Sydney

Prof Kaye Stacey
    Faculty of Education, Science and Mathematics Education, University of Melbourne

Professor David Treagust
    Key Centre for Science and Mathematics Education, Curtin University of Technology, Perth

Teacher organisation representatives

Mr Roy Martin
    Australian Education Union, Melbourne

Ms Lynne Rolley
    Independent Education Union of Australia, Melbourne

Reader's Guide

Data underlying the figures

The data referred to in this report and presented in Figures and Tables are available as online documents from the ACER PISA National website (http://www.acer.edu.au/ozpisa/reports.html).

OECD average

An OECD average was calculated for most indicators in this report and is presented for comparative purposes. The OECD average takes the OECD countries as a single entity, to which each country contributes with equal weight. The OECD average is equivalent to the arithmetic mean of the respective country statistics.

Rounding of figures

Because of rounding, some figures in tables may not exactly add to the totals. Totals, differences and averages are always calculated on the basis of exact numbers and are rounded only after calculation. When standard errors have been rounded to one or two decimal places and the value 0.0 or 0.00 is shown, this does not imply that the standard error is zero, but that it is smaller than 0.05 or 0.005 respectively.

Reporting of student data

The report uses "15-year-olds" as shorthand for the PISA target population. In practice, the target population is students who were aged between 15 years and 3 (complete) months and 16 years and 2 (complete) months at the beginning of the assessment period and who were enrolled in an educational institution that they were attending full-time or part-time.

Confidence intervals and standard errors

In this and other reports, student achievement is often described by a mean score. For PISA, each mean score is calculated from the sample of students who undertook the PISA assessment, and is referred to as the *sample* mean. These sample means are an approximation of the actual mean score, known as the population mean, which would have been derived had *all* students in Australia actually sat the PISA assessment. Since the sample mean is just one point along the range of student achievement scores, more information is needed to gauge whether the sample mean is an underestimation or overestimation of the population mean. The calculation of confidence intervals can assist our assessment of a sample mean's precision as a population mean. Confidence intervals provide a range of scores within which we are 'confident' that the population mean actually lies. In this report, sample means are presented with an associated standard error. The confidence interval, which can be calculated using the standard error, indicates that there is a 95 per cent chance that the actual population mean lies within plus or minus 1.96 standard errors of the sample mean. Comparing confidence interval overlap provides an approximate way of comparing the differences between countries, or states, for example, however exact comparisons using t-tests have been used throughout this report.

Correlational analysis

An analysis of the correlation between two variables can be used to investigate the association between them. If there is a significant positive correlation, it does not imply that one factor depends on the other or that there is a cause-effect relationship between them – it simply means that they occur together. Further analysis and investigation are needed to determine the nature of the association. Values of the correlation coefficient can range from –1 (a negative correlation – as one goes up the other goes down) to a +1 (a positive correlation – as one goes up so does the other). The most commonly used measure is the Pearson correlation coefficient, which is abbreviated as *r*. The statistical significance is indicated by a 'p-value'. For example, $p < 0.01$ indicates a 99% confidence that the correlation between the two variables is significantly greater than zero.

PISA scores

To facilitate the interpretation of the scores assigned to students, scales were constructed to have an average score among the OECD countries of 500 points, with about two-thirds of students across OECD countries scoring between 400 and 600 points (i.e. the scale has a mean of 500 and a standard deviation of 100).

Bonferroni correction

The Bonferroni correction states that if an experimenter is testing n independent hypotheses on a set of data, then the statistical significance level that should be used for each hypothesis separately is 1/n times what it would be if only one hypothesis were tested. In previous cycles of PISA, the Bonferroni correction has been used in the multiple comparison tables – that is, those tables in which all countries are compared to each other, or in the Australian report those tables in which all states are compared to each other. However, it is widely acknowledged that there are technical issues with using the Bonferroni correction with such a large group of countries, and that its results are very conservative. As such, the use of the Bonferroni correction in PISA has been discontinued.

Proficiency levels

To summarise data from responses to the PISA tests, performance scales were constructed for each assessment domain. The scales are used to describe the performance of students in different countries, including in terms of described performance levels. The described performance levels are known as proficiency levels.

At the lowest proficiency level in science, students are able to recall simple factual scientific knowledge (e.g. names, facts, terminology, simple rules); and to use common scientific knowledge in drawing or evaluating conclusions.

Around the OECD average score (500 points) students are typically able to use scientific knowledge to make predictions or provide explanations; to recognise questions that can be answered by scientific investigation and/or identify details of what is involved in a scientific investigation; and to select relevant information from competing data or chains of reasoning in drawing or evaluating conclusions.

Towards the high end of the science proficiency levels, students are generally able to create or use conceptual models to make predictions or give explanations; to analyse scientific investigations in order to grasp, for example, the design of an experiment or to identify an idea being tested; to compare data in order to evaluate alternative viewpoints or differing perspectives; and to communicate scientific arguments and/or descriptions in detail and with precision.

PISA indices

The measures that are presented as indices summarise student responses to a series of related questions constructed on the basis of previous research. In describing students in terms of each characteristic (e.g. interest in science), scales were constructed on which the average OECD student was given an index value of zero, and about two-thirds of the OECD population were given values between –1 and +1 (i.e. the index has a mean of 0 and a standard deviation of 1). Negative values on an index do not necessarily imply that students responded negatively to the underlying questions. Rather, a student with a negative score responded less positively than students on average across OECD countries.

Definitions of background characteristics

There are a number of definitions used in this report that are particular to the Australian context, as well as many which are international. This section provides an explanation for those that are not self-evident.

Indigenous status: Indigenous status is derived from students' self-identification as being of Australian Aboriginal or Torres Strait Islander descent. For the purposes of this report, data for the two groups are presented together for Indigenous Australian students.

Socioeconomic background: Two measures are used by the OECD to represent elements of socioeconomic background. One is the highest level of the father's and mother's occupation (known as HISEI), which is coded in accordance with the International Standard Classification of Occupations. The other measure is the index of economic, social and cultural status (ESCS), which was created to capture the wider aspects of a student's family and home background. The ESCS is based on students' responses on their parents' occupations; the highest level of education of the father and mother converted into years of schooling; the number of books in the home; and access to home educational and cultural resources.

Geographic location: In Australia, the participating schools were coded with respect to the MCEETYA Schools Geographic Location Classification. For the analysis in this report, only the broadest categories are used:

- Metropolitan – including mainland state capital cities or major urban districts with a population of 100,000 or more (e.g. Queanbeyan, Cairns, Geelong, Hobart)
- Provincial – including provincial cities and other non-remote provincial areas (e.g. Darwin, Ballarat, Bundaberg, Geraldton, Tamworth)
- Remote – Remote areas and Very remote areas. Remote: very restricted accessibility of goods, services and opportunities for social interaction (e.g. Coolabah, Mallacoota, Capella, Mt Isa, Port Lincoln, Port Hedland, Swansea and Alice Springs). Very remote: very little accessibility of goods, services and opportunities for social interaction (e.g. Bourke, Thursday Island, Yalata, Condingup, Nhulunbuy).

Immigrant status:

For the analysis in this report, immigrant status has been defined by the following categories:

- Australian-born students – students born in Australia with both parents born in Australia
- First-generation students – students born in Australia with at least one parent born overseas
- Foreign-born students – students born overseas with both parents also born overseas.

Chapter

1

Introduction

Why PISA?

In 1997, the OECD launched the Programme for International Student Assessment (PISA). PISA was the result of a desire by governments to monitor the outcomes of education systems in terms of student achievement on a regular basis and within an internationally accepted common framework. In 2000, the first PISA assessment was carried out in 32 countries (including 28 OECD member countries). This assessment was repeated in a further 11 partner (non-OECD) countries in 2001. The focus of this first assessment was reading literacy, with a lesser emphasis on mathematical and scientific literacy. In 2003, PISA was conducted in 41 countries, including all 30 OECD countries. The major focus of this assessment was mathematical literacy, with less emphasis on reading and scientific literacy. PISA 2003 also included a one-off assessment of cross-curricular problem solving skills. PISA 2006 completes the first full cycle of assessment, with a primary focus on scientific literacy and minor assessments in reading and mathematical literacy. Almost 60 countries participated in this round of PISA.

PISA was designed to help governments not only understand but also to enhance the effectiveness of their educational systems. PISA collects reliable information every three years and derives educational indicators that can monitor differences and similarities over time. PISA findings are being used internationally to:

- compare literacy skills of students in one country to those of students in other participating countries;
- establish benchmarks for educational improvement, in terms of the mean scores achieved by other countries or in terms of a country's capacity to provide high levels of equity in educational outcomes and opportunities; and
- understand the relative strengths and weaknesses of individual education systems.

The overall aim of PISA is to measure how well 15-year-olds approaching the end of their compulsory schooling are prepared for meeting the challenges they will face in their lives beyond school. PISA's orientation towards the future of these students is reflected in its literacy approach, which is concerned with the capacity of students to apply their skills and knowledge in a particular subject area, and to analyse, reason and communicate effectively as they do so.

PISA in Australia

Within Australia PISA is an element of the National Assessment Program. Together with the IEA's Trends in International Mathematics and Science Study (TIMSS), PISA provides data from internationally standardised tests, which enables Australia to compare its performance with that of other countries. The international measures complement state-based literacy and numeracy assessments for students in Years 3, 5 and 7 and national sample assessments of Science at Year

6, Civics and Citizenship at Years 6 and 10, and Information and Communications Technology at Years 6 and 10.

The results from these assessments allow for nationally comparable reporting of student outcomes against the *National Goals for Schooling in the Twenty-first Century*, which aims to provide high quality schooling in Australia that will secure for students the necessary knowledge, understanding, skills and values for a productive and rewarding life. Reporting on the assessments is undertaken through the annual National Reports on Schooling as well as through monographs and reports on particular assessments.

PISA's focus on testing students nearing the completion of the compulsory years of schooling is particularly appropriate for reporting against the National Goals. PISA enables reporting on comparable performance data every three years, and as required for the National Goals, student outcomes are reported disaggregated by sex, Indigenous status, geographic location and socioeconomic background.

The main goals of PISA

Overall, PISA seeks to measure how well young adults, at age 15 and therefore near the end of compulsory schooling, are prepared to use knowledge and skills in particular areas to meet real-life challenges. This is in contrast to assessments that seek to measure the extent to which students have mastered a specific curriculum. PISA's orientation reflects a change in the goals and objectives of curricula themselves, which increasingly address how well students are able to apply what they learn at school.

As part of the PISA process, students complete an extensive background questionnaire while school principals complete a survey describing the context of education at their school – including aspects such as the level of resources in the school, qualifications of staff and teacher morale. The reporting of the findings from PISA is then able to focus on issues such as:

- How well are young adults prepared to meet the challenges of the future? What skills do they possess that will facilitate their capacity to adapt to rapid societal change?
- Are some ways of organising schools or school learning more effective than others?
- What influence does the quality of school resources have on student outcomes?
- What educational structures and practices maximise the opportunities of students from disadvantaged backgrounds? How equitable is the provision of education in a country or across countries?

What skills does PISA assess?

As PISA's goal is measuring competencies that will equip students to participate productively and adaptively in their life beyond school education, the PISA assessment focuses on young people's ability to apply their knowledge and skills to real-life problems and situations. In such situations, are students able to analyse, reason and communicate their ideas effectively? How well do they make use of technological advances? Do they have the capacity and are they equipped with strategies to continue learning throughout their lives?

> PISA uses the term 'literacy' to encompass this broad range of competencies relevant to coping with adult life in today's rapidly changing societies. In such a context, adults need to be literate in many domains, as well as in the traditional literacy areas of being able to read and write. The OECD considers that mathematics, science and technology are sufficiently pervasive in modern life that personal fulfilment, employment, and full participation in society increasingly require an adult population which is not only able to read and write, but is also mathematically, scientifically and technologically literate.
>
> (OECD, 2000, p. 9)

PISA assesses competencies in each of three core domains – reading literacy, mathematical literacy and scientific literacy. During each PISA cycle one (major) domain is tested in detail. The remaining time is allocated to assessing the other (minor) domains. In 2000, the major domain was reading literacy, with mathematical literacy and scientific literacy making up the minor domains. In 2003, the major emphasis moved from reading literacy to mathematical literacy. In 2006, the major focus of the assessment was scientific literacy, with reading literacy and mathematical literacy forming the minor domains.

The domains covered by PISA are defined in terms of the content that students need to acquire, the processes that need to be performed, and the contexts in which knowledge and skills are applied. The assessments are based on assessment frameworks which provide a common language and a vehicle for discussing the purpose of the assessment and what it is trying to measure. Working groups consisting of subject matter experts were formed to develop the assessment frameworks, which are subsequently considered and approved by the PISA Governing Board (PGB) established by the OECD. The frameworks have evolved since PISA began in 1997. Each of the three literacies is described briefly later in the chapter, and in more detail in the relevant chapter of this report.

Scientific literacy

In PISA, scientific literacy is defined as:

> an individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the issues of science, as a reflective citizen.
>
> (OECD, 2006, p. 12)

Scientific literacy relates to the ability to think scientifically and to use scientific knowledge and processes to both understand the world around us and to participate in decisions that affect it. Increasingly, science and technology are shaping our lives. Scientific literacy is considered to be a key outcome of education for all students by the end of schooling – not just for future scientists, given the growing centrality of science and technology in modern societies. The skill of being able to think scientifically about evidence and the absence of evidence for claims that are made in the media and elsewhere is vital to daily life.

The assessment framework for science includes three strands:

- Scientific knowledge or concepts: These constitute the links that aid understanding of related phenomena. In PISA, while the concepts are familiar ones relating to physics, chemistry, biological sciences, and Earth and space sciences, students are required to apply the content of the items and not just recall them.
- Scientific processes or competencies: These are centred on the ability to acquire, interpret and act upon evidence. Three such processes present in PISA are: i) identifying scientific issues, ii) explaining phenomena scientifically, and iii) using scientific evidence.
- Situations and context: These concern the application of scientific knowledge and the use of scientific processes. The framework identifies three main areas: science in life and health, science in Earth and environment, and science in technology.

The scientific literacy framework is elaborated further in Chapter 2.

Reading literacy

Reading literacy in PISA is defined as:

> understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society.
>
> (OECD, 2006, p. 46)

Reading literacy is much more than decoding written words and literally comprehending them. It includes understanding texts at a general level, interpreting them, reflecting on their content and form in relation to the reader's own knowledge of the world, and arguing a point of view in relation to what has been read. The definition incorporates the PISA emphasis on acquiring skills that will be relevant throughout life.

The assessment of reading literacy focuses on three areas: text format; reading processes; and the situation for which the text was constructed. PISA makes the distinction between two types of text format: continuous texts, which are organised in sentences and paragraphs, and non-continuous texts, which present information in, for example, charts and graphs, forms and information sheets. In 2000, when reading literacy was the major domain, three reading literacy subscales were created and used for reporting reading proficiency (retrieving information; interpreting texts; and reflection and evaluation). Results will not be reported using these subscales for this cycle because reading literacy is a minor domain.

For the purposes of the PISA assessment, 'situation' relates to the general category of text based on the author's intended use. There are four situations used in PISA: reading for private use (*personal*); reading for public use; reading for work (*occupational*); and reading for *education*.

Mathematical literacy

PISA defines mathematical literacy as:

> an individual's capacity to identify and understand the role that mathematics play 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.
>
> (OECD, 2006, p. 72)

Thus, mathematical literacy revolves around wider uses of mathematics in people's lives than being able to carry out mechanical operations with numbers and symbols. It indicates the ability to put mathematical knowledge and skills to functional use as well as the ability to pose and solve mathematical problems in a variety of situations and having the interest and motivation to do so.

The assessment framework for mathematical literacy consists of three broad dimensions – mathematical *content*; mathematical *processes*; and the *situations* or contexts in which mathematics is used. Mathematical content is related to broad mathematical concepts and underlying mathematical thinking. In PISA 2000, when mathematical literacy was a minor domain, two overarching ideas: *change and growth* and *space and shape* were assessed. For 2003, the overarching ideas were expanded to assess four areas: *quantity*; *space and shape*; *change and relationships*; and *uncertainty*. These four overarching ideas were reported on separately in PISA 2003, but this cannot be done in this cycle since, like reading literacy, mathematical literacy was a minor domain in 2006.

Mathematical processes are defined by mathematical skills or competencies. PISA has assessed eight characteristic mathematical competencies: *thinking and reasoning; argumentation; communication; modelling; problem posing and solving; representation; using symbolic, formal and technical language and operations;* and *use of aids and tools.*

An important aspect of mathematical literacy is engagement with mathematics in a variety of situations. The context of the mathematics task is its specific setting within a situation, of which four have been identified: *personal; educational/occupational; public;* and *scientific*.

Skills for life

Without further follow-up of future educational and occupational outcomes of the students assessed in PISA it is not possible to say how relevant their skills at age 15 will be in later life. However, there is evidence from both the International Adult Literacy Survey (IALS) and the Longitudinal Surveys of Australian Youth (LSAY) of differential future educational success and labour market experiences of people with higher and lower achievement in literacy.

The International Adult Literacy Survey

The IALS established that people with higher levels of literacy were more likely than those with lower levels to be employed and have higher average salaries. People placed in the lowest two of five defined IALS levels of literacy skills were at least twice as likely to be unemployed as those placed in the top three levels (OECD, 2000). Further, the IALS was able to show that literacy levels predicted how well people did in the labour market over and above what could be predicted from their educational qualifications alone.

The link between LSAY and PISA

The Longitudinal Surveys of Australian Youth (LSAY)[1] focus on the progress of young Australians as they move from their mid-teens to their mid twenties, from their initial education to independent working life. These surveys involve large nationally representative samples of young people from whom data are collected each year about education and training, work and social development. Data from LSAY surveys provide descriptions of what young Australians are doing as they negotiate the transition from school, document changes as the group gets older, and enable comparisons with other groups when they were the same age. Issues investigated in LSAY include school completion, participation in vocational and university education, employment and wellbeing. More detailed investigations examine the links between social characteristics, education and training, and employment.

In 2003, the Australian PISA sample became a commencing cohort for LSAY. The PISA 2006 sample was the second PISA cohort to act as a commencing cohort for LSAY. The link between LSAY and PISA will provide a basis for investigating the enduring effects of the skills and knowledge measured in PISA.

Follow-up studies of several successive cohorts of secondary students in LSAY have shown a consistent picture that those who have acquired sound mastery of literacy and numeracy skills by Year 9 are more likely to go to university, to find jobs and to earn higher incomes. Initial analyses of the 2003 PISA/LSAY cohort have shown a general pattern of increasing odds of completion of Year 12 with increasing proficiency levels (Hillman & Thomson, 2006).

Further evidence from the longitudinal follow-up of students in Canada who had participated in the PISA 2000 reading assessment also shows that the PISA performance of students at age 15 was a very strong predictor for a successful transition to higher education at age 19.

There is also evidence from previous LSAY studies that psychological variables such as engagement in school life (assumed to reflect positive attitudes towards school) and self-concept of academic ability measured in Year 9 both contribute significantly, over and above socio-demographic factors,

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1 LSAY is a program of longitudinal surveys that follows the progress of young people from their mid-teens to their mid-twenties and is managed by the Australian Government of Education, Science and Training (DEST).

to whether students complete their secondary schooling (Fullarton, 2002; Marks, Fleming, Long & McMillan, 2000).

Implementing PISA

What did PISA 2006 participants do?

As mentioned earlier, each cycle of PISA focuses on one assessment domain (scientific literacy in 2006), with the other domains (reading and mathematical literacy) being covered to a lesser extent. Students who participated in PISA 2006 completed an assessment booklet that contained questions about one or more of the domains being tested, and a Student Questionnaire.

Testing occurred during the morning and students were given two hours to complete the assessment and 30 to 40 minutes to complete the Student Questionnaire. In all, there were 13 assessment booklets, which were assembled according to a complex design so that each booklet was linked through common items to other booklets in a balanced way. All booklets contained science items with a rotation system ensuring that the mathematics and reading items appeared equally throughout the 13 booklets. In this way a broader range of tasks can be undertaken, and through Item Response Theory can be linked to other items. This means also that the administration of the test is enhanced because students are unlikely to be doing the same booklet as students around them.

There were five types of question format: multiple choice; complex multiple choice; closed constructed response; open constructed response and short response. In some cases, students selected their response from a list or provided a short written response and in other cases students had to write extended answers.

The internationally standard Student Questionnaire sought information on students and their family background, aspects of learning and instruction in science, and context of instruction including instructional time and class size. Australia also participated in several international options, which involved adding questions on the following topics into the Student Questionnaire: familiarity with ICT, self-regulated learning, and educational career paths.

The School Questionnaire, answered by the principal (or the principal's designate), sought descriptive information about the school and information about instructional practices. For example, questions were asked about qualifications of teachers and numbers of staff, teacher morale, school and teacher autonomy, school resources, and school policies and practices such as use of student assessments.

In Australia, a National Advisory Committee guides all aspects of the project. The National Project Manager is responsible for the implementation of PISA at the national level. ACER (the National Project Manager in Australia) liaised with schools to gain their participation and help with the logistics of arranging assessment sessions (see Appendix 1).

Development of the PISA assessment tasks

The development of assessment items for each of the domains in PISA is guided by a framework that is created and developed by a group of international experts in the relevant field and agreed to by the PISA Governing Board. The Expert Groups meet on a regular basis to review developments and items and to propose future directions. For PISA 2006, in addition to the Science Expert Group, the OECD held a Science Forum, to which all countries were invited to send representatives who could provide input to the development of the items.

The development of the assessment items is an interactive process, which allows for the involvement of participating countries. Each country had the opportunity of submitting materials and providing comments in the review of items on aspects such as cultural appropriateness and interest to 15-year olds. After an extensive Field Trial in 2005, a final set of items was chosen to reflect the intentions of the frameworks for the Main Study in 2006.

How results are reported

International comparative studies have provided an arena to observe the similarities and differences between educational polices and practices and enable researchers and others to observe what is possible for students to achieve and what environment is most likely to facilitate their learning. PISA provides regular information on educational outcomes within and across countries by providing insight about the range of skills and competencies, in different assessment domains, that are considered to be essential to an individual's ability to participate and contribute to society.

Similar to other international studies, PISA results are reported as means that indicate average performance and various statistics that reflect the distribution of performance. School and student variables further enhance the understanding of student performance. PISA also attaches meaning to the performance scale by providing a profile of what students have achieved in terms of skills and knowledge. The performance scale is divided into levels of difficulty, referred to as 'described proficiency levels'. Students at a particular level not only typically demonstrate the knowledge and skills associated with that level but also the proficiencies required at lower levels.

For the major domain of reading in PISA 2000, five proficiency levels were defined. Six levels of proficiency were defined in PISA 2003 for mathematics. In the 2006 cycle of PISA, science was the major domain for the first time and so specific proficiency levels have been defined. Further details on the proficiency levels for scientific literacy are provided in Chapter 2.

Who participates in PISA?

Countries

Although PISA was originally an OECD assessment, created by the governments of OECD countries, it has now become a major assessment tool in many regions and countries around the world. In addition to the 30 OECD member countries, PISA has now been conducted in the following areas:

- East and Southeast Asia: Hong Kong-China, Indonesia, Macao-China, Chinese Taipei and Thailand
- Southwest Asia: Azerbaijan
- Central and Eastern Europe and Central Asia: Bulgaria, Croatia, Estonia, Kyrgyzstan, Latvia, Lithuania, Montenegro, Romania, Serbia, Slovenia and the Russian Federation
- Western Europe: Liechtenstein
- The Middle East: Jordan, Israel and Qatar
- Central and South America: Argentina, Brazil, Chile, Columbia and Uruguay
- North Africa: Tunisia

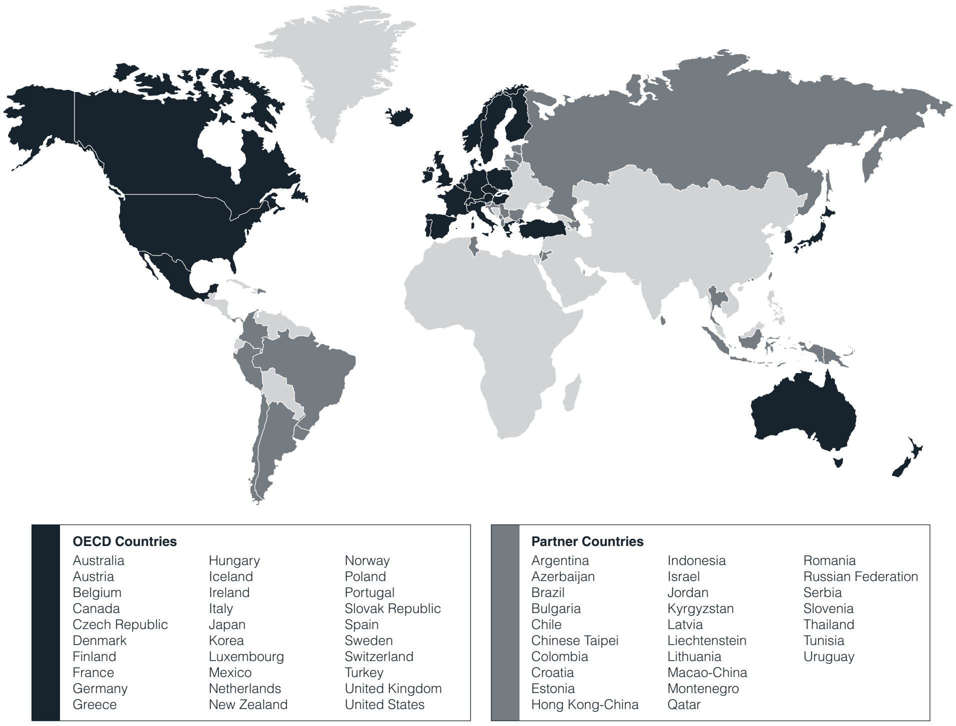


Figure 1.1 Countries participating in PISA 2006

Schools

In most countries 150 schools and 35 students in each school were randomly selected to participate in PISA. In some countries, including Australia, a larger sample of schools and students participated. This allows for countries to carry out specific national options at the same time as the PISA assessment, or for meaningful comparisons to be made between different sectors of the population.

In Australia, a larger sample of schools and students was gathered for three main reasons:

- In order that comparisons can be made between states[2] it is necessary to 'oversample' the smaller states because a random sample proportionate to state populations would not yield sufficient students in the smaller states to give a result that would be sufficiently precise;
- A special focus in PISA in Australia has been to ensure that there is a sufficiently large sample of Australia's Indigenous students, so that valid and reliable separate analysis can be conducted; and
- As noted above, the PISA 2006 sample became a cohort of the Longitudinal Surveys of Australian Youth (LSAY). These students will be tracked, and contacted in future years to trace their progress through school and entry into further education and the work force. A large sample is needed to allow for attrition: over time a proportion of the original sample is not able to be traced.

[2] Throughout this report, the Australian states and territories will be collectively referred to as the states.

In PISA 2006 the achieved sample of schools was 356 schools. The sample was designed so that schools were selected with a probability proportional to the enrolment of 15-year-olds in each school. Stratification ensured the correct ratios for government, Catholic and independent sectors. Table 1.1 shows the distribution of the schools that participated in the Australian PISA sample in 2006.

Table 1.1: Australian PISA 2006 schools by state and sector

	Catholic	Government	Independent	Total
NSW	19	50	11	80
VIC	12	34	10	56
QLD	11	36	10	57
SA	8	26	9	43
WA	7	23	8	38
TAS	5	25	4	34
NT	3	13	6	22
ACT	8	15	3	26
Total	**73**	**222**	**61**	**356**

Eighty-five per cent of the Australian PISA schools were coeducational. The number of all-female and all-male single-sex schools was similar (eight per cent and seven per cent respectively). Fifteen per cent of single-sex schools were government schools, approximately 60 per cent were Catholic and a quarter were independent.

The PISA participating schools were also stratified with respect to the MCEETYA Schools Geographic Location Classification. In PISA 2006, 65 per cent of schools were located in the metropolitan zone, 30 per cent were from provincial zones and around five per cent of schools were in remote areas.

Students

The target population for PISA is students who are 15 years old and enrolled at an educational institution, either full- or part-time, at the time of testing[3]. An age-based sample, focusing on students nearing the end of compulsory schooling, was chosen over a grade-based sample because of the complexities of defining an internationally comparable sample based on grade. There are many differences between the countries with regard to the nature of pre-school education and the age at which formal education commences. These differences also exist within Australia.

From each country, a random sample of 35 students is selected with equal probability from each school using a list of all 15-year-old students that is submitted by the school. In PISA 2006, the Australian student sample was increased to 50 students per school for the reasons described earlier. Further information on sampling can be found in Appendix 2.

Internationally, the desired minimum number of students to be assessed per country is 4,500. In some countries, including Australia, the sample size was increased so that particular language groups or regions could be adequately represented or for other agreed purposes. In a few small countries, such as Iceland, Liechtenstein and Luxembourg, the whole cohort of age-eligible students was assessed. Table 1.2 shows the number of participating students from each country.

[3] Refer to the Reader's Guide for a complete definition.

Table 1.2: Number of students in PISA 2006 sample and population, by country[4]

Country	Sample N	Population N	Country	Sample N	Population N
Argentina	4 339	523 048	Kyrgyzstan	5 904	80 674
Australia	14 170	234 940	Latvia	4 719	29 232
Austria	4 927	89 925	Liechtenstein	339	353
Azerbaijan	5 184	122 208	Lithuania	4 744	50 329
Belgium	8 857	123 161	**Luxembourg**	4 567	4 733
Brazil	9 295	1 875 461	Macao-China	4 760	6 417
Bulgaria	4 498	74 326	**Mexico**	30 971	1190 420
Canada	22 646	370 879	Montenegro	4 455	7 734
Chile	5 235	233 526	**Netherlands**	4 871	189 576
Chinese Taipei	8 815	293 513	**New Zealand**	4 823	53 398
Colombia	4 478	537 262	**Norway**	4 692	59 884
Croatia	5 213	46 523	**Poland**	5 547	515 993
Czech Republic	5 932	128 827	**Portugal**	5 109	90 079
Denmark	4 532	57 013	Qatar	6 265	7 271
Estonia	4 865	18 662	Romania	5 118	223 887
Finland	4 714	61 387	Russian Federation	5 799	1 810 856
France	4 716	739 428	Serbia	4 798	73 907
Germany	4 891	903 512	**Slovak Republic**	4 731	76 201
Greece	4 873	96 412	Slovenia	6 595	20 595
Hong Kong-China	4 645	75 145	**Spain**	19 604	381 686
Hungary	4 490	106 010	**Sweden**	4 443	126 393
Iceland	3 789	4624	**Switzerland**	12 193	89 651
Indonesia	10 647	2 248 313	Thailand	6 192	644 125
Ireland	4 585	55 114	Tunisia	4 640	138 491
Israel	4 584	93 347	**Turkey**	4 942	665 477
Italy	21 773	520 055	**United Kingdom**	13 152	732 004
Japan	5 952	1 113 701	**United States**	5 611	3 578 040
Jordan	6 509	90 267	Uruguay	4 839	36 011
Korea	5 176	576 669	**TOTAL**	**398 750**	**22 296 591**

Note: Countries in bold are OECD countries.

The Australian PISA 2006 sample of 14,170 students, whose results are featured in the national and international reports, was drawn from all states and sectors according to the distributions shown in Table 1.3.

4 Although Chinese Taipei, Hong Kong-China and Macao-China are economic regions, for convenience they will be referred to thoughout this report as countries.

Table 1.3: Australian PISA 2006 students by state and sector

Sector	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	TOTAL
Government									
N students*	2087	1335	1523	882	873	945	461	534	8640
Weighted N#	48060	33250	29700	11030	14587	4431	1260	2602	144920
Catholic									
N students*	861	544	470	346	281	238	133	323	3196
Weighted N#	18532	13264	8906	3698	4544	1146	271	1521	51882
Independent									
N students*	425	393	409	365	330	106	177	129	2334
Weighted N#	10046	9782	7515	4228	4901	607	402	655	38136
TOTALS									
N students*	3373	2272	2402	1593	1484	1289	771	986	14170
Weighted N#	76638	56296	46121	18956	24032	6184	1933	4778	234938

* Achieved sample

\# Number of students in target population represented by sample. Numbers in this row have been rounded.

As the sample is age-based the students come from various grade levels, but they are mostly from Years 9, 10 and 11. There are some variations to the Year-level composition of the sample in the different states as shown in Table 1.4, because of differing school starting ages in different states.

Table 1.4: Distribution of students by year level and state#

	Year level (%)				
State	**8**	**9**	**10**	**11**	**12**
ACT		10	88	3	
VIC	ϵ	10	84	6	
NSW	ϵ	17	80	2	
QLD	ϵ	2	46	52	ϵ
SA		4	79	17	ϵ
WA		ϵ	44	55	ϵ
TAS	ϵ	28	72	ϵ	
NT	ϵ	7	74	18	ϵ
AUS	ϵ	9	71	20	ϵ

\# The percentages are based on weighted data; state totals may not add up to 100 because of rounding.

ϵ Percentage ≤ 1

The aim of PISA is to be as inclusive as possible of the population of 15-year-old students in each country and strict guidelines are enforced with regard to the exclusion of schools and students (which could not exceed five per cent of the nationally desired target population).[5]

There are strict criteria regarding population coverage, response rates and sampling procedures. For initially selected schools, a minimum response rate of 85 per cent (weighted and unweighted) was required as well as a minimum rate of 80 per cent (weighted and unweighted) of selected students. Countries that obtained an initial school response rate between 65 and 85 per cent could still obtain an acceptable school response by the use of replacement schools. Schools with

[5] For more information on sampling, refer to Appendix 2.

a student participation response rate of less than 50 per cent were not regarded as a participating school. Australia successfully achieved the required response rates.

Time of Testing

PISA standards dictate that testing should take place in the second half of the academic year. For countries in the Northern Hemisphere the testing period is usually between March and May. The testing in Australia occurred during a six-week period from late July to early September 2006. Together with appropriate application of the student age definition, this resulted in the students in Australia being at both a comparable age and a comparable stage in the school year to those in the Northern Hemisphere who had been tested earlier in 2006.

Organisation of the report

This report focuses on Australia's results from PISA 2006 in the areas of scientific literacy, reading literacy and mathematical literacy. Chapters 3, 5 and 6 are devoted to each of these respectively. Chapter 2 provides an overview of the context for science education in Australia and focuses on how students are assessed in science for PISA 2006. Chapter 4 examines student attitudes, motivations and engagement influencing scientific literacy performance, Chapter 7 looks at the relationship between socioeconomic background and achievement, and Chapter 8 summarises this report.

Chapter 2

Scientific literacy

The study of science has been a focal area of concern for educators at most levels in Australia and internationally for the past few decades. Over this time, science has played an increasingly important role in terms of economic development for countries in an information technology age. For national development to progress quickly, science could no longer stay the province of an elite group – all sections of society needed to be encouraged to study science.

In order to obtain some international benchmark of national achievement in science, Australia participated in the First International Science Study (FISS) in the early 1970s. The results for the oldest group of students who participated in the FISS drew attention to gender differences in favour of boys in participation and achievement, in physics especially, in a number of countries including Australia (Comber and Keeves, 1973). To redress these inequities as well as the perceived shortage of scientists, government policy in Australia during the 1970s and 1980s focused on encouraging more students, particularly girls, into non-traditional areas of study, including mathematics and science (e.g. McKinnon, 1975; Miland, 1984). The Second International Science Study (SISS) in the early 1980s found that while similar patterns were still observable (boys outperforming girls), the magnitude of the differences had decreased in many countries, including Australia, where programs to reduce the gender gap had been implemented.

Australia next participated in an international science study when it took part in the combined Third International Mathematics and Science Study (TIMSS) in 1994–1995. A feature of the Australian results, found in only a handful of countries, was that there were no gender differences for either younger (Year 4) or mid-secondary (Year 8) students (Beaton et al., 1996). However in the next international study, TIMSS 2002–2003, while there were still no gender differences at Year 4 level, there were significant gender differences in favour of males at Year 8 (Thomson & Fleming, 2002).

Despite government efforts and increasing retention rates to Year 12, the number of students studying science at both the secondary and tertiary level in Australia has declined (Dekkers & De Laeter, 1997; DeLaeter, Malone & Dekkers, 1989; Dobson & Calderon, 1999; FASTS, 2002; Fullarton, Walker, Ainley & Hillman, 2003; Rennie, Fraser & Treagust, 1999, Tytler, 2007). Australian trends are consistent with those found in, for example, the United Kingdom (Gallagher, McEwen & Knipe, 1997; Stables & Stables, 1995, Osborne, 2006), the United States (Sellinger, 2002), and The Netherlands (Bosker & Dekkers, 1994). The on-going OECD Global Science Forum has targeted the declining interest in science studies among young people as a priority issue, and their interim reports show that the ratio of females to males in many areas of science and technology, in particular computer science and engineering, is dramatically low (Duby, 2005).

Background to science learning in Australia

The Australian education system

In Australia, there are both government and non-government schools. Overall, government schools enrol 68 per cent of students, while non-government schools enrol 32 per cent of students. Most non-government schools have some religious affiliation, with approximately two-thirds of non-government school students enrolled in Catholic schools. Most government schools are coeducational; however, there are a few government same-sex high schools in the larger cities like Sydney and Melbourne. Many of the non-government schools are same-sex schools. All schools receive funding from either the federal or a state government.

The compulsory starting age for school varies across states, ranging from 5 years to 6 years, 6 months. As such, generally students are either 17 or 18 by the time they leave Year 12. In most states, students must complete Year 10 or be 16 years old before leaving school. The leaving age varies in New South Wales, the Australian Capital Territory and the Northern Territory, where students may leave when they are 15 years old. Most students go straight on to complete Years 11 and 12 and obtain their Senior Certificate. Year 12 or Adult Matriculation is necessary if students want to go on to higher education courses at universities and also necessary for some Technical and Further Education centres (TAFEs) and private commercial courses.

Each state and territory government in Australia runs their own school system from Kindergarten through to Year 12. However in 1989 State and Commonwealth Education Ministers made an historic commitment to improve Australian schooling within a framework of national collaboration. Agreement was reached at this time to address the areas of common concern embodied in the first set of Common and Agreed National Goals for Schooling in Australia.

National goals for schooling

The 1989 National Goals for Schooling provided, for the first time, a framework for cooperation between schools, States, Territories and the Commonwealth. They were intended to assist schools and systems to develop specific objectives and strategies, particularly in the areas of curriculum and assessment.

From 1991–1993, the Australian Education Council (the forerunner of today´s Ministerial Council on Education, Employment, Training and Youth Affairs, MCEETYA) developed eight sets of statements and profiles. The statements set out a common framework for curriculum development in each learning area, in terms of its content, processes and concepts. The profiles described the progression of learning, in eight levels of achievement, which provided a common framework for reporting student achievement. Although each State and Territory has developed the statements and profiles independently, the focus on outcomes against which the progress of students can be charted remains (Goodrum, Hackling & Rennie, 2001).

Review of science learning

The review of the status and quality of teaching and learning science in Australian schools (Goodrum et al., 2001) conducted in 1999–2000 recommended to the Australian Government that the primary purpose of science education in the compulsory years of schooling should be to develop scientific literacy. In all state curriculum documents there was found to be an:

> emphasis on the relevance and importance of science for all students. Science is described as being part of everyday life and an understanding and appreciation of science concepts and processes is required by all members of society if they are to be active citizens making informed decisions and contributions to debate about relevant issues and events. The rationales emphasise a view of science which fosters students´ curiosity about their world, develops their intrinsic interest in things around them and

> their willingness to be questioning, and to explore explanations for their ideas. These kinds of statements adhere closely to the idea of scientific literacy and, although not all Australian science curricula mention scientific literacy explicitly, it seems fair to say that the rationale for teaching science includes commitment to scientific literacy.
>
> (Goodrum, Hackling & Rennie, 2001, p. 31)

Lokan, Hollingsworth & Hackling (2006) provide an in-depth analysis of science teaching and learning in Australia, drawing from the national review mentioned above, the professional standards for accomplished teachers of science (Australian Science Teachers Association and Monash University, 2002), and the components of effective science teaching developed in the Victorian Science in Schools project (Tytler, 2002). They argued that there is strong convergence among these documents around six characteristics of effective science teaching in Australia:

1. Students experience a curriculum that is relevant to their lives and interests within an emotionally supportive and physically safe learning environment.
2. Classroom science is linked with the broader community.
3. Students are actively engaged with inquiry, ideas and evidence.
4. Students are challenged to develop and extend meaningful conceptual understandings.
5. Assessment facilitates learning and focusing on outcomes that contribute to scientific literacy.
6. Information and communication technologies are exploited to enhance learning of science. (p. 137)

These characteristics highlight the role of the learner in using prior knowledge and experience to construct their own meaning within the socio-cultural context in which they find themselves. They reflect a social constructivist approach to the teaching and learning of science in Australia within which students participating in PISA 2006 will have progressed through the compulsory years of schooling.

At a 2003 meeting of the MCEETYA, Ministers agreed that statements of learning should be developed nationally for English, science, mathematics and civics and citizenship. These have now been finalised and approved. Each statement of learning describes the skills, knowledge, understandings and capacities that students are given the opportunity to learn by the designated year levels, Years 3, 5, 7 and 9. The statement of learning for science, with contributions from all states and territories, was approved in 2006. The purpose of the document is to guide the curriculum documents for individual states and territories. As a result of this, the majority of states are currently re-drafting and finalising the relevant curriculum documents, to address and incorporate the statements of learning.

The statements are not meant to be a comprehensive document of learning opportunities, but a list of those features that all agree should be included in learning for all Australian students. All states and territories document additional learning opportunities not present in the statements.

> *"The Statements of Learning for Science are organised by year level and are structured around three broadly defined aspects of Science curriculums that are considered essential and common – Science as a Human Endeavour, Science as a Way to Know and Science as Body of Knowledge. They articulate a common set of learning opportunities that all students in Australia should have relating to knowledge, skills, understandings and capacities".*
>
> MCEETYA, 2006.

State curricula

The state curriculum arrangements pertaining in 2006 are as follows:

- In the Australian Capital Territory, science is one of eight key learning areas. In 2006 there were five strands across the science curriculum:
  - Working Scientifically;
  - Earth and Beyond;
  - Energy and Change;
  - Life and Living; and
  - Natural and Processed Materials.

  The course content for Year 10 is designed by each school.

- In New South Wales, science studies are mandatory from Years 7–10 with a minimum of 400 compulsory hours to be completed until the end of Year 10. According to the syllabus, students will develop knowledge and understanding of:
  - the history of science;
  - the nature and practice of science;
  - applications and uses of science;
  - implications of science for society and the environment;
  - current issues, research and development;
  - models, theories and laws, and structures and systems related to the physical world, matter, the living world, and Earth and space; and
  - interactions within the physical world, matter, the living world and Earth and space.

- In Victoria, the Curriculum and Standards Framework (CSF) gives a description of what students should be able to do in the areas of learning at regular intervals from the preparatory year to Year 10. The framework provides sufficient detail for schools to be clear about the major elements of the curriculum and the standards expected of successful learners. The areas of study for the science key learning area in the CSF were:
  - Biological science;
  - Chemical science;
  - Earth and space systems; and
  - Physical science.

- In Queensland the science syllabus describes the nature of the science key learning area, the place and context of science in the whole curriculum, the scope and sequence of learnings through the learning outcomes, and assessment issues.
  There are five strands in the Science key learning area:
  - Science and Society;
  - Earth and Beyond;
  - Energy and Change;
  - Life and Living; and
  - Natural and Processed Materials.

- In South Australia, the South Australian Curriculum Standards and Accountability (SACSA) Framework describes the curriculum Key Ideas and Outcomes all learners can expect their education to be built on. Strands within science were:
  - Earth and Space;
  - Energy Systems;
  - Life Systems; and
  - Matter.

- In Western Australia there are two main areas of learning outcomes in science:
  - Working Scientifically (investigating, communicating scientifically, science in daily life, acting responsibly, science in society)
  - Understanding concepts:
    - Earth and Beyond,
    - Energy and Change,
    - Life and Living, and
    - Natural and Processed Materials.

- In Tasmania, areas of study in science in 2006 were:
  - Natural and Processed Materials (including forensic science);
  - Energy and Change;
  - Life and Living;
  - Earth and Beyond; and
  - Working scientifically (including ideas for student investigations).

- In the Northern Territory, the science learning area is organised into two strands:
  - Working Scientifically (five elements: Planning, Investigating, Evaluating, Acting Responsibly, Science in Society)
  - Concepts and Contexts (drawn from four scientific disciplines: Natural and Processed Materials (Chemistry), Life and Living (Biology), Energy and Change (Physics), and Earth and Beyond (Geology).

PISA scientific literacy[6]

To what extent have students learned fundamental scientific concepts and theories? How well can they identify scientific issues, explain phenomena scientifically, and use scientific evidence as they encounter, interpret, and solve real-life problems involving science and technology? The PISA 2006 science assessment provided an opportunity to expand and extend the assessment in the domain of science, with the aim of providing answers to questions such as these. In addition, PISA 2006 provided an important opportunity to assess how students´ scientific knowledge varies between countries and between school contexts within countries, and how these relate to science learning. It is the first international survey to consider scientific competency, interests and attitudes, and school context and science teaching approaches jointly in an international context.

In both PISA 2000 and PISA 2003, scientific literacy was a minor assessment domain. In each of these cycles, only a small proportion of testing time was allocated to the assessment of scientific

6 Parts of this chapter are drawn from *Assessing scientific, reading and mathematical literacy: A framework for PISA 2006*.

literacy, and not all students completed science items. Scientific literacy was reported on a single scale in both these cycles. For PISA 2006, with scientific literacy being the major domain for the first time, the scientific literacy framework was fully developed and expanded and the majority of assessment time was spent assessing scientific literacy.

This chapter provides a detailed description of the PISA 2006 scientific literacy framework that was used as a basis for the development of the items in the assessment. The following chapter presents the results of the assessment.

How is scientific literacy defined in PISA?

PISA 2006 defines *scientific literacy* in terms of an individual´s:

- *Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues*. For example, when individuals read about a health-related issue, can they separate scientific from non-scientific aspects of the text, and can they apply knowledge and justify personal decisions?
- *Understanding of the characteristic features of science as a form of human knowledge and enquiry*. For example, do individuals know the difference between evidence-based explanations and personal opinions?
- *Awareness of how science and technology shape our material, intellectual and cultural environments*. For example, can individuals recognise and explain the role of technologies as they influence a nation´s economy, social organisation, and culture? Are individuals aware of environmental changes and the effects of those changes on economic and social stability?
- *Willingness to engage with science-related issues, and with the ideas of science, as a reflective citizen*. This dimension of scientific literacy addresses the value students place on science, both in terms of topics and in terms of the scientific approach to understanding the world and solving problems. Memorising and reproducing information does not necessarily mean students will select scientific careers or engage in science-related issues. Knowing about 15-year-olds´ interest in science, support for scientific enquiry, and responsibility for resolving environmental issues provides policy makers with early indicators of citizens´ support of science as a force for social progress.

(OECD, 2006, p. 23)

PISA´s approach to assessing scientific literacy is different from more traditional assessments in which mastery of science content is tested. Instead, the PISA assessment focuses on students´ ability to extrapolate from what they have learned and to apply their knowledge and skills in novel situations. This focus reflects the recognition amongst educators that globalisation and computerisation are changing labour markets and societies, and that a different set of skills will be needed by those entering such markets. Evidence from the US, for example, shows that the greatest decline in jobs over the past decade has not been in manual labour, but in tasks that are described as routine cognitive tasks – those that can easily be done at less cost by computer (Levy & Murnane, 2006). Students preparing for the work force of the (near) future will need to be able to solve problems for which there are no clear solutions, and to be able to communicate their ideas effectively, rather than merely learning to memorise and reproduce facts.

There are two key changes from previous PISA science assessments. Firstly, the PISA 2006 assessment more clearly separates *knowledge about science* from *knowledge of science*. Knowledge of science refers to knowledge of the natural world across the major fields of physics, chemistry, biological science, Earth and space science, and science-based technology. Knowledge about science refers to knowledge of the means (scientific enquiry) and the goals (scientific explanations) of science. The PISA framework further elaborates on, and gives greater emphasis to, *knowledge about science* as an aspect of science performance, through the addition of elements that underscore students´ knowledge about the characteristic features of science. The term `scientific literacy´ used in this report refers collectively to both knowledge about science and knowledge of science. Secondly, the PISA 2006 framework has been enhanced by the addition of *knowledge of the relationship between science and technology*.

There have also been two important changes in the way science was assessed in PISA 2006, compared with PISA 2003 and PISA 2000. First, to more clearly distinguish *scientific literacy* from *reading literacy*, the set of PISA 2006 science test items required, on average, less reading than did the sets of science items used in the two earlier PISA surveys. Second, because science was the major domain in 2006 there were 103 science items, compared with 35 in PISA 2003 and 35 in PISA 2000. Of the 103 items used in 2006, 21 items were common to PISA 2006 and PISA 2003, and 13 were common to PISA 2006 and PISA 2000.

As the first major assessment of science, the PISA 2006 assessment establishes the basis for analysis of trends in science performance in the future and it is therefore not possible to compare science learning outcomes from PISA 2006 with those of earlier PISA assessments as is done for reading and mathematics. For PISA 2006 the scientific literacy framework was developed in much more detail than had previously been the case. Indeed, differences in science performance that readers may observe when comparing PISA 2006 science scores with science scores from earlier PISA assessments are largely attributable to changes in the nature of the science assessment as well as changes in the test design.[7]

The PISA science framework

The framework for scientific literacy in PISA 2006 comprises four interrelated aspects: the contexts in which tasks are embedded, the competencies that students need to apply, the knowledge domains involved, and students´ attitudes towards science. These are shown in Figure 2.1.

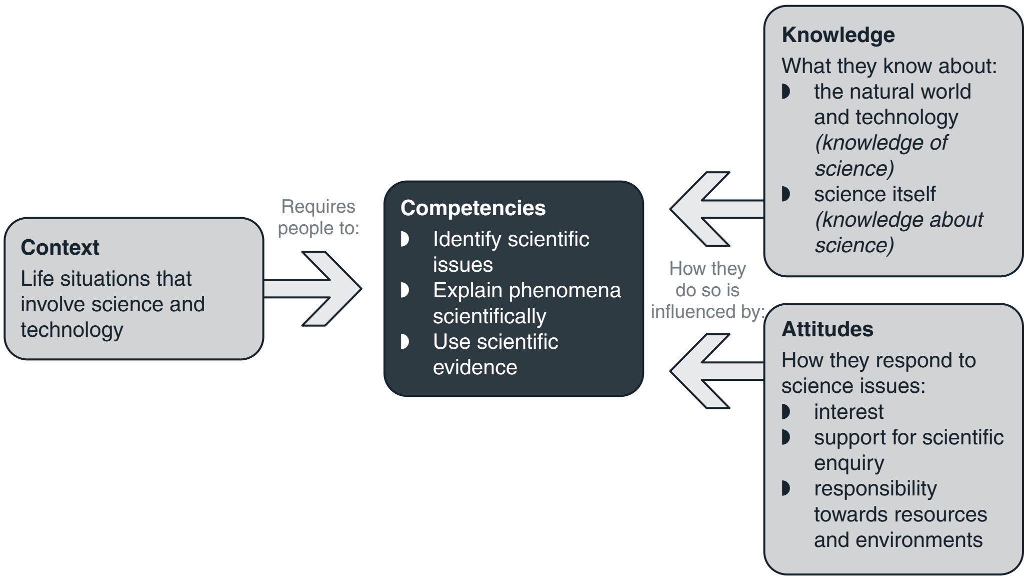


Figure 2.1 Framework for PISA 2006 science assessment (OECD, 2006, p. 26)

[7] Some comparison has been done by the OECD examining student performance on the PISA tasks that were common to the PISA 2003 and PISA 2006 assessments. While noting that these tasks are not representative of the PISA 2006 assessment, a preliminary analysis suggests that significant performance differences can be observed for Australia.

Context

PISA´s orientation is preparing students for their future lives, and so the items for the PISA science assessment are situated in general life, not just life at school. In the PISA 2006 science assessment, the focus of the items is on situations relating to the self, family and peer groups (*personal*), to the community (*social*) and to life across the world (*global*). Some items are framed in an *historical* situation, in which an understanding of the advances in scientific knowledge can be assessed.

The context of an item is its specific setting within a situation. It includes all of the detailed elements used to formulate the question.

PISA 2006 assesses important scientific knowledge relevant to the science education curricula of participating countries without being constrained to the common aspects of participants´ national curricula. The assessment does this by requiring evidence of the successful use of scientific competencies in important situations reflecting the world and in accordance with PISA´s focus on scientific literacy. In turn, this involves the application of selected knowledge about the natural world, and about science itself, and evaluation of students´ attitudes towards scientific matters.

Figure 2.2 lists the applications of science, within *personal, social* and *global* situations, which are primarily used as the contexts for the PISA 2006 assessment. These are not definitive: other situations, such as *technical* and *historical*, and areas of application are also used in PISA. The applications were drawn from a wide variety of life situations and were generally consistent with the areas of application for scientific literacy in the PISA 2000 and 2003 frameworks. The areas of application are: *health, natural resources, the environment, hazards* and *the frontiers of science and technology*. These are the areas in which scientific literacy has particular value for individuals and communities in enhancing and sustaining quality of life, and in the development of public policy.

	Personal (self, family and peer groups)	**Social (the community)**	**Global (life across the world)**
Health	Maintenance of health, prevention of accidents, nutrition	Control of disease, social transmission, food choices, community health	Management of epidemics, spread of infectious diseases
Natural resources	Personal consumption of materials and energy	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply	Renewable and non-renewable natural systems, population growth, sustainable use of species
Environment	Environmentally friendly behaviour, use and disposal of materials	Population distribution, disposal of waste, environmental impact, local weather	Biodiversity, ecological sustainability, control of pollution, production and loss of soil
Hazard	Natural and human-induced risks, decisions about housing	Rapid changes (earthquakes, severe weather), slow and progressive changes (coastal erosion, sedimentation), risk assessment	Climate change, impact of modern warfare
Frontiers of science and technology	Interest in science´s explanations of natural phenomena, science-based hobbies, sport and leisure, music and personal technology	New materials, devices and processes, genetic modification, weapons technology, transport	Extinction of species, exploration of space, origin and structure of the universe

Figure 2.2 Contexts for the PISA 2006 science assessment

Competencies

The PISA 2006 science assessment items required students to identify scientifically-oriented issues, explain phenomena scientifically, and use scientific evidence. These three competencies were chosen because of their importance to the practice of science and their connection to key cognitive abilities such as inductive and deductive reasoning, systems-based thinking, critical decision making, transformation of information (e.g. creating tables or graphs out of raw data), thinking in terms of models and use of science. The essential features of each of the three competencies are described and elaborated in the following text boxes.

Identifying scientific issues

- Recognising issues that are possible to investigate scientifically
- Identifying keywords to search for scientific information
- Recognising the key features of a scientific investigation

Scientific issues must lend themselves to answers based on scientific evidence. The competency *identifying scientific issues* includes recognising questions that it would be possible to investigate scientifically in a given situation and identifying keywords to search for scientific information on a given topic. It also involves recognising key features of a scientific investigation; for example, what things should be compared, what variables should be changed or controlled, what additional information is needed, or what action should be taken so that relevant data can be collected.

Identifying scientific issues requires students to possess knowledge about science itself, and may also draw on students´ knowledge of science.

Explaining phenomena scientifically

- Applying knowledge of science in a given situation
- Describing or interpreting phenomena scientifically and predicting changes
- Identifying appropriate descriptions, explanations, and predictions

Students demonstrate this competency by applying appropriate knowledge of science in a given situation. The competency includes describing or interpreting phenomena and predicting changes, and may involve recognising or identifying appropriate descriptions, explanations, and predictions.

Using scientific evidence

- Interpreting scientific evidence and making and communicating conclusions
- Identifying the assumptions, evidence and reasoning behind conclusions
- Reflecting on the societal implications of science and technological developments

This competency requires students to make sense of scientific findings as evidence for claims or conclusions. The required response can involve knowledge about science or knowledge of science or both. Students should be able to assess scientific information and produce arguments based on scientific evidence. The competency may also involve: selecting from alternative conclusions in relation to evidence; giving reasons for or against a given conclusion in terms of the process by which the conclusion was derived from the data provided; and identifying the assumptions made in reaching a conclusion. Reflecting on the societal implications of scientific or technological developments is another perspective of this competency.

An illustration of the competencies is global climate change – one of the most talked about global issues of the day. As people read or hear about climate change, they must be able to separate the scientific, economic and social issues. It is not uncommon, for example, to hear scientists explain the origins and material consequences of releasing carbon dioxide into the Earth´s atmosphere. This scientific perspective is sometimes countered with an economic argument and citizens should be able to recognise the difference between scientific and economic positions. Further, as people are presented with more, and sometimes conflicting, information about such phenomena they need to be able to assess scientific knowledge and understand the scientific assessments of various bodies. Finally, citizens should be able to use the results of scientific studies to support their conclusions about scientific issues of personal, social and global consequence.

Scientific knowledge

In PISA 2006, scientific knowledge refers to both *knowledge of science* and *knowledge about science* itself.

Clearly only a sample of students´ knowledge of science could be assessed in the PISA 2006 science assessment, and the focus of the assessment is the extent to which students are able to apply their knowledge in contexts of relevance to their lives. The assessed knowledge was selected from the major fields of physics, chemistry, biology, Earth and space science, and technology according to the following criteria. Items had to be:

- relevant to real-life situations: scientific knowledge differs in the degree to which it is useful to the life of individuals
- representative of important scientific concepts and thus have enduring utility
- appropriate to the developmental level of 15-year-old students.

Figure 2.3 shows the four content areas defined within *knowledge of science*. The four areas represent knowledge required for understanding the natural world and for making sense of experiences in *personal, social* and *global* contexts. For this reason the framework uses the term "systems" instead of "sciences" in the descriptors of the content areas. The intention is to convey the idea that citizens have to understand concepts from the physical and life sciences, Earth and space science, and technology in different contexts.

Physical Systems

- Structure of matter (e.g. particle models, bonds)
- Properties of matter (e.g. changes of state, thermal and electrical conductivity)
- Chemical changes of matter (e.g. reactions, energy transfer, acids/bases)
- Motions and forces (e.g. velocity, friction)
- Energy and its transformation (e.g. conservation, dissipation, chemical reactions)
- Interactions of energy and matter (e.g. light and radio waves, sound and seismic waves)

Living Systems

- Cells (e.g. structures and functions, DNA, plant and animal)
- Humans (e.g. health, nutrition, subsystems [i.e. digestion, respiration, circulation, excretion, and their relationship], disease, reproduction)
- Populations (e.g. species, evolution, biodiversity, genetic variation)
- Ecosystems (e.g. food chains, matter and energy flow)
- Biosphere (e.g. ecosystem services, sustainability)

Earth And Space Systems

- Structures of Earth systems (e.g. lithosphere, atmosphere, hydrosphere)
- Energy in Earth systems (e.g. sources, global climate)
- Change in Earth systems (e.g. plate tectonics, geochemical cycles, constructive and destructive forces)
- Earth's history (e.g. fossils, origin and evolution)
- Earth in space (e.g. gravity, solar systems)

Technology Systems

- Role of science-based technology (e.g. solve problems, help humans meet needs and wants, design and conduct investigations)
- Relationships between science and technology (e.g. technologies contribute to scientific advancement)
- Concepts (e.g. optimisation, trade-offs, cost, risk, benefit)
- Important principles (e.g. criteria, constraints, innovation, invention, problem solving)

Figure 2.3 PISA 2006 *knowledge of science* content areas

As well as *knowledge of science*, PISA 2006 assessed *knowledge about science*, for which there were two categories defined by the framework. The first of these is "scientific enquiry", which centres on enquiry as the central process of science and the various components of that process. The second is "scientific explanations", which are the results of scientific enquiry. Enquiry can be thought of as the means of science – how scientists obtain evidence – and explanations as the goals of science – how scientists use data. The examples shown in Figure 2.4 convey the general meanings of the two categories.

Scientific enquiry

- Origin (e.g. curiosity, scientific questions)
- Purpose (e.g. to produce evidence that helps answer scientific questions, current ideas/models/theories guide enquiries)
- Experiments (e.g. different questions suggest different scientific investigations, design)
- Data (e.g. quantitative [measurements], qualitative [observations])
- Measurement (e.g. inherent uncertainty, replicability, variation, accuracy/precision in equipment and procedures)
- Characteristics of results (e.g. empirical, tentative, testable, falsifiable, self-correcting)

Scientific explanations

- Types (e.g. hypothesis, theory, model, scientific law)
- Formation (e.g. existing knowledge and new evidence, creativity and imagination, logic)
- Rules (e.g. logically consistent, based on evidence, based on historical and current knowledge)
- Outcomes (e.g. new knowledge, new methods, new technologies, new investigations)

Figure 2.4 PISA 2006 *knowledge about science* categories

Attitudes

Alongside helping students gain scientific and technical knowledge, an important goal of science education is helping students develop interest in science and support for scientific enquiry. Attitudes towards science play an important role in students´ decisions to develop their science knowledge further, pursue careers in science, and use scientific concepts and methods productively throughout their lives. PISA´s view of scientific literacy includes not just a student´s ability in science, but also their disposition towards science. This includes attitudes, beliefs, motivational orientations, self-efficacy, and values.

Interest in science

- Indicate curiosity in science and science-related issues and endeavours
- Demonstrate willingness to acquire additional scientific knowledge and skills, using a variety of resources and methods
- Demonstrate willingness to seek information and have an ongoing interest in science, including consideration of science-related careers

Support for scientific enquiry

- Acknowledge the importance of considering different scientific perspectives and arguments
- Support the use of factual information and rational explanations
- Express the need for logical and careful processes in drawing conclusions

Responsibility towards resources and environments

- Show a sense of personal responsibility for maintaining a sustainable environment
- Demonstrate awareness of the environmental consequences of individual actions
- Demonstrate willingness to take action to maintain natural resources

Figure 2.5 PISA 2006 survey of student attitudes

The PISA 2006 science assessment evaluated students´ attitudes in four areas: *interest in science, support for scientific enquiry, responsibility towards resources and environments and self-belief as science learners*. The first three of these are elaborated in Figure 2.5, and data on self-belief was collected via the student questionnaire. Broadly, these areas were selected because they provide an international portrait of students´ general appreciation of science, specific attitudes and values concerning science, and sense of responsibility toward selected science-related issues that have personal, local, national and international ramifications.

Interest in science was selected because of its established relationships with achievement, course selection, career choice, and lifelong learning. PISA 2006 collected data about students´ engagement in science-related social issues, their willingness to acquire scientific knowledge and skills, and their consideration of science-related careers.

Support for scientific enquiry is widely regarded as a fundamental objective of science education. Appreciation of and support for scientific enquiry implies that students value scientific ways of gathering evidence, thinking creatively, reasoning rationally, responding critically and communicating conclusions as they confront life situations related to science. Thus, support is not simply a matter of being interested in science but of an informed engagement that bases support on an understanding of the roles that science plays. Aspects of this area in PISA 2006 include the use of evidence (knowledge) in making decisions and the appreciation for logic and rationality in formulating conclusions.

Responsible attitude towards resources and environments is an international concern and it is also of economic relevance to countries. This third aspect of attitudes addressed in PISA 2006 presents information in reference to mounting global problems specifically related to the environment and resources; for example biodiversity, deforestation, pollution and water deficits.

PISA 2006 gathered rich data on students´ attitudes towards science not only by using the Student Questionnaire but also, for the first time, by embedding contextualised questions about student attitudes towards science in the actual test units. The inclusion of these contextualised items enables PISA to investigate whether students´ attitudes differed when assessed in and out of context, whether they vary between contexts and whether they correlate with students´ performance on the cognitive items in the unit. Students´ *interest in science* (specifically their interest in learning about science) and students´ *support for scientific enquiry* were directly assessed in the test, using embedded items that targeted *personal, social* and *global* contexts.

The structure of the assessment

Item response formats

In all PISA assessments pen and paper tests have been used. Under this constraint, certain types of item response format are possible and convenient, while others are less so. The response formats used must provide for the generation of reliable data. They must also be sufficiently credible to satisfy participants and observers that useful information is generated about student performance.

Students were presented with units that required them to construct a response to a stimulus and a series of questions (or "items"). Context was represented in each unit by the stimulus material, which was typically a brief written passage or text accompanying a table, chart, graph, photograph or diagram, and then each unit contained several questions or items. While students needed to possess a certain level of reading competency in order to understand and answer the science items, the stimulus material used language that was as clear, simple and brief as possible while still conveying the appropriate meaning. More importantly, the items required students to use one or more of the scientific competencies as well as knowledge of science and/or knowledge about science.

A range of item response formats were employed to cover the full range of cognitive abilities and scientific knowledge identified in the PISA 2006 framework. These comprised: basic and complex multiple choice items, in which students selected from among several possible answers; closed-constructed response items in which students were required to provide an unambiguous single word or diagrammatic answer; and open-constructed response items in which students wrote a short explanation in response to a question, showing the methods and thought processes they had used.

Of the 103 science test items used in the PISA 2006 assessment:

- 37 were multiple-choice items;
- 28 were complex multiple-choice items;
- 34 were open-constructed response items; and
- 4 were closed-constructed response items.

The majority of items were either right or wrong, and so could be scored as either "full credit" or "no credit". However, a number of the open-constructed responses could show varying levels of understanding, and so required partial credit scoring. For each open-constructed response item, a detailed scoring rubric was developed that allowed for "full credit", "partial credit", or "no credit". These categories divided students´ responses according to the extent to which the students demonstrated ability to answer the question. A "full credit" response showed the highest level of understanding of the topic appropriate for a 15-year-old. Less sophisticated but still correct responses qualified for "partial credit", while completely incorrect, irrelevant or missing responses, or those which showed very little evidence of understanding, received "no credit".

Constructing the test booklets

In total, 103 science items were developed to ensure that the broadest possible coverage of scientific literacy was achieved. These items, together with reading and mathematics items, were placed in 13 item clusters (seven science, four mathematics and two reading) each designed to occupy 30 minutes of test time. From those clusters assessment booklets were formed, each containing four clusters, using a balanced, rotated test design that ensured each individual item appeared in the same number of test booklets, that each cluster appeared in each of the four possible positions in the booklets, and that each cluster appeared once with each other cluster. While the number of science clusters varied among test booklets, every student completed at least one cluster on science.

Distribution of items

The PISA 2006 science items were distributed across the three scientific competencies (*identifying scientific issues, explaining phenomena scientifically,* and *using scientific evidence*) and the two knowledge domains (*knowledge of science* and *knowledge about science*) as shown in Table 2.1 and Table 2.2.

Table 2.1 Distribution of science items by competency in PISA 2006

	Number of items (and score points)	% of total competency items
Identifying scientific issues	23 (24)	22%
Explaining phenomena scientifically	49 (52)	48%
Using scientific evidence	31 (36)	30%
Total	**103 (112)**	**100%**

The weightings assigned to the three scientific competencies were determined by both the need to have sufficient items to ensure that a reliable scale could be developed for each and their relative importance in PISA´s definition of *scientific literacy*. The lower weighting assigned to the first competency reflects its narrower definition and lesser importance.

The PISA 2006 definition of *scientific literacy* places almost as much emphasis on *knowledge about science* as it does on *knowledge of science*, and this is reflected in their respective weightings (44% and 56% respectively). About 38 per cent of the items in the *knowledge of science* domain were items regarding "living systems", reflecting that a majority of the contexts relevant and interesting to 15-year-old students involve the life sciences. A further 29 per cent of items were in the area of "physical systems", 19 per cent in "Earth and space systems" and 14 per cent in "technology systems".

The distribution of items across the *knowledge about science* categories reflects the fact that they are regarded as equally important and ensures sufficient coverage of each category while allowing some flexibility.

Table 2.2 Distribution of science items by category and subcategory of knowledge in PISA 2006

	Number of items (and score points)	% of total knowledge items
Knowledge of science	**58 (62)**	**56%**
Earth and space systems	11(11)	19%
Living systems	22 (23)	38%
Physical systems	17 (19)	29%
Technology systems	8 (9)	14%
Knowledge about science	**45 (51)**	**44%**
Scientific enquiry	24 (26)	53%
Scientific explanations	21 (25)	47%
Total	**103 (113)**	**100%**

The distribution of items across contexts and themes also varied, with the greatest focus on the *social* context (56%) and the least focus on the *global* context (17%), while the remaining 27 per cent of items had a *personal* focus. Within these contexts, the majority of items were concentrated on the topics "health" and "frontiers of science and technology", followed by "natural resources" and "environment".

Scaling the scientific literacy tasks

The relative ability of students taking a particular test can be estimated by considering the proportion of test items they answer correctly. The relative difficulty of items in a test can be estimated by considering the proportion of test takers getting each item correct. The mathematical model used to analyse the PISA data estimates the likelihood that a particular student will respond correctly to a given test item, and the likelihood that a particular test item will be answered correctly by a given student. As a result, a continuum is defined to represent *scientific literacy*, and on that continuum it is possible to estimate the location of individual students, to show how scientifically literate they are. This continuum is referred to as the PISA *scientific literacy scale*. Within this scale, science items are ranked by difficulty and linked to student proficiency.

The *scientific literacy scale*, and the relationship between students and test items, is shown in Figure 2.6.

A student whose ability estimate places him or her at a certain point on the PISA scientific literacy scale would most likely be able to successfully complete tasks at or below that location, and increasingly more likely to complete tasks located at progressively lower points on the scale, but would be less likely to be able to complete tasks above that point, and increasingly less likely to complete tasks located at progressively higher points on the scale.

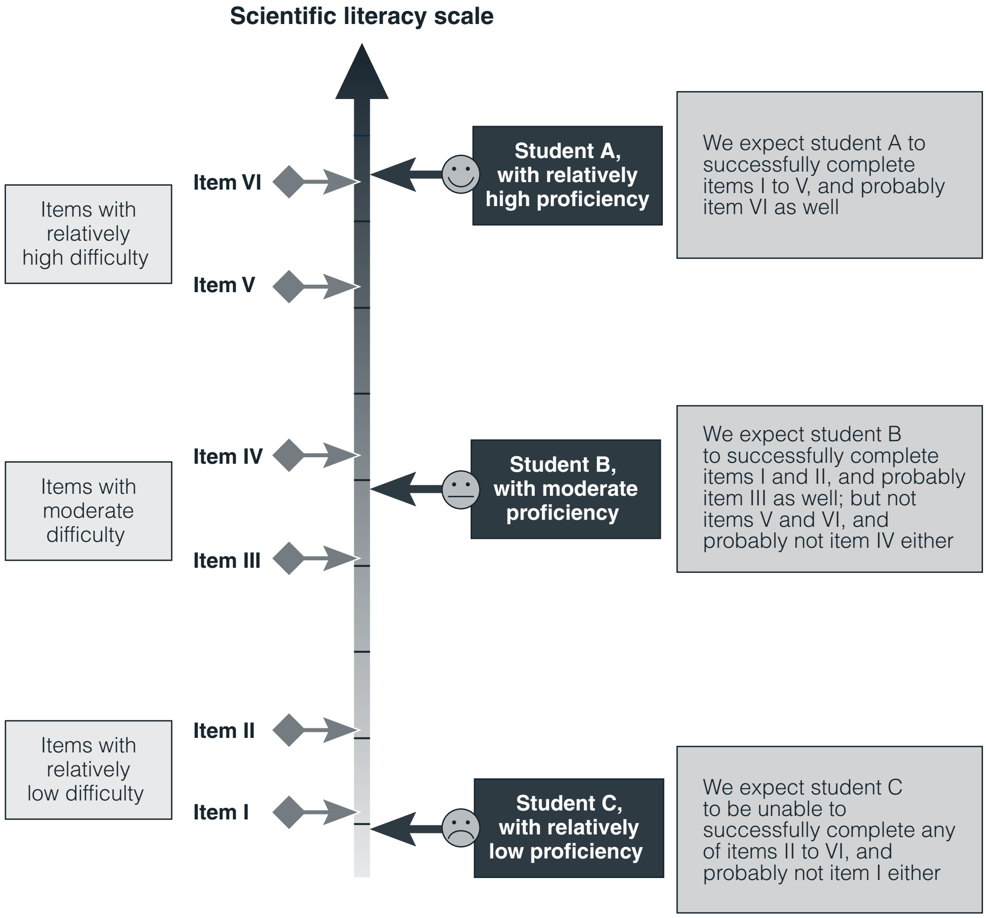


Figure 2.6 The relationship between items and students on a proficiency scale

The relationship between the student and the items is probabilistic – there is some probability that a particular student can correctly do any particular item. If a student is located at a point above an item, the probability that the student can successfully complete that item is relatively high, and if the student is located below the item, the probability of success for that student on that item is relatively low.

This immediately raises the question as to the exact criterion that should be used in order to locate a student on the same scale on which the items are laid out. When placing a student at a particular point on the scale, what probability of success should we insist on in relation to items located at the same point on the scale? If a student were given a test comprising a large number of items each with the same specified difficulty, what proportion of those items would we expect the student to successfully complete? Or, thinking of it in another way, if a large number of students of equal ability were given a single test item with a specified item difficulty, about how many of those students would we expect to successfully complete the item?

The answer to these questions is essentially arbitrary, but in order to define and report PISA outcomes in a consistent manner, an approach to defining performance levels, and of associating students with those levels, is needed. The definitions used for the proficiency scale developed for scientific literacy in PISA 2006 are described in the next section of this chapter.

Science proficiency levels in PISA 2006

While it is useful for countries to be able to examine their mean performance against other countries, PISA is also able to provide a profile of students´ scientific performance using proficiency levels as was done for reading literacy in PISA 2000 and mathematical literacy in PISA 2003.

In the case of reading, five levels were defined, while for mathematics six levels were defined. Descriptions were developed to characterise typical student performance at each level. The levels were used to summarise the performance of students, to compare performances across subgroups of students, and to compare average performances among groups of students. A similar approach has been used in the current PISA cycle to analyse and report outcomes in science for PISA 2006.

For PISA 2006 science, six levels of proficiency have been defined and described as shown in Figure 2.7.

The information about the items in each band has been used to develop summary descriptions of the kinds of scientific competencies associated with different levels of proficiency. These summary descriptions can then be used to encapsulate typical scientific proficiency of students associated with each level. As a set, the descriptions encapsulate a representation of growth in scientific literacy. Figure 2.7 describes the levels of proficiency in detail.

Level 2 has been defined internationally as a "baseline" proficiency level. This level does not separate scientific literacy and illiteracy; rather it defines the level of achievement on the PISA scale at which students begin to demonstrate the scientific competencies that will enable them to actively participate in life situations related to science and technology. Students performing below this baseline are at serious risk of not achieving at levels sufficient to allow them to adequately participate in the 21st century work force and contribute as a productive citizen.

Students achieving at Level 2, for example, demonstrate competencies such as identifying key features of a scientific investigation, recalling single scientific concepts and information related to a current event, and using results of a scientific experiment represented in a data table as they support a personal decision. Students at Level 1, on the other hand, often confuse key features of an investigation, apply incorrect scientific information, and mix personal beliefs with scientific facts in support of a decision. Science tasks any easier than the Level 1 tasks in PISA do not fit the PISA concept of scientific literacy as skills that will enable young adults to participate fully in society beyond school. Students performing below the lower boundary of Level 1 are not necessarily incapable of performing any scientific tasks but are unable to utilise these skills in a given situation, as required by the easiest PISA tasks.

Proficiency descriptions for each of the six levels have also been developed for each of the three scales related to the science competencies of the scientific literacy framework. These are summarised in Figures 2.8, 2.9 and 2.10.

Proficiency level	General scientific literacy proficiencies students should have at each level
6	At Level 6, students can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they are willing to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social or global situations.
707.9 points	
5	At Level 5, students can identify the scientific components of many complex life situations, apply both scientific concepts and knowledge about science to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to situations. They can construct explanations based on evidence and arguments based on their critical analysis.
633.3 points	
4	At Level 4, students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence.
558.7 points	
3	At Level 3, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.
484.1 points	
2	At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.
409.5 points	
1	At Level 1, students have such a limited scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence.
334.9 points	

Figure 2.7 Summary descriptions for six levels of overall scientific literacy[8]

Interpreting the *scientific literacy* levels

The proficiency levels defined and described in the preceding sections require one more set of technical decisions before they can be used to summarise and report the performance of particular students. The scale of 'PISA scientific literacy' is a continuous scale. The use of performance bands, or levels of proficiency, involves a division of that continuous scale into discrete parts. The number of divisions and the location of the cut-points that mark the boundaries of the divisions are two matters that must be determined. For PISA science, the scale has been divided into a number of regions, including 5 bounded regions labelled levels 1 to 5, an unbounded region below Level 1, and an unbounded upper region (labelled Level 6).The creation of these performance bands leads to a situation where a range of values on the continuous scale is grouped together into each single band. Given that range of performances within each level, how do we assign individual students to the levels, and what meaning do we ascribe to 'being at a level'? In the context of the OECD reporting of PISA 2000 results, a common sense interpretation of the meaning of 'being at a level' was developed and adopted. That is, students are assigned to the highest level for which they would be expected to correctly answer the majority of assessment items. If we could imagine a test composed of items spread uniformly across a level, a student near the bottom of the level will be expected to correctly answer at least half of the test questions from that level. Students at progressively higher points in that level would be expected to correctly answer progressively more of the questions in that level. It should be remembered that the relationship between students and items is probabilistic – it is possible to estimate the probability that a student at a particular location on the scale will get an item at a particular location on the scale correct. Students assigned to a particular level will be expected to successfully complete some items from the next higher level, and it is only when that expectation reaches the threshold of 'at least half of the items' in the next higher level that the student would be placed in the next higher level. Mathematically, the probability level used to assign students to the scale to achieve this common-sense interpretation of being at a level is 0.62. Students are placed on the scale at the point where they have a 62% chance of correctly answering test questions located at the same point. The same meaning has been applied in the reporting of PISA 2006 results. Such an approach makes it possible to summarise aspects of student proficiency by describing the things related to PISA scientific literacy that students can be expected to do at different locations on the scale.

[8] These cut-off points are also applicable to the scientific literacy subscales.

Proficiency level	General proficiencies students should have at each level	Tasks a student should be able to do
6	Students at this level demonstrate an ability to understand and articulate the complex modelling inherent in the design of an investigation.	◗ Articulate the aspects of a given experimental design that meet the intent of the scientific question being addressed. ◗ Design an investigation to adequately meet the demands of a specific scientific question. ◗ Identify variables that need to be controlled in an investigation and articulate methods to achieve that control.
5	Students at this level understand the essential elements of a scientific investigation and thus can determine if scientific methods can be applied in a variety of quite complex, and often abstract contexts. Alternatively, by analysing a given experiment, can identify the question being investigated and explain how the methodology relates to that question.	◗ Identify the variables to be changed and measured in an investigation of a wide variety of contexts. ◗ Understand the need to control all variables extraneous to an investigation but impinging on it. ◗ Ask a scientific question relevant to a given issue.
4	Students at this level can identify the change and measured variables in an investigation and at least one variable that is being controlled. They can suggest appropriate ways of controlling that variable. The question being investigated in straightforward investigations can be articulated.	◗ Distinguish the control against which experimental results are to be compared. ◗ Design investigations in which the elements involve straightforward relationships and lack appreciable abstractness. ◗ Show an awareness of the effects of uncontrolled variables and attempt to take this into account in investigations.
3	Students at this level are able to make judgements about whether an issue is open to scientific measurement and, consequently, to scientific investigation. Given a description of an investigation can identify the change and measured variables.	◗ Identify the quantities able to be scientifically measured in an investigation. ◗ Distinguish between the change and measured variables in simple experiments. ◗ Recognise when comparisons are being made between two tests (but are unable to articulate the purpose of a control).
2	Students at this level can determine if scientific measurement can be applied to a given variable in an investigation. They can recognise the variable being manipulated (changed) by the investigator. Students can appreciate the relationship between a simple model and the phenomenon it is modelling. In researching topics students can select appropriate key words for a search.	◗ Identify a relevant feature being modelled in an investigation. ◗ Show an understanding of what can and cannot be measured by scientific instruments. ◗ Select the most appropriate stated aims for an experiment from a given selection. ◗ Recognise what is being changed (the cause) in an experiment. ◗ Select a best set of internet search words on a topic from several given sets.
1	Students at this level can suggest appropriate sources of information on scientific topics. They can identify a quantity that is undergoing variation in an experiment. In specific contexts they can recognise whether that variable can be measured using familiar measuring tools or not.	◗ Select some appropriate sources from a given number of sources of potential information on a scientific topic. ◗ Identify a quantity that is undergoing change, given a specific but simple scenario. ◗ Recognise when a device can be used to measure a variable (within the scope of the student´s familiarity with measuring devices).

Figure 2.8 Description of proficiency levels for *identifying scientific issues*

Proficiency level	General proficiencies students should have at each level	Tasks a student should be able to do
6	Students at this level draw on a range of abstract scientific knowledge and concepts and the relationships between these in developing explanations of processes within systems.	◗ Demonstrate an understanding of a variety of complex, abstract physical, biological or environmental systems. ◗ In explaining processes, articulate the relationships between a number of discrete elements or concepts.
5	Students at this level draw on knowledge of two or three scientific concepts and identify the relationship between them in developing an explanation of a contextual phenomenon.	◗ Take a scenario, identify its major component features, whether conceptual or factual, and use the relationships between these features in providing an explanation of a phenomenon. ◗ Synthesise two or three central scientific ideas in a given context in developing an explanation for, or a prediction of, an outcome.
4	Students at this level have an understanding of scientific ideas, including scientific models, with a significant level of abstraction. They can apply a general, scientific concept containing such ideas in the development of an explanation of a phenomenon.	◗ Understand a number of abstract scientific models and can select an appropriate one from which to draw inferences in explaining a phenomenon in a specific context (e.g. the particle model, planetary models, models of biological systems). ◗ Link two or more pieces of specific knowledge (including from an abstract source) in an explanation (e.g. increased exercise leads to increased metabolism in muscle cells, this in turn requires an increased exchange of gases in the blood supply, which is achieved by an increased rate of breathing).
3	Students at this level can apply one or more concrete or tangible scientific ideas/concepts in the development of an explanation of a phenomenon. This is enhanced when there are specific cues given or options available from which to choose. When developing an explanation, cause and effect relationships are recognised and simple, explicit scientific models may be drawn upon.	◗ Understand the central feature(s) of a scientific system and, in concrete terms, can predict outcomes from changes in that system (e.g. the effect of a weakening of the immune system in a human). ◗ In a simple and clearly defined context, recall several relevant, tangible facts and apply these in developing an explanation of the phenomenon.
2	Students at this level can recall an appropriate, tangible, scientific fact applicable in a simple and straightforward context and can use it to explain or predict an outcome.	◗ Given a specific outcome in a simple context, indicate, in a number of cases and with appropriate cues the scientific fact or process that has caused that outcome (e.g. water expands when it freezes and opens cracks in rocks, land containing marine fossils was once under the sea). ◗ Recall specific scientific facts with general currency in the public domain (e.g. vaccination provides protection against viruses that cause disease).
1	Students at this level can recognise simple cause and effect relationships given relevant cues. The knowledge drawn upon is a singular scientific fact that is drawn from experience or has widespread popular currency.	◗ Choose a suitable response from among several responses, given the context is a simple one and that recall of a single scientific fact is involved (e.g. ammeters are used to measure electric current). ◗ Given sufficient cues, recognise simple cause and effect relationships (e.g. Do muscles get an increased flow of blood during exercise? Yes or No.)

Figure 2.9 Description of proficiency levels for *explaining phenomena scientifically*

Proficiency level	General proficiencies students should have at each level	Tasks a student should be able to do
6	Students at this level demonstrate an ability to compare and differentiate among competing explanations by examining supporting evidence. They can formulate arguments by synthesising evidence from multiple sources.	◗ Recognise that alternative hypotheses can be formed from the same set of evidence. ◗ Test competing hypotheses against available evidence. ◗ Construct a logical argument for an hypothesis by using data from a number of sources.
5	Students at this level are able to interpret data from related datasets presented in various formats. They can identify and explain differences and similarities in the datasets and draw conclusions based on the combined evidence presented in those datasets.	◗ Compare and discuss the characteristics of different datasets graphed on the one set of axes. ◗ Recognise and discuss relationships between datasets (graphical and otherwise) in which the measured variable differs. ◗ Based on an analysis of the sufficiency of the data, make judgements about the validity of conclusions.
4	Students at this level can interpret a dataset expressed in a number of formats, such as tabular, graphic and diagrammatic, by summarising the data and explaining relevant patterns. They can use the data to draw relevant conclusions. Students can also determine whether the data supports assertions about a phenomenon.	◗ Locate relevant parts of graphs and compare these in response to specific questions. ◗ Understand how to use a control in analysing the results of an investigation and developing a conclusion. ◗ Interpret a table that contains two measured variables and suggest credible relationships between those variables. ◗ Identify the characteristics of a straightforward technical device by reference to diagrammatic representations and general scientific concepts and thus form conclusions about its method of operation.
3	Students at this level are able to select a piece of relevant information from data in answering a question or in providing support for or against a given conclusion. They can draw a conclusion from an uncomplicated or simple pattern in a dataset. Students can also determine, in simple cases, if enough information is present to support a given conclusion.	◗ Given a specific question, locate relevant scientific information in a body of text. ◗ Given specific evidence/data, choose between appropriate and inappropriate conclusions. ◗ Apply a simple set of criteria in a given context in order to draw a conclusion or make a prediction about an outcome. ◗ Given a set of functions, determine if they are applicable to a specific machine.
2	Students at this level are able to recognise the general features of a graph if they are given appropriate cues and can point to an obvious feature in a graph or simple table in support of a given statement. They are able to recognise if a set of given characteristics apply to the function of everyday artifacts in making choices about their use.	◗ Compare two columns in a simple table of measurements and indicate differences. ◗ State a trend in a set of measurements or simple line or bar graph. ◗ Given a common artifact can determine some characteristics or properties pertaining to the artifact from among a list of properties.
1	In response to a question, students at this level can extract information from a fact sheet or diagram pertinent to a common context. They can extract information from bar graphs where the requirement is simple comparisons of bar heights. In common, experienced contexts students at this level can attribute an effect to a cause.	◗ In response to a specific question pertaining to a bar graph, make comparisons of the height of bars and give meaning to the difference observed. ◗ Given variation in a natural phenomenon can, in some cases, indicate an appropriate cause (e.g. fluctuations in the output of wind turbines may be attributed to changes in wind strength).

Figure 2.10 Description of proficiency levels for *using scientific evidence*

Sample scientific literacy items and responses

A sample of scientific literacy items, including responses from students, is provided in this section to illustrate the variety of tasks and the scope of PISA´s scientific literacy domain. Only a small number of scientific literacy items has been released for public use as the majority of items remain secure for subsequent linking of items between cycles.

The sample items shown below have been selected to show the variation in questions used in assessing the competencies, the context of the items, and the knowledge required by students. In addition, the units, `Genetically Modified Crops´, `Grand Canyon´, `Acid Rain´ and `Mary Montagu´ provide examples of units with embedded attitudinal questions.

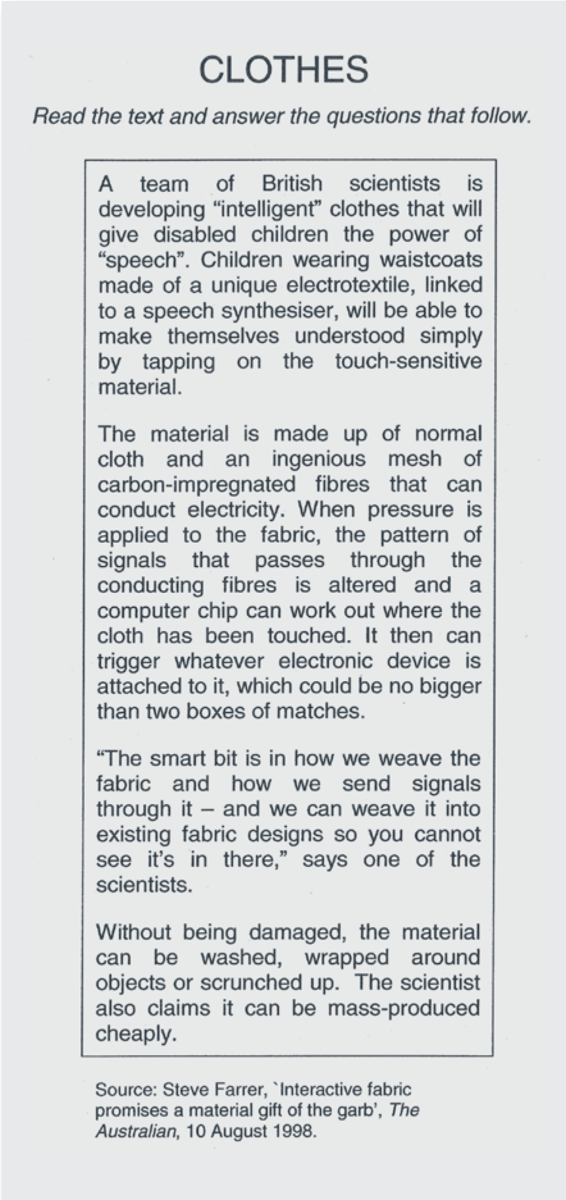
Figure 2.11 shows a map of the sample items included in this section. For each of the items, information is provided about the competency assessed, the proficiency level and score of the item (the number in brackets) as well as whether the response is awarded full credit or partial credit (where appropriate). The map shows the items ordered according to difficulty, with the most difficult at the top and the least difficult at the bottom.

Proficiency Level	Competencies		
	Identifying scientific issues	Explaining phenomena scientifically	Using scientific evidence
6	ACIDRAIN Question 5 (717) (full credit)	GREENHOUSE Question 5 (709)	
707.9 points			
5			GREENHOUSE Question 4 (659) (full credit)
633.3 points			
4	SUNSCREENS Question 2 (588) Question 4 (574) CLOTHES Question 1 (567)	PHYSICAL EXERCISE Question 5 (583)	SUNSCREENS Question 5 (629) (full credit) Question 5 (616) (partial credit) GREENHOUSE Question 4 (568) (partial credit)
558.7 points			
3	ACID RAIN Question 5 (513) (partial credit) SUNSCREENS Question 3 (499) GENETICALLY MODIFIED CROPS Question 2 (488) GRAND CANYON Question 7 (485)	PHYSICAL EXERCISE Question 1 (545) MARY MONTAGU Question 4 (507) ACID RAIN Question 2 (506)	GREENHOUSE Question 3 (529)
484.1 points			
2	GENETICALLY MODIFIED CROPS Question 3 (421)	GRAND CANYON Question 3 (451) MARY MONTAGU Question 2 (436) Question 3 (431) GRAND CANYON Question 5 (411)	ACID RAIN Question 3 (460)
409.1 points			
1		CLOTHES Question 2 (399) PHYSICAL EXERCISE Question 3 (386)	
334.9 points			

Figure 2.11 Sample items from PISA 2006 and cut-off points for the scientific literacy proficiency levels

Clothes

Two competencies are assessed in the unit `Clothes´, the stimulus for which follows.



CLOTHES

Read the text and answer the questions that follow.

A team of British scientists is developing "intelligent" clothes that will give disabled children the power of "speech". Children wearing waistcoats made of a unique electrotextile, linked to a speech synthesiser, will be able to make themselves understood simply by tapping on the touch-sensitive material.

The material is made up of normal cloth and an ingenious mesh of carbon-impregnated fibres that can conduct electricity. When pressure is applied to the fabric, the pattern of signals that passes through the conducting fibres is altered and a computer chip can work out where the cloth has been touched. It then can trigger whatever electronic device is attached to it, which could be no bigger than two boxes of matches.

"The smart bit is in how we weave the fabric and how we send signals through it – and we can weave it into existing fabric designs so you cannot see it's in there," says one of the scientists.

Without being damaged, the material can be washed, wrapped around objects or scrunched up. The scientist also claims it can be mass-produced cheaply.

Source: Steve Farrer, `Interactive fabric promises a material gift of the garb', *The Australian*, 10 August 1998.

Clothes Question 1

The first question, set out below, is a complex multiple-choice question, which assesses the *identifying scientific issues* competency. Students are asked whether claims made in the article can be tested through scientific investigation in a laboratory, and students need to rely on their knowledge about science, specifically scientific enquiry, to complete this question. The question is set in a social context and is framed in the setting: frontiers of science and technology, as the stimulus refers to the development of a new device, `a waistcoat made of a unique electrotextile´. This question is located at the lower boundary of Level 4 with a difficulty of 567 score points.

Can these claims made in the article be tested through scientific investigation in the laboratory?

Circle either "Yes" or "No" for each.

The material can be	Can the claim be tested through scientific investigation in the laboratory?
washed without being damaged.	Yes / No
wrapped around objects without being damaged.	Yes / No
scrunched up without being damaged.	Yes / No
mass-produced cheaply.	Yes / No

In helping to illustrate the sample scientific literacy items, the percentage correct for several groups has been included in tabular form. For each illustrated item, Australian students´ results are shown both overall and by gender. The results of the highest performing country, the lowest performing country, and the OECD average have also been included. For the purposes of generating the OECD averages, countries were weighted equally in computing these statistics.

Overall per cent correct	
Liechtenstein (Highest achieving country)	71%
Australian females	67%
Australia	64%
Australian males	61%
OECD average	48%
Kyrgyzstan and Azerbaijan (Lowest achieving countries)	11%

Clothes Question 2

The second question in the `Clothes´ unit asks the student to recall a single piece of laboratory equipment that could check that the fabric was conducting electricity. This question assesses the *explaining phenomena scientifically* competency and is located in the knowledge of science area – technical systems. The item is framed in the personal setting in the frontiers area. This item is an example of an easy scientific literacy item, with a multiple-choice format, located at the bottom of the proficiency scale at Level 1 (with a difficulty of 399 score points).

Which piece of laboratory equipment would be among the equipment you would need to check that the fabric is conducting electricity?

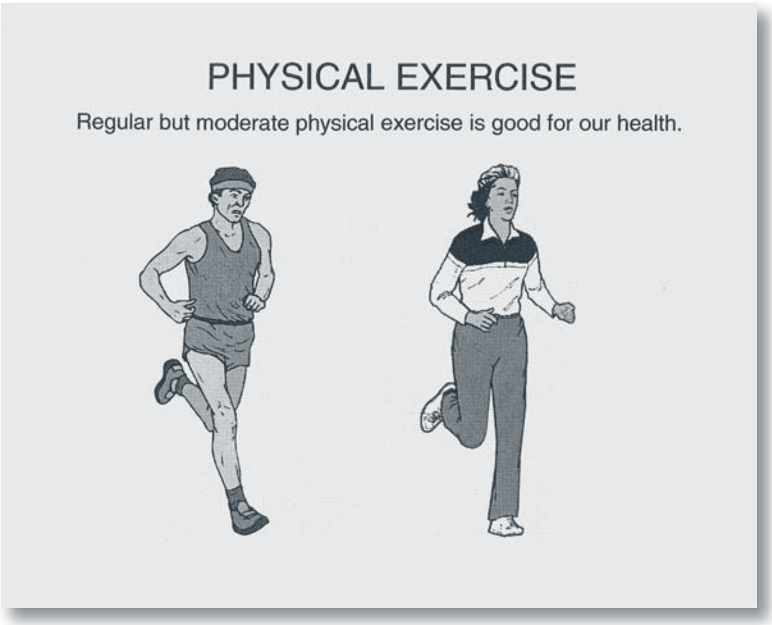
A Voltmeter
B Light box
C Micrometer
D Sound meter

Overall per cent correct	
Finland (Highest achieving country)	95%
Australian males	84%
Australia	82%
Australian females	80%
OECD average	79%
Qatar (Lowest achieving country)	37%

Physical Exercise

The `Physical Exercise´ unit consists of three questions and assesses the competency *explaining phenomena scientifically*. These questions require students to apply their knowledge of science, specifically of living systems. They must be able to understand the impact of exercise on various biological systems, for example, the circulatory, muscular and respiratory systems. The application area for this unit is health and the unit is set in a personal context.

The stimulus for `Physical Exercise´ was minimal with a picture and a sentence about exercise.



Physical Exercise Question 1

This question, placed at Level 3 (with a difficulty of 545 score points), is a complex multiple-choice item and students must have some knowledge about the benefits of physical exercise to the human body.

What are the advantages of regular physical exercise? Circle "Yes" or "No" for each statement.

Is this an advantage of regular physical exercise?	Yes or No?
Physical exercise helps prevent heart and circulation illnesses.	Yes / No
Physical exercise leads to a healthy diet.	Yes / No
Physical exercise helps to avoid becoming overweight.	Yes / No

Overall per cent correct	
Finland (Highest achieving country)	78%
Australian females	52%
Australia	51%
Australian males	50%
OECD average	53%
Indonesia (Lowest achieving country)	5%

Physical Exercise Question 3

Question 3 of `Physical Exercise´ was another complex multiple-choice item, located at Level 1. Students found this item easier than the previous one with a difficulty of 386 score points. Students must have knowledge about the effect of exercise on muscles to complete this question.

What happens when muscles are exercised? Circle "Yes" or "No" for each statement.

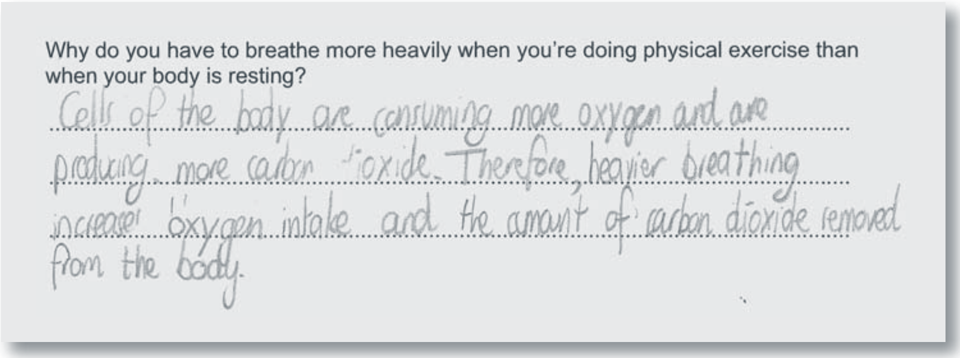
Does this happen when muscles are exercised?	Yes or No?
Muscles get an increased flow of blood.	Yes / No
Fats are formed in the muscles.	Yes / No

Overall per cent correct	
Finland (Highest achieving country)	93%
Australian females	86%
Australia	85%
Australian males	84%
OECD average	82%
Qatar (Lowest achieving country)	53%

Physical Exercise Question 5

The next question is an `open constructed response item´, requiring students to have an understanding of why individuals have to breathe more heavily when they are doing physical exercise than when their body is resting.

This is a Level 4 item with a difficulty of 583 score points. It is more difficult because of the level of scientific knowledge that is needed to answer the question. Students need to be familiar with the respiratory system and must have an understanding about the balance of carbon dioxide and oxygen and the changes that take place when you are doing physical exercise. To be scored as correct, a response had to point out that you breathe more heavily when doing physical exercise to remove increased levels of carbon dioxide and to supply more oxygen to your body. No codes were provided for students who used `air´ instead of carbon dioxide or oxygen. A correct sample response is shown.


Why do you have to breathe more heavily when you're doing physical exercise than when your body is resting?

Cells of the body are consuming more oxygen and are producing more carbon dioxide. Therefore, heavier breathing increases oxygen intake and the amount of carbon dioxide removed from the body.

Overall per cent correct	
Finland (Highest achieving country)	71%
Australian males	57%
Australia	52%
Australian females	47%
OECD average	45%
Kyrgyzstan (Lowest achieving country)	7%

Acid Rain

There are three cognitive questions in the unit `Acid Rain´, which assess each of the three competencies. This unit also includes two embedded attitudinal questions to ask students about their attitudes to acid rain.

The `Acid Rain´ stimulus features a photograph of the Caryatids statues from the Acropolis in Athens and a short paragraph of text as shown here.

ACID RAIN

Below is a photo of statues called Caryatids that were built on the Acropolis in Athens more than 2500 years ago. The statues are made of a type of rock called marble. Marble is composed of calcium carbonate.

In 1980, the original statues were transferred inside the museum of the Acropolis and were replaced by replicas. The original statues were being eaten away by acid rain.

Acid Rain Question 2

This question assesses the competency *explaining phenomena scientifically*. To answer this question, students must have knowledge of science, in particular of physical systems. The context of this question relates to hazards and it is framed in a social setting. This item was placed at Level 3 with a difficulty of 506 score points.

In the stem of the question, students are told `acid rain is more acidic than normal rain because it has absorbed gases like sulphur oxides and nitrogen oxides as well´. They are asked where sulphur oxides and nitrogen oxides in the air come from. Responses were coded correct if they included any one of car exhausts, factory emissions, burning fossil fuels (such as oil and coal), gases from volcanoes, or other similar things. Two sample responses are shown, although both were coded as correct.

Normal rain is slightly acidic because it has absorbed some carbon dioxide from the air. Acid rain is more acidic than normal rain because it has absorbed gases like sulphur oxides and nitrogen oxides as well.

Where do these sulphur oxides and nitrogen oxides in the air come from?

They come from pollutants in the air such as ~~ex vehicle~~ ~~vehicl~~ car/truck exhaust and power plants.

Volcanic eruptions, the gases and oxides have been absorbed into the air and next time it rains, or near to, its acidic.

Overall per cent correct	
Finland and Hong Kong-China (Highest achieving countries)	73%
Australian males	60%
Australia	58%
Australian females	57%
OECD average	58%
Indonesia (Lowest achieving country)	14%

Acid Rain Question 3

The next question assesses the competency *using scientific evidence* and is placed at Level 2 with a difficulty of 460 score points. The science-related situation of this question relates to a hazard that is caused by humans and is set in a personal context. Knowledge of physical systems is required to successfully answer the question. Students were provided with a simple model showing the influence of acid rain on marble and were asked to draw a conclusion about the effects of vinegar on marble.

A marble chip has a mass of 2.0 grams before being immersed in vinegar overnight. The chip is removed and dried the next day. What will the mass of the dried marble chip be?

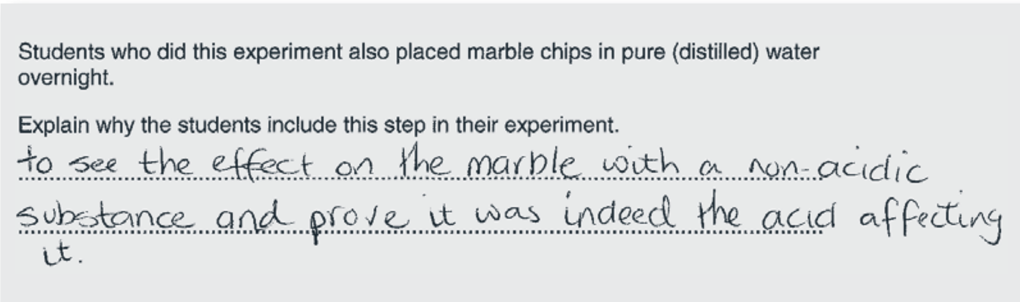
A Less than 2.0 grams
B Exactly 2.0 grams
C Between 2.0 and 2.4 grams
D More than 2.4 grams

Overall per cent correct	
Korea (Highest achieving country)	84%
Australian males	74%
Australia	72%
Australian females	69%
OECD average	67%
Qatar (Lowest achieving country)	35%

Acid Rain Question 5

The final cognitive question in this unit assesses the competency *identifying scientific issues* and involves knowledge about scientific enquiry. The question is set in a personal context and the situation involves hazards humans have to overcome. Students have to demonstrate an ability to understand scientific investigation and the purpose of using a control variable. In the previous question students were provided information about the effects of vinegar on marble. In this question students were asked to explain why some chips were placed in distilled water overnight.

This question is an example of a partial credit item. To achieve full credit, students had to explain that the marble chips placed in distilled water were to compare with the test of vinegar and marble to show that the acid (vinegar) was necessary for the reaction to occur. A full credit item was located at Level 6 with a difficulty of 717 score points. Below is an example of a response that achieved full credit.

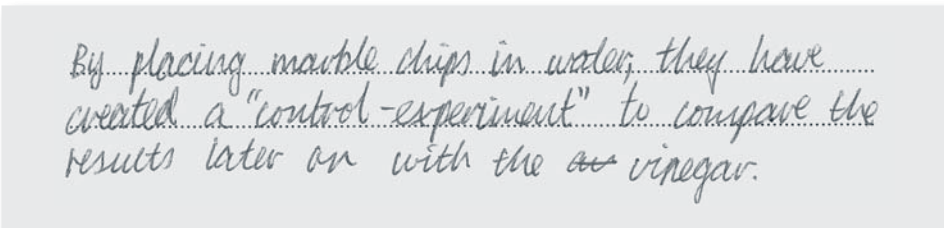


Students who did this experiment also placed marble chips in pure (distilled) water overnight.

Explain why the students include this step in their experiment.

to see the effect on the marble with a non-acidic substance and prove it was indeed the acid affecting it.

To achieve a partial credit, with a difficulty of 513 score points (Level 3), students provided a response that included a comparison with the test of vinegar and marble, but did not make clear that this was being done to show that the acid (vinegar) is necessary for the reaction. A partial credit response is shown below.



By placing marble chips in water, they have created a "control-experiment" to compare the results later on with the ~~ac~~ vinegar.

Overall per cent correct*	
New Zealand (Highest achieving country)	47%
Australian females	47%
Australia	45%
Australian males	44%
OECD average	36%
Qatar (Lowest achieving country)	8%
* These results are percentages weighted for the numbers of fully and partially correct answers.	

Acid Rain Attitudinal Questions

The first attitudinal question of `Acid Rain´ probes the level of students´ interest in the topic of acid rain.

How much interest do you have in the following information?

Tick only one box in each row.

		High Interest	*Medium Interest*	*Low Interest*	*No Interest*
a)	Knowing which human activities contribute most to acid rain	☐ 1	☐ 2	☐ 3	☐ 4
b)	Learning about technologies that minimise the emission of gases that cause acid rain	☐ 1	☐ 2	☐ 3	☐ 4
c)	Understanding the methods used to repair buildings damaged by acid rain	☐ 1	☐ 2	☐ 3	☐ 4

Further details about students´ attitudes to science are provided in Chapter 4. However, this section provides the percentages of Australian students who responded to each category of the question as well as the respective OECD average.

Table 2.3 Responses for Australian students and students across OECD countries to the first Acid Rain attitudinal question

Attitudinal statements	Interest (%)							
	High		Medium		Low		No	
	Aust.	OECD	Aust.	OECD	Aust.	OECD	Aust.	OECD
a) Knowing which human activities contribute most to acid rain	10	19	41	42	36	27	13	11
b) Learning about technologies that minimise the emission of gases that cause acid rain	13	22	34	36	38	28	15	12
c) Understanding the methods used to repair buildings damaged by acid rain	8	14	31	34	41	34	19	17

The second question asks students how much they agree with statements supporting further research in this area.

How much do you agree with the following statements?

Tick only one box in each row.

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
a)	Preservation of ancient ruins should be based on scientific evidence concerning the causes of damage.	☐1	☐2	☐3	☐4
b)	Statements about the causes of acid rain should be based on scientific research.	☐1	☐2	☐3	☐4

Table 2.4 Responses for Australian students and students across OECD countries to the second Acid Rain attitudinal question

Attitudinal statements	Support (%)							
	Strongly agree		Agree		Disagree		Strongly disagree	
	Aust.	OECD	Aust.	OECD	Aust.	OECD	Aust.	OECD
a) Preservation of ancient ruins should be based on scientific evidence concerning the causes of damage.	19	24	62	58	15	14	3	3
b) Statements about the causes of acid rain should be based on scientific research.	22	26	65	58	10	12	2	3

Mary Montagu

The unit `Mary Montagu´ assesses the competency *explaining phenomena scientifically* and students must have knowledge of living systems to complete the questions. The context of the questions is framed in a health setting of a social nature. `Mary Montagu´ also contains an attitudinal question.

The stimulus features the following newspaper article.

MARY MONTAGU

Read the following newpaper article and answer the questions that follow.

THE HISTORY OF VACCINATION

Mary Montagu was a beautiful woman. She survived an attack of smallpox in 1715 but she was left covered with scars. While living in Turkey in 1717, she observed a method called inoculation that was commonly used there. This treatment involved scratching a weak type of smallpox virus into the skin of healthy young people who then became sick, but in most cases only with a mild form of the disease.

Mary Montagu was so convinced of the safety of these inoculations that she allowed her son and daughter to be inoculated.

In 1796, Edward Jenner used inoculations of a related disease, cowpox, to produce antibodies against smallpox. Compared with the inoculation of smallpox, this treatment had less side effects and the treated person could not infect others. The treatment became known as vaccination.

Mary Montagu Question 2

This multiple-choice question relies on students´ knowledge of vaccinations and asks students what kinds of diseases people can be vaccinated against. This question was placed at Level 2 with 436 score points.

What kinds of diseases can people be vaccinated against?

A Inherited diseases like haemophilia.
B Diseases that are caused by viruses, like polio.
C Diseases from the malfunctioning of the body, like diabetes.
D Any sort of disease that has no cure.

Overall per cent correct	
Liechtenstein (Highest achieving country)	86%
Australian females	83%
Australia	80%
Australian males	76%
OECD average	75%
Kyrgyzstan (Lowest achieving country)	32%

Mary Montagu Question 3

The next question is another multiple-choice item, placed at Level 2 with 431 score points. Students must have some knowledge about immunity to answer this question correctly.

If animals or humans become sick with an infectious bacterial disease and then recover, the type of bacteria that caused the disease does not usually make them sick again.

What is the reason for this?

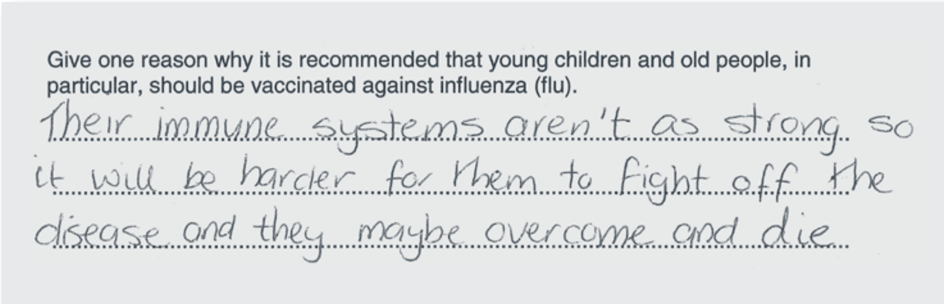
A The body has killed all bacteria that may cause the same kind of disease.
B The body has made antibodies that kill this type of bacteria before they multiply.
C The red blood cells kill all bacteria that may cause the same kind of disease.
D The red blood cells capture and get rid of this type of bacteria from the body.

Overall per cent correct	
Chinese Taipei (Highest achieving country)	90%
Australian females	76%
Australia	75%
Australian males	74%
OECD average	75%
Azerbaijan (Lowest achieving country)	36%

Mary Montagu Question 4

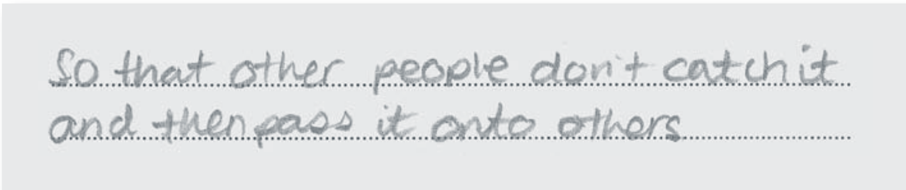
The final cognitive question in this unit is an open constructed response, requiring students to provide a written answer, making this question slightly harder at 507 score points (Level 3). Students were asked to provide one reason why young children and old people should be vaccinated against influenza.

For a response to be coded as correct, students had to refer to young and old people having weaker immune systems than other people. The following student response was coded as correct.


Give one reason why it is recommended that young children and old people, in particular, should be vaccinated against influenza (flu).

Their immune systems aren't as strong so it will be harder for them to fight off the disease and they maybe overcome and die.

The following sample response was coded as incorrect because it did not refer to the weaker immune system.


So that other people don't catch it and then pass it onto others

Overall per cent correct	
Hong Kong-China (Highest achieving country)	87%
Australian females	61%
Australia	57%
Australian males	52%
OECD average	62%
Indonesia (Lowest achieving country)	12%

Mary Montagu Attitudinal Question

This unit contained an attitudinal question that asked students about their support for further research into developing vaccines and the purpose of using scientific research to validate treatments and find the cause of disease.

How much do you agree with the following statements?

Tick only one box in each row.

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
a)	I am in favour of research to develop vaccines for new strains of influenza.	☐ 1	☐ 2	☐ 3	☐ 4
b)	The cause of a disease can only be identified by scientific research.	☐ 1	☐ 2	☐ 3	☐ 4
c)	The effectiveness of unconventional treatments for diseases should be subject to scientific investigation.	☐ 1	☐ 2	☐ 3	☐ 4

Table 2.5 Responses for Australian students and students across OECD countries to the Mary Montagu attitudinal question

Attitudinal statements	Support (%)							
	Strongly agree		Agree		Disagree		Strongly disagree	
	Aust.	OECD	Aust.	OECD	Aust.	OECD	Aust.	OECD
a) I am in favour of research to develop vaccines for new strains of influenza.	41	54	51	39	7	4	2	1
b) The cause of a disease can only be identified by scientific research.	18	21	55	48	24	27	2	3
c) The effectiveness of unconventional treatments for diseases should be subject to scientific investigation.	21	30	63	56	13	11	2	2

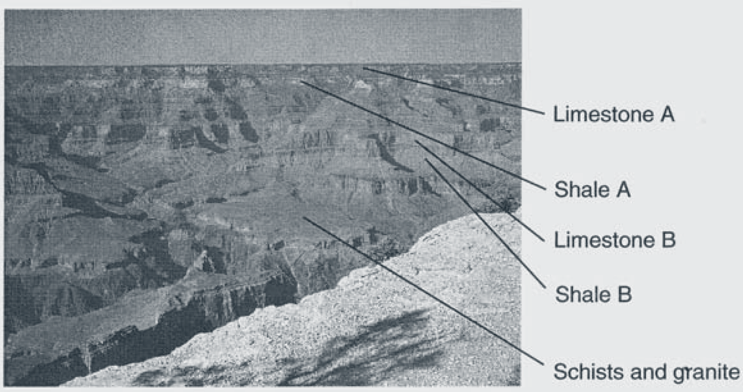
Grand Canyon

The stimulus for the unit `Grand Canyon´ provided students with information about the Grand Canyon and its geomorphological features as shown below.

THE GRAND CANYON

The Grand Canyon is located in a desert in the USA. It is a very large and deep canyon containing many layers of rock. Sometime in the past, movements in the Earth's crust lifted these layers up. The Grand Canyon is now 1.6 km deep in parts. The Colorado River runs through the bottom of the canyon.

See the picture below of the Grand Canyon taken from its south rim. Several different layers of rock can be seen in the walls of the canyon.



Grand Canyon Question 3

This question assesses the competency *explaining phenomena scientifically*. Students must have knowledge about Earth and space systems. The question is framed in an environmental setting with a social context. This question requires students to know the fact that freezing water expands and may influence the weathering of rocks. It is placed at Level 2 with a difficulty of 451 score points.

The temperature in the Grand Canyon ranges from below 0 °C to over 40 °C. Although it is a desert area, cracks in the rocks sometimes contain water. How do these temperature changes and the water in rock cracks help to speed up the breakdown of rocks?

A Freezing water dissolves warm rocks.
B Water cements rocks together.
C Ice smoothes the surface of rocks.
D Freezing water expands in the rock cracks.

Overall per cent correct	
Ireland (Highest achieving country)	87%
Australian females	73%
Australia	72%
Australian males	71%
OECD average	68%
Uruguay (Lowest achieving country)	31%

Grand Canyon Question 5

This question also assesses the competency *explaining phenomena scientifically*, with knowledge of Earth and space systems required to answer the question successfully. Natural resources are the area of focus for this question, which is within a social context. The question was located at Level 2 with 411 score points. Students are asked to indicate what happened millions of years ago to explain why fossils are found in a particular layer of rock. Students are required to know that when the seas recede they may reveal fossils of organisms deposited at an earlier age.

There are many fossils of marine animals, such as clams, fish and corals, in the Limestone A layer of the Grand Canyon. What happened millions of years ago that explains why such fossils are found there?

A In ancient times, people brought seafood to the area from the ocean.
B Oceans were once much rougher and sea life washed inland on giant waves.
C An ocean covered this area at that time and then receded later.
D Some sea animals once lived on land before migrating to the sea.

Overall per cent correct	
Finland (Highest achieving country)	87%
Australia	84%
Australian males	84%
Australian females	84%
OECD average	76%
Qatar (Lowest achieving country)	36%

Grand Canyon Question 7

This question had a difficulty of 485 score points and is located at Level 3, close to the boundary between Levels 2 and 3. It assesses the competency *identifying scientific issues*. The environment is the focus of the question, which is set within a social context. Students need to identify whether two issues can be investigated scientifically.

About five million people visit the Grand Canyon national park every year. There is concern about the damage that is being caused to the park by so many visitors.

Can the following questions be answered by scientific investigation? Circle "Yes" or "No" for each question.

Can this question be answered by scientific investigation?	**Yes or No?**
How much erosion is caused by use of the walking tracks?	Yes / No
Is the park area as beautiful as it was 100 years ago?	Yes / No

Overall per cent correct	
United Kingdom (Highest achieving country)	76%
Australian females	76%
Australia	74%
Australian males	72%
OECD average	61%
Azerbaijan (Lowest achieving country)	36%

Grand Canyon Attitudinal Question

The embedded attitudinal question in `Grand Canyon´ asks students about their support for scientific inquiry concerning fossils, protection of national parks and rock formations.

How much do you agree with the following statements?
Tick only one box in each row.

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
a)	The systematic study of fossils is important.	☐1	☐2	☐3	☐4
b)	Action to protect National Parks from damage should be based on scientific evidence.	☐1	☐2	☐3	☐4
c)	Scientific investigation of geological layers is important.	☐1	☐2	☐3	☐4

Table 2.6 Responses for Australian students and students across OECD countries to the Grand Canyon attitudinal question

Attitudinal statements	Support (%)							
	Strongly agree		Agree		Disagree		Strongly disagree	
	Aust.	OECD	Aust.	OECD	Aust.	OECD	Aust.	OECD
a) The systematic study of fossils is important.	19	26	66	58	11	11	3	3
b) Action to protect National Parks from damage should be based on scientific evidence.	16	26	56	46	24	22	4	2
c) Scientific investigation of geological layers is important.	18	41	63	47	15	7	4	1

Genetically Modified Crops

The competency *identifying scientific issues* was assessed in the unit `Genetically Modified Crops´, the stimulus for which follows. Students are required to demonstrate knowledge about the design of science experiments. The nature of this unit places this question in the frontiers category within a social context.

GENETICALLY MODIFIED CROPS

GM CORN SHOULD BE BANNED

Wildlife conservation groups are demanding that a new genetically modified (GM) corn be banned.

This GM corn is designed to be unaffected by a powerful new herbicide that kills conventional corn plants. This new herbicide will kill most of the weeds that grow in cornfields.

The conservationists say that because these weeds are feed for small animals, especially insects, the use of the new herbicide with the GM corn will be bad for the environment. Supporters of the use of the GM corn say that a scientific study has shown that this will not happen.

Here are details of the scientific study mentioned in the above article:

- Corn was planted in 200 fields across the country.
- Each field was divided into two. The genetically modified (GM) corn treated with the powerful new herbicide was grown in one half, and the conventional corn treated with a conventional herbicide was grown in the other half.
- The number of insects found in the GM corn, treated with the new herbicide, was about the same as the number of insects in the conventional corn, treated with the conventional herbicide.

Genetically Modified Crops Question 2

This question is a complex multiple-choice item which asks students to identify the factors that were varied in the scientific investigation. This item was placed at Level 3 with a difficulty of 488 score points.

What factors were deliberately varied in the scientific study mentioned in the article? Circle "Yes" or "No" for each of the following factors.

Was this factor deliberately varied in the study?	Yes or No?
The number of insects in the environment	Yes / No
The types of herbicide used	Yes / No

Overall per cent correct	
Korea (Highest achieving country)	77%
Australian females	67%
Australia	64%
Australian males	61%
OECD average	61%
Kyrgyzstan (Lowest achieving country)	26%

Genetically Modified Crops Question 3

This multiple-choice item, located at Level 2 with 421 score points, asks students a simple question about varying conditions in a scientific investigation.

Corn was planted in 200 fields across the country. Why did the scientists use more than one site?

A So that many farmers could try the new GM corn.
B To see how much GM corn they could grow.
C To cover as much land as possible with the GM crop.
D To include various growth conditions for corn.

Overall per cent correct	
Finland (Highest achieving country)	87%
Australian females	86%
Australia	86%
Australian males	85%
OECD average	74%
Tunisia (Lowest achieving country)	29%

Genetically Modified Crops Attitudinal Question

The embedded attitudinal question in the unit `Genetically Modified Crops´ asks students to specify their interest in learning more about various aspects of genetically modified crops.

How much interest do you have in the following information?

Tick only one box in each row.

		High Interest	*Medium Interest*	*Low Interest*	*No Interest*
a)	Learning about the process by which plants are genetically modified	☐1	☐2	☐3	☐4
b)	Learning why some plants are not affected by herbicides	☐1	☐2	☐3	☐4
c)	Understanding better the difference between cross-breeding and genetic modification of plants	☐1	☐2	☐3	☐4

Table 2.7 Responses for Australian students and students across OECD countries to the Genetically Modified Crops attitudinal question

Attitudinal statements	Interest (%)							
	High		Medium		Low		No	
	Aust.	OECD	Aust.	OECD	Aust.	OECD	Aust.	OECD
a) Learning about the process by which plants are genetically modified	7	23	31	42	37	24	24	6
b) Learning why some plants are not affected by herbicides	5	28	26	35	42	24	26	7
c) Understanding better the difference between cross-breeding and genetic modification of plants	9	30	30	32	36	22	24	10

Sunscreens

The stimulus `Sunscreens´ provides a description of a scientific experiment being undertaken by two people to investigate which sunscreen product provides the best protection for their skin. The unit is set in a personal context in the area of health.

SUNSCREENS

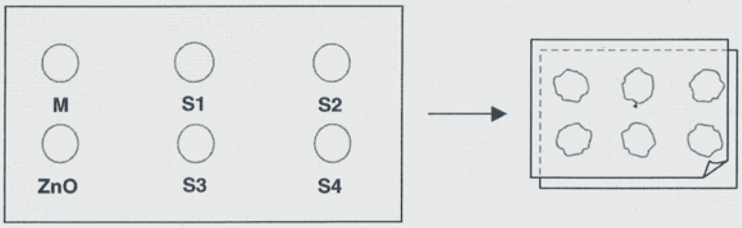
Mimi and Dean wondered which sunscreen product provides the best protection for their skin. Sunscreen products have a *Sun Protection Factor (SPF)* that shows how well each product absorbs the ultraviolet radiation component of sunlight. A high SPF sunscreen protects skin for longer than a low SPF sunscreen.

Mimi thought of a way to compare some different sunscreen products. She and Dean collected the following:

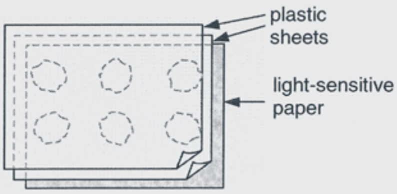
- two sheets of clear plastic that do not absorb sunlight;
- one sheet of light-sensitive paper;
- mineral oil (M) and a cream containing zinc oxide (ZnO); and
- four different sunscreens that they called S1, S2, S3, and S4.

Mimi and Dean included mineral oil because it lets most of the sunlight through, and zinc oxide because it almost completely blocks sunlight.

Dean placed a drop of each substance inside a circle marked on one sheet of plastic, then put the second plastic sheet over the top. He placed a large book on top of both sheets and pressed down.



Mimi then put the plastic sheets on top of the sheet of light-sensitive paper. Light-sensitive paper changes from dark grey to white (or very light grey), depending on how long it is exposed to sunlight. Finally, Dean placed the sheets in a sunny place.



Sunscreens Question 2

Question 2 in the `Sunscreen´ unit requires students to apply their knowledge of scientific enquiry by selecting the statement that is a scientific description of the role of the two substances in comparing the effectiveness of two sunscreens. This question assesses the competency *identifying scientific issues*. It is a multiple-choice item at Level 4 with a difficulty of 588 score points.

Which one of these statements is a scientific description of the role of the mineral oil and the zinc oxide in comparing the effectiveness of the sunscreens?

A Mineral oil and zinc oxide are both factors being tested.
B Mineral oil is a factor being tested and zinc oxide is a reference substance.
C Mineral oil is a reference substance and zinc oxide is a factor being tested.
D Mineral oil and zinc oxide are both reference substances.

Overall per cent correct	
Finland (Highest achieving country)	68%
Australian females	47%
Australia	43%
Australian males	39%
OECD average	41%
Azerbaijan (Lowest achieving country)	15%

Sunscreens Question 3

The next question is a multiple-choice item assessing the competency *identifying scientific issues*. This item was placed at Level 3 (with a difficulty of 499 score points) and students must rely on their knowledge about scientific enquiry to answer this question correctly. It is noteworthy (and perhaps not unexpected) that Australian students achieved the highest per cent correct for this question.

Which one of these questions were Mimi and Dean trying to answer?

A How does the protection for each sunscreen compare with the others?
B How do sunscreens protect your skin from ultraviolet radiation?
C Is there any sunscreen that gives less protection than mineral oil?
D Is there any sunscreen that gives more protection than zinc oxide?

Overall per cent correct	
Australia (Highest achieving country)	72%
Australian females	75%
Australian males	69%
OECD average	58%
Argentina (Lowest achieving country)	21%

Sunscreens Question 4

This question also assesses students´ knowledge about scientific enquiry in the *identifying scientific issues* competency. It was located at 574 score points in Level 4. Students were asked to identify why the second sheet of plastic was pressed down.

Why was the second sheet of plastic pressed down?

A To stop the drops from drying out.
B To spread the drops out as far as possible.
C To keep the drops inside the marked circles.
D To make the drops the same thickness.

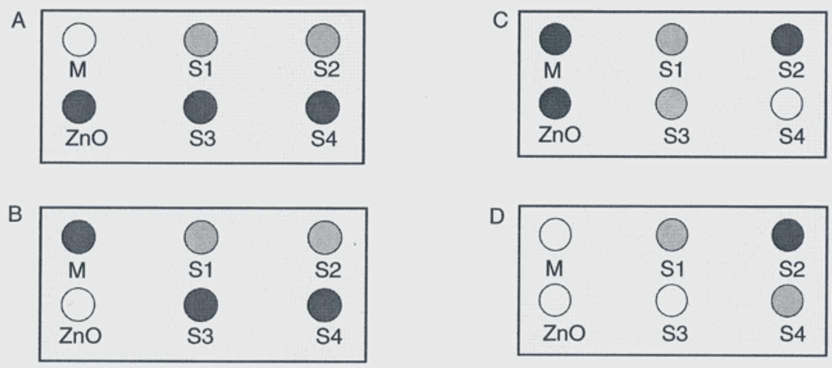
Overall per cent correct	
Australia and New Zealand (Highest achieving countries)	56%
Australian females	58%
Australian males	53%
OECD average	43%
Azerbaijan (Lowest achieving country)	23%

Sunscreens Question 5

The final question from this unit was also placed at a proficiency of Level 4 with a full credit of 629 score points and a partial credit of 616 score points. This question assessed the competency *using scientific evidence* and students had to rely on their knowledge about scientific explanations. In this question, students are given an experiment and asked to interpret a pattern of results and explain their conclusion.

The light-sensitive paper is a dark grey and fades to a lighter grey when it is exposed to some sunlight, and to white when exposed to a lot of sunlight.

Which one of these diagrams shows a pattern that might occur? Explain why you chose it.



Answer: ....

Explanation: ....

....

....

The coding guide for this question is included here to illustrate the nature of the PISA coding criteria. It also shows the way that items in PISA were coded as full or partial credit.

Sunscreen Coding Guide

Full Credit

Code 2: A. With explanation that the ZnO spot has stayed dark grey (because it blocks sunlight) **and** the M spot has gone white (because mineral oil absorbs very little sunlight).
[It is **not** *necessary (though it is sufficient) to include the further explanations that are shown in parentheses.]*

- A. ZnO has blocked the sunlight as it should and M has let it through.
- I chose A because the mineral oil needs to be the lightest shade while the zinc oxide is the darkest.

Partial Credit

Code 1: A. Gives a correct explanation for either the ZnO spot or the M spot, but not both, and does not give an incorrect explanation for the other spot.

- A. Mineral oil provides the lowest resistance against UVL. So with other substances the paper would not be white.
- A. Zinc oxide absorbs practically all rays and the diagram shows this.

No Credit

Code 0: Other responses.

- A because ZnO blocks the light and M absorbs it.
- B. ZnO blocks the sunlight and mineral oil lets it through.

Code 9: Missing.

The next two samples are examples of responses that were awarded full marks for completing this question accurately.

Answer: A

Explanation: Because zinc is very strong and blocks a lot of sunlight (thus being dark grey) and mineral oil doesn't block any (thus being white)

Answer: A

Explanation: The circle with the zinc oxide in it stayed dark grey, where as the circle with the mineral oil turned a stark white - proving that mineral oil lets most light through & zinc oxide completely blocks out sun light. The circles with S3 + S4 remained dark grey & S2 + S1 were only slightly lighter, showing that some sunscreens will protect your skin more than others, depending on their SPF rating.

Overall per cent correct	
Korea (Highest achieving country)	46%
Australian females	39%
Australia	36%
Australian males	34%
OECD average	27%
Kyrgyzstan (Lowest achieving country)	3%

The next two student samples were awarded partial credit for their responses because they referred only to one of the products, not both.

Answer: ~~B~~ A

Explanation: The mineral oil lets sun through easily so it must be a white or light grey color after being exposed to the sun.

Answer: A

Explanation: Zno almost completly blocks out the sun. and the results look accurate.

Finally, this sample is an example of a response that was given no credit.

Answer: A

Explanation: I chose A because the oil is thin and would slide off where as other sunscreens are thick and easier to cover.

Greenhouse

The unit `Greenhouse´ assesses two competencies, *using scientific evidence* and *explaining phenomena scientifically*, from an environmental perspective with a global focus.

GREENHOUSE

Read the texts and answer the questions that follow.

THE GREENHOUSE EFFECT: FACT OR FICTION?

Living things need energy to survive. The energy that sustains life on the Earth comes from the Sun, which radiates energy into space because it is so hot. A tiny proportion of this energy reaches the Earth.

The Earth's atmosphere acts like a protective blanket over the surface of our planet, preventing the variations in temperature that would exist in an airless world.

Most of the radiated energy coming from the Sun passes through the Earth's atmosphere. The Earth absorbs some of this energy, and some is reflected back from the Earth's surface. Part of this reflected energy is absorbed by the atmosphere.

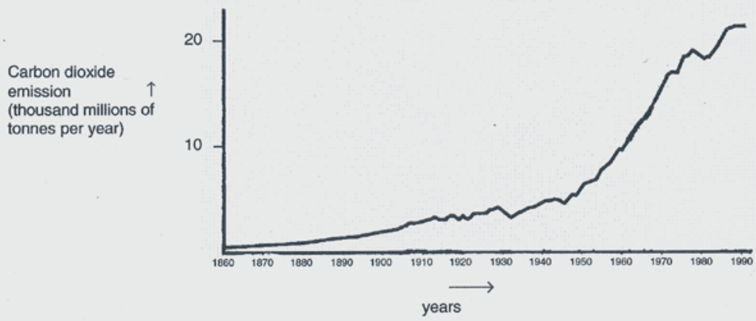
As a result of this the average temperature above the Earth's surface is higher than it would be if there were no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term *greenhouse effect.*

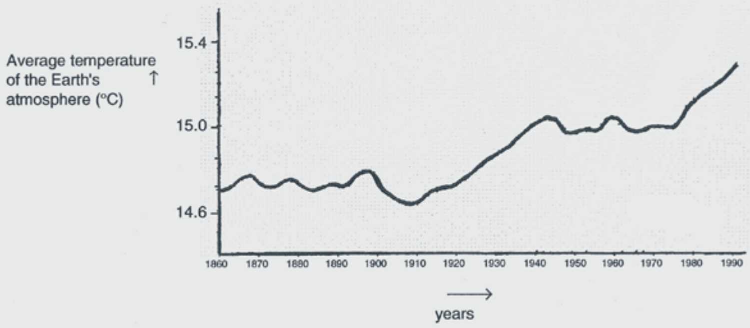
The greenhouse effect is said to have become more pronounced during the twentieth century.

It is a fact that the average temperature of the Earth's atmosphere has increased. In newspapers and periodicals the increased carbon dioxide emission is often stated as the main source of the temperature rise in the twentieth century.

A student named André becomes interested in the possible relationship between the average temperature of the Earth's atmosphere and the carbon dioxide emission on the Earth.

In a library he comes across the following two graphs.





André concludes from these two graphs that it is certain that the increase in the average temperature of the Earth's atmosphere is due to the increase in the carbon dioxide emission.

Greenhouse Question 3

This question is an open constructed response item assessing the using scientific evidence competency. It also assesses students´ knowledge about scientific explanation. For this question, students are asked to identify information in two graphs that supports a conclusion. Students must interpret the graphs to conclude there is an increase in both average temperature and carbon dioxide emissions. This question is placed at Level 3 with a difficulty of 529 score points.

What is it about the graphs that supports André's conclusion?

They both follow the same pattern. When there is a decrease in the emissions there is a decrease in the temperature.

Overall per cent correct	
Hong Kong-China (Highest achieving country)	75%
Australian females	69%
Australia	67%
Australian males	65%
OECD average	54%
Kyrgyzstan (Lowest achieving country)	11%

Greenhouse Question 4

This next question is an open constructed response item with full and partial credit awarded. It assesses the competency *using scientific evidence* and students must rely on their knowledge about scientific explanation.

Students are asked to provide an example of the two graphs that do not support André´s conclusion. To achieve full credit students must identify a segment on both graphs in which the curves are not both descending or both climbing and give a corresponding explanation. A full credit response was located at Level 5 with 659 score points.

Another student, Jeanne, disagrees with André's conclusion. She compares the two graphs and says that some parts of the graphs do not support his conclusion.

Give an example of a part of the graphs that does not support André's conclusion. Explain your answer.

In the years 1940 – 1980 the top graph takes a pretty steep rise, where as the bottom one goes pretty flat with a few rises and falls then becomes steep in 1980 – 1990

Students were awarded partial credit for example, if they mentioned the correct period but without any explanation, mentioned only one particular year (not a period of time) with an acceptable explanation, or referred to differences between the two curves without mentioning a specific period. A partial credit response was located at Level 4 with 568 score points.

> In 1910 while carbon dioxide is on the rise there is a dip in the tem perature.

Overall per cent correct	
Japan (Highest achieving country)	54%
Australian males	45%
Australia	44%
Australian females	43%
OECD average	35%
Kyrgyzstan (Lowest achieving country)	4%

Greenhouse Question 5

The final question in the unit `Greenhouse´ assesses the competency *explaining phenomena scientifically* and students´ knowledge of Earth and space systems. This question is one of the harder scientific literacy items to complete, placed at Level 6 with a difficultly of 709 score points. In this question students must provide a factor that could influence the greenhouse effect.

Two sample responses are shown. Both were coded as correct, though providing different perspectives.

> André persists in his conclusion that the average temperature rise of the Earth's atmosphere is caused by the increase in the carbon dioxide emission. But Jeanne thinks that his conclusion is premature. She says: "Before accepting this conclusion you must be sure that other factors that could influence the greenhouse effect are constant".
>
> Name one of the factors that Jeanne means.
>
> the rate of energy coming from the sun

Name one of the factors that Jeanne means.

Pollution - Gas, petrol /Transport etc/factories/.

Overall per cent correct	
The Netherlands (Highest achieving country)	34%
Australian males	22%
Australia	22%
Australian females	21%
OECD average	19%
Kyrgyzstan (Lowest achieving country)	3%

The next chapter, Chapter 3, provides details about Australian students' performance in scientific literacy in PISA 2006.

Chapter

3

Australian Students' Performance in Scientific Literacy

This chapter presents the international and national results for scientific literacy, firstly for science overall and then for the subscales described in Chapter 2. The reporting of these results includes both mean scores and proficiency levels, as both are important to policy makers.

Performance in overall scientific literacy

An international perspective

Table 3.1 and Figure 3.1 provide a summary of the overall performance of different countries on the combined science scale, in terms of the mean scores achieved by students in each country, and the differences between the 5th and 95th percentile scores. Typically, changes in mean performance are used to assess improvement in the quality of schools and education systems. However, the mean level of performance does not provide the complete picture of student achievement and can mask significant variation within an individual class, school or education system. Countries aim not only to encourage high performance but also to minimise internal disparities in performance.

Australian students achieved a mean score of 527 in overall scientific literacy, significantly higher than the OECD mean of 500[9]. Finland achieved the highest score with an average of 563 score points. This is significantly higher than Hong Kong-China, the next highest achieving country, with a score of 542 score points. Three countries, two of them OECD countries, achieved higher mean scores on the overall scientific literacy scale than Australia – Finland, Hong Kong-China and Canada. Seven countries had mean scores not significantly different from that of Australia. These included Japan, New Zealand, the Netherlands and Korea. Australia's score was significantly higher than that of all other countries, including Germany, the United Kingdom and the United States.

[9] Multiple comparison tables, which provide the statistical significance of differences between all countries, are provided in Appendix 4 of this report.

How big is big? Interpreting differences in PISA scores

How do we go about understanding the difference in average scores between two groups of students? Is the difference of 36 score points, on average, between students in Finland and students in Australia big? Small? Meaningful? The following comparisons can help to judge the magnitude of score differences. A difference of 75 score points represents one proficiency level on the PISA science scales. This can be considered a comparatively large difference in student performance in substantive terms. For example, with regard to the skills that were described in Chapter 2 in the section on the PISA 2006 assessment framework, Level 3 requires students to select facts and knowledge to explain phenomena and apply simple models or inquiry strategies, whereas at Level 2 students are only required to engage in direct reasoning and make literal interpretations.

Another benchmark is that for the 28 OECD countries in which a sizeable number of 15-year-olds in the PISA samples were enrolled in at least two different grades, the difference in mean scores between students in the two grades implies that one school year corresponds to an average of 34 score points on the PISA science scale. So the difference in average scores between Australian and Finnish students is around one school year.

Fourteen of the 30 OECD countries – Finland, Canada, New Zealand, Japan, Australia, the Netherlands, Korea, Germany, United Kingdom, Czech Republic, Switzerland, Austria, Belgium and Ireland – scored higher than the OECD average. Five OECD countries – Hungary, Sweden, Poland, Denmark and France – scored at a level not significantly different from the OECD mean. The remaining 11 OECD countries – Iceland, United States, Spain, Slovak Republic, Norway, Luxembourg, Italy, Portugal, Greece, Turkey and Mexico – scored at a level significantly lower than the OECD average.

The highest achieving partner countries were Hong Kong-China, with an average score of 542 score points, Chinese Taipei and Estonia, with scores of 532 and 531 score points respectively.

It is evident from Figure 3.1 that there is a considerable range of scores within most countries, and that the relationship between average score and amount of spread is not a simple one. In the countries with the lowest average scores, Kyrgyzstan and Qatar, the spread is also quite low – 276 score points. While the spread of scores in Finland is similar, at 281 score points, Finland's mean score is more than 200 (563 compared with 322) score points higher. Within the group of countries with scores statistically similar to Australia's, the spread ranges from 352 score points in New Zealand to 276 score points in Estonia. Australia's spread of 327 score points is in the middle of these two, although somewhat higher than the OECD average of 312 score points, and is narrower than the spread in the United States and the United Kingdom but wider than that of most other countries.

Table 3.1 Distribution of science achievement scores and variation, PISA 2006

Country		Mean Score	SE	Difference 5^{th} – 95^{th} percentile
Finland	Significantly higher than Australia	563	(2.0)	281
Hong Kong-China		542	(2.5)	301
Canada		534	(2.0)	309
Chinese Taipei	Not significantly different from Australia	532	(3.6)	307
Estonia		531	(2.5)	276
Japan		531	(3.4)	328
New Zealand		530	(2.7)	352
Australia		**527**	**(2.3)**	**327**
Netherlands		525	(2.7)	313
Liechtenstein		522	(4.1)	317
Korea		522	(3.4)	296
Slovenia	Significantly lower than Australia	519	(1.1)	322
Germany		516	(3.8)	328
United Kingdom		515	(2.3)	348
Czech Republic		513	(3.5)	322
Switzerland		512	(3.2)	325
Macao-China		511	(1.1)	257
Austria		511	(3.9)	321
Belgium		510	(2.5)	323
Ireland		508	(3.2)	309
Hungary		504	(2.7)	288
Sweden		503	(2.4)	308
OECD average		**500**	**(0.5)**	**312**
Poland		498	(2.3)	293
Denmark		496	(3.1)	305
France		495	(3.4)	333
Croatia		493	(2.4)	280
Iceland		491	(1.6)	316
Latvia		490	(3.0)	279
United States		489	(4.2)	344
Slovak Republic		488	(2.6)	305
Spain		488	(2.6)	295
Lithuania		488	(2.8)	293
Norway		487	(3.1)	313
Luxembourg		486	(1.1)	318
Russian Federation		479	(3.7)	295
Italy		475	(2.0)	312
Portugal		474	(3.0)	288
Greece		473	(3.2)	303
Israel		454	(3.7)	361
Chile		438	(4.3)	300
Serbia		436	(3.0)	279
Bulgaria		434	(6.1)	346
Uruguay		428	(2.7)	310
Turkey		424	(3.8)	274
Jordan		422	(2.8)	292
Thailand		421	(2.1)	253
Romania		418	(4.2)	266
Montenegro		412	(1.1)	263
Mexico		410	(2.7)	263
Indonesia		393	(5.7)	232
Argentina		391	(6.1)	337
Brazil		390	(2.8)	295
Colombia		388	(3.4)	280
Tunisia		386	(3.0)	273
Azerbaijan		382	(2.8)	185
Qatar		349	(0.9)	276
Kyrgyzstan		322	(2.9)	276

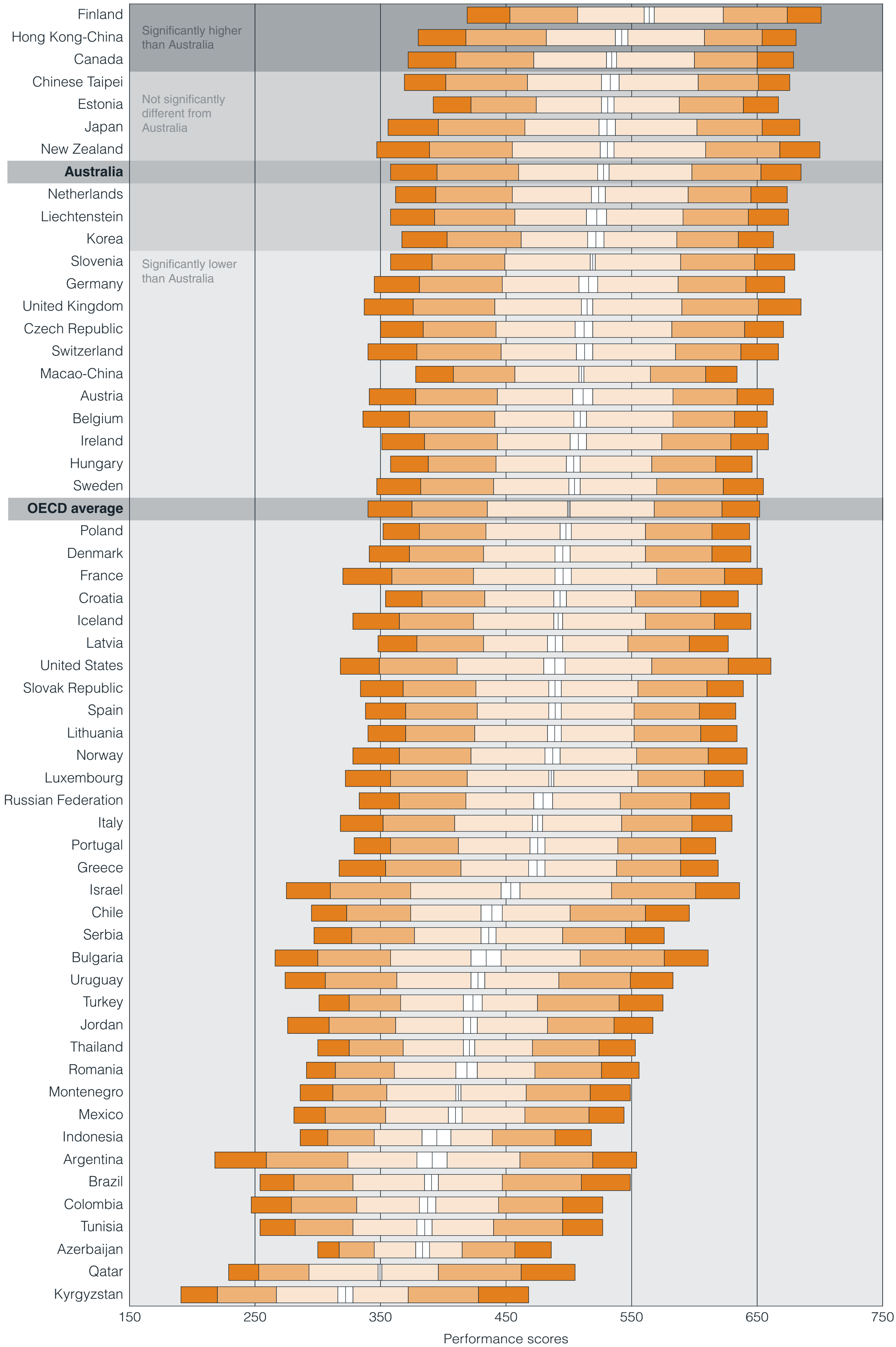


Figure 3.1 International student performance in scientific literacy

In addition to comparing country mean scores, it is possible to use the proficiency levels described in Chapter 2 to gain further insight into student achievement. Figure 3.2 provides the proportion of students in each country at each of the proficiency levels. Countries are ordered from top to bottom according to the percentage of students achieving below Level 2.

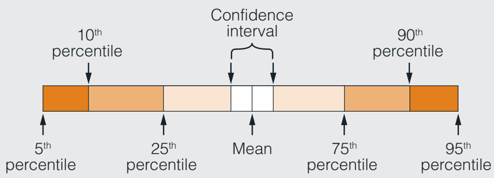
PISA devotes significant attention to the assessment of students at the high end of the skill distribution. In the case of science, in particular, there is a growing demand for highly-skilled workers, and while basic competencies are generally considered important for the absorption of new technology, high-level competencies are critical for the creation of new technology and innovation.

On average across OECD countries just over one per cent of 15-year-olds reach the highest level on the PISA overall science scale, Level 6, but in Finland and New Zealand almost four per cent achieved this level. In the United Kingdom, Australia, Japan and Canada, as well as the partner countries Liechtenstein, Slovenia and Hong Kong-China, between two and three per cent reached this level.

The proportion of 15-year-olds across OECD countries who achieve at least Level 5 is nine per cent. However in Finland, as many as one-fifth (21%) of students achieve at this level of scientific literacy. Finnish authorities attribute much of this enormous success to the Luma program, which fostered excellence in science education and was progressively implemented between 1996 and 2002. As well as the outstanding proportion of students in the very high achievement levels, Finland has had higher enrolments in the higher education areas of science and technology, and the Luma program has led to the establishment of specialised classes or streams in high schools, which specialise in mathematics or science.

New Zealand (with 18% of students at Level 5 or above), Australia (15%), Japan (15%) and partner country Hong Kong-China (16%) are also well-placed to create a pool of talented scientists, if these high-performing students can be encouraged to continue their studies in the area of science.

The proportion of students in the lower levels of scientific literacy is also important for countries to be aware of, as these students may have difficulty participating in the labour force, especially in highly developed economies such as Australia's. As described earlier, Level 2 has been established as a baseline level, defining the level of achievement on the PISA scale at which students begin to demonstrate the scientific competencies that will enable them to participate actively in life situations related to science and technology.



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Each country's results are represented in horizontal bars with various colours. On the left end of the bar is the 5th percentile – this is the score below which 5 per cent of the students have scored. The next two lines indicate the 10th percentile and the 25th percentile. The next line at the left of the white band is the lower limit of the confidence interval for the mean – i.e. there is 95 per cent confidence that the mean will lie in this white band. The line in the centre of the white band is the mean. The lines to the right of the white band indicate the 75th, 90th and 95th percentiles.

Results for states are presented vertically, however the interpretation is the same.

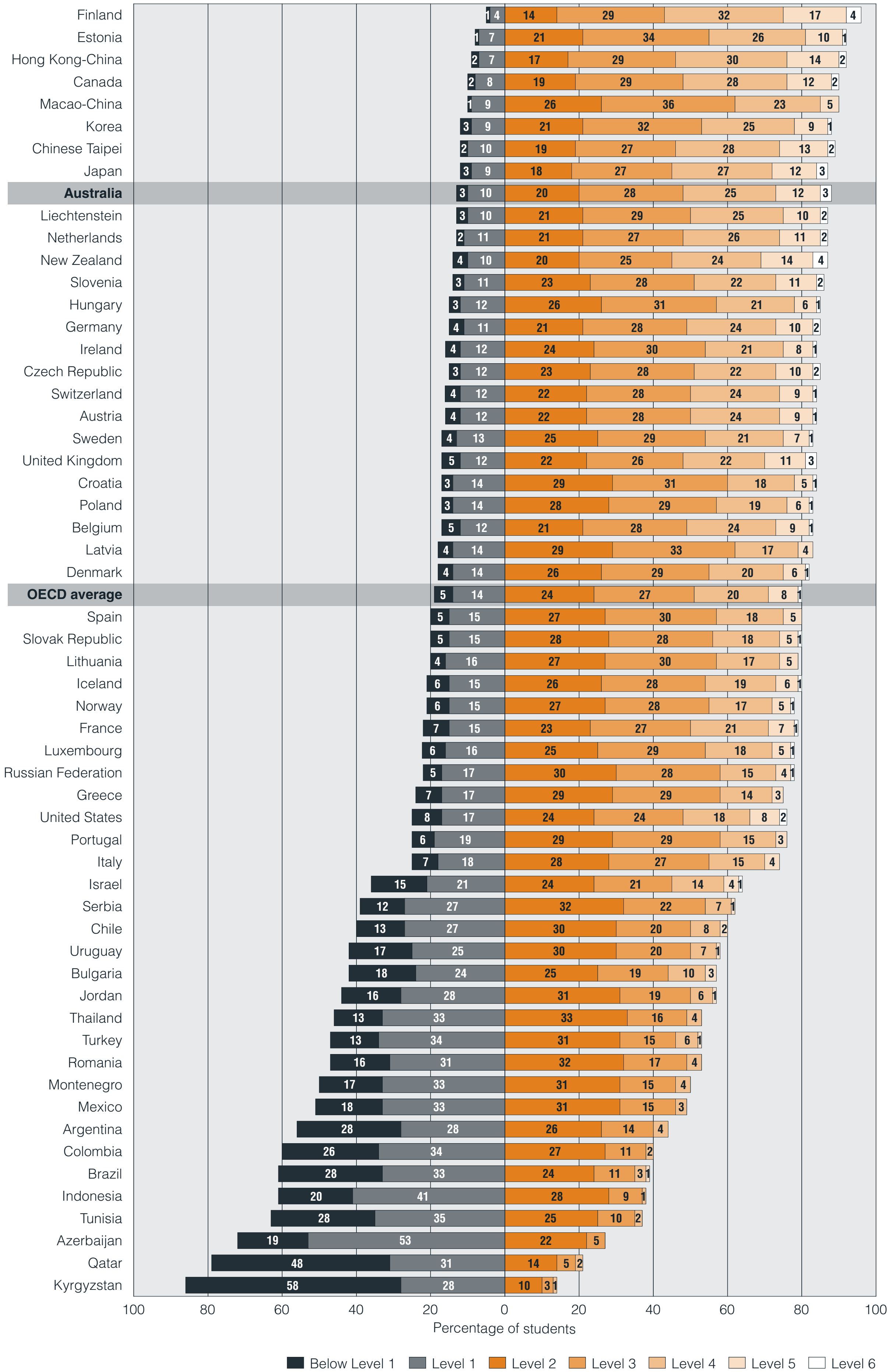


Figure 3.2 Proficiency levels for students in scientific literacy by country

Across the OECD, 19 per cent of students are categorised as achieving below Level 2. However, here again there is a substantial variability. In two OECD countries around half of the students are not proficient at Level 2: Mexico (51%) and Turkey (47%). In Australia, around 13 per cent of students achieved below Level 2. Whilst this is clearly of concern, it is important to put it in an international perspective. While in Finland and Estonia, the proportions of students achieving at these very low levels are five and eight per cent respectively, in other countries with which it is more relevant to compare Australian results, the proportions of students performing below Level 2 range from 10 per cent in Canada, 12 per cent in Japan and 14 per cent in New Zealand, to some 17 per cent in the United Kingdom and one-quarter (25%) in the United States.

Performance by gender

Figure 3.3 shows that there are statistically significant gender differences in performance on the overall scientific literacy scale in about one-third of the participating countries. Mean scores and standard errors are shown in the table on the left of the figure, while the right side of the figure illustrates the difference between males and females graphically. If the bar is shaded, the difference between male and female students is significant.

The OECD average shows a small but statistically significant difference in favour of males. Among OECD countries, males significantly outperformed females in the United Kingdom, Luxembourg, Denmark, Switzerland, Mexico and the Netherlands. In Greece and Turkey, females significantly outperformed males. Among the partner countries, gender differences were seen in favour of females in Qatar (31 score points) and Jordan (28 score points) and in favour of males in Chile (22 score points). In a total of 12 countries females significantly outperformed males and in eight countries males outscored females.

	Females		Males	
	Mean score	SE	Mean score	SE
Qatar	365	(1.3)	334	(1.2)
Jordan	436	(3.3)	408	(4.5)
Bulgaria	443	(6.9)	426	(6.6)
Thailand	428	(2.5)	411	(3.4)
Argentina	397	(6.8)	384	(6.5)
Turkey	430	(4.1)	418	(4.6)
Greece	479	(3.4)	468	(4.5)
Liechtenstein	527	(6.3)	516	(7.6)
Lithuania	493	(3.1)	483	(3.1)
Slovenia	523	(1.9)	515	(2.0)
Azerbaijan	386	(2.7)	379	(3.1)
Latvia	493	(3.2)	486	(3.5)
Iceland	494	(2.1)	488	(2.6)
Kyrgyzstan	325	(3.0)	319	(3.6)
Serbia	438	(3.8)	433	(3.3)
Tunisia	388	(3.5)	383	(3.2)
Norway	489	(3.2)	484	(3.8)
New Zealand	532	(3.6)	528	(3.9)
Estonia	533	(2.9)	530	(3.1)
Finland	565	(2.4)	562	(2.6)
Uruguay	430	(2.7)	427	(4.0)
Croatia	494	(3.1)	492	(3.3)
Romania	419	(4.8)	417	(4.1)
Montenegro	413	(1.7)	411	(1.7)
Korea	523	(3.9)	521	(4.8)
Ireland	509	(3.3)	508	(4.3)
Australia	527	(2.7)	527	(3.2)
United States	489	(4.0)	489	(5.1)
Belgium	510	(3.2)	511	(3.3)
Sweden	503	(2.9)	504	(2.7)
OECD average	499	(0.6)	501	(0.7)
France	494	(3.6)	497	(4.3)
Russian Federation	478	(3.7)	481	(4.1)
Italy	474	(2.5)	477	(2.8)
Japan	530	(5.1)	533	(4.9)
Poland	496	(2.6)	500	(2.7)
Israel	452	(4.2)	456	(5.6)
Macao-China	509	(1.6)	513	(1.8)
Canada	532	(2.1)	536	(2.5)
Spain	486	(2.7)	491	(2.9)
Czech Republic	510	(4.8)	515	(4.2)
Portugal	472	(3.2)	477	(3.7)
Switzerland	509	(3.6)	514	(3.3)
Slovak Republic	485	(3.0)	491	(3.9)
Hungary	501	(3.5)	507	(3.3)
Mexico	406	(2.6)	413	(3.2)
Hong Kong-China	539	(3.5)	546	(3.5)
Chinese Taipei	529	(5.1)	536	(4.3)
Germany	512	(3.8)	519	(4.6)
Netherlands	521	(3.1)	528	(3.2)
Austria	507	(4.9)	515	(4.2)
Denmark	491	(3.4)	500	(3.6)
Brazil	386	(2.9)	395	(3.2)
Colombia	384	(4.1)	393	(4.1)
Luxembourg	482	(1.8)	491	(1.8)
United Kingdom	510	(2.8)	520	(3.0)
Indonesia	387	(3.7)	399	(8.2)
Chile	426	(4.4)	448	(5.4)

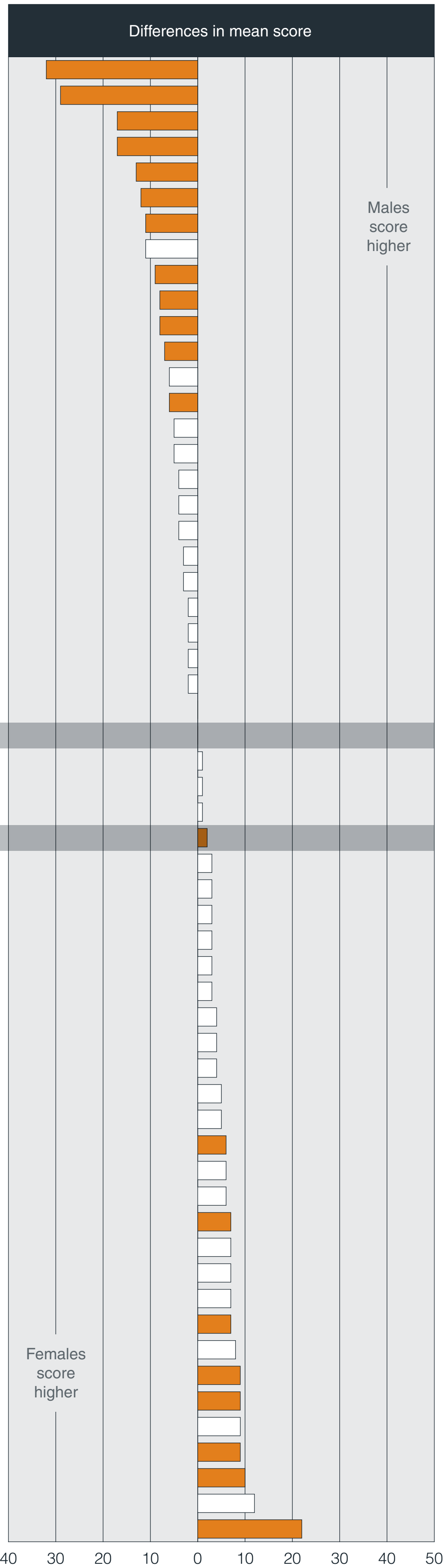


Figure 3.3 Means by gender and gender differences in scientific literacy by country

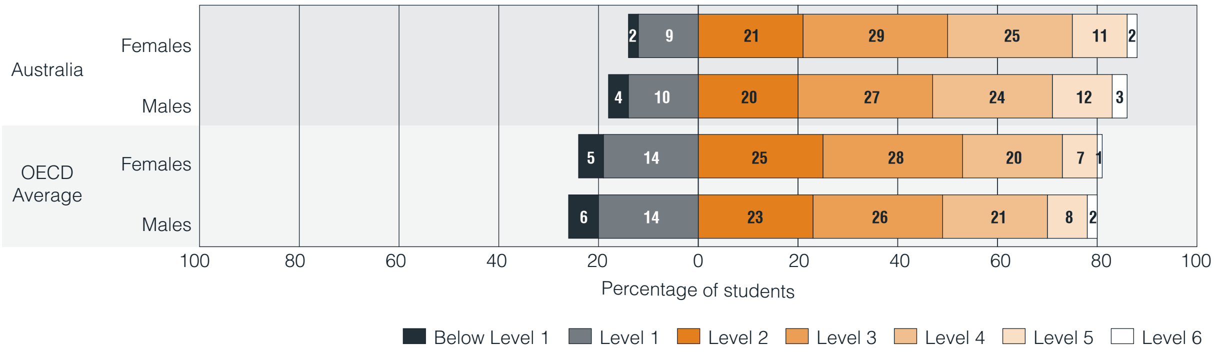


Figure 3.4 Proficiency levels for students in scientific literacy by gender, Australia and OECD average

Figure 3.4 shows the percentage of Australian male and female students at each proficiency level, along with the percentages for the OECD. Within Australia, there was a slightly higher percentage of males at both ends of the proficiency levels: 14 per cent of males and 11 per cent of females not achieving Level 2, and 15 per cent of males and 13 per cent of females achieving at Level 5 or above. As might be expected given Australia's good performance relative to the OECD average, these figures are more favourable than those for the OECD. Across the OECD, about 20 per cent of both males and females did not achieve Level 2, while only 10 per cent of males and eight per cent of females achieved at Level 5 or higher.

Performance by state

Figure 3.5 presents the distribution of performance for each of the Australian states in the same way as the international results are presented in Figure 3.1. To place the state results in perspective, the means and distributions for the OECD, for Australia as a whole, and for the highest achieving country, Finland, are also included in the figure. The states are shown in order from lowest to highest mean scores.

Figure 3.5 should be read in conjunction with Table 3.2, which presents the multiple comparisons of mean performance between the states.

All states had mean scores at least as high as the OECD average. Other than Tasmania and the Northern Territory, all states performed at a significantly higher level than the OECD average. The average scores for Tasmania and the Northern Territory were not significantly different to the OECD average.

For all states there was a range in performance scores on the PISA overall scientific literacy assessment that was wider than the average for the OECD. The Northern Territory had the widest range from the 5th to 95th percentile of 414 score points, whilst the ranges for the two highest performing states, Western Australia and the Australian Capital Territory, were 328 and 337 score points respectively.

Figure 3.5 Student performance in scientific literacy by state

Figure 3.5 and Table 3.2 together show that the performance of students in the Australian Capital Territory was significantly better than that of students in all other states except Western Australia. Western Australia's average score was also similar to the average for students in New South Wales and South Australia, but higher than that for students in Queensland, Victoria, Tasmania and the Northern Territory. The average score in the Northern Territory was significantly lower than the score for any other state.

Table 3.2 Multiple comparisons of mean performance in scientific literacy by state

			ACT	WA	NSW	SA	QLD	VIC	TAS	NT	OECD
		Mean	549	543	535	532	522	513	507	490	500
	Mean	SE	4.9	6.8	4.6	4.9	4.2	4.9	4.6	6.6	0.5
ACT	549	4.9		●	▲	▲	▲	▲	▲	▲	▲
WA	543	6.8	●		●	●	▲	▲	▲	▲	▲
NSW	535	4.6	▼	●		●	▲	▲	▲	▲	▲
SA	532	4.9	▼	●	●		●	▲	▲	▲	▲
QLD	522	4.2	▼	▼	▼	●		●	▲	▲	▲
VIC	513	4.9	▼	▼	▼	▼	●		●	▲	▲
TAS	507	4.6	▼	▼	▼	▼	▼	●		▲	●
NT	490	6.6	▼	▼	▼	▼	▼	▼	▼		●

Note: Read across the row to compare a state's performance with the performance of each state listed in the column heading.
▲ Average performance statistically significantly higher than in comparison state
● No statistically significant difference from comparison state
▼ Average performance statistically significantly lower than in comparison state

As shown in Table 3.3, within the Australian states there were no statistically significant gender differences in performance on the overall scientific literacy scale.

Table 3.3 Means by gender and gender differences in scientific literacy by state

	Females		Males	
	Mean score	SE	Mean score	SE
NSW	539	4.8	531	7.5
NT	491	11.4	489	5.8
TAS	508	6.1	506	5.3
QLD	522	5.7	523	4.7
SA	531	6.1	533	5.6
WA	540	7.0	545	8.8
ACT	545	7.2	553	8.8
VIC	508	6.4	517	5.9

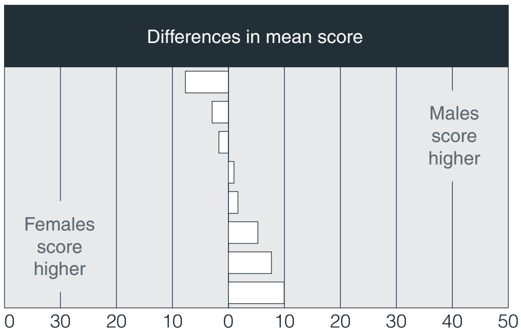


Figure 3.6 shows the proportion of students in each state at each of the described proficiency levels, along with the percentages for the OECD, Australia as a whole, and the highest scoring country, Finland.

As noted earlier, across the OECD, just over one per cent of students achieved at proficiency level 6, the highest proficiency level, while in Finland this proportion was almost four per cent. A similar proportion was achieved in the Australian Capital Territory, Western Australia and New South Wales. In all other states of Australia, the proportion of students achieving at the highest proficiency level was above the average for the OECD, at either two or three per cent.

All states achieved a higher proportion of students at Level 5 or greater than for the OECD as a whole. The Australian Capital Territory had the same proportion of students in these two levels as Finland, with one-fifth of its students achieving at this level. A similar proportion of students in Western Australia (19%) achieved at this level, while 17 per cent of students in New South Wales and 15 per cent of students in South Australia also achieved this very high level of scientific literacy. In the Northern Territory, 13 per cent of students, around one in six, achieved at this proficiency level.

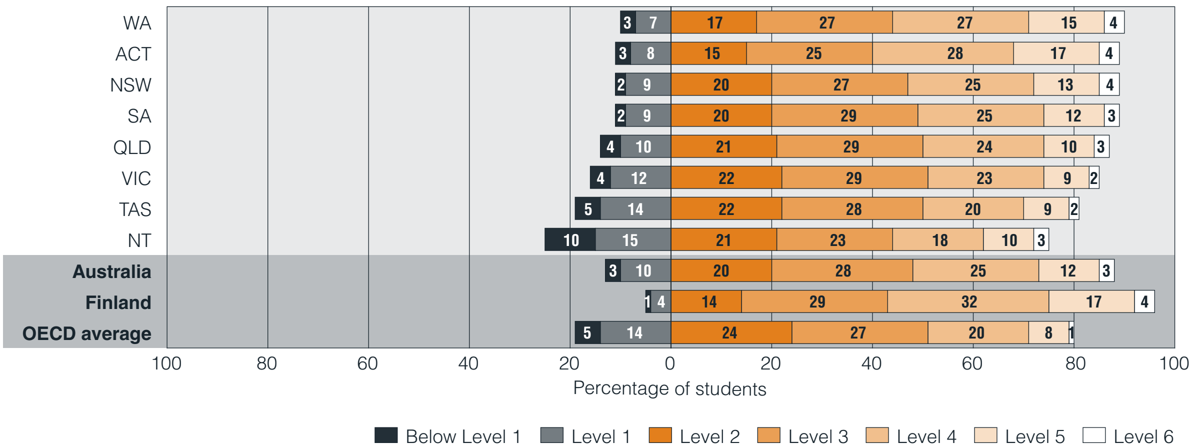


Figure 3.6 Proficiency levels in scientific literacy by state

The Australian Capital Territory and Western Australia both do well in not only having so many students at the highest proficiency level, but also in having high proportions of students beyond the minimum proficiency levels. In these two states, almost half of the students achieved at Level

4 or higher, and only around one in ten were unable to complete tasks at Level 2. In the Northern Territory, almost one-third (31%) of students were performing at Level 4 or higher; however, one-quarter were unable to complete tasks above Level 2.

Proficiency level data confirm that there were few gender differences within states in overall scientific literacy (Figure 3.7). In most states there is a slightly higher proportion of males than females who were not achieving at Level 2. However, only in New South Wales are these large enough to warrant comment. In New South Wales around nine per cent of females and almost 14 per cent of males did not achieve at Level 2, while almost the same proportion of males and females were achieving at the top proficiency levels.

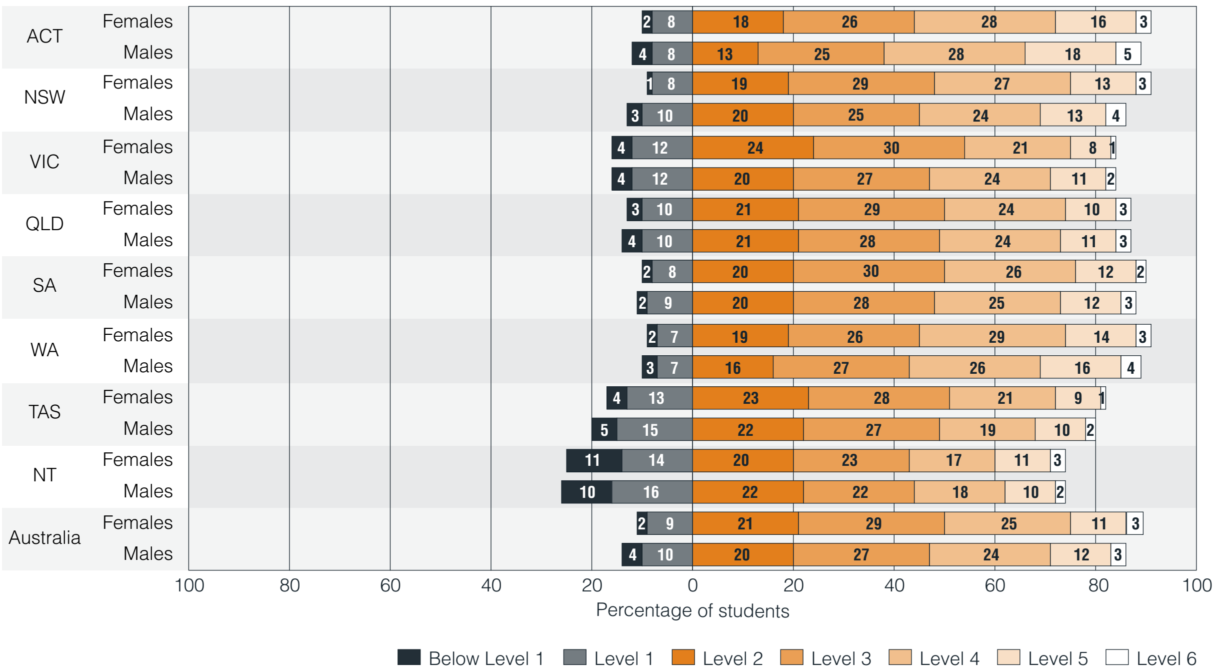


Figure 3.7 Proficiency levels in scientific literacy by state and gender

Performance of Indigenous students

The educational attainment of Australia's Indigenous population is an important policy issue. For this reason, PISA oversamples Indigenous students to ensure that detailed analysis is possible. Indigenous status is based on students' self-reports. A total of 425 students in the main sample identified as such, and an additional 655 15-year-old students from the participating PISA schools also participated in the assessment, providing a total sample of 1,080 Indigenous students.[10] The mean scores for overall scientific literacy for Indigenous and non-Indigenous students are shown in Table 3.4, and the spread of scores for both groups is shown in Figure 3.8.

Table 3.4 Means by gender in scientific literacy for Indigenous and non-Indigenous students

	Females		Males		Total	
	Mean	SE	Mean	SE	Mean	SE
Indigenous	443	11.7	439	10.1	441	7.8
Non-Indigenous	529	2.6	530	3.2	529	2.3

[10] All data analyses investigating Indigenous students include all (1,080) participating Indigenous students in PISA 2006.

It is evident from Table 3.4 that there is a very wide gap (88 score points) between the average performance in scientific literacy between Indigenous and non-Indigenous students. This reflects findings in both the PISA 2000 and PISA 2003 national reports in which similarly large gaps were found in terms of reading, mathematical literacy and scientific literacy. Clearly this difference is large and is significant not only statistically but educationally. It represents a difference of one full proficiency level, or two and a half years of formal schooling. There were no significant differences between the achievement levels of male and female Indigenous students.

The spread of scores for Indigenous students (between the 5th and 95th percentiles) was 356 score points, substantially larger than that for non-Indigenous students (324 score points). The fact that the spread is large for Indigenous students is not all bad news, however, as it means that some Indigenous students are scoring at high levels (above 600 score points) as well as at lower levels.

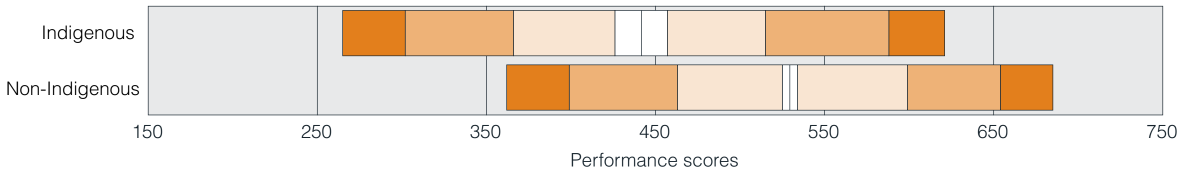


Figure 3.8 Indigenous and non-Indigenous performance in scientific literacy

Figure 3.9 adds to the picture of performance by showing the proportion of Indigenous and non-Indigenous students in each of the six science proficiency levels, as well as the OECD average for comparison. There is an over-representation of Indigenous students at the lower levels of achievement, with 40 per cent (that is four in ten) not able to achieve Level 2 and 17 per cent (almost one in five) scoring below Level 1. In contrast, 12 per cent of non-Indigenous students were not achieving Level 2, and only three per cent were below Level 1. At the high end of the achievement spectrum the differences are also stark. While some Indigenous students do achieve scores above 600, only three per cent achieved at Level 5 or above compared with 15 per cent of non-Indigenous students.

Consistent with the findings of Table 3.4 there were no significant differences in achievement at proficiency levels between male and female Indigenous students.

Poor performance by Indigenous students is inextricably linked to geographic location and to socioeconomic background. The performance of Indigenous students in these contexts will be examined in a subsequent report.

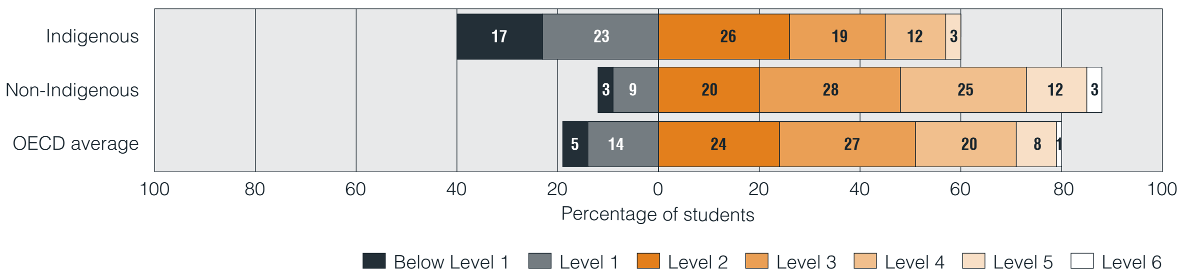


Figure 3.9 Proficiency levels for Indigenous and non-Indigenous students in scientific literacy

Performance by geographic location of school

In the 1900s more than half of Australia's population lived in rural areas (Squires, 2003); however, this figure dropped to about 20 per cent towards the end of the 20th century and continues to decline. As a result, rural schools face problems attracting and retaining qualified teachers, maintaining services and in sending staff to participate in professional development (Lyons, Cooksey, Panizzon, Parnell & Pegg, 2006). It is also estimated that average household income in remote areas is substantially lower than the national average (Squires, 2003).

To undertake the analysis in this section of the report, schools' addresses were coded using the MCEETYA Schools Geographic Location Classification (see Reader's Guide). Only the broad categories – Metropolitan, Provincial and Remote – are used in these analyses. The means and standard errors of students attending schools in the three location categories are shown in Table 3.5. The differences shown in the table are significant. The gaps between the scores of students in remote schools and those in other areas are particularly large – the 57 score point gap between those students attending schools in remote areas and those attending metropolitan schools represents almost two full school years.

Table 3.5 Means in scientific literacy by geographic location

	Mean	SE	Differences
Metropolitan	531	2.8	
Provincial	521	3.5	–10 (to Metropolitan)
Remote	474	15.6	– 47 (to Provincial)

The spread of achievement by geographic location is shown in Figure 3.10. The spread between the 5th and 95th percentile for metropolitan and provincial schools is 326 score points, and for remote schools the spread of scores was only slightly larger at 347 score points.

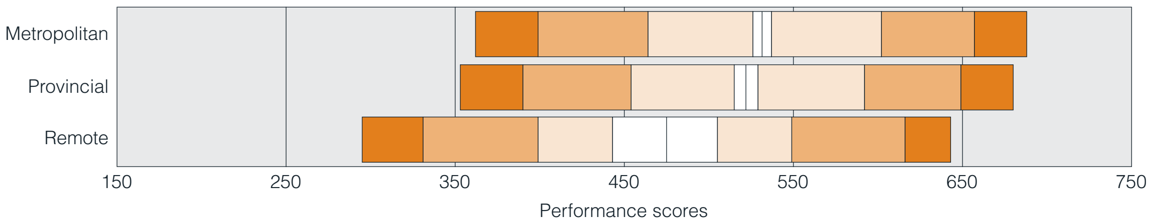


Figure 3.10 Student performance in scientific literacy by geographic location

Figure 3.11 shows the proficiency levels in scientific literacy by geographic location. This indicates little difference between students in metropolitan and provincial schools, but rather a large gap to the scores for those in remote schools. More than one-quarter of students in remote schools were not achieving at Level 2, compared with around 12 per cent of the cohort in metropolitan or provincial areas. At the higher end of the achievement scale, only seven per cent of students in remote areas achieved Level 5 or higher, compared with 13 and 15 per cent of students in provincial and metropolitan schools respectively.

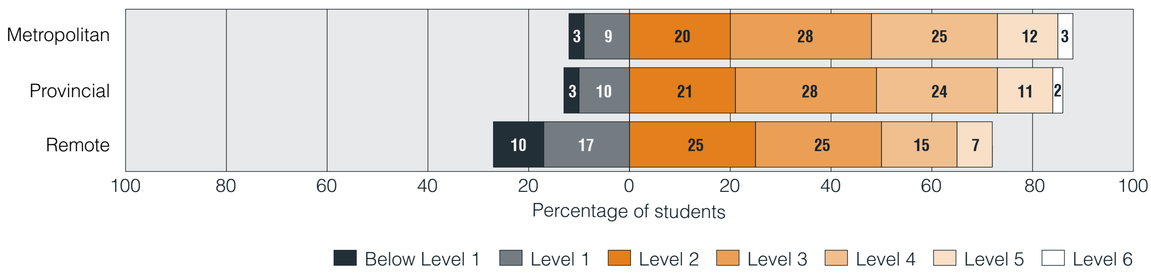


Figure 3.11 Proficiency levels in scientific literacy by geographic location

Scientific literacy and socioeconomic background

Socioeconomic background in PISA is measured via an index of economic, social and cultural status (ESCS), which captures the wider aspects of a student's family and home background (see Reader's Guide). Table 3.6 presents the mean scores for achievement in scientific literacy by quartile of socioeconomic background.

Table 3.6 Means in scientific literacy by quartiles of socioeconomic background

	Mean	SE	Difference from next lower quartile (score points)
Lowest quartile	485	2.2	
Second quartile	516	2.4	31
Third quartile	540	2.8	24
Highest quartile	572	2.8	32

Clearly, socioeconomic background is strongly related to achievement. The difference in score points between each level is of the order of approximately one school year. The distribution of scores for each group as shown in Figure 3.12 is similar, with each having a spread from the 5th to 95th percentile of around 300 score points.

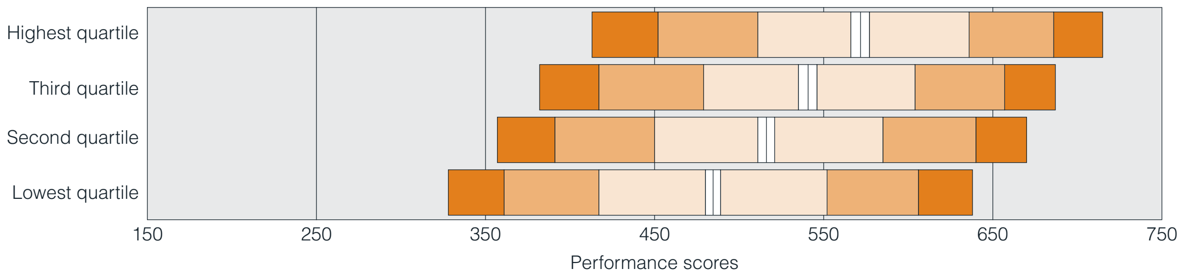


Figure 3.12 Student performance in scientific literacy by socioeconomic background

Figure 3.13 shows the proficiency levels for Australian students by quartiles of socioeconomic background. Almost one-quarter (23%) of students in the lowest quartile of socioeconomic background did not achieve Level 2, compared with just five per cent of those students in the highest quartile.

Students in the higher socioeconomic quartiles achieve well, with few students at lower proficiency levels and a high proportion at higher proficiency levels. It is quite striking that 26 per cent of students in the highest socioeconomic quartile were achieving at Level 5 or greater, compared to 16 per cent of those in the third quartile, 12 per cent of those in the second quartile and six per cent of those students in the lowest quartile. Almost five times the proportion of students in the lowest socioeconomic quartile compared to those in the highest socioeconomic quartile were achieving below the OECD's baseline level, Level 2.

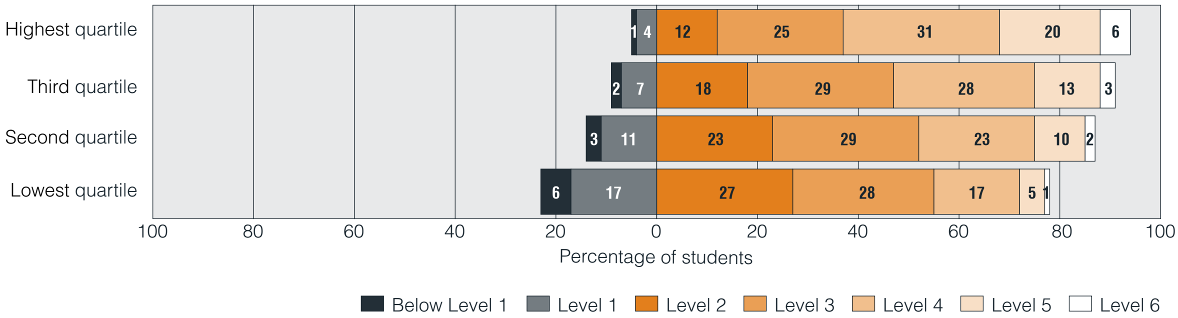


Figure 3.13 Proficiency levels in scientific literacy by socioeconomic background

Scientific literacy performance and immigrant status

To examine the effects of immigrant status on scientific literacy two indicators were used: immigrant status (based on country of birth of students and their parents) and language background. Language background is of interest because unfamiliarity with the language of testing could possibly be a factor in student performance in scientific literacy. As noted in Chapter 2, however, a special effort was made in PISA 2006 to minimise the language demands of the science test. Furthermore, students who had less than one year's tuition in the language of the test were excluded from the test population.

Table 3.7 shows the means and standard errors for scientific literacy by immigrant status (see Reader's Guide for definitions).

As was seen with mathematical literacy in the PISA 2003 assessment, there is no statistically significant difference in the mean scores for Australian-born, first-generation and foreign-born students. This is an indication that the reading load of the science test does not bias the test against those students not born in Australia.

Table 3.7 Means in scientific literacy by immigrant status

Immigrant status	Proportion of students	Mean	SE
Australian-born	60	528	2.1
First-generation	31	531	3.5
Foreign-born	9	526	5.7

Figure 3.14 shows the distribution of scores in scientific literacy by immigrant status. There is a very strong similarity in the distribution of scores for Australian-born and first-generation students, and the spread for foreign-born students is only a little larger (7 score points larger for the 5th to 95th percentile).

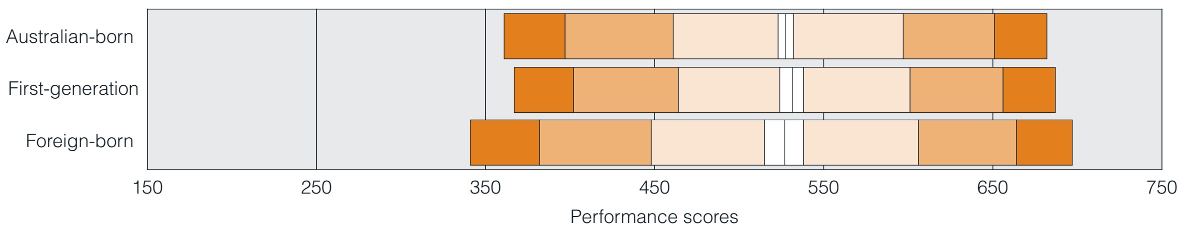


Figure 3.14 Student performance in scientific literacy by immigrant status

Figure 3.15 presents the proficiency levels for scientific literacy by immigrant status. This figure highlights two interesting differences between Australian-born students and foreign-born students. At the lower levels of achievement, the proportion of students not achieving Level 2 is a little higher for foreign-born students. However, at the upper end of achievement, 17 per cent of foreign-born students, compared to 15 per cent of Australian-born students, were achieving at Level 5 or above. Clearly with these students language is not an issue, and further study could examine characteristics of these groups of students in relation to Australian-born students.

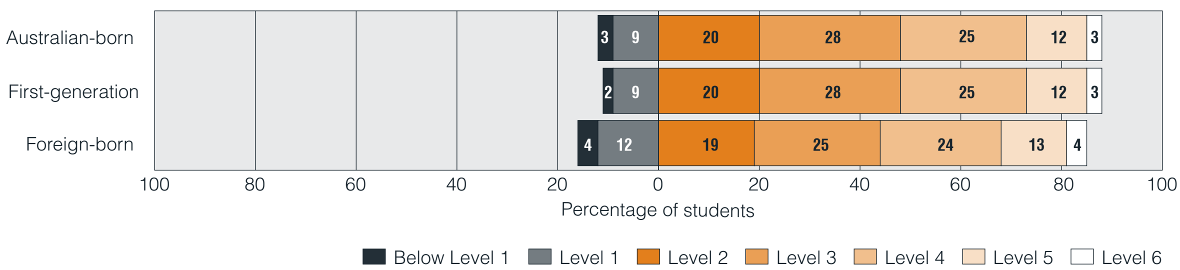


Figure 3.15 Proficiency levels in scientific literacy by immigrant status

Table 3.8 presents the means and associated standard errors in scientific literacy for those students whose language background is English and for those students for whom this is not the case. In this instance, the difference between the means is significant, and at around 23 score points represents about two-thirds of a school year difference in scientific literacy. Despite this difference, it is also clear that the students who spoke a language other than English at home also perform very well, their mean score being at a level statistically similar to the OECD mean.

Table 3.8 Means in scientific literacy by language background

Language background	Percentage of students	Mean	SE
Speak English at home	92	530	2.0
Language other than English spoken at home	8	507	7.6

Figure 3.16 shows the distribution of scientific literacy scores for each group of students and this shows that the distribution of scores at the lower achievement levels seems to be elongated. The difference in scores between the 5th and 95th percentiles is 321 for English speakers and 357 for those who do not speak English at home.

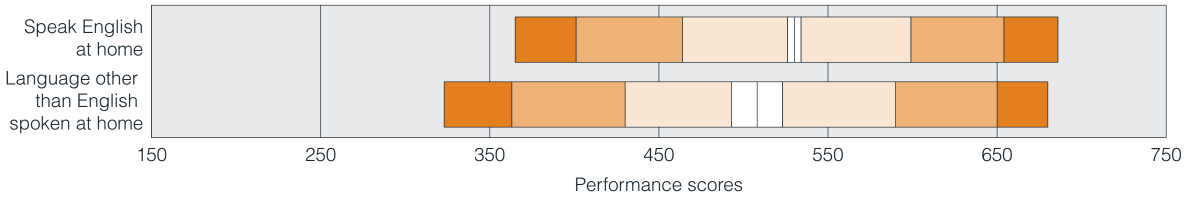


Figure 3.16 Student performance in scientific literacy by language background

This can be investigated a little further by examining the proportion of students at each of the proficiency levels, shown in Figure 3.17. At the higher levels, 15 per cent of English-speaking students and 13 per cent of those with a language background other than English were found to be achieving at Level 5 or greater. At the other end of the scale, 11 per cent of English-speaking students and 20 per cent of those with a language background other than English were found not to be achieving at least Level 2. Further study on this group of students would need to be undertaken to ascertain whether language is a barrier to good performance in the PISA assessment or whether understanding of the science curriculum is different.

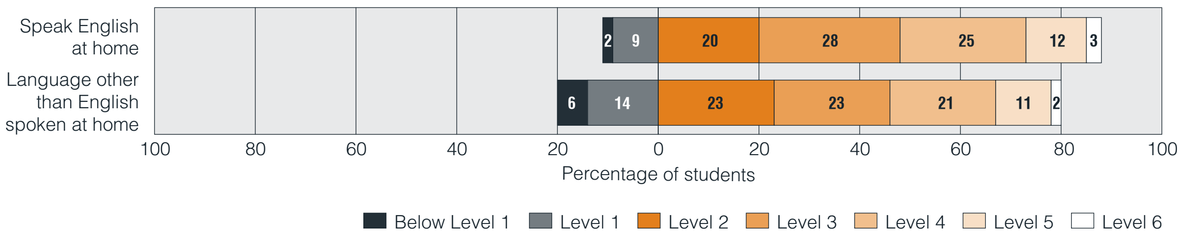


Figure 3.17 Proficiency levels in scientific literacy by language background

Achievement in the PISA knowledge domains

There were two knowledge domains defined in scientific literacy – knowledge about science and knowledge of science. Australian students scored significantly higher than the OECD average in both domains, scoring 533 points for knowledge about science compared to the OECD average of 500, and 528 points for knowledge of science, compared to the OECD average of 500.

The knowledge of science domain can be divided into the content areas "physical systems","living systems" and "Earth and space systems". The fourth content area, "technology systems", is not analysed separately as it contains too few items for analysis. An analysis will be presented in this section from the PISA 2006 International Report for completeness only – no further sub-national analysis is possible.[11] An overall view of Australian students' strengths and weaknesses across the content areas is valuable for relating PISA 2006 science results to national curricula. This is presented in Table 3.9.

[11] The data for these two scales was not scaled for the purposes of sub-national analyses.

Table 3.9 Comparison of mean performance on the different scales in science

	Australia	SE	Males	SE	Females	SE	OECD average	SE
Physical systems	515	(1.9)	528	(2.6)	502	(2.3)	500	(0.5)
Living systems	522	(2.1)	522	(2.9)	521	(2.6)	502	(0.5)
Earth and space systems	530	(1.9)	538	(2.6)	522	(2.4)	500	(0.5)
Overall science performance	527	(2.3)	527	(3.2)	527	(2.7)	500	(0.5)

Australia's mean scores in "Earth and space systems" and "living systems" are not significantly different from Australia's mean score for overall science. However, Australia's mean score in "physical systems" represents a relative weakness, with achievement a significant 12 points lower than for overall science performance. Australian students scored significantly higher than the OECD average in all content areas.

Internationally, gender differences on the combined science scale tend to be small. However in two of the three content areas, gender differences are apparent in a number of countries. In Australia, significant gender differences can be seen in the scores for both "Earth and space systems" and "physical systems", with males outperforming females by 16 score points in the former and 26 score points in the latter.

Within Australia, male and female students had mean scores above the OECD averages in all three content areas with the single exception of females in "physical systems" where the average score for females is not significantly different from the OECD average.

Figure 3.18 shows that this pattern of gender differences in achievement in the three content areas is consistent internationally. In "physical systems", which relates to the structure and properties of matter, changes of matter, and energy transformations, gender differences are particularly strong and consistently in favour of males. In all OECD countries other than Turkey, males significantly outscored females. The largest gender differences in OECD countries were found in Austria (45 score points), the Czech Republic (39 score points), Luxembourg (38 score points), Hungary (36 score points) and the Slovak Republic (35 score points).

There were few significant gender differences in the area of "living systems", which covers the areas of cell structure, human biology, the nature of populations, and ecosystems. In the OECD countries of Mexico (13 score points), Hungary (12 score points), Luxembourg (11 score points), Denmark (11 score points) and the Slovak Republic (11 score points), gender differences were evident in favour of males, while in Greece (12 score points) and Finland (11 score points) gender differences were significantly in favour of females.

In the content area "Earth and space systems", which focuses on the structure and energy of the Earth and its systems, the Earth's history, and its place in space, males tend to outperform females, although there are fewer significant differences than for "physical systems". The largest differences in OECD countries were in the Czech Republic (29 score points), Luxembourg (27 score points), Japan, Switzerland and Denmark (26 score points), and the Netherlands (25 score points).

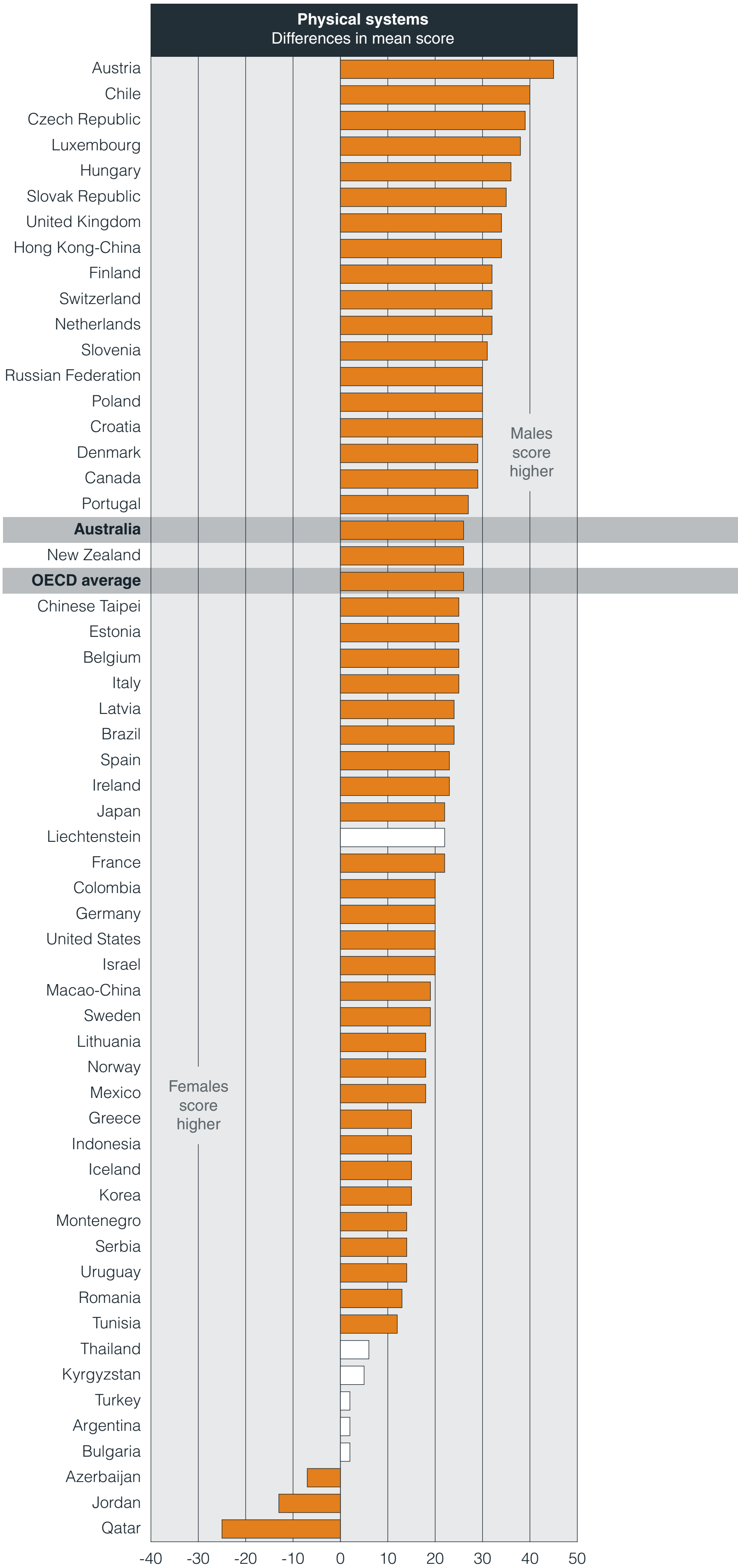
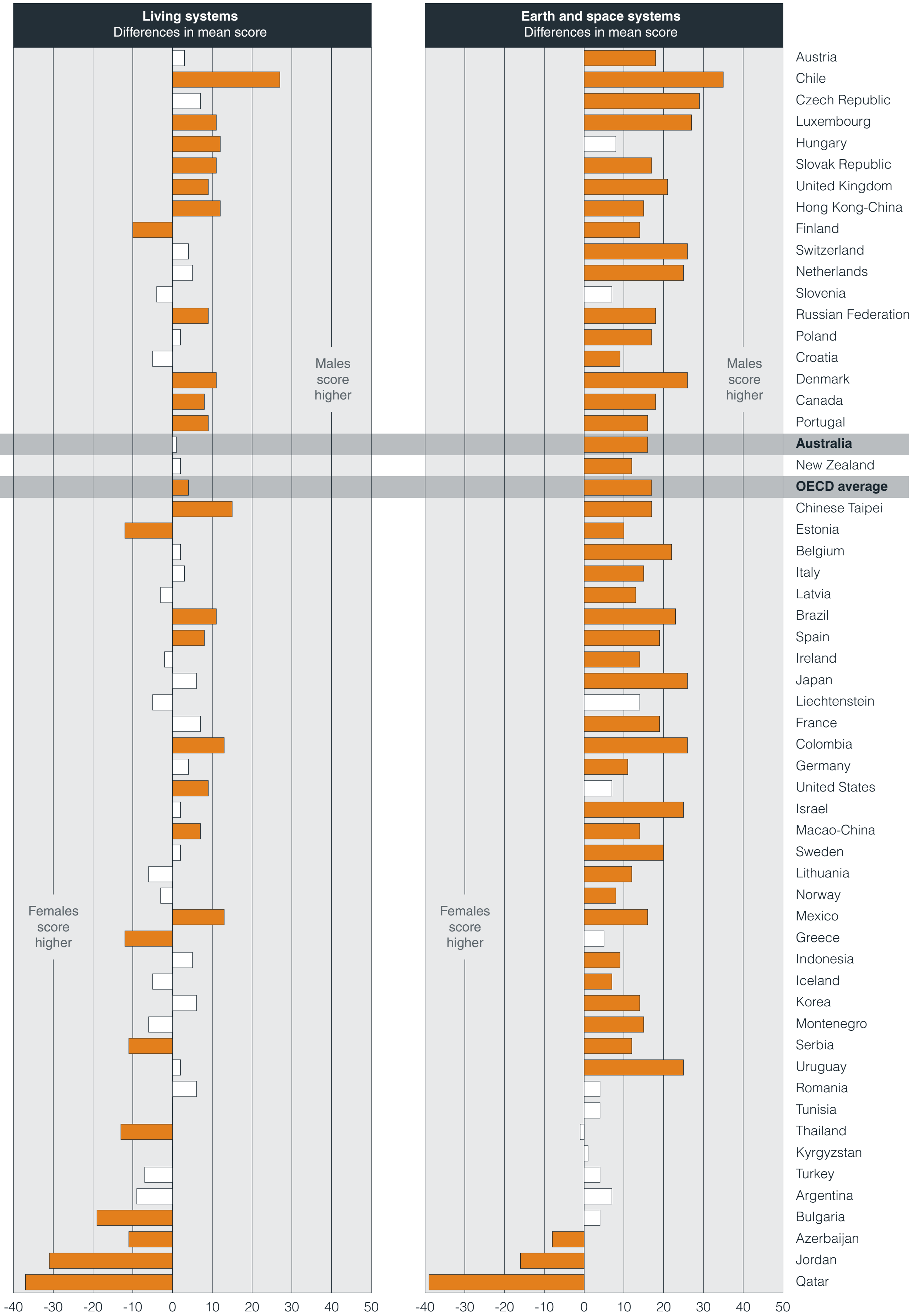


Figure 3.18 Gender differences on the "Physical systems", "Living systems" and "Earth and space systems" scales



Living systems
Differences in mean score
Earth and space systems
Differences in mean score
Males score higher
Females score higher
Austria
Chile
Czech Republic
Luxembourg
Hungary
Slovak Republic
United Kingdom
Hong Kong-China
Finland
Switzerland
Netherlands
Slovenia
Russian Federation
Poland
Croatia
Denmark
Canada
Portugal
Australia
New Zealand
OECD average
Chinese Taipei
Estonia
Belgium
Italy
Latvia
Brazil
Spain
Ireland
Japan
Liechtenstein
France
Colombia
Germany
United States
Israel
Macao-China
Sweden
Lithuania
Norway
Mexico
Greece
Indonesia
Iceland
Korea
Montenegro
Serbia
Uruguay
Romania
Tunisia
Thailand
Kyrgyzstan
Turkey
Argentina
Bulgaria
Azerbaijan
Jordan
Qatar
-40 -30 -20 -10 0 10 20 30 40 50

Achievement in the PISA scientific competencies

The design of the PISA scientific literacy assessment is unique in that it allows examination of students' science competencies as well as their overall scientific literacy. The remainder of this chapter provides a detailed description of student performance in the individual science competency scales. A simplified way of looking at these competencies is in terms of a sequence when dealing with science problems: first identifying the problem, then applying knowledge of scientific phenomena, and finally interpreting and using the results. Traditional science teaching often concentrates on the middle process, explaining phenomena scientifically, which needs students to be familiar with key science knowledge and theories.

However without first being able to recognise a science problem, or to be able to interpret the findings in the context of the real world, students are not fully scientifically literate. A student who has understood and mastered the theory, but who cannot reflect on and weigh up the evidence, for example, will not make full use of science in their adult lives.

The pattern of results shown in Table 3.10 indicates that, overall, Australia performed above the OECD average in all three competencies. In terms of relative strengths, the data suggest that Australian students are more skilled at identifying scientific problems and interpreting the results of a study in real life terms, than they are in mastering scientific knowledge.

Table 3.10 Mean scores on scientific competencies

	Identifying scientific issues		Explaining phenomena scientifically		Using scientific evidence	
	Mean	SE	Mean	SE	Mean	SE
OECD average	499	0.5	500	0.5	499	0.6
Australia	535	2.3	520	2.3	531	2.4
Difference from Australia's overall science mean	8		-7		4	

Identifying scientific issues, internationally

About 22 per cent of the science tasks given to students in the PISA assessment were related to *identifying scientific issues*. The essential features of this competency are recognising issues that are possible to investigate scientifically, identifying keywords to search for scientific information, and recognising the key features of a scientific investigation. The scientific knowledge most applicable to this competency is that associated with an understanding of science processes and of the content areas of "physical sciences", "life systems" and "Earth and space systems".

Australian students performed well in this competency area, scoring second only to Finland, and not significantly different from students in New Zealand and the Netherlands and partner country Hong Kong-China. Australia's mean score for this competency was 8 score points higher than its mean score on the overall science scale (Figure 3.19).

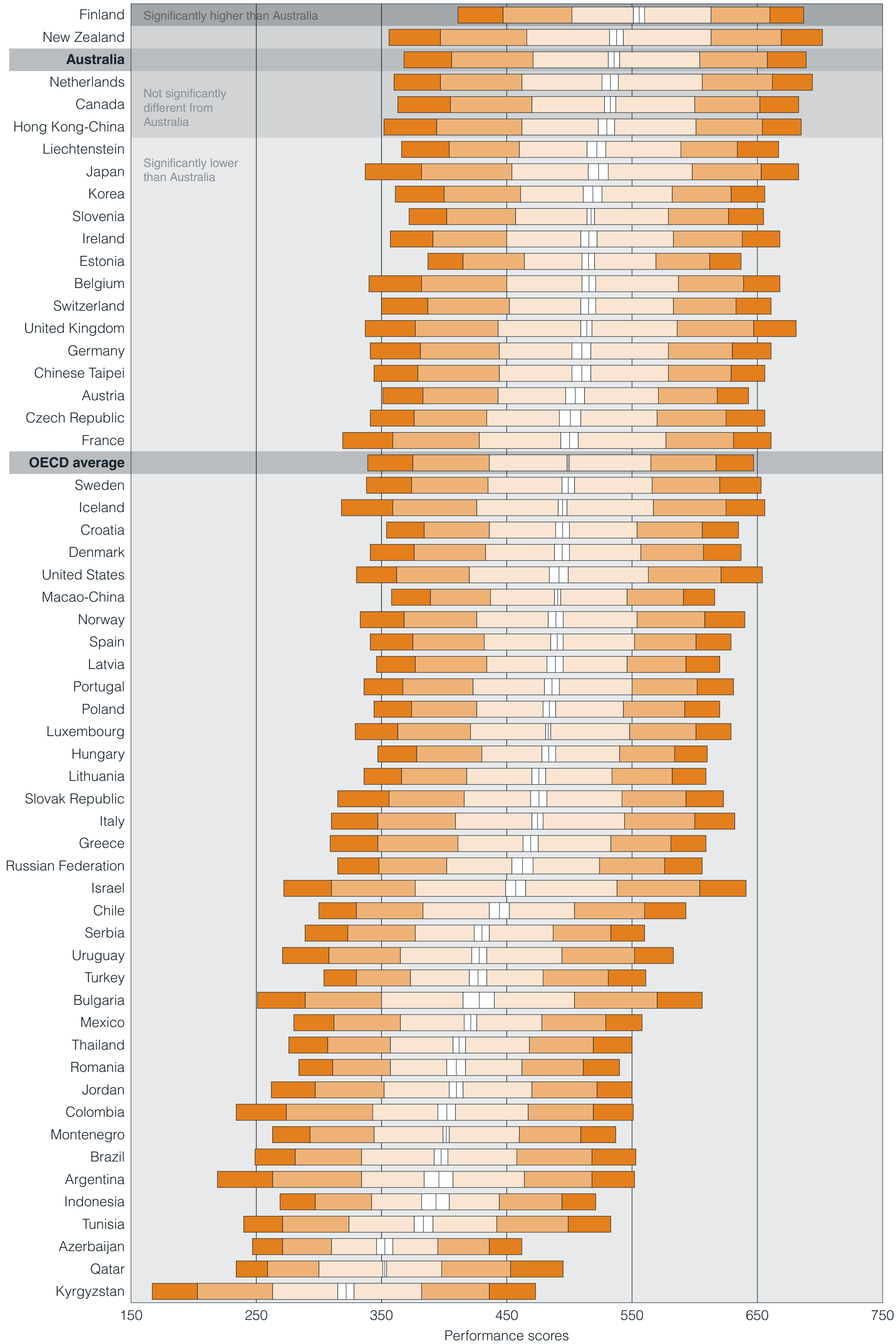


Figure 3.19 International student performance in *identifying scientific issues*

Figure 3.20 shows the international proficiency levels for this competency scale. New Zealand, Finland and the Netherlands are three OECD countries that have a large proportion of students highly proficient in this area (17 or 18% of students at Level 5 or above). New Zealand and Finland both had a large proportion of students in the two highest proficiency levels in the overall science scale, whereas in the Netherlands only 13 per cent of students were highly proficient on the overall science scale, indicating that identifying scientific issues is an area of strength in that country.

In Australia this is also an area of relative strength; almost 16 per cent of Australian students achieved at Level 5 or 6, compared with 13 per cent on the overall science scale and a little more than eight per cent for the OECD on average. In the lower levels of achievement, almost 11 per cent of students in Australia did not achieve Level 2, compared with 13 per cent in the overall science scale and an average OECD figure of 19 per cent.

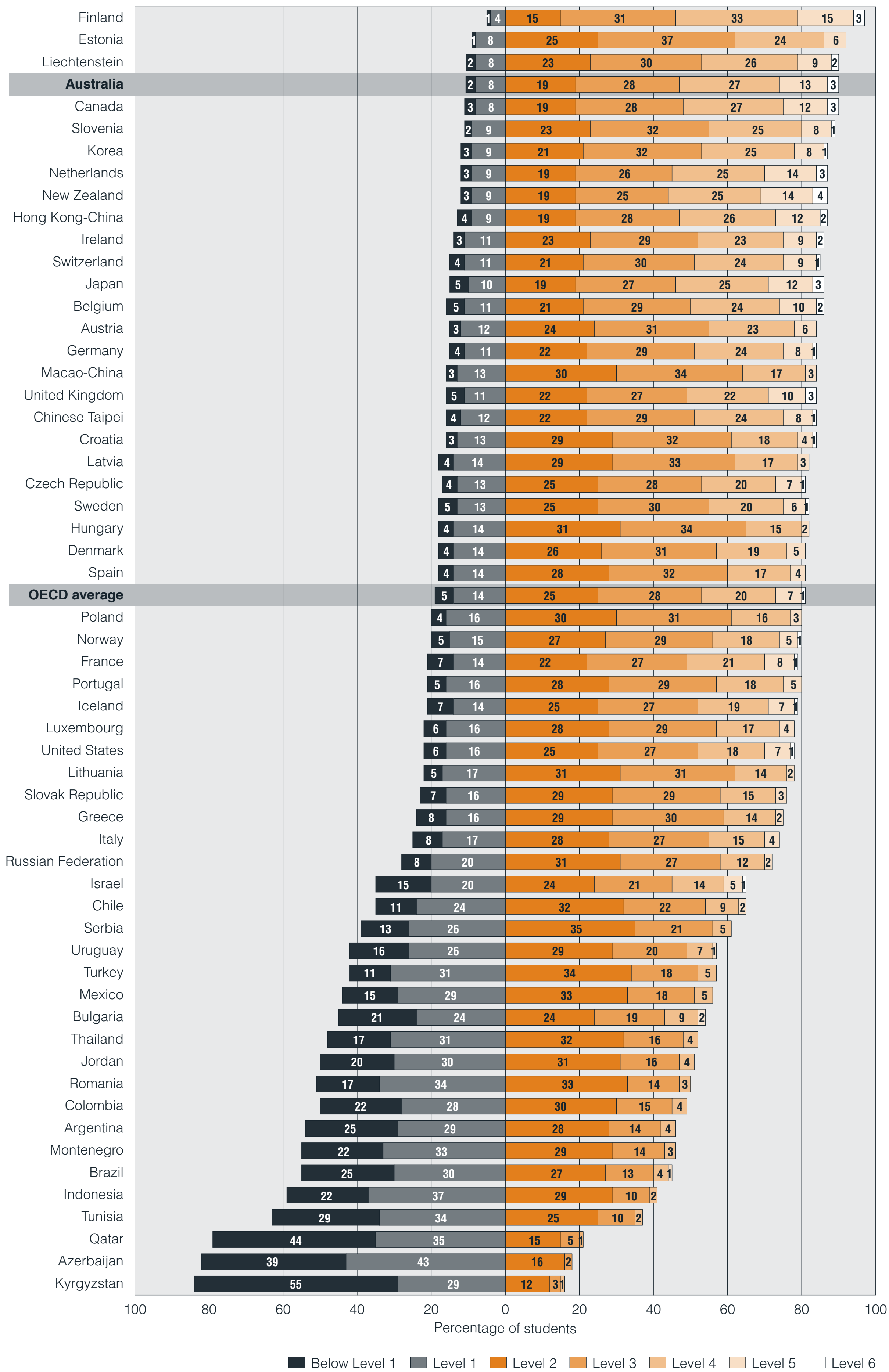


Figure 3.20 Proficiency levels internationally in *identifying scientific issues*

Figure 3.21 shows gender differences internationally in the identifying scientific issues competency. This is a competency in which females perform strongly. There were significant gender differences in favour of females in all OECD countries and in all partner countries other than Israel, Indonesia, Chile, Colombia and Chinese Taipei. In Australia, females outperformed males by a significant 21 score points, just a little higher than the OECD average difference of 18 score points.

The largest gender differences were found in Qatar (37 score points) and Bulgaria (34 score points) and the smallest in Chile (2 score points) and Colombia (3 score points).

	Females		Males	
	Mean score	SE	Mean score	SE
Qatar	371	(1.3)	334	(1.2)
Bulgaria	445	(7.1)	411	(6.6)
Thailand	427	(2.8)	394	(3.7)
Jordan	425	(2.8)	393	(4.6)
Greece	485	(3.1)	453	(4.1)
Latvia	504	(3.5)	473	(3.7)
Iceland	509	(2.4)	479	(2.9)
Turkey	443	(3.6)	414	(4.1)
Croatia	507	(3.1)	480	(3.5)
Slovenia	530	(2.0)	504	(2.0)
Argentina	408	(6.4)	381	(5.8)
Liechtenstein	534	(5.7)	508	(7.0)
Finland	568	(2.6)	542	(2.7)
Lithuania	489	(3.0)	463	(2.9)
Estonia	528	(2.6)	504	(3.1)
Norway	501	(3.3)	478	(3.9)
New Zealand	547	(3.7)	525	(3.7)
Korea	530	(4.2)	508	(4.9)
Austria	516	(4.7)	495	(4.2)
Uruguay	439	(2.8)	418	(4.2)
Serbia	441	(3.6)	420	(3.3)
Australia	546	(2.6)	525	(3.2)
Tunisia	394	(4.2)	373	(3.9)
Slovak Republic	485	(3.6)	465	(4.5)
Russian Federation	472	(4.1)	453	(4.6)
Kyrgyzstan	330	(3.3)	311	(3.6)
Czech Republic	511	(5.3)	492	(4.8)
Japan	531	(6.6)	513	(5.1)
OECD average	508	(0.6)	490	(0.7)
Romania	418	(4.4)	401	(3.6)
Italy	483	(2.5)	466	(2.9)
Sweden	507	(3.1)	491	(2.9)
Ireland	524	(3.5)	508	(4.4)
Montenegro	409	(1.8)	393	(2.0)
Germany	518	(3.9)	502	(4.5)
France	507	(3.7)	491	(4.6)
United States	500	(3.8)	484	(4.6)
Macao-China	498	(1.6)	483	(1.9)
Hong Kong-China	535	(4.5)	520	(4.1)
Spain	496	(2.6)	482	(2.7)
Belgium	523	(3.1)	508	(3.8)
Canada	539	(2.4)	525	(2.7)
Poland	490	(2.7)	476	(2.8)
Portugal	493	(3.4)	480	(3.6)
Hungary	489	(3.3)	477	(3.4)
Netherlands	539	(3.5)	527	(3.8)
Israel	463	(4.0)	451	(5.9)
Luxembourg	489	(1.8)	477	(1.7)
Denmark	499	(3.2)	488	(3.5)
Switzerland	520	(3.3)	510	(3.1)
Azerbaijan	357	(3.3)	349	(3.3)
Brazil	402	(3.0)	394	(3.2)
United Kingdom	517	(2.8)	510	(2.9)
Mexico	425	(2.8)	418	(2.9)
Chinese Taipei	512	(5.0)	506	(4.4)
Colombia	404	(4.0)	401	(4.4)
Chile	443	(4.1)	445	(5.0)
Indonesia	389	(3.6)	397	(8.0)

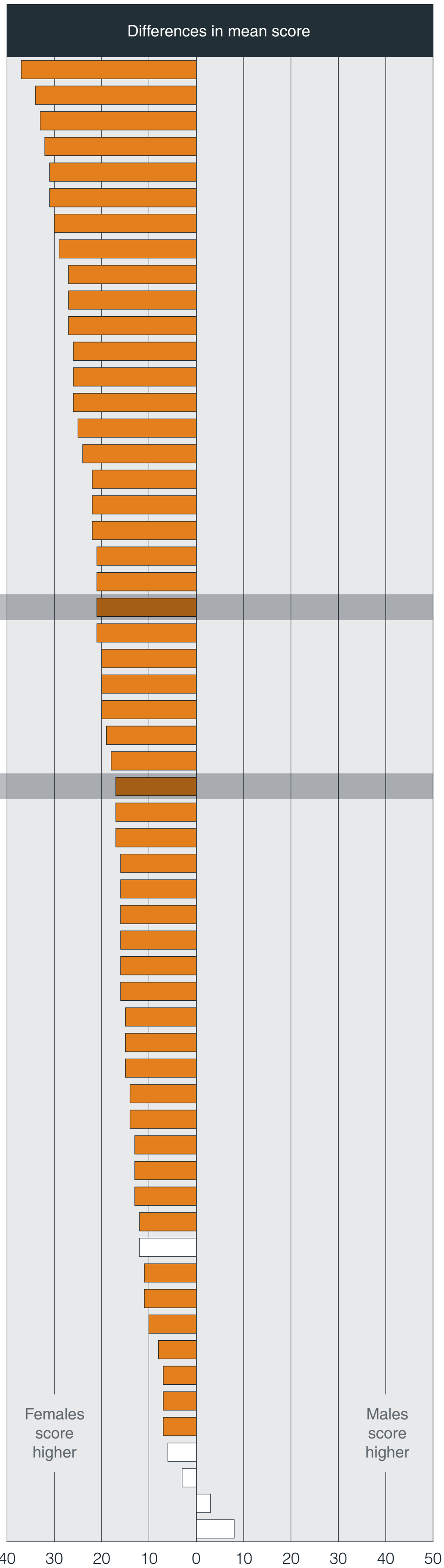


Figure 3.21 Gender differences internationally in *identifying scientific issues*

Explaining phenomena scientifically, internationally

Approximately 46 per cent of the science tasks on the PISA assessment were related to *explaining phenomena scientifically*. As described earlier, the main areas of interest in this competency are applying knowledge of science in a given situation, describing or interpreting phenomena scientifically and predicting changes, and identifying appropriate descriptions, explanations and predictions. The distribution of scores on this scale is shown for all countries in Figure 3.22.

Australia demonstrated a relative weakness in this area. Australia's mean score in this competency was 7 points below Australia's mean score for science overall, and Australia was outperformed by the OECD countries Finland and Canada and partner countries Hong Kong-China, Chinese Taipei and Estonia. Nevertheless, Australia's score in this competency was still significantly higher than the OECD average, and statistically similar to those of New Zealand, the Netherlands, Japan, Germany and the United Kingdom.

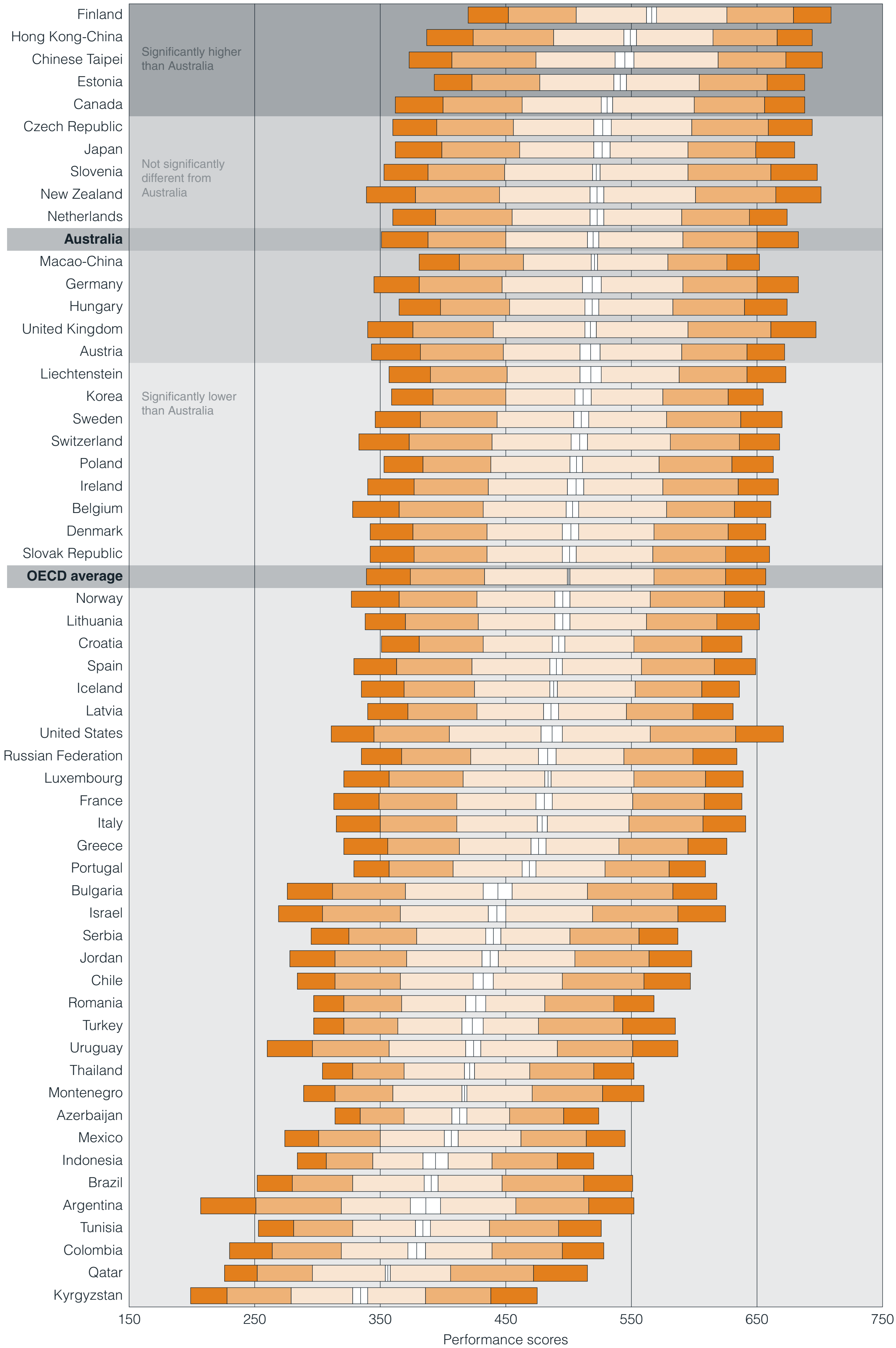


Figure 3.22 International student performance in *explaining phenomena scientifically*

Figure 3.23 shows the proficiency levels internationally for *explaining phenomena scientifically*. In Finland more than one in five students (23%) achieved at Level 5 or higher and only four per cent failed to achieve Level 2. In Australia 14 per cent of students achieved Level 5 or higher, almost the same as the 15 per cent in overall scientific literacy. Fourteen per cent of Australian students failed to achieve Level 2 in this competency, compared to 13 per cent of students in overall scientific literacy.

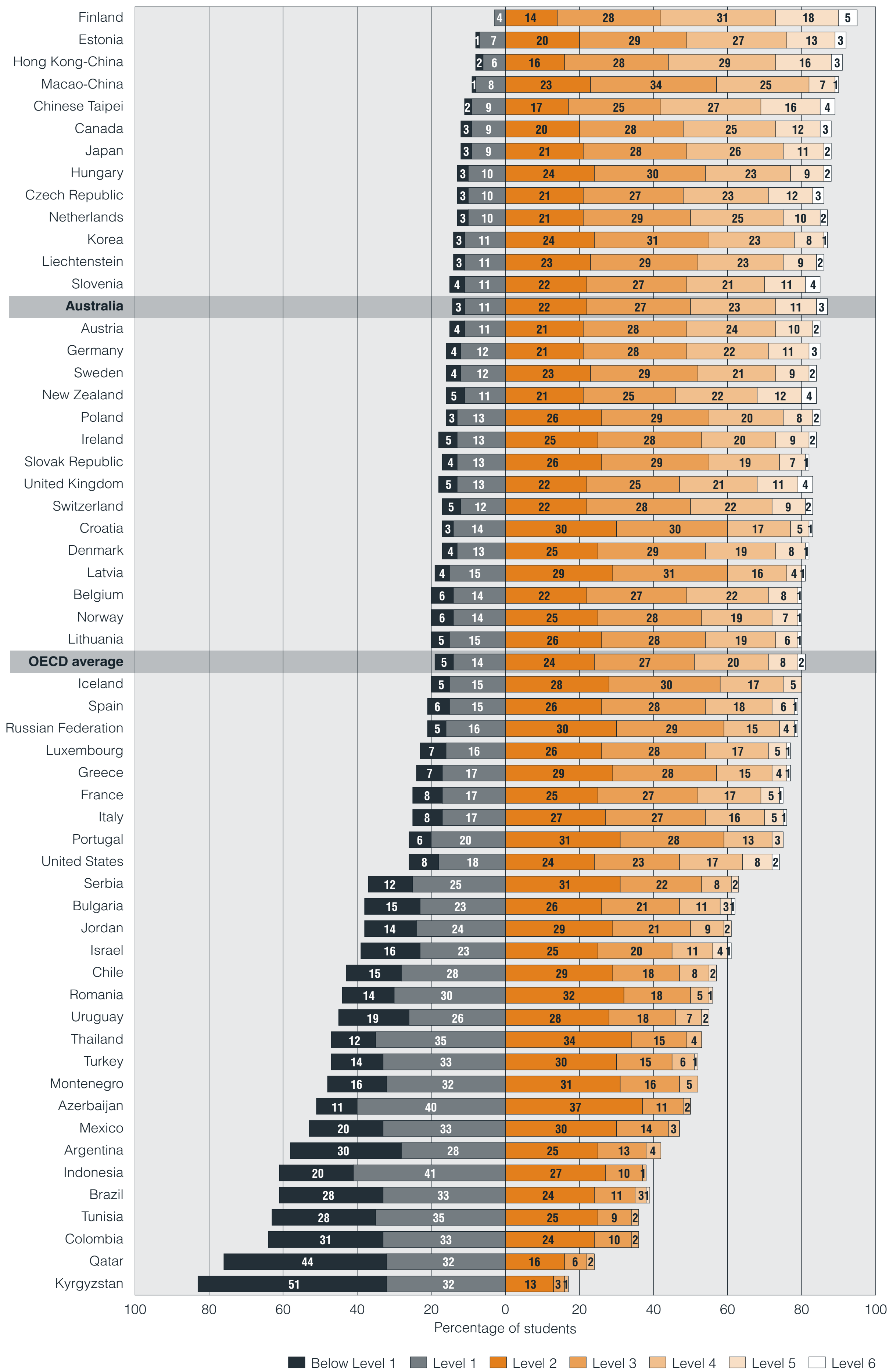


Figure 3.23 Proficiency levels in *explaining phenomena scientifically*

Figure 3.24 shows the gender differences internationally in this competency area. Unlike the previous competency, the gender differences in this competency are fewer and primarily in favour of males. In Australia males outperformed female students by 14 score points, around the same as the OECD average of 15 score points.

The largest gender difference in favour of males was found in Chile (34 score points). The largest gender differences in favour of females were found in Qatar (29 score points) and Jordan (21 score points) and there were no gender differences in 13 countries, including the OECD countries Korea, Norway, Iceland, Greece and Turkey.

	Females		Males	
	Mean score	SE	Mean score	SE
Qatar	371	(1.6)	342	(1.4)
Jordan	448	(4.1)	427	(4.6)
Azerbaijan	417	(3.0)	408	(3.3)
Bulgaria	447	(6.5)	442	(6.5)
Thailand	421	(2.2)	418	(3.4)
Argentina	386	(7.0)	387	(6.4)
Turkey	423	(4.5)	423	(4.7)
Kyrgyzstan	333	(2.9)	335	(3.9)
Greece	475	(3.0)	478	(4.3)
Tunisia	381	(3.5)	386	(3.1)
Serbia	438	(3.8)	444	(3.7)
Norway	492	(3.2)	498	(3.9)
Liechtenstein	513	(6.4)	519	(7.5)
Iceland	485	(2.1)	491	(2.6)
Estonia	537	(3.0)	544	(3.2)
Montenegro	412	(1.7)	421	(1.8)
Lithuania	490	(3.4)	499	(3.3)
Finland	562	(2.5)	571	(2.5)
Ireland	501	(3.5)	510	(4.4)
Romania	421	(4.5)	431	(4.3)
Latvia	481	(3.2)	491	(3.6)
Slovenia	518	(2.2)	528	(2.3)
New Zealand	517	(3.6)	528	(4.0)
Korea	506	(4.0)	517	(4.8)
Uruguay	418	(3.1)	429	(4.0)
Croatia	487	(3.3)	498	(3.2)
Sweden	504	(3.5)	516	(3.0)
United States	480	(4.0)	492	(5.3)
Australia	513	(2.7)	527	(3.1)
Macao-China	513	(1.6)	527	(2.0)
France	474	(3.4)	489	(4.2)
OECD average	493	(0.6)	508	(0.7)
Italy	472	(2.5)	487	(2.8)
Portugal	462	(3.0)	477	(3.6)
Israel	436	(4.0)	451	(5.4)
Belgium	494	(3.1)	510	(3.4)
Japan	519	(4.4)	535	(4.6)
Poland	498	(2.8)	514	(2.9)
Canada	522	(2.3)	539	(2.6)
Indonesia	386	(3.8)	403	(7.0)
Mexico	398	(2.6)	415	(3.3)
Colombia	371	(4.3)	388	(4.3)
Spain	481	(2.7)	499	(2.8)
Switzerland	498	(3.9)	517	(3.4)
Netherlands	512	(3.1)	531	(3.1)
Austria	507	(4.7)	526	(4.4)
Brazil	382	(2.9)	400	(3.0)
Russian Federation	474	(3.4)	493	(4.0)
Chinese Taipei	535	(5.3)	554	(4.3)
Hong Kong-China	539	(3.3)	560	(3.5)
Germany	508	(3.7)	529	(4.5)
Czech Republic	516	(4.6)	537	(4.3)
Denmark	491	(3.7)	512	(3.8)
United Kingdom	506	(2.7)	527	(3.0)
Slovak Republic	490	(3.0)	512	(4.0)
Hungary	507	(3.6)	529	(3.2)
Luxembourg	471	(2.0)	495	(1.8)
Chile	414	(4.1)	448	(5.1)

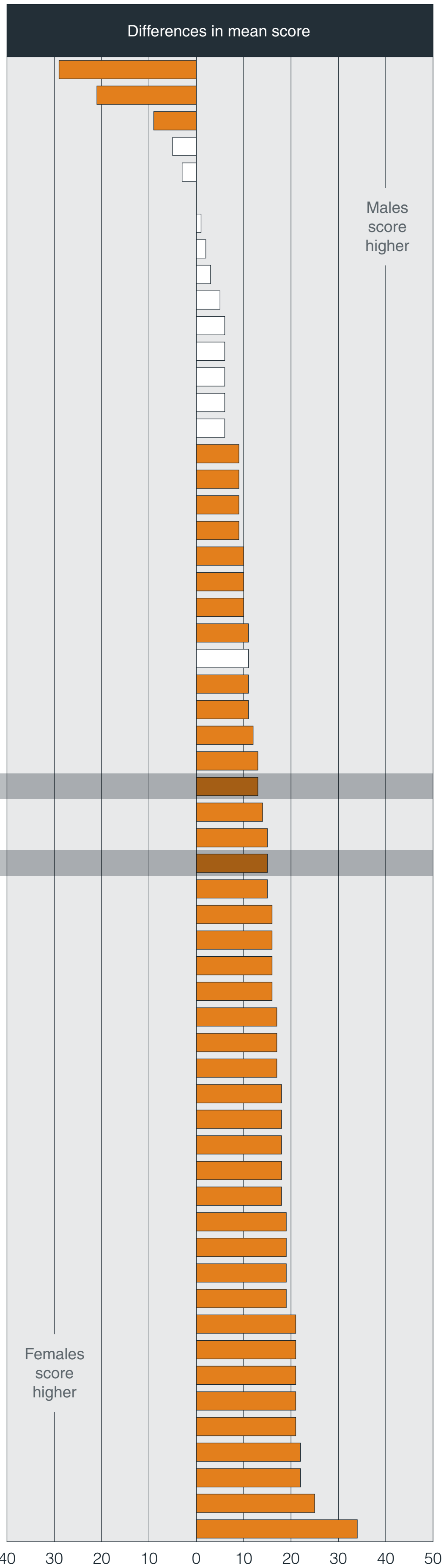


Figure 3.24 Gender differences internationally in *explaining phenomena scientifically*

Using scientific evidence, internationally

Approximately 32 per cent of the science tasks presented to students in the PISA assessment related to *using scientific evidence*. This competency requires students to synthesise knowledge about science and knowledge of science as they apply both of these to a life situation or a contemporary social problem. Figure 3.25 shows the distribution of scores internationally in this competency.

Australian students performed moderately well in this competency, being outscored by only four other countries, Finland, Japan, Canada and partner country Hong Kong-China. Australia's mean score of 531 points was significantly higher than the OECD average and four score points higher than the Australian mean score for science overall, indicating some facility in interpreting problems in terms of the real world.

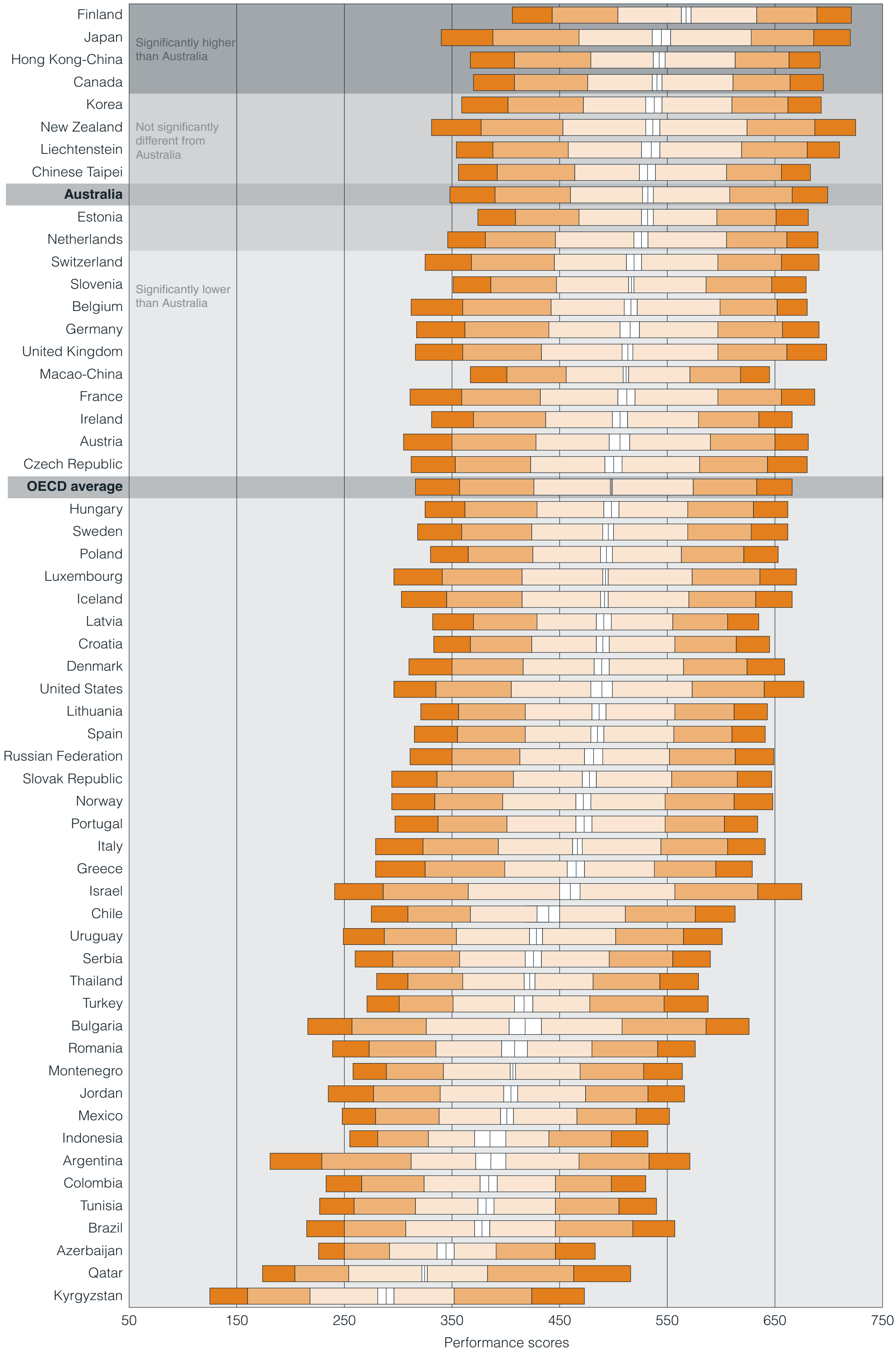


Figure 3.25 International student performance in *using scientific evidence*

Figure 3.26 provides the proficiency levels internationally in *using scientific evidence*.

In Finland one-quarter of the students achieved at Level 5 or higher and just five per cent failed to achieve Level 2. In Japan, 23 per cent of students achieved at least Level 5, however 14 per cent did not attain Level 2. In Australia, 17 per cent of students achieved Level 5 or higher, comparing favourably to the proportion at this level in high-scoring countries such as Canada (18%) and Hong Kong-China (18%), and the OECD average of 11 per cent. Fourteen per cent of Australian students did not achieve Level 2, which is the same proportion as in over all scientific literacy and not substantially different to the proportion failing to reach this baseline level in either Canada (10%) or Hong Kong-China (11%). The OECD average was 22 per cent.

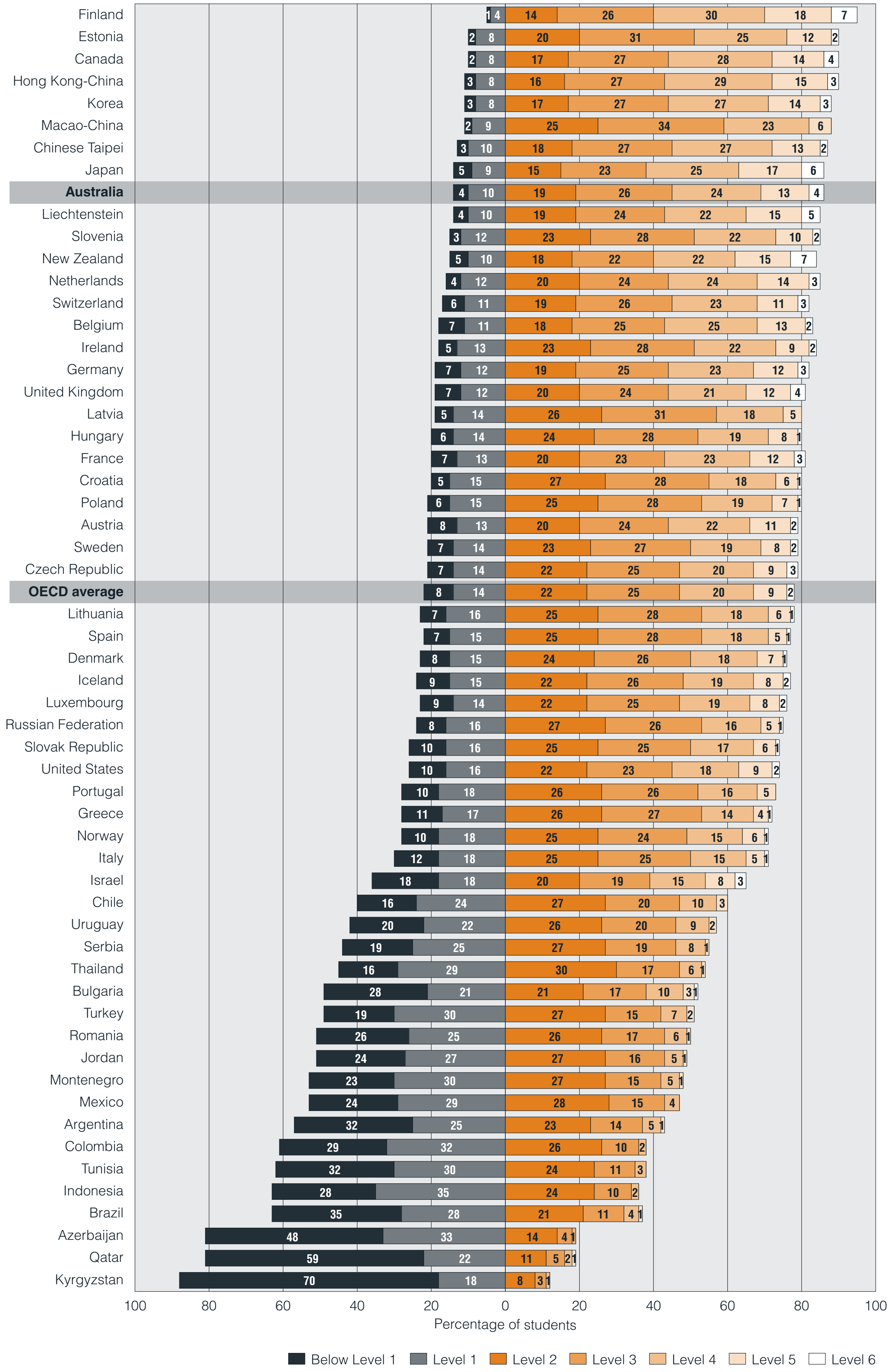


Figure 3.26 Proficiency levels in *using scientific evidence*

Figure 3.27 presents gender differences internationally in this competency. There were few significant differences, and while there are some significant gender differences in favour of both males and females, the larger differences are in favour of female students.

The largest gender differences in favour of females were found in Jordan (39 score points) and Qatar (34 score points), while the largest difference in favour of males was in Chile (16 score points). Australia was one of the many countries which showed no significant difference by gender.

	Females		Males	
	Mean score	SE	Mean score	SE
Jordan	424	(3.6)	385	(5.5)
Qatar	341	(1.9)	307	(1.5)
Bulgaria	430	(8.2)	404	(8.0)
Thailand	433	(2.7)	409	(4.2)
Argentina	396	(7.7)	374	(7.4)
Greece	475	(3.7)	456	(5.6)
Liechtenstein	544	(6.8)	524	(8.2)
Lithuania	495	(3.3)	478	(3.7)
Turkey	426	(4.6)	410	(5.2)
Kyrgyzstan	295	(3.9)	280	(4.7)
Latvia	497	(3.6)	484	(4.1)
Slovenia	522	(2.0)	510	(2.3)
Serbia	431	(4.8)	419	(4.0)
Tunisia	387	(4.3)	377	(4.1)
New Zealand	541	(4.3)	532	(4.4)
Romania	412	(6.7)	403	(6.0)
Belgium	521	(3.8)	512	(3.8)
Montenegro	411	(2.0)	403	(2.0)
Korea	542	(4.5)	535	(5.2)
Uruguay	433	(3.5)	425	(4.0)
Israel	464	(5.4)	456	(6.7)
Iceland	495	(2.5)	487	(3.1)
Norway	476	(3.9)	469	(4.2)
Ireland	509	(3.5)	503	(4.8)
Finland	571	(2.7)	564	(3.0)
Azerbaijan	347	(3.9)	342	(4.5)
Croatia	493	(3.5)	488	(4.1)
Sweden	499	(3.2)	494	(3.1)
United States	491	(4.6)	486	(6.1)
Estonia	533	(3.0)	529	(3.2)
Russian Federation	483	(4.4)	478	(4.5)
France	513	(4.2)	509	(5.0)
Poland	495	(3.0)	492	(3.0)
Australia	533	(3.0)	530	(3.4)
OECD average	501	(0.7)	498	(0.8)
Italy	468	(3.1)	466	(3.2)
Japan	545	(6.4)	543	(5.8)
Canada	542	(2.3)	541	(2.7)
Spain	485	(3.1)	484	(3.4)
Hungary	498	(4.5)	497	(4.1)
Chinese Taipei	532	(5.1)	532	(4.5)
Slovak Republic	478	(3.6)	478	(4.8)
Macao-China	511	(1.6)	512	(2.0)
Czech Republic	500	(5.4)	501	(5.0)
Portugal	471	(4.0)	473	(4.2)
Hong Kong-China	541	(4.0)	544	(3.8)
Switzerland	517	(3.9)	520	(3.6)
Netherlands	524	(3.7)	527	(3.8)
Denmark	487	(4.0)	490	(4.1)
Luxembourg	490	(2.2)	493	(2.0)
Mexico	401	(3.0)	404	(3.7)
Germany	513	(4.5)	517	(5.6)
Colombia	381	(4.8)	386	(4.5)
Indonesia	383	(5.0)	388	(10.2)
Brazil	375	(3.8)	382	(3.9)
United Kingdom	510	(3.1)	517	(3.1)
Austria	500	(6.2)	509	(4.9)
Chile	431	(5.2)	447	(6.2)

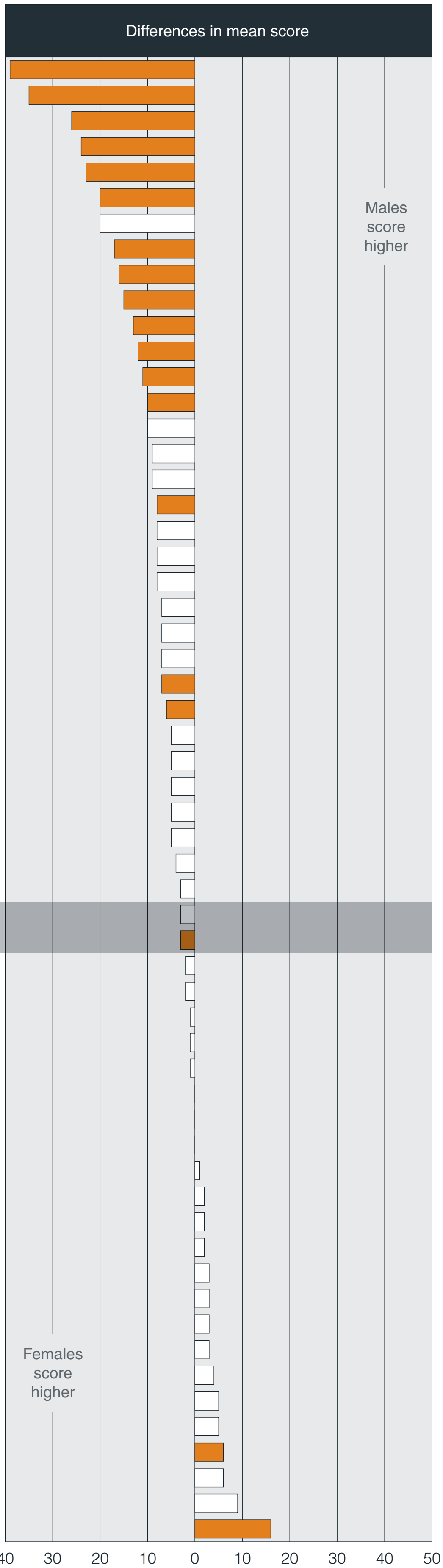


Figure 3.27 Gender differences in *using scientific evidence*

Achievement in the PISA scientific competencies by state

The following three tables present the achievement scores on each of the PISA competency scales for each of the Australian states. In each table the states are presented in decreasing order of average score.

Table 3.11 shows the achievement of students on the *identifying scientific issues* competency scale, as well as the difference in the score for the competency compared to the overall score on science for the state.

Students in Western Australia and the Australian Capital Territory both performed at a very high level in this competency, the mean scores in these two states being not significantly different from that of students in Finland. The mean scores on *identifying scientific issues* for all states other than the Northern Territory was higher than the OECD average.

In terms of relative performance in the three competencies, Tasmania, Western Australia and Victoria all performed relatively well on this competency, with Tasmania scoring 19 points higher and Victoria and Western Australia scoring 11 points higher than the overall science mean score for the state. It is notable that the Australian Capital Territory's mean score on this competency was identical to its mean score for overall scientific literacy.

Table 3.11 Multiple comparisons for *identifying scientific issues*

			WA	ACT	NSW	SA	QLD	TAS	VIC	NT	OECD	Difference from overall state mean
		Mean	554	549	542	537	529	525	524	497	499	
	Mean	SE	7.0	5.2	5.0	5.4	5.0	5.0	4.4	6.4	0.5	
WA	554	7.0		●	●	●	▲	▲	▲	▲	▲	11
ACT	549	5.2	●		●	●	▲	▲	▲	▲	▲	0
NSW	542	5.0	●	●		●	●	▲	▲	▲	▲	7
SA	537	5.4	●	●	●		●	●	●	▲	▲	5
QLD	529	4.2	▼	▼	●	●		●	●	▲	▲	7
TAS	525	5.0	▼	▼	▼	●	●		●	▲	▲	19
VIC	524	4.4	▼	▼	▼	●	●	●		▲	▲	11
NT	497	6.4	▼	▼	▼	▼	▼	▼	▼		●	7

Note: Read across the row to compare a state's performance with the performance of each state listed in the column heading.

▲ Average performance statistically significantly higher than in comparison state

● No statistically significant difference from comparison state

▼ Average performance statistically significantly lower than in comparison state

Table 3.12 shows the achievement of students on the *explaining phenomena scientifically* competency scale, as well as the difference in the score for the competency compared to the overall score on science for the state.

There were no really outstanding scores on this competency, with the Australian Capital Territory having statistically similar scores to Western Australia and New South Wales, and Western Australia having statistically similar scores to New South Wales, South Australia and Queensland. All scores were significantly lower than the score for Finland. The mean scores for the Australian Capital Territory, Western Australia, New South Wales, South Australia and Queensland are all significantly higher than the OECD average, while for Victoria, Tasmania and the Northern Territory there was no significant difference from the OECD average.

In comparison with their performance on the other two competencies, all states performed relatively poorly on this competency, with the Australian Capital Territory, Western Australia, Victoria and Tasmania scoring nine points lower and South Australia eight points lower than the overall mean score for the state.

Table 3.12 Multiple comparisons for *explaining phenomena scientifically*

			ACT	WA	NSW	SA	QLD	VIC	TAS	NT	OECD	Difference from overall state mean
		Mean	540	534	529	524	518	504	497	487	500	
	Mean	SE	5.4	7.0	4.4	4.9	4.5	4.9	5.1	6.8	0.5	
ACT	540	5.4		●	●	▲	▲	▲	▲	▲	▲	-9
WA	534	7.0	●		●	●	●	▲	▲	▲	▲	-9
NSW	529	4.4	●	●		●	●	▲	▲	▲	▲	-5
SA	524	4.9	▼	●	●		●	▲	▲	▲	▲	-8
QLD	518	4.5	▼	●	●	●		▲	▲	▲	▲	-4
VIC	504	4.9	▼	▼	▼	▼	▼		●	▲	●	-9
TAS	497	5.1	▼	▼	▼	▼	▼	●		●	●	-9
NT	487	6.8	▼	▼	▼	▼	▼	▼	●		●	-3

Note: Read across the row to compare a state's performance with the performance of each state listed in the column heading.
▲ Average performance statistically significantly higher than in comparison state
● No statistically significant difference from comparison state
▼ Average performance statistically significantly lower than in comparison state

Table 3.13 shows the multiple comparisons for the competency *using scientific evidence*, as well as the difference in the score for the competency compared to the overall score on science for the state.

While the Australian Capital Territory again performed strongly, with only Western Australia achieving scores that were not significantly different, none of the states achieved scores as high as those of Finland. All but Tasmania and the Northern Territory scored significantly higher than the OECD average, while these two states' scores were not significantly different from the OECD average.

Most states performed relatively well in this competency compared with their mean score for science overall, the Australian Capital Territory and South Australia in particular. However, the Northern Territory performed quite poorly in this area, relative to all other states.

Table 3.13 Multiple comparisons for *using scientific evidence*

			ACT	WA	NSW	SA	QLD	VIC	TAS	NT	OECD	Difference from overall state mean
		Mean	557	549	539	538	525	519	505	485	499	
	Mean	SE	4.9	7.3	4.9	5.2	4.3	5.0	4.7	10.7	0.6	
ACT	557	4.9		●	▲	▲	▲	▲	▲	▲	▲	9
WA	549	7.3	●		●	●	▲	▲	▲	▲	▲	6
NSW	539	4.9	▼	●		●	▲	▲	▲	▲	▲	4
SA	538	5.2	▼	●	●		▲	▲	▲	▲	▲	7
QLD	525	4.3	▼	▼	▼	▼		●	▲	▲	▲	2
VIC	519	5.0	▼	▼	▼	▼	●		▲	▲	▲	6
TAS	505	4.7	▼	▼	▼	▼	▼	▼		▲	●	-1
NT	485	10.7	▼	▼	▼	▼	▼	▼	▼		●	-5

Note: Read across the row to compare a state's performance with the performance of each state listed in the column heading.
▲ Average performance statistically significantly higher than in comparison state
● No statistically significant difference from comparison state
▼ Average performance statistically significantly lower than in comparison state

Summarising these three tables, students from all states other than the Australian Capital Territory performed relatively strongly in the competency area requiring students to identify the problem and other than Tasmania and the Northern Territory in interpreting findings in relation to the real world. All of the states were found to have a relative weakness in the area that requires students to apply their scientific knowledge and theories. This set of findings is consistent with a constructivist way of teaching in which the focus is more on identifying and interpreting than on learning facts, and consistent with the finding from the 1999 TIMSS science video study that "Australian Year 8 science lessons tended to focus on developing a limited number of canonical ideas (that is, generally-accepted scientific facts, ideas, concepts or theories) by making connections between ideas and evidence rather than by acquiring facts, definitions and algorithms" (Lokan et al, 2006, p. xix).

Achievement by gender

In Table 3.14, the means are shown by gender for each state. Consistent with international findings, significant gender differences in favour of females were apparent in *identifying scientific issues* in all states other than Victoria and the Australian Capital Territory. These differences ranged in magnitude from 20 score points to 28 score points. Again consistent with other findings, significant gender differences in favour of males were found in *explaining phenomena scientifically* in Western Australia, South Australia, Queensland, Tasmania and Victoria. These ranged in magnitude from five score points in New South Wales to 23 score points in the Australian Capital Territory. Finally in the area of *using scientific evidence*, there were no gender differences apparent.

Table 3.14 Means for scientific competencies by state and gender

	Identifying scientific issues				*Explaining phenomena scientifically*				*Using scientific evidence*			
	Females		Males		Females		Males		Females		Males	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
WA	**564**	6.7	544	8.6	525	7.1	**543**	9.1	547	7.4	550	9.3
NSW	**556**	4.9	528	7.6	527	4.6	532	7.0	545	5.6	533	8.2
ACT	555	7.8	543	8.4	528	8.1	551	8.7	556	8.2	559	9.2
SA	**547**	6.7	526	5.4	516	5.7	**532**	5.7	539	6.4	538	6.0
QLD	**540**	5.9	518	4.9	511	6.3	**525**	4.6	526	6.1	524	5.2
TAS	**537**	7.0	512	5.6	489	6.6	**506**	6.0	508	6.9	503	5.8
VIC	530	5.9	520	5.7	492	6.6	**514**	6.0	516	6.8	522	6.2
NT	**511**	11.3	485	5.9	481	11.7	492	6.0	485	17.2	485	7.6

Note: Significant differences shown in bold

Proficiency levels

Figure 3.28 shows the proportion of students in each state at each of the proficiency levels for *identifying scientific issues*.

New South Wales, the Australian Capital Territory and Western Australia all did very well in this area, with in excess of 18 per cent of students achieving at Level 5 or greater and in Western Australia and the Australian Capital Territory half of the students achieving at Level 4 or greater. At the same time, fewer than 10 per cent of students in these states failed to achieve Level 2.

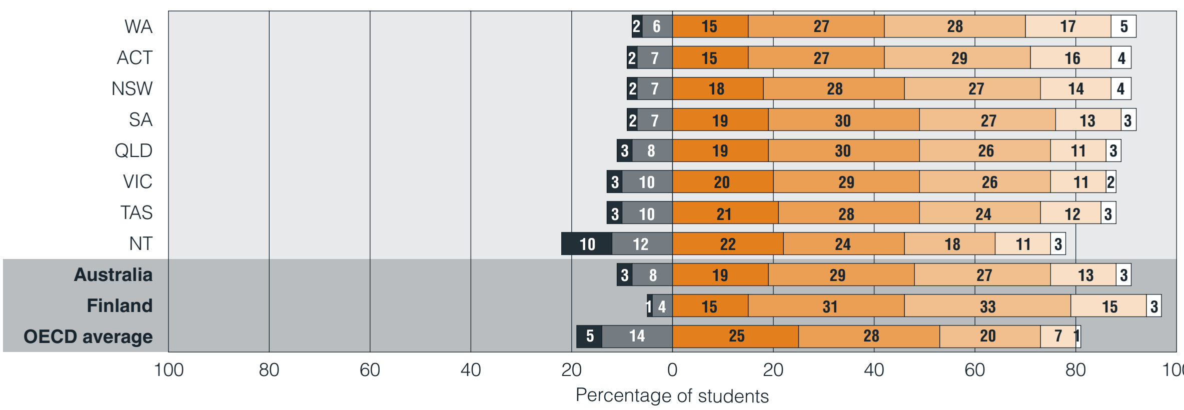


Figure 3.28 Proficiency levels in *identifying scientific issues* by state

In all other states achievement at Level 5 and above is higher than that for the OECD as a whole, and, other than in the Northern Territory, a smaller proportion of students failed to achieve Level 2 than for the OECD as a whole. There are some particular areas of concern however. In a competency in which Australian students, in general, performed at a relatively high level, the proportion of students in Victoria and Queensland achieving at Level 5 and above is quite low. In addition, Victoria and Tasmania both have 13 per cent of students not achieving Level 2.

Figure 3.29 examines achievement of proficiency levels by gender for each state. As would be expected, more females achieved Level 5 or greater, although in Victoria this was very marginal, with 12 per cent of males and 13 per cent of females at this level. Females in Western Australia did particularly well in this competency; with one-quarter achieving Level 5 or greater and six per cent not achieving Level 2.

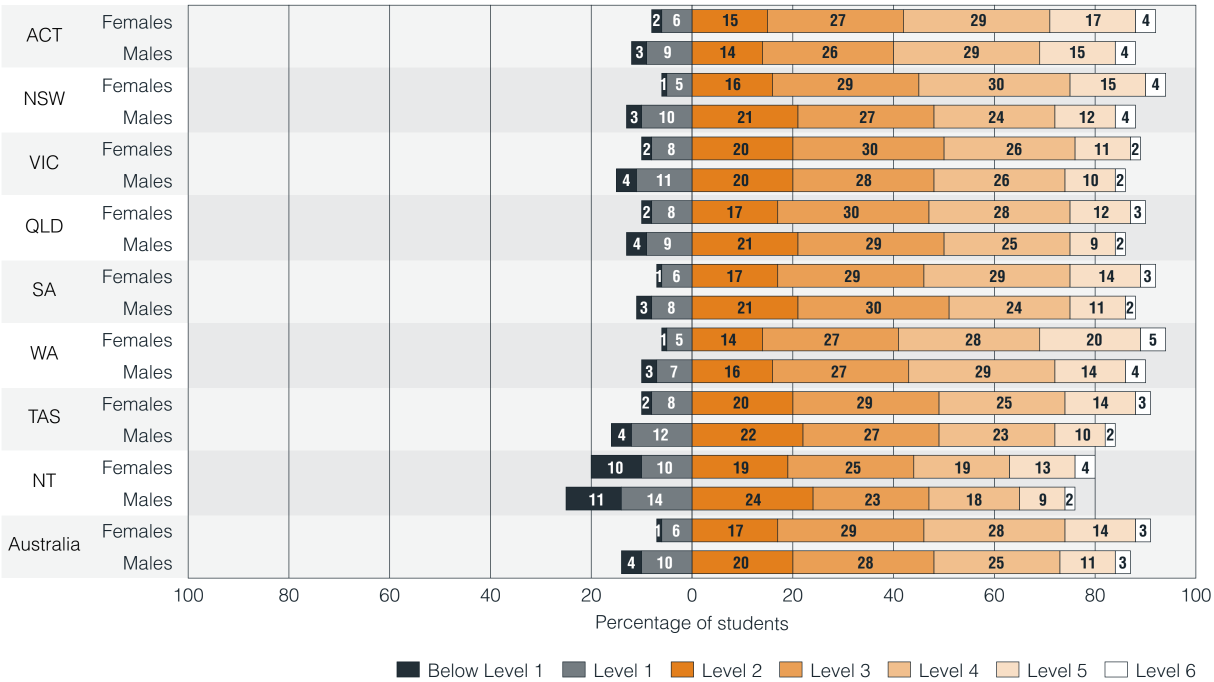


Figure 3.29 Proficiency levels in *identifying scientific issues* by state and gender

Figure 3.30 shows the proportion of students at each proficiency level of *explaining phenomena scientifically* by state. Again, Western Australia, the Australian Capital Territory and New South Wales all did very well, with high proportions of students in Levels 5 or 6, and also in the proportions of students achieving at least the baseline Level 2. This was a competency in which Australian students performed relatively poorly on average, and in Tasmania and Victoria, the proportion of students achieving at Level 5 or 6 was the same as or smaller than the OECD average and the proportion failing to achieve at Level 2 was the same as or greater than the OECD average.

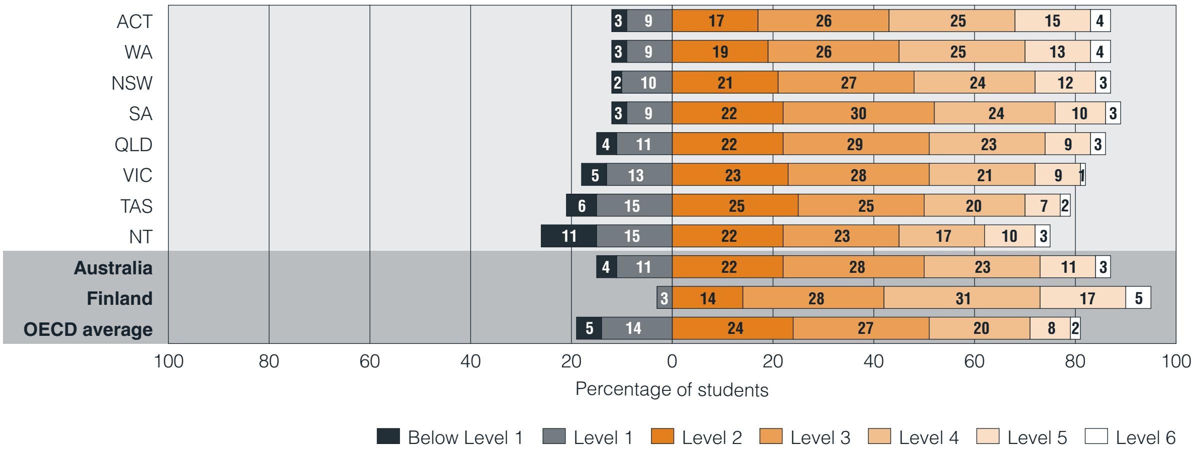


Figure 3.30 Proficiency levels in *explaining phenomena scientifically* by state

Figure 3.31 shows achievement at the proficiency levels for explaining phenomena scientifically by gender. Almost one-quarter of the males in the Australian Capital Territory (24%), one in five males in Western Australia (20%) and just a little less than this (18%) of males in New South Wales, achieved at Level 5 or 6; however, achievement in the other states was a little more mixed. The proportion of students at lower levels of achievement is of some concern in a number of states: 17 per cent of males and 20 per cent of females in Victoria, 20 per cent of males and 22 per cent of females in Tasmania, and 25 per cent of males and 28 per cent of females in the Northern Territory were found to be below Level 2 in this competency.

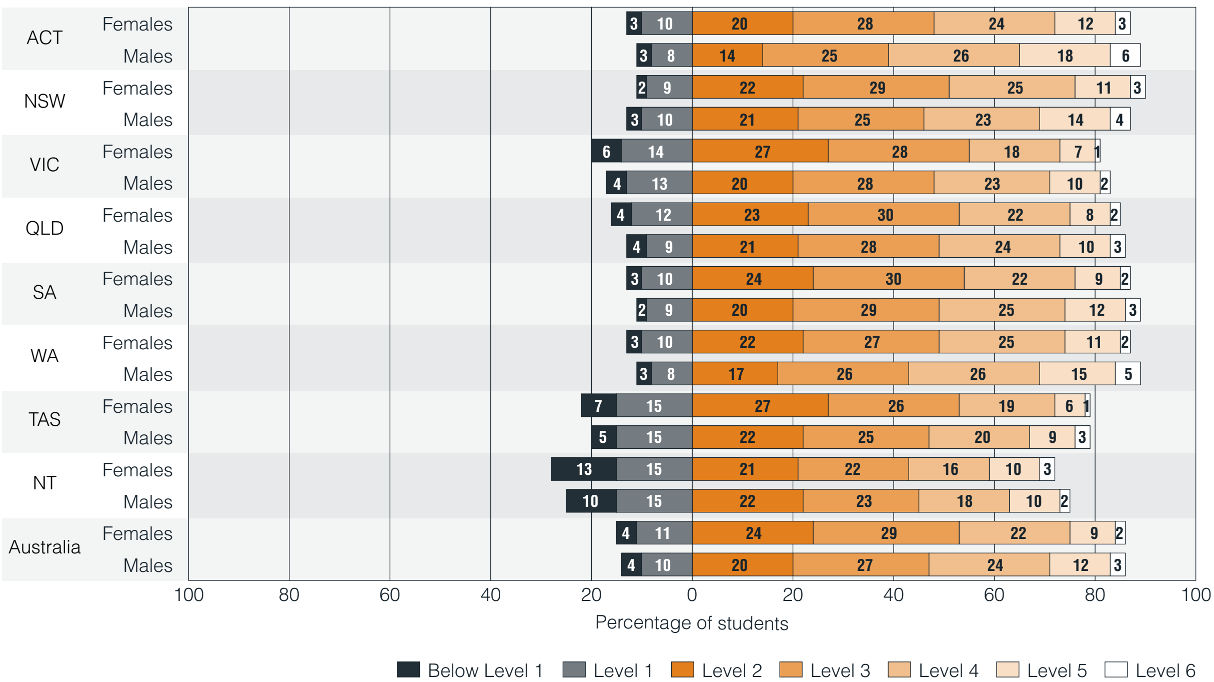


Figure 3.31 Proficiency levels in *explaining phenomena scientifically* by state and gender

Figure 3.32 shows the proportions at each proficiency level by state and Figure 3.33 for each state by gender for the competency *using scientific evidence*, which reflects students' ability to interpret findings scientifically in a real world situation. This was an area in which Australian students performed relatively well overall.

In Finland, 25 per cent of students achieved Level 5 or higher. In the Australian Capital Territory 25 per cent of students and in Western Australia 22 per cent of students also achieved this level. In Victoria, Tasmania and the Northern Territory, however, only 13 or 14 per cent of students achieved at this level. South Australia and New South Wales also achieved around 18 to 20 per cent of students at the highest levels while all but around 12 per cent achieved above Level 2. In the Northern Territory and Tasmania, however, this is a problem area, with around 13 per cent of students achieving at or above Level 5 but 20 per cent (for Tasmania) and 27 per cent (for the Northern Territory) of students failing to achieve proficiency Level 2.

There were very few gender differences in this competency area within states although the tendency was for more males to achieve at least Level 5 and for more to have failed to reach Level 2.

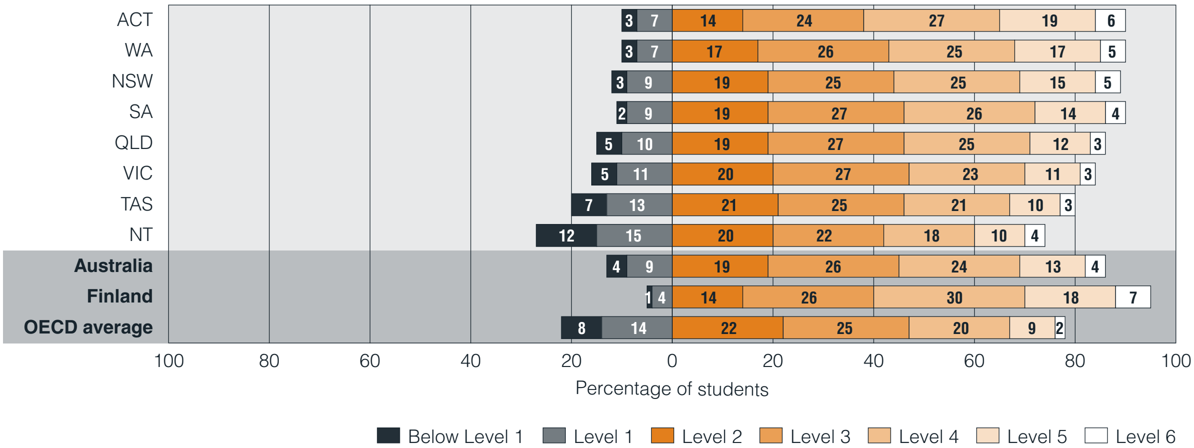


Figure 3.32 Proficiency levels in *using scientific evidence* by state

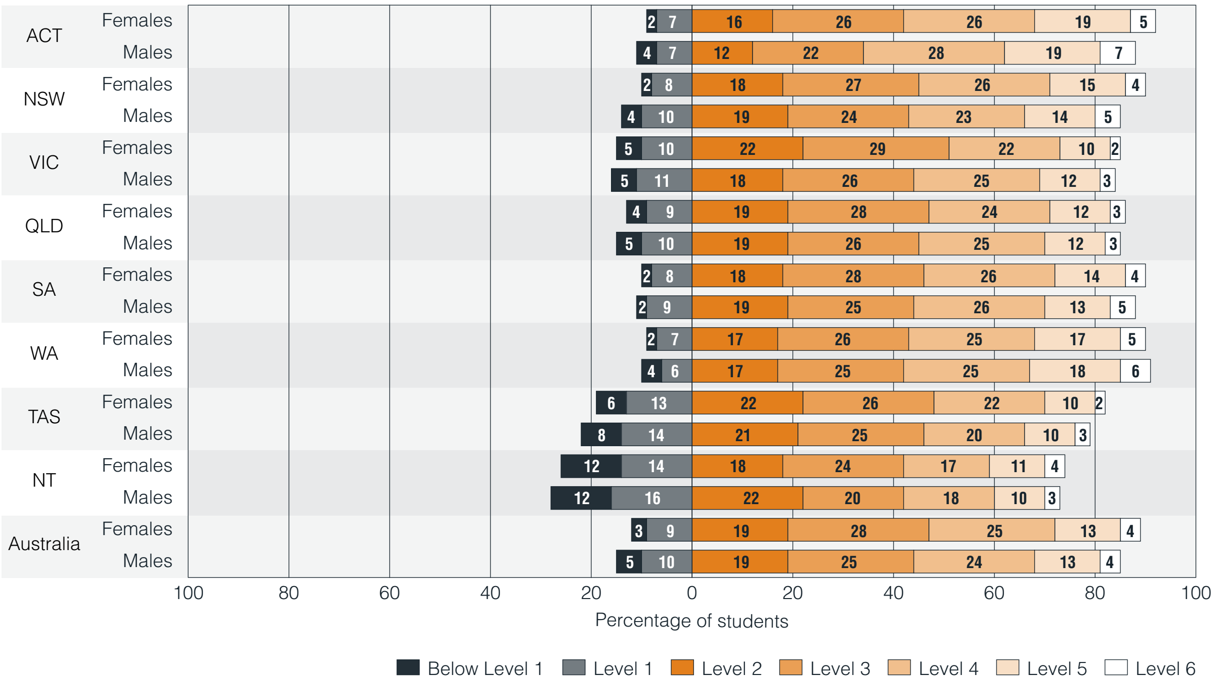


Figure 3.33 Proficiency levels in *using scientific evidence* by state and gender

Achievement by Indigenous and non-Indigenous students

Table 3.15 summarises the performance of Indigenous and non-Indigenous students in each of the three PISA science competencies. In each case, the mean scores for Indigenous students are significantly below those for non-Indigenous students. In terms of relative performance, Indigenous students perform best on the *identifying scientific issues* competency.

Table 3.15 Mean scores for Indigenous and non-Indigenous students on science competencies

	Identifying scientific issues		Diff from mean	Explaining phenomena scientifically		Diff from mean	Using scientific evidence		Diff from mean
	Mean	SE		Mean	SE		Mean	SE	
Indigenous	453	7.9	12	438	7.6	-3	439	8.0	2
Non-Indigenous	538	2.3	9	523	2.3	-6	534	2.4	5

The proficiency levels for Indigenous and non-Indigenous students on all three competencies are shown in Figure 3.34. As would be expected from the mean scores for both groups, the proportion of Indigenous students at each of the higher proficiency levels is low. In *identifying scientific issues*, five per cent of Indigenous students compared to 16 per cent of non-Indigenous students achieved Level 5 or greater, while 34 per cent of Indigenous compared to 10 per cent of non-Indigenous students failed to achieve Level 2. In *explaining phenomena scientifically*, three per cent of Indigenous students and 14 per cent of non-Indigenous students achieved at least Level 5, while 41 per cent of Indigenous compared to 13 per cent of non-Indigenous students failed to achieve Level 2. For *using scientific evidence*, only five per cent of Indigenous students compared to 18 per cent of non-Indigenous students achieved Level 5 or greater, while 39 per cent of Indigenous compared to 12 per cent of non-Indigenous students achieved below Level 2.

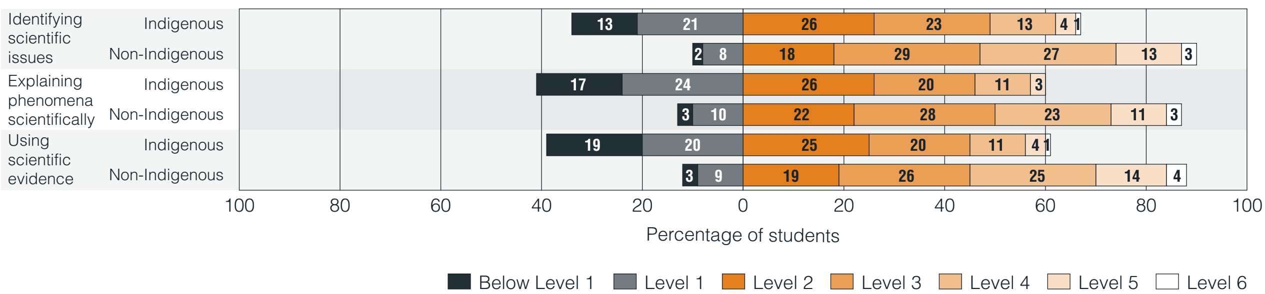


Figure 3.34 Proficiency levels in science competencies for Indigenous and non-Indigenous students

Summary

This chapter has examined Australian performance in scientific literacy overall, in the two knowledge domains, including the three content areas identified within the *knowledge of science* domain, and in the three competencies described by the science framework. It is important that Australia has a strong pool of talented scientists to push forward technological and scientific boundaries – to tackle problems associated with global warming and drought for example. However, with the influence of science and technology on today's society, all citizens, not just those destined to become scientists and engineers, need to be scientifically literate.

It is important, therefore, that mean scores are not looked at in isolation. Analysis of the international data showed that countries with similar mean scores may have very different profiles of performance and both profiles and the overall mean score are important for considering policy directions.

Australia performed very well in science overall, being significantly outscored by only three countries: Finland, Hong Kong-China and Canada, and achieving a similar score to seven other countries, including Japan, New Zealand and the Netherlands. Australia outperformed the remaining 46 countries, including the United Kingdom and United States. The spread of scores in Australia, that is the gap between the strongest and weakest students, is 327 score points. This is somewhat higher than the OECD average, but lies in the middle of the spread of scores for countries with similar means.

Fifteen per cent of Australian students achieved a score that placed them in proficiency level 5 or higher, while 13 per cent failed to achieve Level 2. This compares favourably with the OECD averages of nine and 19 per cent respectively.

There was no gender difference apparent in scientific literacy overall, but there were some differences in performance in content areas and between the scientific competencies. Australian female students performed at a significantly lower level than Australian male students in both "Earth and space systems" and "physical systems". In "physical systems" the average score for females was not significantly different to the OECD mean. Australian males significantly outscored Australian females in the competency *explaining phenomena scientifically*; however, in the competency *using scientific evidence*, there was no significant gender difference and in *identifying scientific issues*, females outscored males.

In terms of overall scientific literacy, the Australian Capital Territory and Western Australian students achieved the highest mean scores. Students in remote areas were found to score significantly lower than students in provincial or metropolitan areas.

Socioeconomic background was found to be closely related to achievement. Students in the lowest quartile of socioeconomic background scored significantly lower than those in the next highest quartile, and the difference between those in the highest and lowest socioeconomic quartiles was 87 score points – almost three school years. Furthermore, almost one-quarter of students in the lowest socioeconomic quartile were not achieving at proficiency level 2, compared with just five per cent of those in the highest socioeconomic quartile.

Indigenous students' performance was found to be the equivalent of one full proficiency level, or two and a half years of formal schooling, below that of non-Indigenous students on the overall scientific literacy scale. In general, Indigenous students are under-represented in the higher proficiency levels and over-represented in the lower proficiency levels.

There were no significant differences in the mean scores for Australian-born, first-generation or foreign-born students; however, a much larger proportion of students with a language background other than English were found to be achieving below Level 2, and a much smaller percentage performing at Level 5 or greater.

Australian students scored significantly higher than the OECD average in both of the defined knowledge areas: *knowledge of science* and *knowledge about science*. Within the *knowledge of science* domain, Australian students showed a relative weakness in the "physical systems" content area, while their performance on both the "Earth and space systems" and "living systems" content areas was found to be similar to the overall mean. Mean scores in all three content areas were significantly higher than the OECD averages.

Australia scored relatively well in two of the three competencies identified in the science framework: *identifying scientific issues* and *using scientific evidence*, but less well in *explaining phenomena scientifically*. A particular area of concern identified through this analysis is the relatively poor performance of students in most states on *explaining phenomena scientifically*; this points to a lack of mastery of scientific knowledge and facts.

Chapter

4

Student Attitudes, Engagement and Movitation in Science

An important outcome of science education is the attitudes students have to science, how they respond to scientific issues, the motivation they have to excel in their science subjects(s), their interest in learning science at school and beyond school and their motivation to pursue a science-related course or career. The focus on scientific literacy as the major domain in PISA 2006 provides an opportunity to examine the attitudes, interest and engagement of 15-year-old students.

This chapter describes four areas that provide a summary of students´ general appreciation of science, their attitudes towards science, their personal beliefs as science learners and their responsibility towards selected science-related issues that have local and global consequences. The four constructs: support for scientific enquiry; self-belief as science learners; interest in science; and responsibility towards resources and environments are summarised in Figure 4.1.

Support for scientific enquiry

Students show they can:

- Acknowledge the importance of considering different scientific perspectives and arguments.
- Support the use of factual information and rational explanations.
- Express the need for logical and careful processes in drawing conclusions.

Measures include: questions on support for scientific enquiry (that were integrated into the assessment of science performance); general value of science; personal value of science.

Student beliefs and learning science

Students believe they can:

- Handle scientific tasks effectively.
- Overcome difficulties to solve scientific problems.
- Demonstrate strong scientific abilities.

Measures include: questions on self-efficacy in science; self-concept in science.

Interest, engagement and motivation in science

Students show they can:

- Indicate curiosity in science and science-related issues and endeavours.
- Demonstrate willingness to acquire additional scientific knowledge and skills, using a variety of resources and methods.
- Demonstrate willingness to seek information and have an ongoing interest in science, including consideration of science-related careers.

Measures include: questions on interest in learning science topics (that were integrated into the assessment of science performance); general interest in science; importance of learning science; enjoyment of science; instrumental motivation to learn science and future-oriented science motivation.

Responsibility towards resources and environments

Students show they can:

- Show a sense of personal responsibility for maintaining a sustainable environment.
- Demonstrate awareness of the environmental consequences of individual actions.
- Demonstrate willingness to take action to maintain natural resources.

Measures include: questions on responsibility for sustainable development; awareness of environmental issues; level of concern for environmental issues; optimism for the evolution of selected environmental issues.

Figure 4.1 Summary of PISA 2006 assessment of attitudes (OECD, 2007, p.123)

Measuring student attitudes, motivation and engagement in PISA

Information about students´ attitudes towards science and student engagement in science was collected in two ways. For each PISA cycle, contextual data including student attitudes has been gathered through the Student Questionnaire. However, in PISA 2006 many of the scientific literacy units in the cognitive assessment contained one or two items designed to assess students´ attitudes towards science – in particular, their support for scientific enquiry and their interest in science. Incorporating attitudinal items into the cognitive assessment captured how students value science in relation to specific topics.

Several of PISA´s measures reflect indices that summarise responses from students to a series of related questions. The questions were selected on the basis of theoretical considerations and previous research. Values on the index were standardised so that the mean value for the OECD student population was zero and the standard deviation was one. For further information, please refer to the Reader´s Guide.

This chapter provides a description of the constructs at an international level and a national level. When considering the results it is necessary to bear in mind the following points. Firstly, the results described in this chapter are self-reported, and the impact that social desirability has on students´ response patterns is unknown. For this reason, comparisons between countries are not always possible as students may not answer questions in the same way. Secondly, the questions in PISA investigate the relationship between constructs and scientific literacy performance, and reports these as correlations, but it is not possible to determine what comes first. For example, there may be a positive relationship between attitudes towards learning science and scientific literacy performance, but it is not possible to determine whether the attitudes influence performance or if performance influences attitudes (see Reader´s Guide).

Support for scientific enquiry

Support for scientific enquiry is often regarded as an important object of science education. Students have beliefs about the general appreciation of science and scientific enquiry and their own perceptions of the personal importance of science. In addition to these two constructs (general value of science and personal value of science) students´ support for scientific enquiry was directly assessed in the cognitive assessment using embedded questions that targeted personal, social and global contexts. Examples of the units incorporating questions about the support for scientific enquiry were `Acid Rain´, `Grand Canyon´ and `Mary Montagu´ (see Chapter 2). For the attitudinal questions measuring students´ support for scientific enquiry, students were asked to express their level of agreement on a four-point scale: strongly agree; agree; disagree and strongly disagree. Students reporting that they agree or strongly agree were considered to support scientific enquiry. The responses for Australian students and for students across all OECD countries to these embedded items are shown in Chapter 2, in the section describing sample scientific literacy items and responses.

General value of science

PISA collected information on students´ perception of the general value of science. A strong general value of science relates to students valuing the contribution of science and technology, for understanding the natural and constructed world, and for the improvement of natural, technological and social conditions of life. Students were asked to indicate whether they agreed with the following statements:

- Advances in science and technology usually improve people´s living conditions.
- Science is important for helping us to understand the natural world.
- Advances in science and technology usually help improve the country.
- Science is valuable to society.
- Advances in science and technology usually bring social benefits.

These statements were used to create an index on the general value of science. This index, like all the indices that involve student responses to multiple questions, was scaled using a weighted maximum likelihood estimate. Values on the index were standardised so that the mean value for the OECD student population was zero and the standard deviation was one.

Thailand, Chinese Taipei and Tunisia reported the highest levels on the general value of science index (with a mean score of 0.70 or more). Denmark and the Netherlands reported the lowest levels on the general value of science index (with a mean score of less than –0.20). Australia had a mean of –0.05, which was slightly lower than the OECD average. Eighty per cent of countries had significant gender differences, but there was no clear pattern. Among the countries where females showed a greater general value of science than males were Jordan, Thailand and Turkey. However, males from Japan, the United Kingdom and the Netherlands had higher mean scores than females. Australian males reported significantly higher levels on the general value of science index (equal to the OECD average of 0.0) than females (with a mean score of –0.11).

Figure 4.2 shows the mean for all students and separately for females and males by country on the general value of science index. The figure also shows the mean for students in the lowest quartile (those students reporting the lowest levels on the index) and the mean for students in the highest quartile (those students with the highest levels on the index). The difference between the highest quartile mean and lowest quartile mean illustrates the range of scores on the index. This data is presented graphically for each of the indices presented in this chapter.

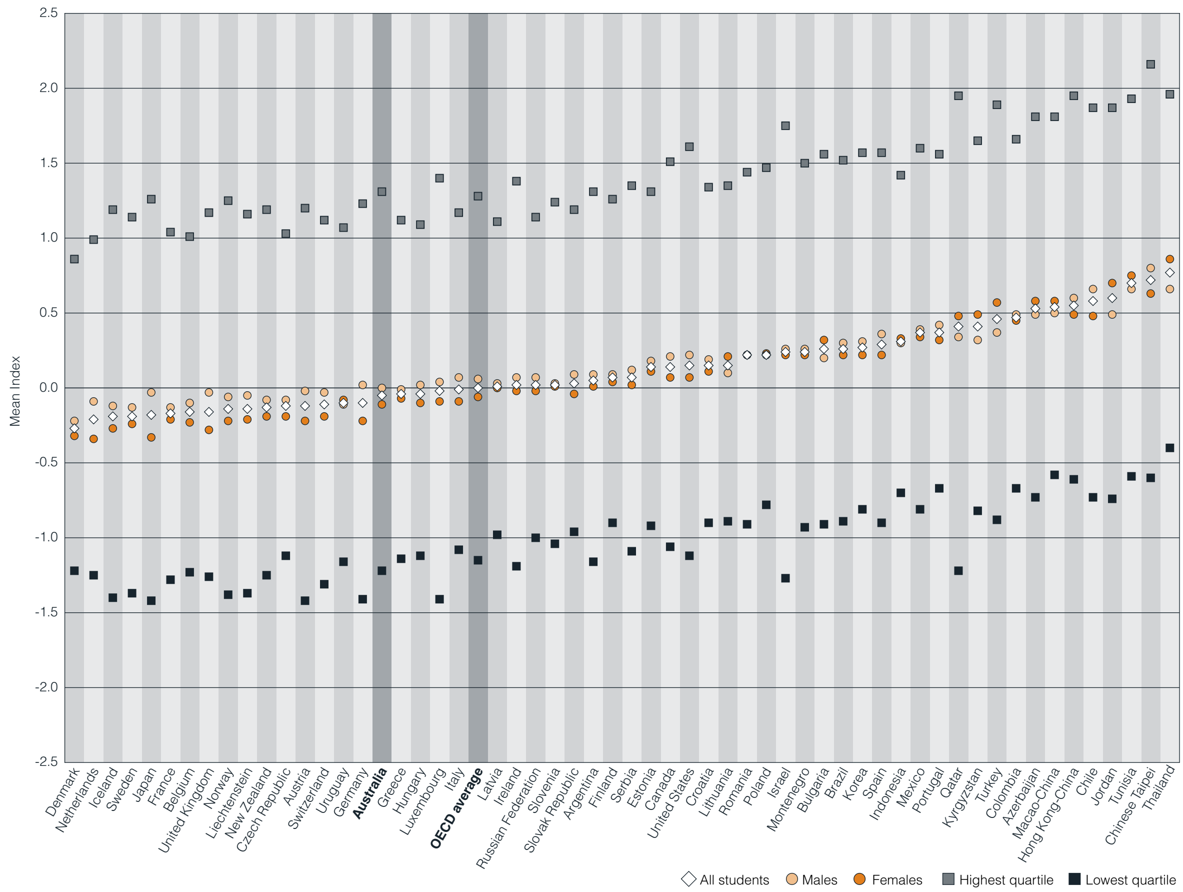


Figure 4.2 General value of science by country

Figure 4.3 shows the percentage of students by state who agreed[12] with the statements about the general value of science. Results for Australia overall and for Finland, the highest performing country in scientific literacy, have been included for comparison. More than 60 per cent of students agreed that advances in science and technology usually bring social benefits and more than 80 per cent of Australian students agreed advances in science and technology usually help to improve the economy and to improve people´s living conditions and that science is valuable to society. The majority of Australian students agreed that science is important for helping them to understand the natural world.

Percentage of students who agree or strongly agree with the statements

	Advances in science and technology usually improve people's living conditions	Science is important for helping us to understand the natural world	Advances in science and technology usually help to improve the economy	Science is valable to society	Advances in science and technology usually bring social benefits
ACT	91	94	85	91	72
NSW	91	94	85	89	69
VIC	90	94	83	87	65
QLD	90	93	85	89	70
SA	91	94	87	92	67
WA	91	94	88	92	73
TAS	86	92	84	86	64
NT	88	93	83	89	72
Australia	90	94	85	89	68
Finland	94	96	84	93	89

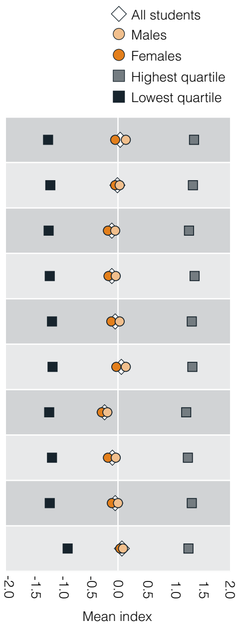


Figure 4.3 General value of science by state

On average, students in each state had a lower level of value for science than was the average in the OECD. Tasmania had the lowest levels of students´ general value of science with a mean score of –0.24 (Figure 4.3). Australian females in each state had a lower level of value for science than on average across all OECD countries. Males from Western Australia, the Australian Capital Territory, New South Wales and South Australia were more positive in their views than the OECD average.

Australian students who reported the highest levels on the general value of science index scored 98 score points higher on average, almost the equivalent of three school years, in scientific literacy performance than those students who had the lowest levels on the general value of science index. The correlation coefficient between the general value of science index and scientific literacy was 0.38.

On average, students scored 37 points higher in scientific literacy performance per unit increase on the general value of science index (Figure 4.4). General value of science explained 14 per cent of the explained variance on scientific literacy performance.

[12] Includes responses for studentss who `agreed´ or `strongly agreed´.

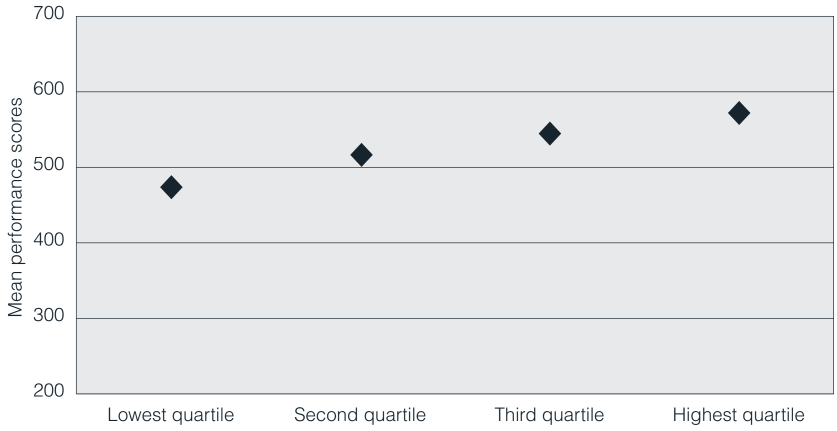


Figure 4.4 Relationship between general value of science and scientific literacy performance for Australian students

It is useful to be able to make comparisons between countries on attitudinal measures; however, the distribution of these scores can vary widely across countries. To make comparisons simpler effect sizes are used to account for these differences in distributions. In keeping with the reporting practices of the OECD, only indices with an effect size of at least 0.20 or greater, or –0.20 or less are reported. Effect sizes of between ±0.20 to ±0.49 are considered small, ±0.50 to ±0.79 are considered medium, and ±0.80 or more are considered large.

The general value of science index is positively associated with students´ socioeconomic background (as measured by the ESCS index) in Australia. The effect size of the difference in scores between students in the highest and lowest quartile of the socioeconomic background index and general value of science index is 0.60.

Personal value of science

The majority of Australian students perceived science as generally important. The personal values of science scale considered whether science was important in a student´s own life and affected their behaviour. The personal value of science related to students´ value of science and the scientific advancement of understanding the world for their own sake, and the usefulness of science and scientific inquiry at an individual level.

Five items were used to measure perceptions of the personal value of science. Students were asked to indicate the extent of their agreement with the following statements:

- Some concepts in science help me see how I relate to other people.
- I will use science in many ways when I am an adult.
- Science is very relevant to me.
- I find that science helps me to understand the things around me.
- When I leave school there will be many opportunities for me to use science.

Students from Colombia, Thailand and Azerbaijan showed the most positive perceptions of the personal value of science, and students from Austria, Liechtenstein and Germany showed the least positive perceptions on this index. Australia had a mean index of 0.02, which was similar to that of the OECD average (Figure 4.5). Over half the countries showed significant gender differences on the personal value of science index, including Australia. The largest gender differences in favour of females were found in Lithuania, Uruguay and Azerbaijan. The largest differences in favour of males occurred in Chinese Taipei, Japan and the Netherlands. Australia´s gender difference was in favour of males, meaning that male students could see more use for science in their present and future lives.

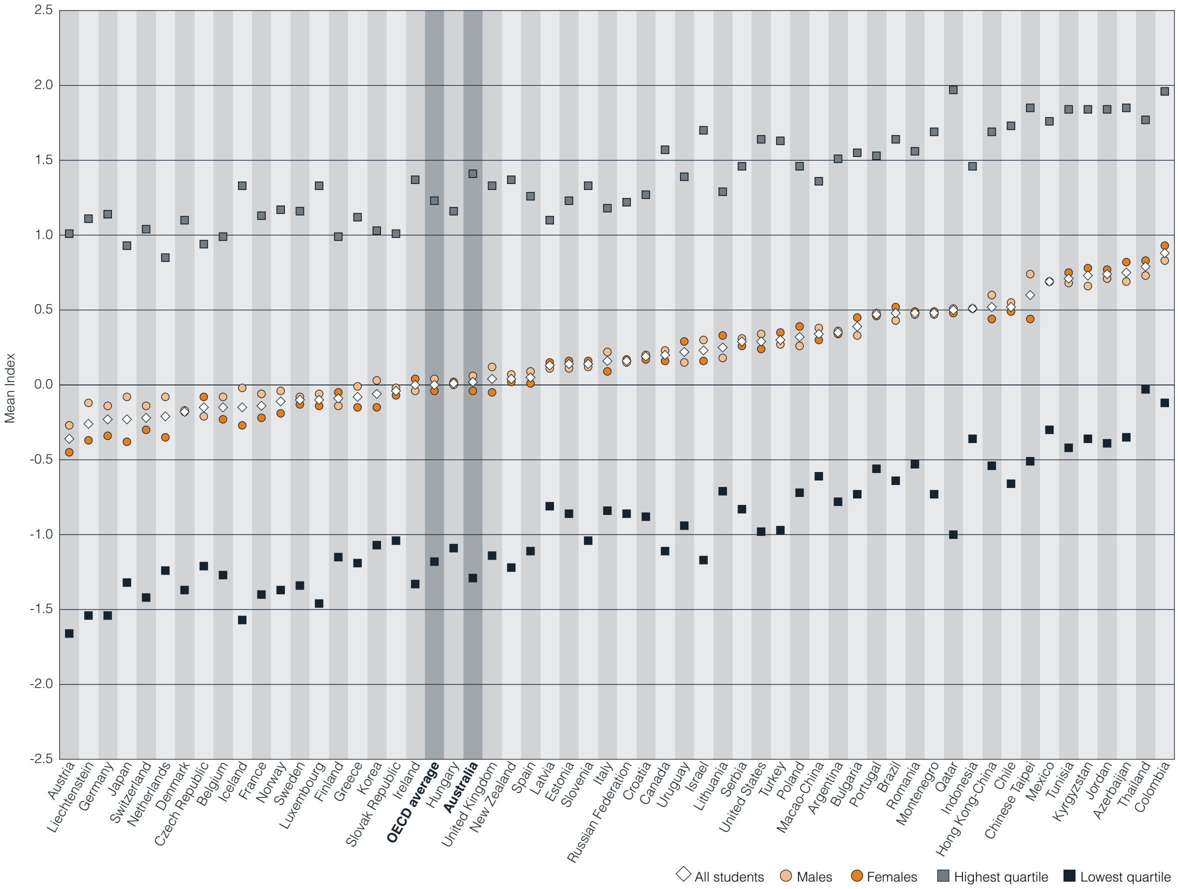


Figure 4.5 Personal value of science by country

Seventy four per cent of Australian students agreed that science helps them to understand the things around them. However, fewer students reported that they will use science in many ways when they are an adult, or that some concepts in science help them to see how they relate to other people or that when they leave school there will be many opportunities for them to use science (63, 62 and 60 per cent respectively). Only a little more than half the Australian students indicated that science is very relevant to them. Students from Western Australia reported the highest percentage on all but one of the statements on the personal value of science (Figure 4.6).

In three states (Queensland, Tasmania and Victoria) students had perceptions that were less positive than the OECD average. All other states had mean scores that were more positive than the OECD average on the personal value of science index. Males from all states held more positive values on science than their females counterparts with the largest differences reported in Western Australia and the Northern Territory.

	Some concepts in science help me see how I relate to other people	I will use science in many ways when I am an adult	Science is very relevant to me	I find that science helps me to understand the things around me	When I leave school there will be many opportunities for me to use science
	Percentage of students who agree or strongly agree with the statements				
ACT	64	65	59	77	66
NSW	63	62	56	77	56
VIC	62	62	53	72	59
QLD	61	61	51	72	59
SA	58	66	57	74	63
WA	65	69	62	77	68
TAS	59	64	54	67	64
NT	65	69	58	79	64
Australia	62	63	55	74	60
Finland	66	57	48	76	59

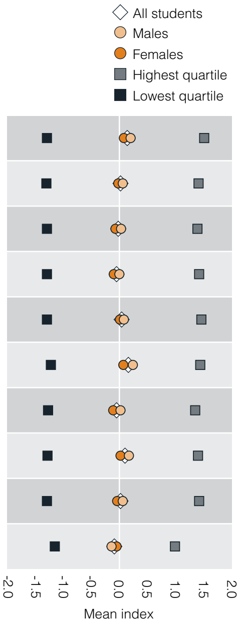


Figure 4.6 Personal value of science by state

Figure 4.7 shows that there is a moderate positive relationship between the personal value of science and scientific literacy performance for Australian students (r = 0.34). Students in the highest quartile of the personal value of science index scored 94 points higher on average (almost the equivalent of three school years) than students in the lowest quartile of the index.

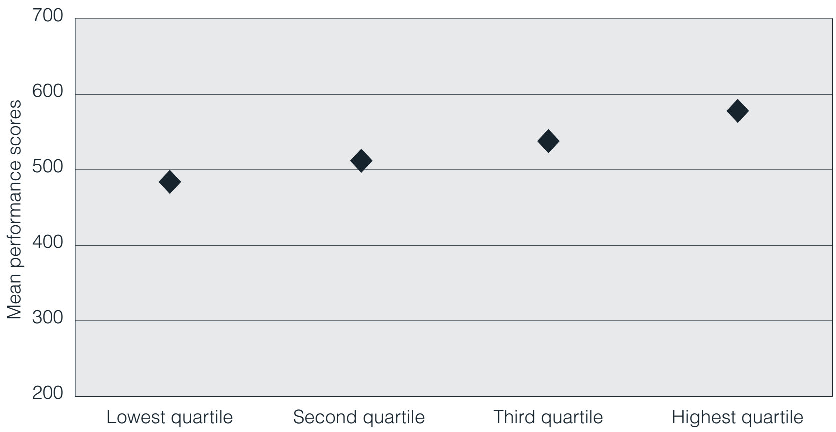


Figure 4.7 Relationship between personal value of science and scientific literacy performance for Australian students

On average, students scored 33 points higher in performance in scientific literacy per unit (increase) on the personal value of science index. Personal value of science explained 13 per cent of the demonstrated variance on scientific literacy performance. There was a positive and significant effect size (of 0.49) between the scores of students in the highest and lowest quartile of socioeconomic background.

Students´ beliefs and learning science

Of all the attitudinal and student belief constructs examined in PISA 2003 for Australian students, self-efficacy and self-concept were found to have the strongest positive associations with mathematical literacy. This was also the case for PISA 2006 and scientific literacy. Self-efficacy and self-concept in science appear to play an important role in influencing behaviour.

Self-efficacy in science

Students´ feelings of confidence about a specific problem are important to an individual´s capacity to solve that problem. Eight items measuring the student´s confidence to perform science-related tasks were used to assess self-efficacy in science for PISA 2006. These statements cover important themes identified in the scientific literacy framework. Students were asked how confidently they could:

- Recognise the science question that underlies a newspaper report on a health issue.
- Explain why earthquakes occur more frequently in some areas than in others.
- Describe the role of antibiotics in the treatment of disease.
- Identify the science question associated with the disposal of garbage.
- Predict how changes to an environment will affect the survival of certain species.
- Interpret the scientific information provided on the labelling of food items.
- Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.
- Identify the better of two explanations for the formation of acid rain.

Students from Poland had the highest levels of self-efficacy in science with a mean of 0.26, while students in Finland, the highest performing country, had a mean similar to the OECD average. Australian students averaged 0.12 points, indicating that students had higher levels of self-efficacy in science than the OECD average (Figure 4.8). There were significant gender differences in two-thirds of the countries on the self-efficacy in science index, with males from the majority of countries having higher levels of self-efficacy than females. Iceland and Liechtenstein had the largest gender differences. In Australia, males scored significantly higher (at 0.19 points) than females (at 0.04). The gender difference was thus 0.14, which was around the same as the average difference for the OECD (0.12 points, which was also significant).

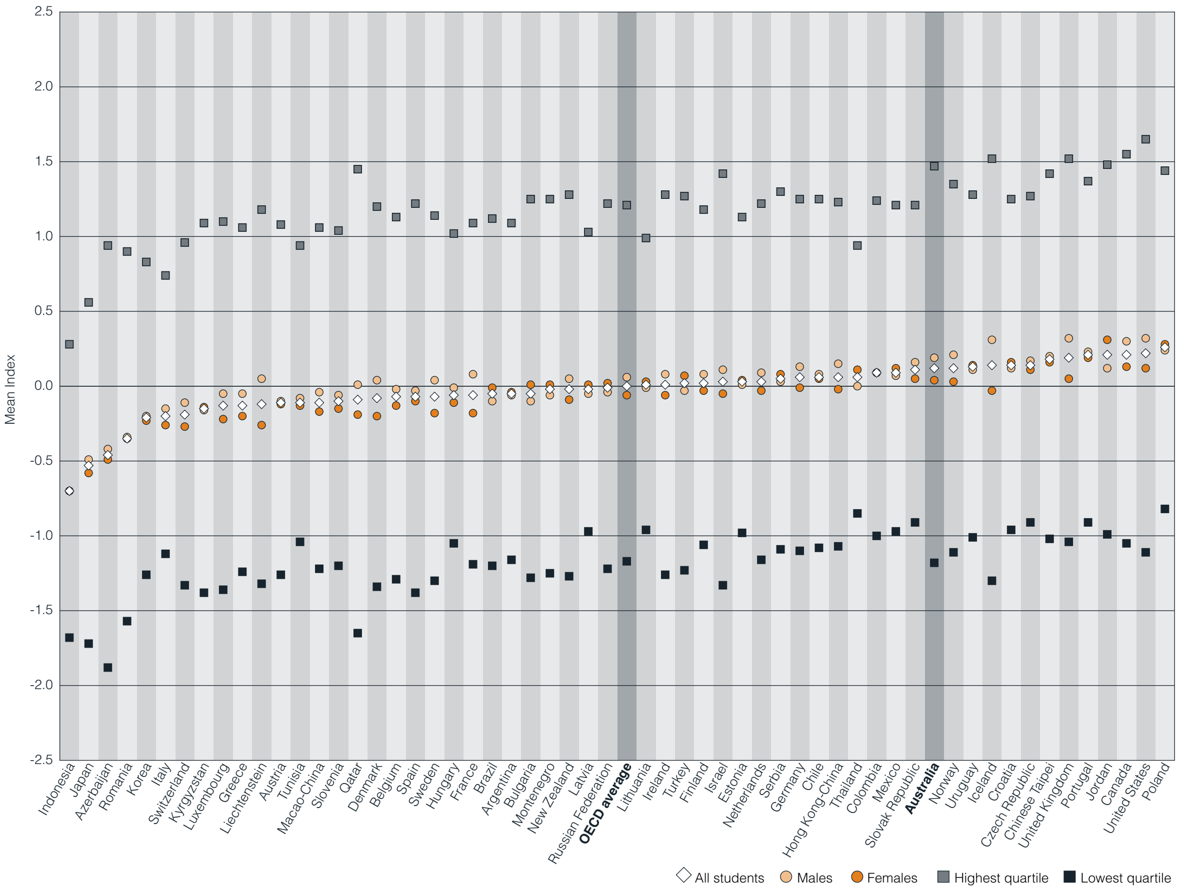


Figure 4.8 Self-efficacy in science by country

On most items examined, Australian students showed high self-efficacy. On average, at least three-quarters of Australian students indicated they could easily, or could with a bit of effort, predict how changes to an environment will affect the survival of certain species, recognise the science question that underlies a newspaper report on a health issue, or explain why earthquakes occur more frequently in some areas than in others. Sixty-eight per cent of students reported they could confidently interpret the scientific information on the labelling of food items, 61 per cent could confidently identify the science question associated with the disposal of garbage and 59 per cent could confidently describe the role of antibiotics in the treatment of disease. Figure 4.9 shows, however, that fewer Australian students indicated they could easily discuss how new evidence can lead you to change your understanding about the possibility of life on Mars or identify the better of two explanations for the formation of acid rain (with 55 and 54 per cent respectively).

	Percentage of students who believe they can perform the following tasks easily or with a bit of effort							
	Recognise the science question that underlies a newspaper report on a health issue	Explain why earthquakes occur more frequently in some areas than in others	Describe the role of antibiotics in the treatment of disease	Identify the science question associated with the disposal of garbage	Predict how changes to an environment will affect the survival of certain species	Interpret the scientific information provided on the labelling of food items	Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars	Identify the better of two explanations for the formation of acid rain
ACT	79	80	64	65	73	74	62	53
NSW	82	83	66	70	80	72	58	59
VIC	77	78	55	55	71	63	53	48
QLD	72	73	55	57	71	64	51	49
SA	78	74	58	59	73	65	51	55
WA	84	80	59	63	82	71	57	59
TAS	78	72	57	60	71	65	51	50
NT	74	76	59	62	75	68	62	58
Australia	78	78	59	61	75	68	55	54
Finland	77	83	53	63	56	68	64	48

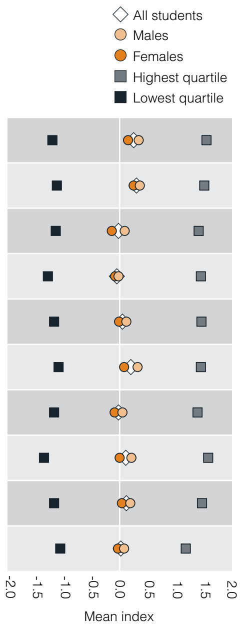


Figure 4.9 Self-efficacy in science by state

Students from New South Wales had the highest levels of self-efficacy in science with a mean index of 0.30, followed by the Australian Capital Territory and Western Australia. South Australia and the Northern Territory also had means that indicated their students had higher levels of self-efficacy in science than the OECD average. Victoria, Tasmania and Queensland had means that were slightly lower than the OECD average. Males from all states showed higher levels on the self-efficacy in science index than females. The largest gender differences were found in Western Australia and Victoria, with differences of approximately 0.25 points.

Figure 4.10 shows the positive relationship between self-efficacy in science and scientific literacy performance for Australian students ($r = 0.49$). Students in the highest quartile scored 130 points on average higher than students in the lowest quartile on the self-efficacy in science index. The difference is massive – equivalent to almost four years of schooling or almost two proficiency levels on the scientific literacy scale. The difference in performance in the Northern Territory between students in the highest and lowest quartiles on the self-efficacy in science index was even greater, at 177 score points.

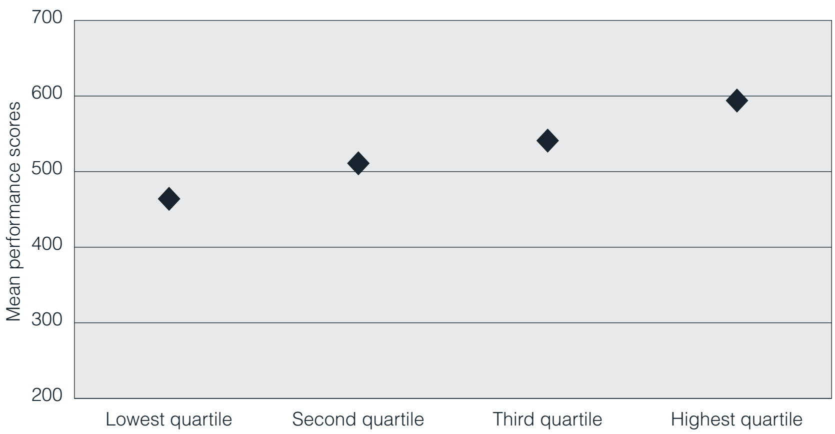


Figure 4.10 Relationship between self-efficacy in science and scientific literacy performance for Australian students

Self-efficacy in science explained 24 per cent of the variation on scientific literacy performance, with an increase of 44 score points in scientific literacy performance per unit increase in the self-efficacy in science index.

In Australia, self-efficacy in science is strongly and positively associated with students´ socioeconomic background. The effect size between students in the highest and lowest quartile of the socioeconomic background index and self-efficacy in science is 0.72.

Self-concept in science

PISA collected information on student´s beliefs about their competence in science. If students believe in their own capacities, they will be more willing to make the necessary investments in learning, with the outcome being improved performance.

Six items on science self-concept were used in PISA 2006 to examine this construct. Students were asked about their experience in learning topics by indicating their level of agreement on the following statements:

- Learning advanced science topics would be easy for me.
- I can usually give good answers to test questions on science topics.
- I learn science topics quickly.
- Science topics are easy for me.
- When I am being taught science, I can understand the concepts very well.
- I can easily understand new ideas in science.

Figure 4.11 shows the means by country and gender as well as the means for students in the lowest and highest quartiles of the index on self-concept in science. Students from three Asian countries: Japan, Korea and Chinese Taipei, had the lowest levels of self-concept in science with means less than –0.40. The average for Australia was –0.03, which was not significantly different to the OECD average.

In eighty-six per cent of countries, males had a significantly higher self-concept in science than females. The largest gender differences were in Japan and Chinese Taipei with 0.5 points difference between males and females. The smallest significant differences were in Kyrgyzstan and Romania. In Australia, the gender difference was significant at 0.22 points, with a mean for males of 0.07 compared to a mean of –0.14 for females. This means that Australian males were generally more confident in science than the OECD mean for males, while females were on average less confident than the OECD mean for females.

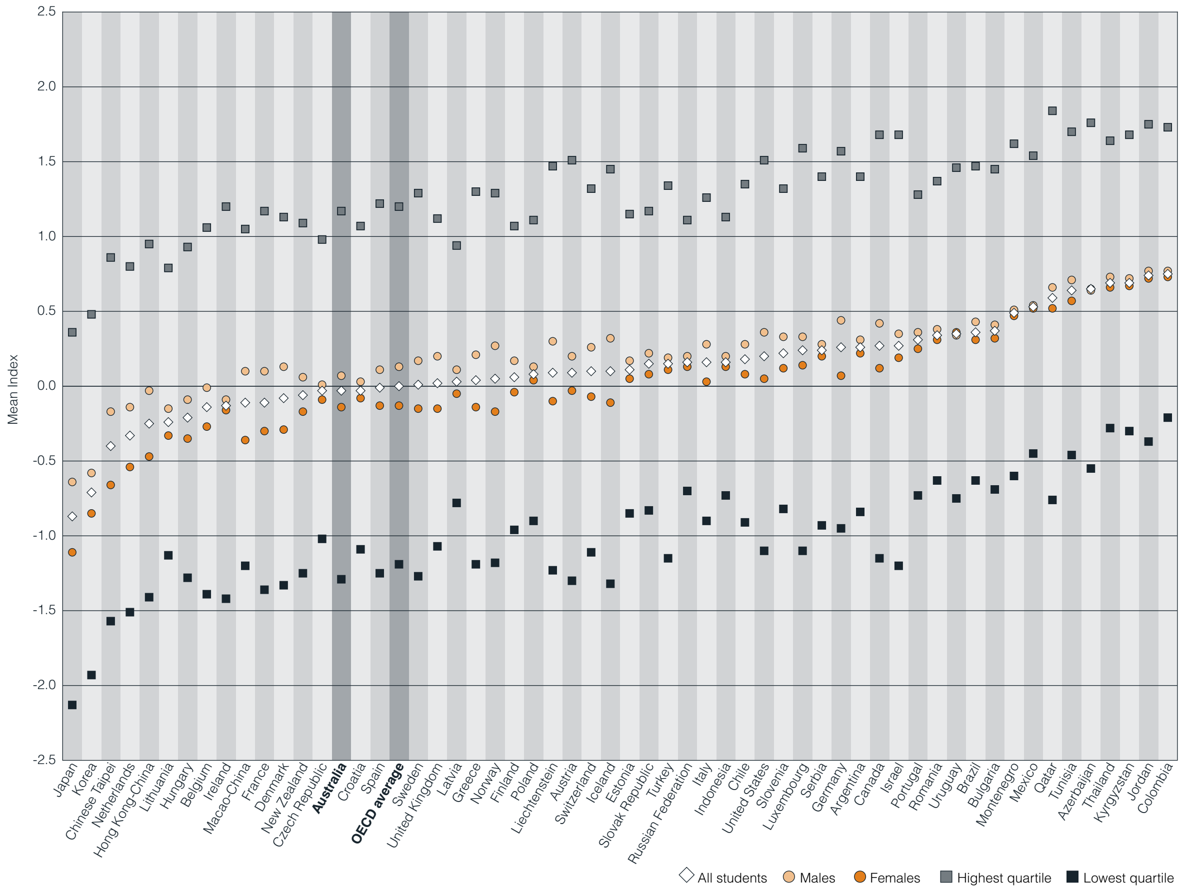


Figure 4.11 Self-concept in science by country

Sixty-seven per cent of Australian students agreed they can usually give good answers to test questions on science topics and 60 per cent of students agreed that when they are being taught science they understand concepts very well. There were fewer students who indicated that they learn science topics quickly (55%) or that science topics are easy for them (47%). Thirty-five per cent of Australian students reported that learning advanced science topics was easy for them. Students from Western Australia had the highest percentage of students in any state who agreed with the statements about self-concept in science (Figure 4.12).

All states except Western Australia had a mean score that was below that of the OECD average, indicating lower levels of self-concept in science than students across OECD countries. Western Australia had a mean score 0.07 points, which was just higher than the OECD mean. The largest gender differences, of approximately 0.25 points, were in the Northern Territory and Western Australia.

	Percentage of students who agree or strongly agree with the following statements					
	Learning advanced science topics would be easy for me	I can usually give good answers to test questions on science topics	I learn science topics quickly	Science topics are easy for me	When I am being taught science, I can understand the concepts very well	I can easily understand new ideas in science
ACT	41	64	54	48	59	59
NSW	38	68	55	46	60	60
VIC	41	66	55	49	60	58
QLD	40	65	54	47	58	58
SA	40	66	55	45	60	58
WA	42	71	60	51	63	62
TAS	35	62	54	43	56	59
NT	47	67	55	49	59	60
Australia	39	67	55	47	60	59
Finland	50	69	61	53	52	61

Figure 4.12 Self-concept in science by state

Figure 4.13 shows the relationship between science self-concept and scientific literacy performance for Australian students. Self-concept in science has a moderately strong positive relationship with scientific literacy performance (*r* = 0.43). There were 113 score points on average (or the equivalent of three years of schooling) between students in the highest quartile of the self-concept in science index and students in the lowest quartile. As for self-efficacy in science, the difference in performance between students in the highest and lowest quartile of the index was even larger for students in the Northern Territory where 131 score points separated the two groups.

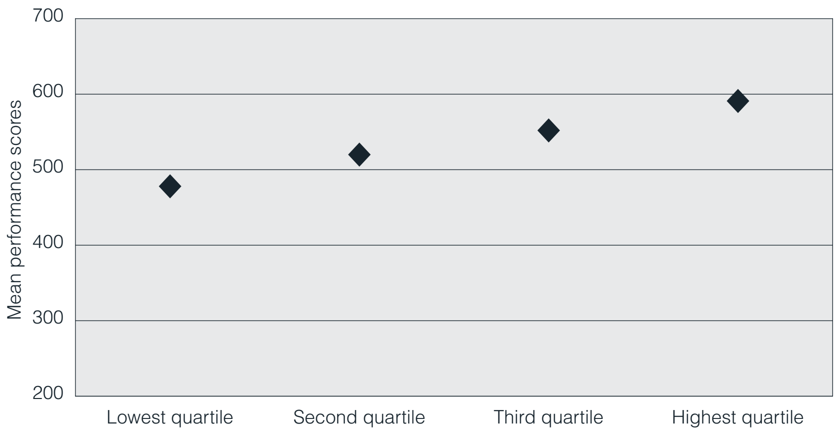


Figure 4.13 Relationship between self-concept in science and scientific literacy performance for Australian students

Self-concept in science explained 18 per cent of the variance in scientific literacy performance. For every unit change in the self-concept in science index, there was a 43 point change in the scientific literacy scores. Self-concept in science was positively associated with students´ socioeconomic background (with an effect size of 0.51 between students in the highest and lowest quartiles of the socioeconomic background index and self-concept in science).

Interest, engagement and motivation in science

Previous PISA cycles have reported students´ interest in reading and mathematics, and for PISA 2006 interest in science is examined. Interest, motivation and engagement are important constructs in student learning. Interest in and the enjoyment of particular subjects relates to intrinsic motivation, which influences whether students will be encouraged to work diligently and continue to learn in this area beyond school or even pursue further educational opportunities in this field.

Attitudinal items were also integrated into the cognitive assessment to assess interest in learning specific science topics. To measure students´ interest in learning science topics, students were asked how much interest they had for specific topics on a four-point scale: high interest; medium interest; low interest; or no interest. Students reporting high interest or medium interest were considered to report an interest in science. Examples of the embedded questions on students´ interest in learning science are shown in the units `Acid Rain´ and `Genetically Modified Crops´ in Chapter 2 (in the section with sample scientific literacy items and responses). The tables in that section show the percentages of Australian students who indicated a high, medium, low or no interest in the particular science topic. The percentages of all students from OECD countries are also included.

General interest in learning science

Eight items were used to measure how interested students are in learning science as a subject. These items from the Student Questionnaire provide data on students´ interests in more general terms than the embedded questions in the cognitive assessment, which provide data on interest in specific contexts.

Students were asked to indicate their level of interest on a range of science topics on a four-point scale (high interest, medium interest, low interest and no interest). The science topics were: physics, chemistry, astronomy, geology, biology of plants, human biology, ways scientists design experiments, and what is required for scientific explanations. An overall index of general interest in learning science was created using the data from these questions.

Figure 4.14 shows the means for all students, for females and males, as well as the means for students in the highest and lowest quartile of the general interest in learning science index. Students from Colombia, Kyrgyzstan and Thailand reported the highest general interest in learning science, whereas students from the Netherlands, Finland, Korea and Australia showed the lowest general interest in learning science. Clearly lack of interest is no handicap to performance, nor is interest a guarantee of high levels of performance.

The gender difference on the general interest in learning science index ranged from –0.20 in Thailand to 0.29 in Chinese Taipei. There was no significant gender difference on this index for Australia.

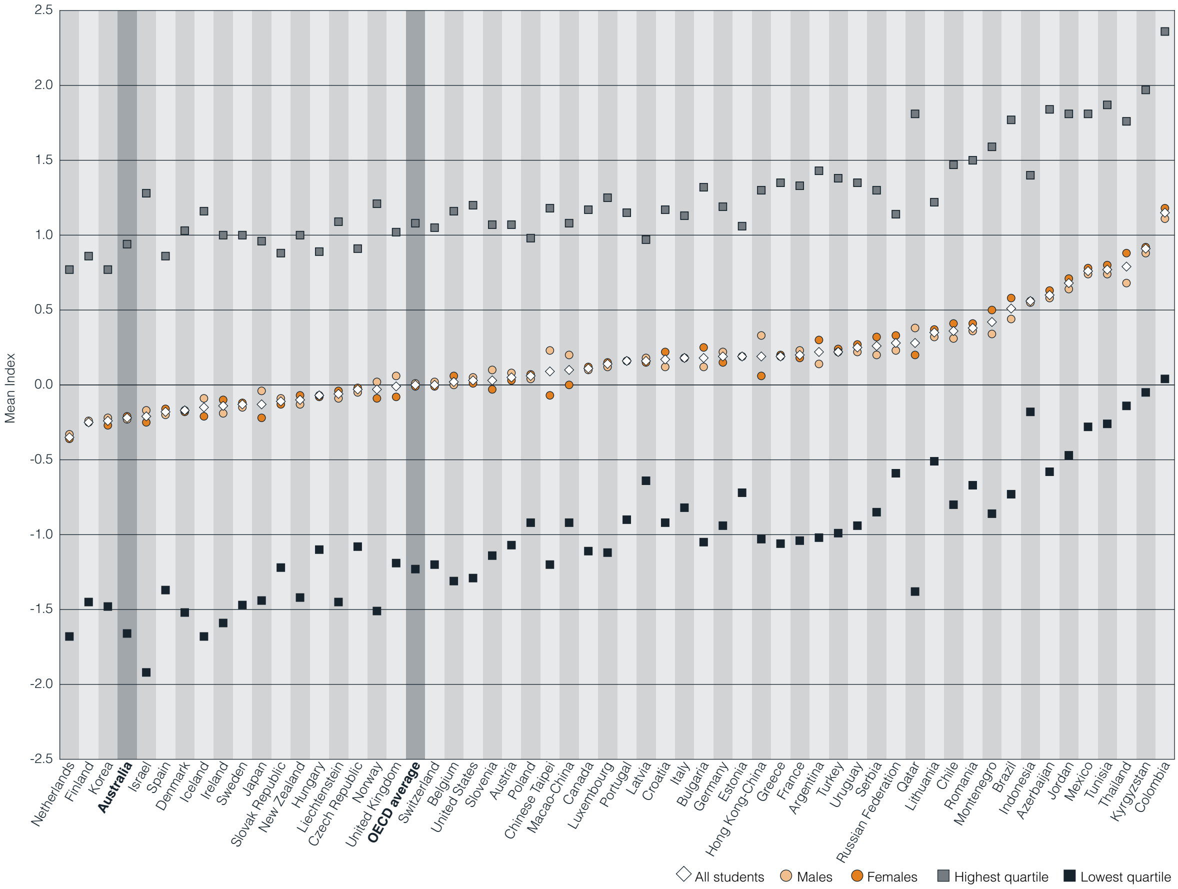


Figure 4.14 General interest in learning science by country

Figure 4.15 shows the average percentage of students reporting high or medium interest for various science topics by state. Overall, students were most interested in human biology, followed by chemistry, astronomy and physics. Students from the Australian Capital Territory had the highest interest in human biology (67%). Students from the Northern Territory had the highest levels of interest in physics (58%), chemistry (55%), astronomy (51%), and in the ways scientists design experiments (39%) and geology (38%) – although neither of the latter elicited much interest from students in any state in Australia.

	Topics in physics	Topics in chemistry	The biology of plants	Human biology	Topics in astronomy	Topics in geology	Ways scientists design experiments	What is required for scientific explanations
	Percentage of students who indicated a high or medium interest in the following topics							
ACT	49	54	40	67	47	34	37	30
NSW	46	49	44	65	50	34	36	28
VIC	46	50	39	62	46	31	36	29
QLD	37	41	37	58	42	29	37	29
SA	49	50	42	65	45	34	33	26
WA	42	46	36	63	45	30	37	29
TAS	50	49	33	59	42	35	37	28
NT	58	55	43	60	51	38	39	29
Australia	44	48	40	62	46	32	36	29
Finland	41	45	33	66	48	31	24	26

Figure 4.15 General interest in learning science by state

The index of general interest in learning science showed very little variation by state. All states had means that were lower than the OECD average, that is Australian students generally showed less interest in learning science than the OECD average.

In Australia, there was a moderate positive association between general interest in learning science and scientific literacy performance (*r* = 0.30). There were 73 score points on average, the equivalent of one scientific literacy proficiency level, between the mean performance of students who reported the lowest levels of general interest in science and the mean performance of those students with the highest levels of general interest in science. The relationship between scientific literacy performance and the general interest in science index for states showed a similar pattern as that for Australia overall (Figure 4.16).

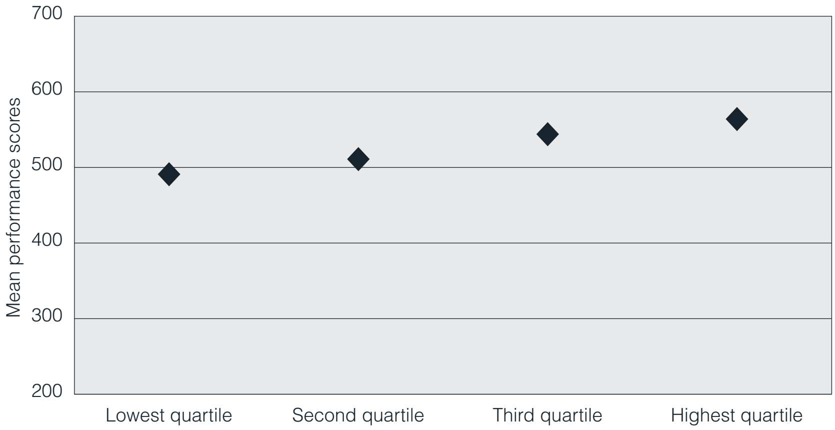


Figure 4.16 Relationship between general interest in science and scientific literacy performance for Australian students

General interest in learning science explained nine per cent of the demonstrated variance on scientific literacy performance, with an increase of 27 score points (or almost one school year) in scientific literacy performance per unit increase in the general interest in learning science index. In Australia, general interest in learning science is positively associated with students´

socioeconomic background. The effect size between the scores of students in the highest and lowest quartiles of the socioeconomic background index and the index of general interest in learning science was 0.40.

Enjoyment of science

Students were asked to think about their views on various issues relating to science and indicate their agreement with the following statements:

- I generally have fun when I am learning science topics.
- I like reading about science.
- I am happy doing science problems.
- I enjoy acquiring new knowledge in science.
- I am interested in learning about science.

Students from Tunisia and Kyrgyzstan showed the highest levels of enjoyment of science and students from the Netherlands, Japan and Poland reported the lowest levels of enjoyment of science. Australia had a mean index of –0.08, which was slightly lower than the OECD average. Figure 4.17 shows the means for females and males on the enjoyment of science index. The largest gender differences were in Japan, Chinese Taipei and Hong Kong-China with males reporting significantly higher levels of enjoyment of science than females. In contrast, females from the Czech Republic and Uruguay reported higher means on the index than males. Australian males had a higher mean index (–0.03 points) than females (–0.12 points), although both were lower than the OECD average.

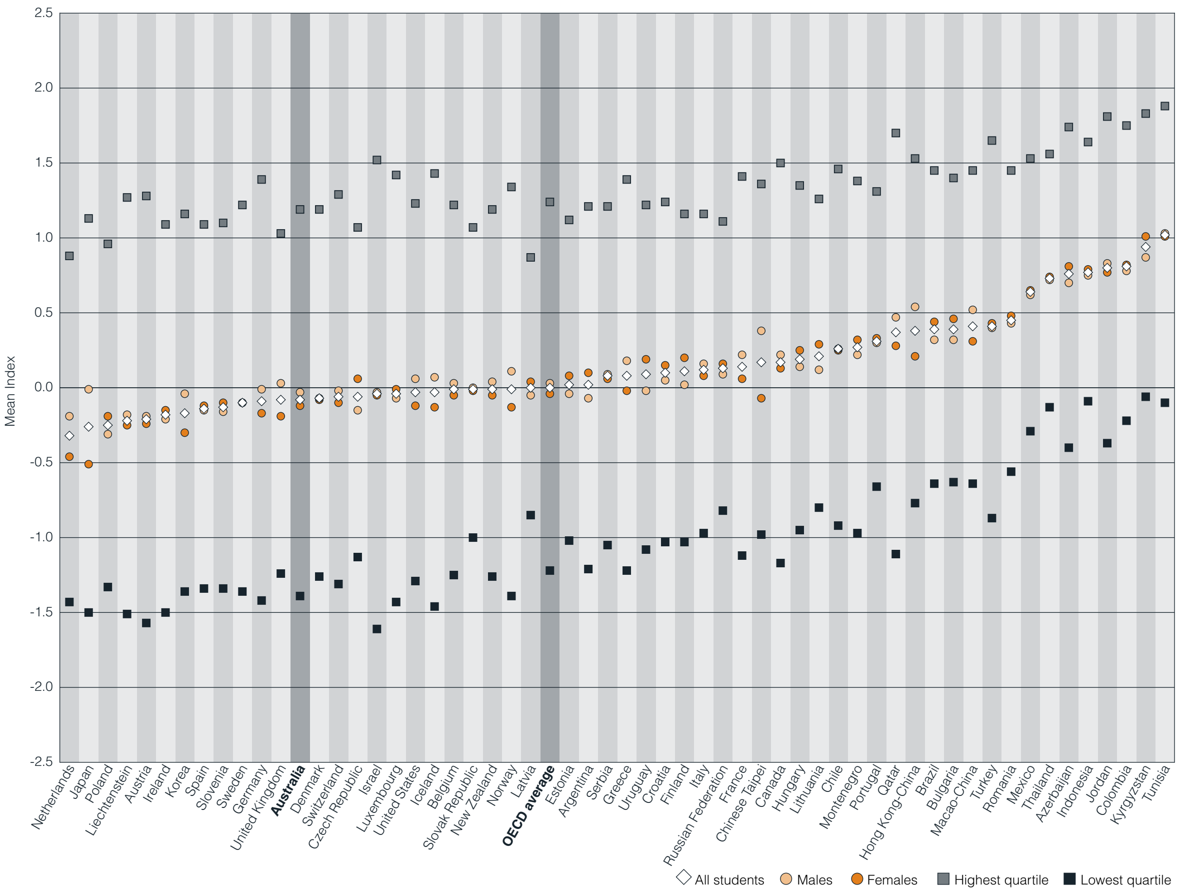


Figure 4.17 Enjoyment of science by country

In Australia, relatively high percentages of students reported they enjoyed acquiring new knowledge in science (67%), that they are interested in learning about science (61%), and that they generally have fun when they are learning science topics (58%). On the other hand, fewer than half the Australian students were happy doing science problems and reading about science (Figure 4.18).

Australian students overall and students from Tasmania, South Australia, Queensland and Victoria enjoy science less than the OECD average, while students from the Northern Territory, Western Australia, the Australian Capital Territory and New South Wales reported similar levels of enjoyment in science to students across all OECD countries. Male students from all Australian states reported higher levels on the enjoyment of science index compared to females. The largest gender differences were in Western Australia and New South Wales (0.18 and 0.10 points respectively) and the smallest gender differences in South Australia (0.03 points).

	Percentage of students who agree or strongly agree with the following statements				
	I generally have fun when I am learning science topics	I like reading about science	I am happy doing science problems	I enjoy acquiring new knowledge in science	I am interested in learning about science.
ACT	60	44	52	70	63
NSW	60	46	50	70	64
VIC	56	42	47	64	59
QLD	57	42	47	63	58
SA	56	40	50	65	60
WA	64	45	56	70	65
TAS	58	38	53	63	58
NT	61	44	53	70	64
Australia	58	43	49	67	61
Finland	68	60	51	74	68

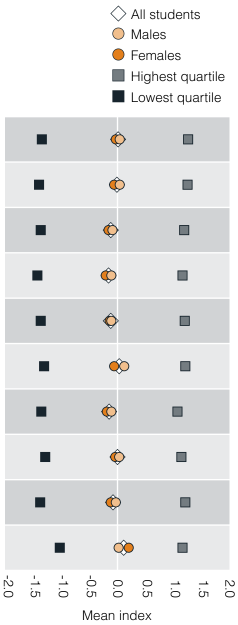


Figure 4.18 Enjoyment of science by state

The relationship between enjoyment of science and scientific literacy performance for Australian students is shown in Figure 4.19. The association between these two variables was stronger than the relationship between the general interest in science index and scientific literacy (r = 0.43). Students in the highest quartile of the enjoyment of science index scored 109 score points on average (or almost 1½ proficiency levels) higher than students in the lowest quartile of the index.

Enjoyment of science explained 19 per cent of the explained variance on scientific literacy performance, with an increase of 42 score points in scientific literacy performance per unit increase in the enjoyment of science index. Enjoyment of science was positively associated with students´ socioeconomic background (with an effect size of 0.51 between students in the highest and lowest quartile of the socioeconomic background index and enjoyment of science).

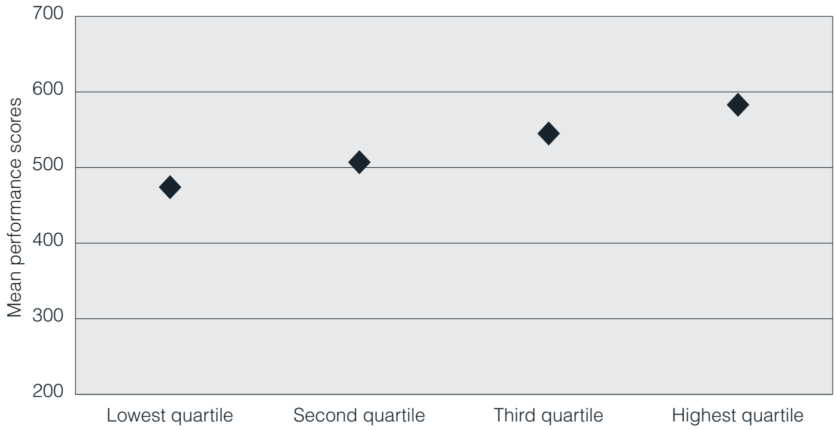


Figure 4.19 Relationship between enjoyment of science and scientific literacy performance for Australian students

Instrumental motivation in science

PISA also assessed instrumental motivation in science. Instrumental motivation focuses on the external rewards that encourage students to learn, to choose subjects and to choose careers.

Five items were used to assess instrumental motivation. Students were asked how much they agreed or disagreed on a four-point scale (strongly agree; agree; disagree; and strongly disagree) with the following:

- Making an effort in my science subject(s) is worth it because this will help me in the work I want to do later on.
- What I learn in my science subject(s) is important for me because I need this for what I want to study later on.
- I study science because I know it is useful for me.
- Studying my science subject(s) is worthwhile for me because what I learn will improve my career prospects.
- I will learn many things in my science subject(s) that will help me get a job.

Figure 4.20 shows the country means on the index of instrumental motivation to learn science derived from the list of statements above. Students from Kyrgyzstan and Tunisia had the highest means on the instrumental motivation scale, while students from Japan and Austria had the lowest means. Australia had a mean of 0.11, indicating Australian students were more instrumentally motivated than was the average for the OECD.

Significant gender differences were found in almost 70 per cent of countries. In approximately half these countries, males reported significantly higher levels of instrumental motivation than females, with Chinese Taipei and Liechtenstein having the largest gender differences in favour of males. In the other half of the countries, females were more instrumentally motivated than males, with Ireland, Portugal and the Czech Republic having the greatest differences in favour of females.

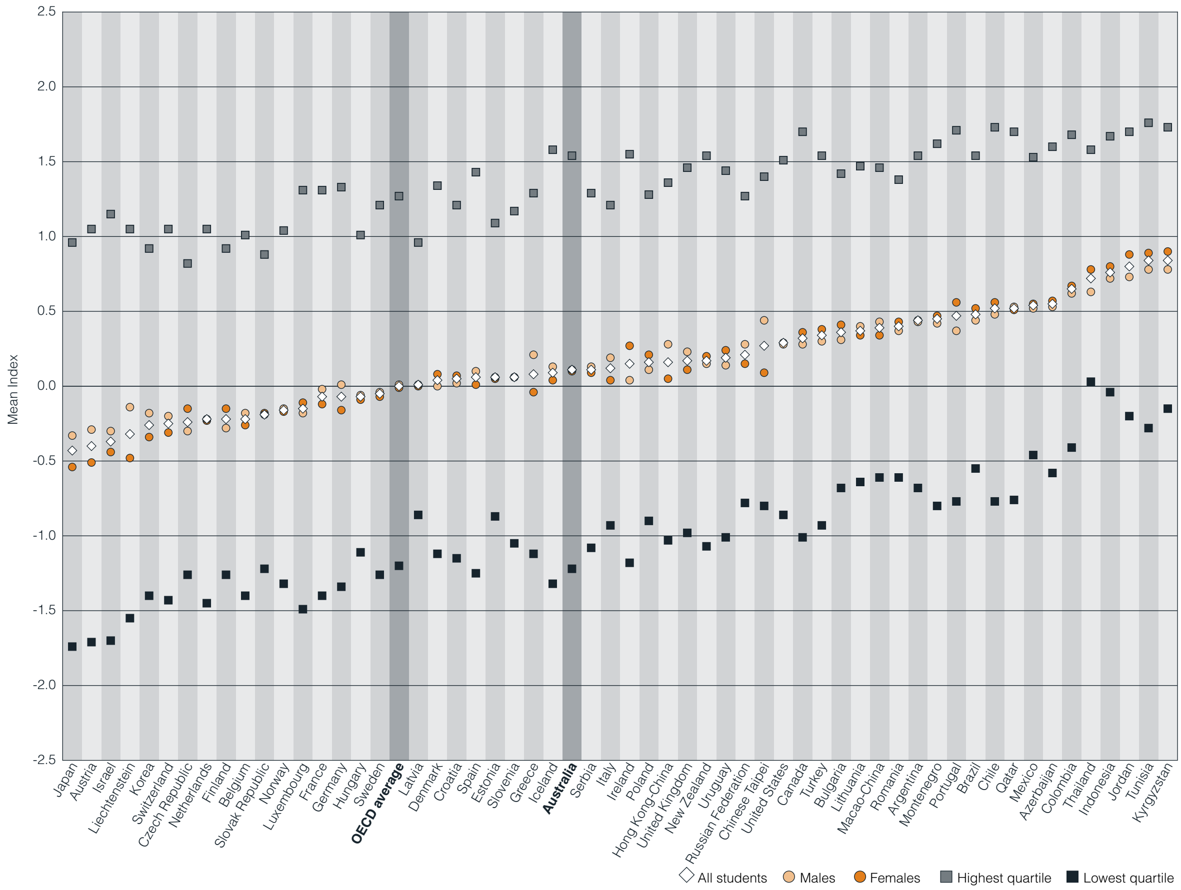


Figure 4.20 Instrumental motivation by country

The proportion of students agreeing with each of the statements is a good indicator of the influences on Australian students. On average, three-quarters of Australian students agreed or strongly agreed that they study science because they know it is useful to them, 72 per cent of Australian students agreed or strongly agreed that making an effort in their science subject(s) is worth it because this will help them in the work they want to do later on, and 71 per cent agreed or strongly agreed studying science subject(s) is worthwhile for them because what they learn will improve their career prospects. Two-thirds of students responded positively to the statement that they will learn many things in their science subject(s) that will help them get a job, and 61 per cent of students agreed or strongly agreed that they study science because they know it is useful for them. Interestingly given their strong performance in scientific literacy, the highest percentage of students who responded positively to all the items on instrumental motivation was from Western Australia (Figure 4.21). Perhaps students are able to see first-hand the links between science and the current mining boom in that state and this has influenced their beliefs.

The means for Australian students and for each of the states as well as the means for females and males (for Australia and for each state) on the index of instrumental motivation were all higher than the OECD average.

	Percentage of students who agree or strongly agree with the following statements				
	Making an effort in my science subject(s) is worth it because this will help me in the work I want to do later on	What I learn in my science subject(s) is important for me because I need this for what I want to study later on	I study science because I know it is useful for me	Studying my science subject(s) is worthwhile for me because what I learn will improve my career prospects	I will learn many things in my science subject(s) that will help me get a job
ACT	68	56	72	67	63
NSW	65	52	67	62	59
VIC	66	55	67	64	62
QLD	66	54	70	63	61
SA	68	57	74	68	65
WA	72	61	76	71	67
TAS	65	54	66	64	60
NT	69	56	73	68	63
Australia	66	55	69	64	62
Finland	53	43	63	51	48

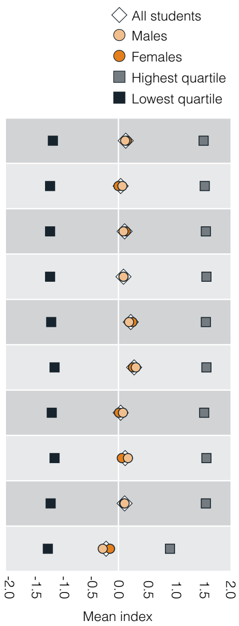


Figure 4.21 Instrumental motivation by state

The relationship between instrumental motivation and scientific literacy performance for Australian students is shown in Figure 4.22. The association between instrumental motivation and scientific literacy performance was positive ($r = 0.31$). Students in the highest quartile of the enjoyment of science index scored 87 score points on average (or just over one proficiency level) higher than students in the lowest quartile of the index.

Instrumental motivation explained ten per cent of the explained variance on scientific literacy performance, with an increase of 30 score points in scientific literacy performance per unit increase in the enjoyment of science index. The instrumental motivation index was positively associated with students´ socioeconomic background in Australia, with an effect size of 0.40.

Figure 4.22 Relationship between instrumental motivation and scientific literacy performance for Australian students

Future-oriented motivation to learn science

Students´ expectations about studying science subjects beyond secondary school and working in science-related careers are another important aspect of student motivation to learn science, and they are also an important factor in countries´ ongoing and future scientific development. Four items in the PISA 2006 Student Questionnaire assessed students´ future-oriented science motivation to take up a science-related career by asking students to indicate their level of agreement with the following (using a four-point scale: strongly agree; agree; disagree; and strongly disagree):

- I would like to work in a career involving science.
- I would like to study science after secondary school.
- I would like to spend my life doing advanced science.
- I would like to work on science projects as an adult.

At an international level Tunisia, Jordan and Kyrgyzstan had the highest means (more than 1.0 points) on the future-oriented science motivation index. Students with the lowest levels on the index were Austria and Liechtenstein with means of around –0.30 points. Australia´s mean was –0.07, slightly below that of the OECD average (Figure 4.23).

There were significant gender differences in almost 70 per cent of countries. Males from most countries had higher expectations about doing science studies at a tertiary level and working in a science-related career than females. This reflects current statistics about the actual proportion of women entering science areas in universities, and perhaps is an indication that this imbalance is unlikely to change.

The gender difference was largest in Chinese Taipei and Japan. Australian males had a mean of –0.03 points while the mean for females was –0.12 points. The Australian gender difference was similar to that of the OECD average (0.10 points). In the Czech Republic, Poland and Uruguay females reported higher expectations on the future-oriented science motivation index than males.

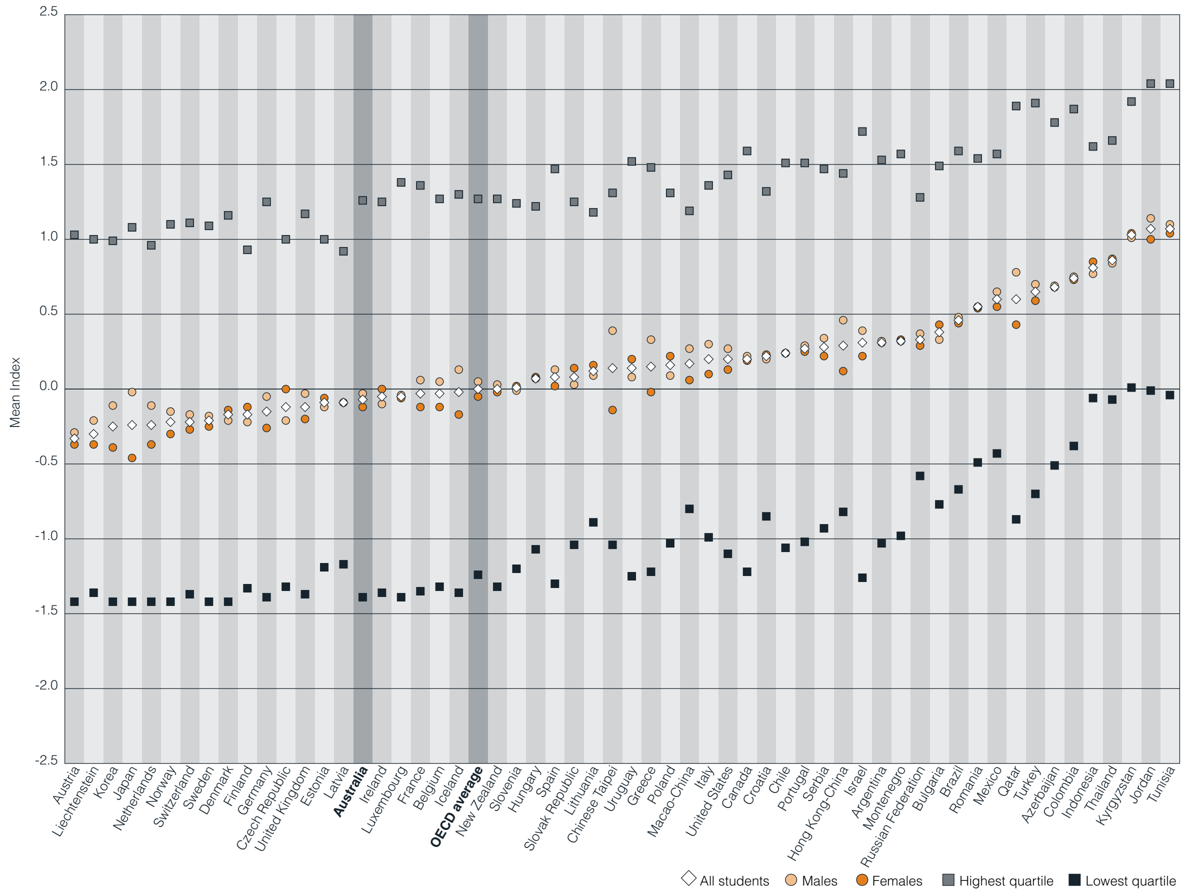


Figure 4.23 Future-oriented motivation to learn science by country

Overall, a high percentage of Australian students did not expect to have a science-related career or complete further study in the area of science after secondary school (Figure 4.24). Only 40 per cent of students indicated they would like to work in a career involving science and 34 per cent of students would like to study science after secondary school. There were fewer students who indicated they would like to work on science projects as an adult and even fewer who wanted to spend their life doing advanced science (22% and 15% respectively).

The Australian Capital Territory had a mean of zero and Western Australia and the Northern Territory had means slightly above the OECD average. All other states had means that were lower than the OECD average. In terms of gender differences, Western Australia and the Northern Territory reported the largest differences; however, in all states males reported higher expectations than females of future study or a career in science.

	Percentage of students who agree or strongly agree with the following statements			
	I would like to work in a career involving science	I would like to study science after secondary school	I would like to spend my life doing advanced science	I would like to work on science projects as an adult
ACT	41	42	17	23
NSW	38	33	14	21
VIC	40	35	16	23
QLD	37	31	16	21
SA	43	35	17	23
WA	44	38	18	25
TAS	34	33	13	19
NT	41	36	18	28
Australia	39	34	15	22
Finland	26	23	12	21

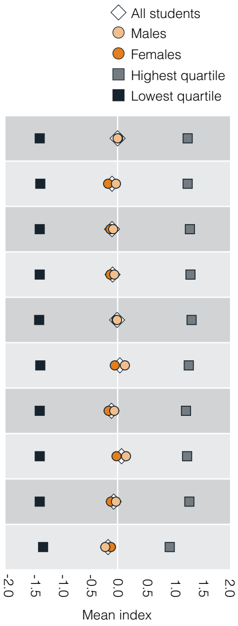


Figure 4.24 Future-oriented motivation to learn science by state

Being highly motivated to learn science for future study or career purposes was found to be moderately associated with scientific literacy performance (r = 0.29). There was an average 85 point difference in science literacy scores between students in the highest and lowest quartiles in the future-oriented motivation to learn science index. This was equivalent to more than one proficiency level or two-and-a-half years of schooling (Figure 4.25).

This index explained 10 per cent of the variance in scientific literacy performance, with an increase of 30 points in scientific literacy performance per unit increase in the index.

Future-oriented motivation to learn science was positively associated with students´ socioeconomic background (with an effect size of 0.33 between students in the highest and lowest quartile of the socioeconomic background index and the index of future-oriented motivation to learn science).

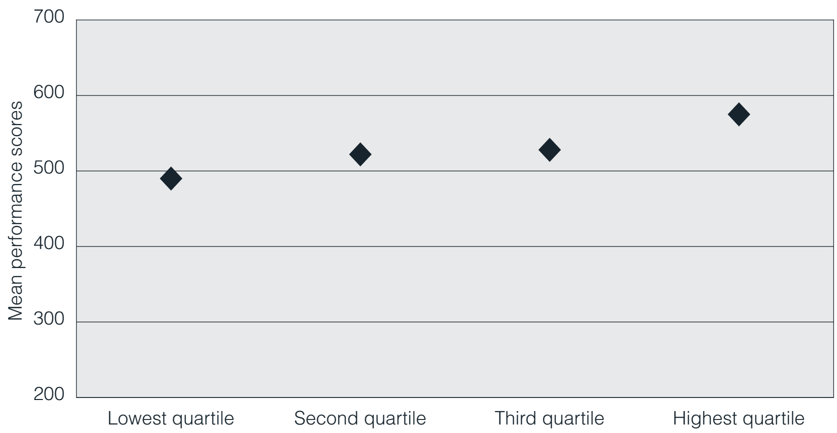


Figure 4.25 Relationship between future-oriented motivation to learn science and scientific literacy performance for Australian students

Importance of doing well in science

Students were asked to respond on a four-point scale about how important they thought it was for them to do well in science. The categories were very important, important, of little importance, and not important at all.

Overall, 72 per cent of Australian students considered it important or very important to do well in science, which was similar to the OECD average and higher than the percentage reported for Finnish students. The percentage of students who reported it was important or very important to do well in science ranged from 69 per cent in Victoria to 79 per cent in the Northern Territory (Table 4.1). With the exception of two states (New South Wales and the Northern Territory) there were slightly more females than males who considered it important to do well in science.

Table 4.1 Percentage of students who reported that doing well in science is important or very important by state

	All students (%)	Females (%)	Males (%)
ACT	75	75	74
NSW	72	71	74
VIC	69	74	65
QLD	70	71	68
SA	76	77	75
WA	77	79	76
TAS	72	73	71
NT	79	78	80
AUSTRALIA	72	73	71
OECD Average	73	73	72
Finland	62	66	58

Figure 4.26 shows that the more importance students place on doing well in science at school, the higher their performance on the scientific literacy scale ($r = 0.36$). This is an important construct: the difference in scientific literacy performance with each increase in the category of the importance of doing well in science was about one school year.

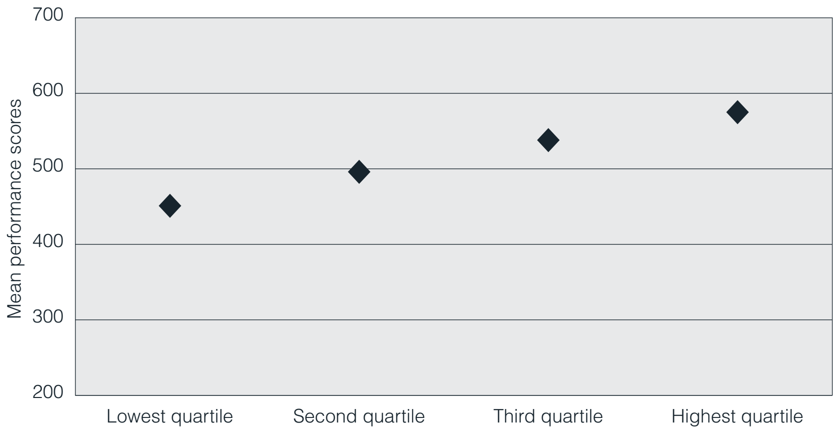


Figure 4.26 Relationship between the importance of doing well in science and scientific literacy performance for Australian students

Responsibility towards resources and environments

PISA 2006 has provided an opportunity to examine scientific literacy in detail, not only at a cognitive level but also at an attitudinal level where students´ opinions towards science learning can be investigated. The skills and knowledge of 15-year-old students in scientific literacy equips them to assess environmental situations, to demonstrate a willingness to take action to maintain natural resources, and to show a sense of personal responsibility for maintaining a sustainable environment. The last part of this chapter examines four constructs related to responsibility towards resources and environments.

Responsibility for sustainable development

PISA collected information about students´ responsibility for sustainable development by asking students how much they agreed with the following statements:

- It is important to carry out regular checks on the emissions from cars as a condition of their use.
- It disturbs me when energy is wasted through the unnecessary use of electrical appliances.
- I am in favour of having laws that regulate factory emissions even if this would increase the price of products.
- To reduce waste, the use of plastic packaging should be kept to a minimum.
- Industries should be required to prove that they safely dispose of dangerous waste materials.
- I am in favour of having laws that protect the habitats of endangered species.
- Electricity should be produced from renewable sources as much as possible, even if this increases the cost.

At an international level, students with the highest levels of responsibility for sustainable development were from Chinese Taipei and Turkey with means of around 0.75 points (Figure 4.27). On the other hand, students from the Netherlands had the lowest levels of responsibility for sustainable development, with a mean score of –0.48. Australia had a mean score of –0.24 points, indicating that Australian students had lower levels of responsibility for sustainable development than the OECD average.

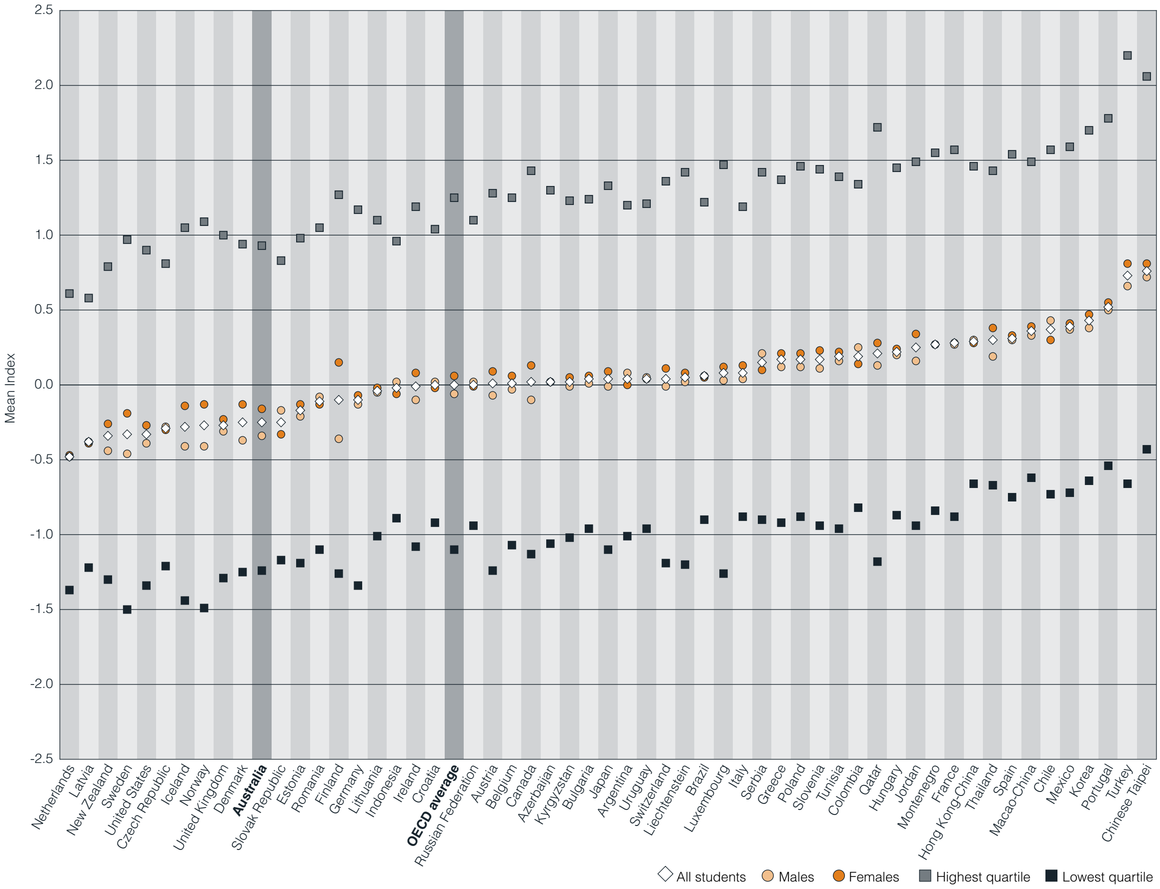


Figure 4.27 Responsibility for sustainable development by country

Seventy per cent of countries had significant gender differences, which mostly showed females having higher levels on this index. The Nordic countries (Finland, Norway, Iceland, Sweden and Denmark) had the largest gender differences. In Australia, females had a significantly higher mean index (of –0.16 points) than males (with a mean index of –0.34 points), although both were lower than the OECD average.

Over 90 per cent of Australian students were in favour of having laws protecting the habitats of endangered species, of ensuring that industries were required to prove that they safely dispose of dangerous waste materials, and of regular checks being carried out on the emissions from cars as a condition of their use. Eighty-eight per cent of students strongly agreed or agreed that the use of plastic packaging should be kept to a minimum to reduce waste, and 78 per cent strongly agreed or agreed that electricity should be produced from renewable sources as much as possible, even if this increases the cost. There were fewer students who indicated being disturbed when energy is wasted through the unnecessary use of electrical appliances or being in favour of having laws that regulate factory emissions even if this would increase the price of products (with 62 and 52 per cent respectively). Comparing states, Tasmania had the lowest percentage of students who agreed or strongly agreed with the statements about responsibility for sustainable development (Figure 4.28).

	Percentage of students who agree or strongly agree with the following statements						
	It is important to carry out regular checks on the emissions from cars as a condition of their use	It disturbs me when energy is wasted through the unnecessary use of electrical appliances	I am in favour of having laws that regulate factory emissions even if this would increase the price of products	To reduce waste, the use of plastic packaging should be kept to a minimum	Industries should be required to prove that they safely dispose of dangerous waste materials	I am in favour of having laws that protect the habitats of endangered species	Electricity should be produced from renewable sources as much as possible, even if this increases the cost
ACT	90	60	56	86	91	92	81
NSW	91	63	53	90	92	94	79
VIC	89	61	50	87	90	91	77
QLD	90	64	54	88	92	93	80
SA	89	61	49	89	92	92	78
WA	89	60	52	87	93	94	79
TAS	85	51	47	81	88	88	72
NT	87	58	52	85	89	90	79
Australia	90	62	52	88	92	93	78
Finland	93	59	71	81	91	91	79

Figure 4.28 Responsibility for sustainable development by state

Although all states had means that were lower than the OECD average, students from Tasmania, followed by those in the Northern Territory and Victoria, had the lowest means (of more than –0.31 points). Females from all states had higher levels than males on the responsibility for sustainable development index (with an effect size of 0.20). The largest gender difference was found in the Northern Territory with a 0.28 point difference.

In Australia, responsibility for sustainable development was moderately related to scientific literacy performance ($r = 0.29$), as shown in Figure 4.29. Students in the highest quartile scored 76 points on average (or the equivalent of almost two school years or one proficiency level) higher than students in the lowest quartile. An increase of one unit in the index of responsibility for sustainable development was associated with a substantial performance difference of 32 points on the scientific literacy performance scale. This index explained eight per cent of the demonstrated variance in student performance.

In Australia, the responsibility for sustainable development index was positively associated with students´ socioeconomic background. The effect size between students in the highest and lowest quartile of the socioeconomic background and the responsibility for sustainable development index is 0.43.

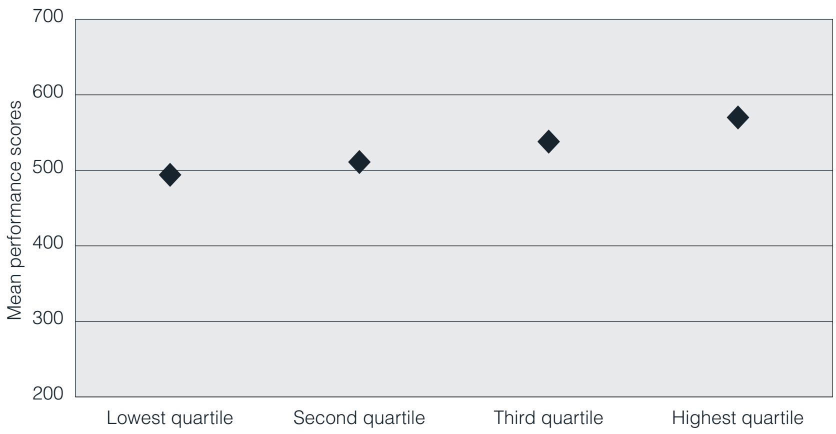


Figure 4.29 Relationship between awareness of responsibility for sustainable development and scientific literacy performance for Australian students

Awareness of environmental issues

Awareness of environmental issues was assessed using five items in PISA 2006. Students were asked how informed they were about the following environmental issues:

- The increase of greenhouse gases in the atmosphere.
- Use of genetically modified organisms (GMO).
- Acid rain.
- Nuclear waste.
- The consequences of clearing forests for other land use.

Student responses were collected on a four-point scale with the categories: I have never heard of this; I have heard of this but I would not be able to explain what it is really about; I know something about this and could explain the general issue; and I am familiar with this and I would be able to explain this well.

Figure 4.30 shows the means of students on the awareness of environmental issues index, with students from Chinese Taipei having the highest levels with a mean of 0.46 points, followed by Ireland and Poland. Students with the lowest levels of awareness of environmental issues were from Indonesia with a mean of –1.09 points. Australia had a mean of 0.10 points, indicating a slightly higher level of awareness of environmental issues than the OECD average.

Males and females from over 70 per cent of countries reported significantly different levels of awareness of environmental issues. In the majority of cases, males had higher levels of awareness of environmental issues than females. The largest gender difference was found in Iceland where the difference was 0.43 points. This was also the case for Australia, where the mean for males was 0.19 compared to the mean for females of 0.01 points.

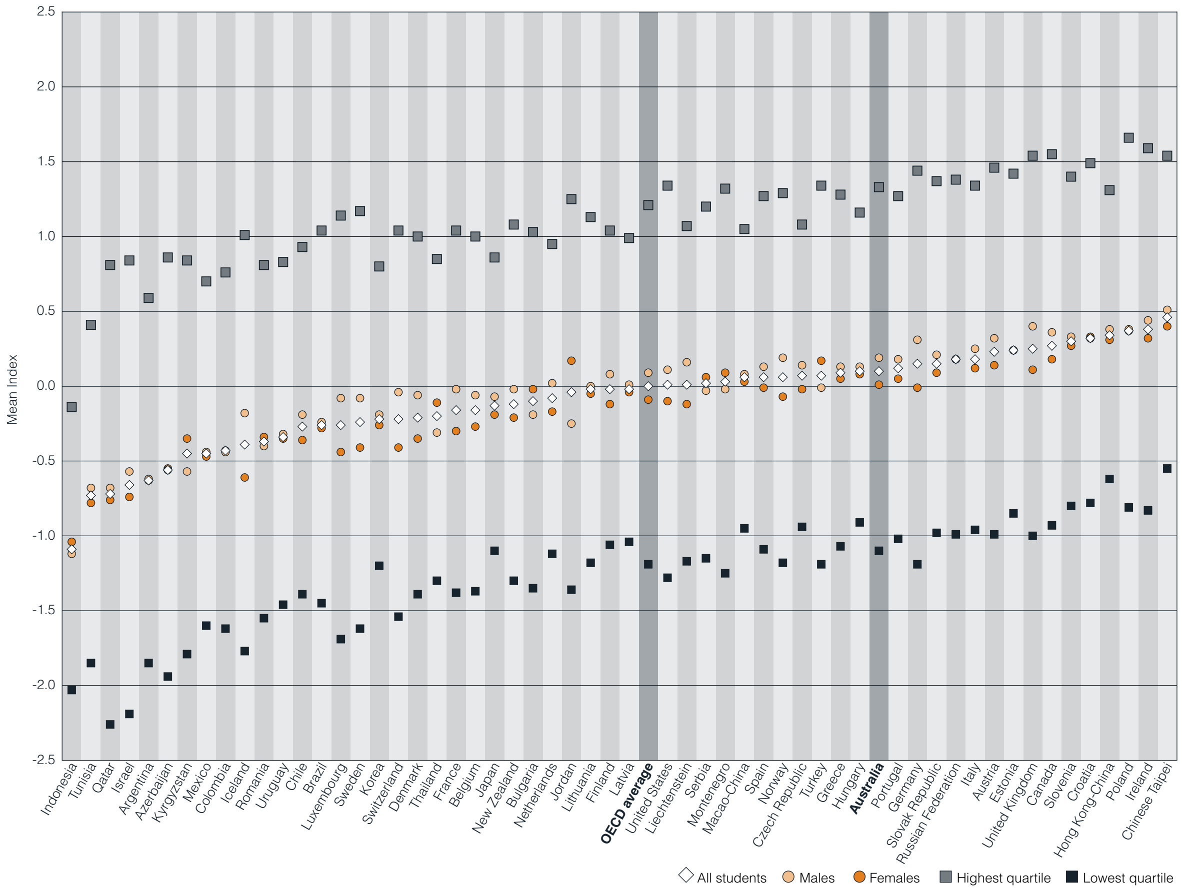


Figure 4.30 Awareness of environmental issues by country

The results show that Australian students´ awareness differs across environmental issues. Figure 4.31 shows the percentages of students who either claimed to be familiar with the issue and would be able to explain it well or indicated they knew something about the issue and could explain it generally. More Australian students indicated they were familiar with or knew something about the consequences of clearing forests for other land use (80%) and the increase of greenhouse gases in the atmosphere (72%) than for the other environmental issues. Approximately half of the Australian students were informed about nuclear waste, but fewer knew about acid rain and the use of genetically modified organisms. The awareness of environmental issues was highest in students from New South Wales and lowest in Tasmania.

	Percentage of students who are familiar with or know something about the following environmental issues				
	The increase of greenhouse gases in the atmosphere	Use of genetically modified organisms (GMO)	Acid rain	Nuclear waste	The consequences of clearing forests for other land use
ACT	70	41	45	51	75
NSW	79	46	56	60	85
VIC	68	35	39	47	76
QLD	67	32	45	49	78
SA	69	35	48	51	74
WA	76	36	51	55	84
TAS	60	26	35	41	71
NT	64	35	49	58	73
Australia	72	38	48	53	80
Finland	65	22	60	63	74

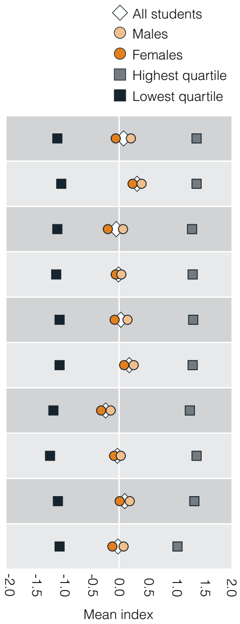


Figure 4.31 Awareness of environmental issues by state

Means on the index relating to awareness of environmental issues are shown by state in Figure 4.31. New South Wales along with Western Australia, the Australian Capital Territory and South Australia had higher levels of awareness of environmental issues than students on average in OECD countries. Students from Queensland, the Northern Territory, Victoria and Tasmania had less awareness about environmental issues than the OECD average. Males from all states felt they were more informed about environmental issues than females.

In Australia, there was a positive association (r = 0.46) between the awareness of environmental issues and scientific literacy performance. Figure 4.32 shows there was a huge 125 score point difference in scientific literacy performance between students in the highest and lowest quartile on the index of awareness of environmental issues. On average an increase of one unit in the index of awareness of environmental issues was associated with a performance increase of 46 points (more than one school year) on the scientific literacy performance scale. The index of awareness of environmental issues explained 21 per cent of the explained variance in student performance.

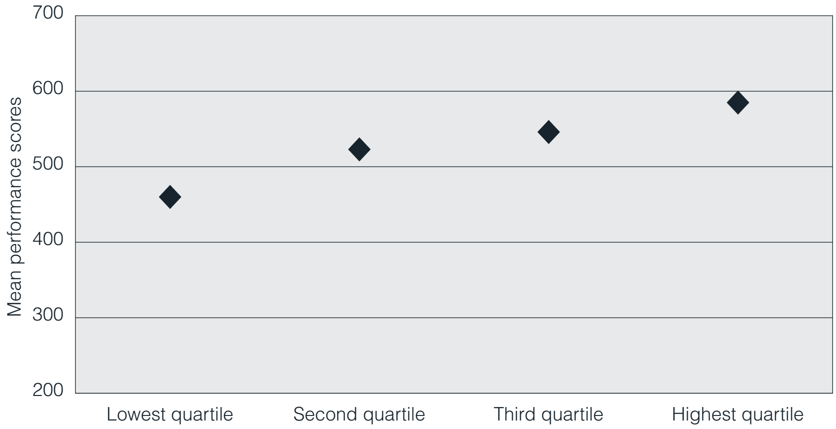


Figure 4.32 Relationship between awareness of environmental issues and scientific literacy performance for Australian students

The relationship between awareness of environmental issues and socioeconomic background was significant, with students in the highest quartile of the socioeconomic index having higher levels of environmental awareness than students in the lowest quartile (with an effect size of 0.68).

Concern for environmental issues

Students were asked to indicate their perceptions on a range of environmental issues by marking one of four categories: this is a serious concern for me personally as well as others; this is a serious concern for other people in my country but not me personally; this is a serious concern for people in other countries; and this is not a serious concern to anyone. The environmental issues were:

- Air pollution
- Energy shortages
- Extinction of plants and animals
- Clearing of forests for other land use
- Water shortages
- Nuclear waste.

Students in Turkey, Colombia and Portugal had the highest means on the index (with 0.60 points or more), indicating that students in these countries considered these environmental issues to be of serious concern to themselves or to others, or a serious concern to people in their country (Figure 4.33). On the other hand, students from the Nordic countries had the lowest means, indicating they were the least concerned that these environmental issues affected themselves or others. Australian students were less concerned about environmental issues (with a mean score of –0.19) than students across the OECD on average.

Over ninety per cent of countries had significant gender differences in favour of females. The largest gender differences were in Thailand, Sweden and Norway. In Australia there was a large gender difference as well, with females having a mean of –0.07 points compared to the mean of –0.29 for males.

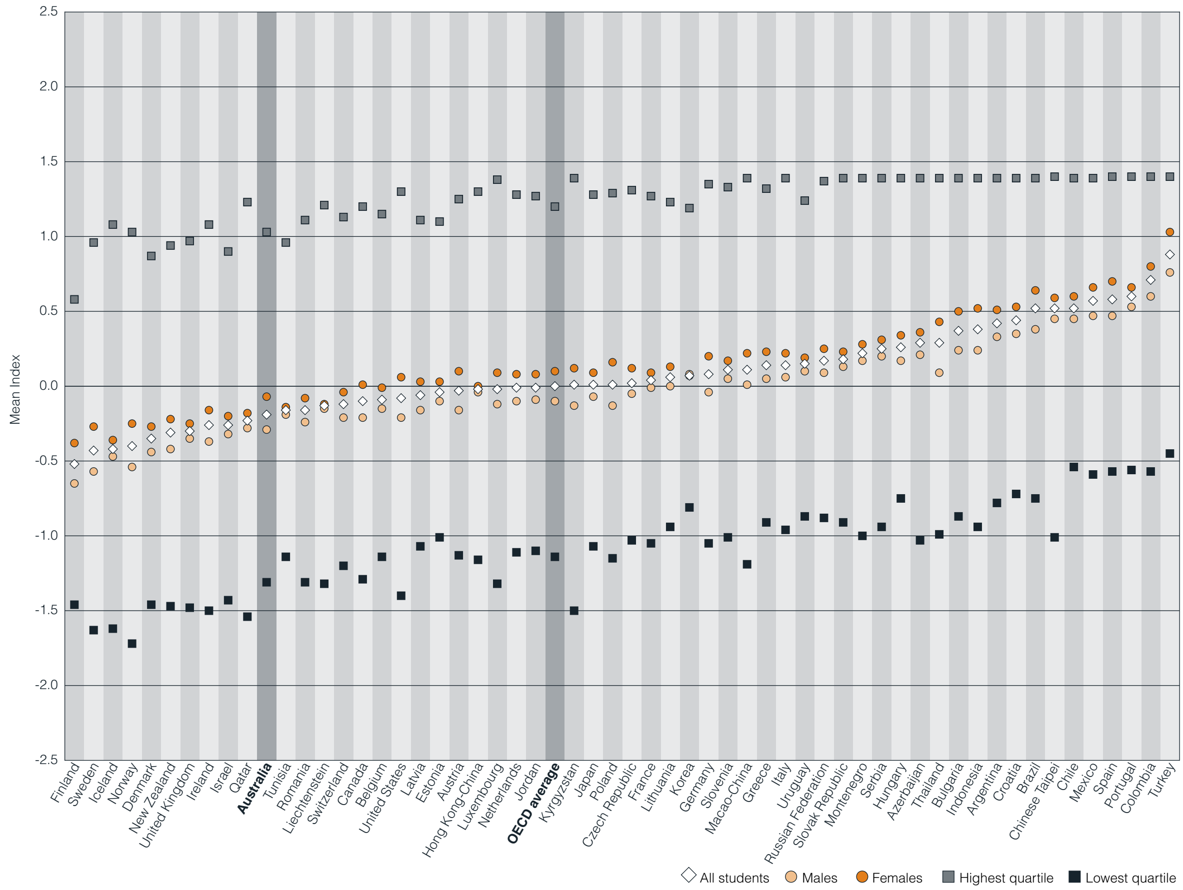


Figure 4.33 Concern for environmental issues by country

Figure 4.34 shows the percentages of students in Australia, by state, who indicated either that environmental issues were a serious concern for them personally as well as for others or that they were a concern for other people in Australia. The results reflect the concerns about environmental issues currently faced in this country. The majority of Australian students (92%) considered water shortages a serious concern for themselves and/or others in the country. Over 80 per cent of students reported air pollution, the clearing of forests for other land use, extinction of plants and animals and energy shortages as serious concerns. Three-quarters of Australian students considered nuclear waste to be a serious concern. Students from the Northern Territory had the lowest level of concern for all the environmental issues considered, except for nuclear waste where students from Queensland had the lowest level of concern.

	Percentage of students who believe the following environmental issues are a serious concern for themselves or other people in their country					
	Air pollution	Energy shortages	Extinction of plants and animals	Clearing of forests for other land use	Water shortages	Nuclear waste
ACT	85	77	85	88	93	75
NSW	90	81	86	88	93	76
VIC	87	80	83	85	91	74
QLD	87	79	85	86	94	69
SA	88	86	87	87	92	82
WA	87	83	87	88	92	74
TAS	85	76	86	88	85	72
NT	78	73	80	79	84	80
Australia	88	81	85	87	92	75
Finland	88	67	74	76	45	74

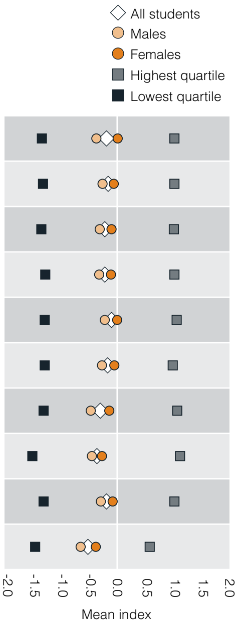


Figure 4.34 Concern for environmental issues by state

All states had mean scores on the concern for environmental issues index lower than the OECD average. The lowest levels of concern on environmental issues were shown by students in the Northern Territory who had a mean of –0.36 points. Females from all states were more concerned about environmental issues than males (with a significant effect size of 0.22). The largest gender differences were found in the Australian Capital Territory and Tasmania.

The association between the index of concern for environmental issues and scientific literacy performance was curvilinear with a correlation coefficient of 0.08 (Figure 4.35). Students in the highest quartile of the index performed at a similar level to students in the lowest quartile, the difference in mean scores in scientific literacy being only 18 points. The index of concern for environmental issues explained very little (only 1%) in the variation of scientific literacy performance. There was an eight point change in scientific literacy performance per unit change in the index.

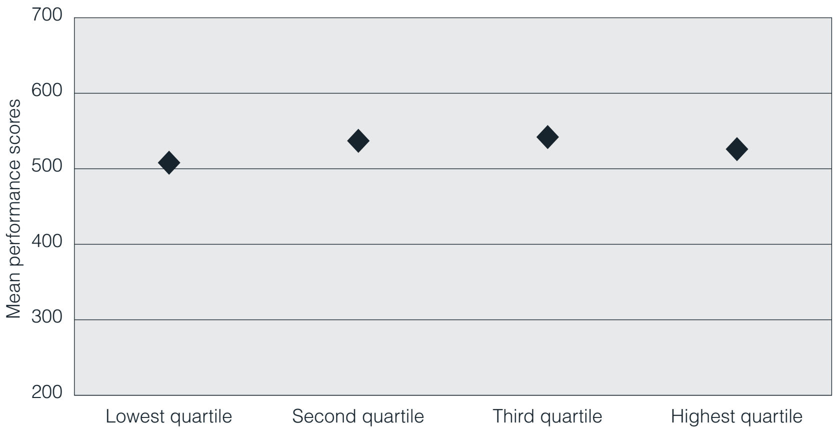


Figure 4.35 Relationship between concern for environmental issues and scientific literacy performance for Australian students

Optimism regarding environmental issues

Using the same set of environmental issues used in the concern for environmental issues index, students were asked whether they thought that the problems associated with these environmental issues would improve or get worse over the next 20 years. Students had to choose one category from the following: improve; stay about the same; or get worse.

The Australian result on the optimism regarding environmental issues index (–0.13) was lower than the OECD average, meaning that Australian students are, on average, less optimistic about environmental issues than was the average in the OECD. Lowest on the index was Croatia (with a mean index of –0.29), followed by Liechtenstein, New Zealand and Canada. Highest on the index were Qatar and Kyrgyzstan with means of around 0.75 points. These are presented in Figure 4.36.

Significant gender differences were found in three-quarters of the countries. In all but two countries (Azerbaijan and Kyrgyzstan) males were more likely than females to be optimistic about environmental issues over the next 20 years. The largest differences were found in the United States and Canada. Australian males (mean of –0.03) were more optimistic than Australian females (mean of –0.24). This difference was slightly more than the OECD average gender difference (of 0.21 points).

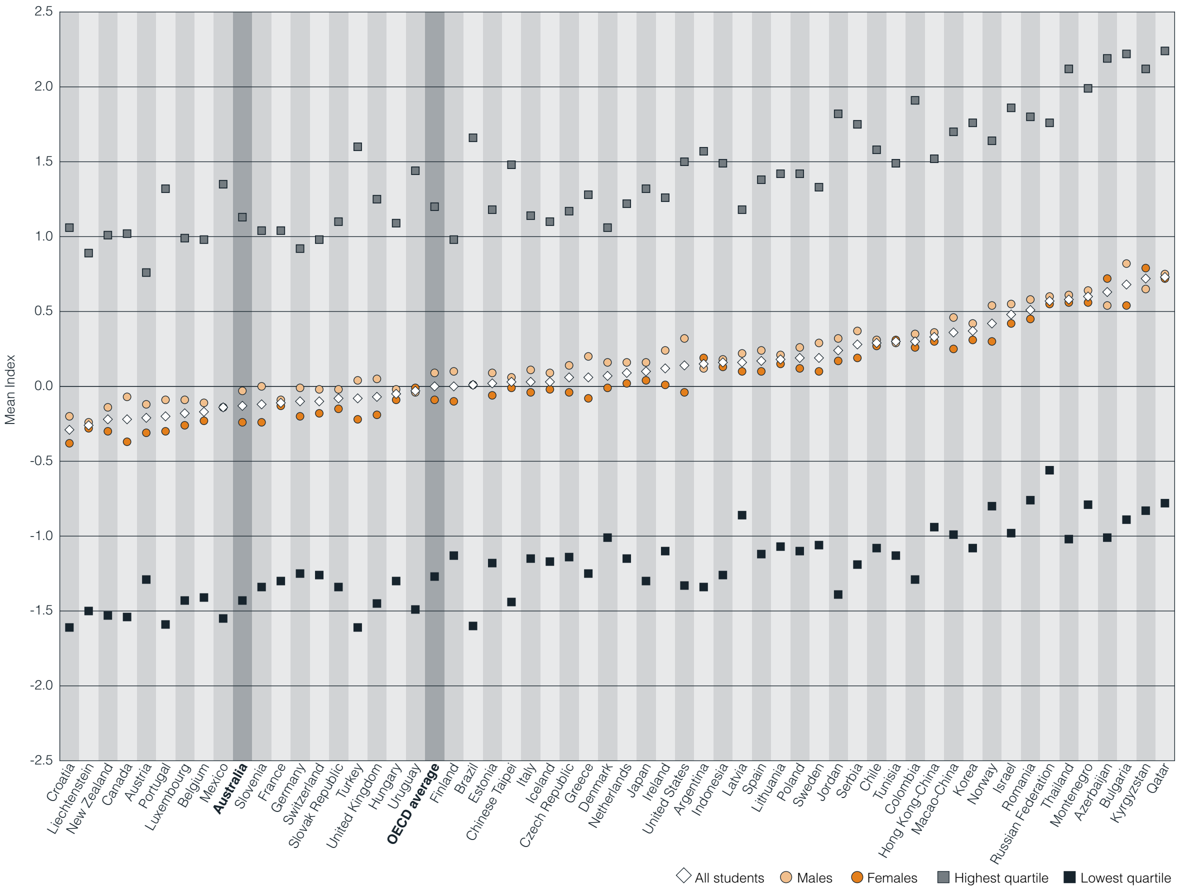


Figure 4.36 Optimism regarding environmental issues by country

The data collected from PISA 2006 indicates Australian students are not optimistic about an improvement in these environmental issues over the next 20 years. Only a little over ten per cent of Australian students considered there would be less clearing of forests, that nuclear waste would not become an environmental issue, that extinction of plants and animals would slow and that air pollution would decrease. About one-fifth of Australian students considered that energy shortages would not be an issue, and almost the same proportion were somewhat optimistic about the situation with water shortages improving over the next 20 years (Figure 4.37).

Percentage of students who believe the problem associated with the environmental issues below will improve over the next 20 years

	Air pollution	Energy shortages	Extinction of plants and animals	Clearing of forests for other land use	Water shortages	Nuclear waste
ACT	10	19	10	8	14	11
NSW	14	21	13	11	20	13
VIC	15	21	14	11	18	12
QLD	13	18	11	10	16	10
SA	13	20	13	10	14	11
WA	13	22	11	11	17	13
TAS	16	21	13	12	15	12
NT	14	22	12	9	17	11
Australia	14	21	12	11	18	12
Finland	9	14	11	6	16	8

Figure 4.37 Optimism regarding environmental issues by state

The mean index scores for students in all states were lower than the OECD average. Gender differences were all in favour of males, who were more optimistic about environmental issues than females, and the effect size of 0.21 was significant. Students in the Australian Capital Territory were least optimistic about the future. The largest differences in the index scores between states were found in Queensland, South Australia and Tasmania, and were approximately 0.25 points.

There was a weak negative association between optimism regarding environmental issues and scientific literacy performance ($r = -0.12$); in other words, more scientifically literate students were less optimistic about the future. There was a 29 point difference in terms of mean scores in scientific literacy between students in the highest and lowest quartiles of the index of optimism regarding environmental issues. However, this index accounted for only two per cent of the explained variance on scientific literacy performance (Figure 4.38).

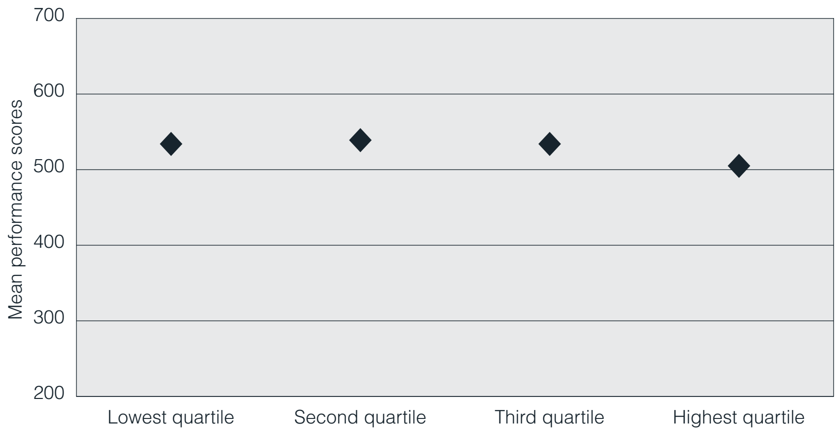


Figure 4.38 Relationship between optimism regarding environmental issues and scientific literacy performance for Australian students

Summary

In each PISA cycle students complete a questionnaire about their background, their attitudes and their beliefs, as well as questions on their engagement and motivation. In PISA 2006, student characteristics focused on science.

PISA 2006 collected information in four areas: support for scientific enquiry; self-belief as science learners; interest in science; and responsibility towards resources and environments. These areas were assessed to create a picture of students´ attitudes to and engagement in science, including how students handle scientific tasks effectively; how they overcome difficulties to solve scientific problems; whether they support the use of factual information and rational explanations; whether they demonstrate the willingness to seek information and have an ongoing interest in science; and whether they demonstrate awareness of the environmental consequences of individual actions. These constructs are worth examining in attempting to understand education in a broader context.

Many of the constructs were found to be correlated with scientific literacy performance in Australia, but typically at weak to moderately weak levels. The data showed a positive association between the constructs and scientific literacy performance except in the case of optimism regarding environmental issues where students with high levels of optimism about future environmental issues scored lower than students with low levels of optimism. The highest correlations between constructs discussed in this chapter and Australian scientific literacy performance were 0.49 for self-efficacy in science, 0.46 for awareness of environmental issues and 0.43 for both self-concept in science and enjoyment of science.

Significant gender differences were found for all indices in Australia with the exception of two: the index of general interest in learning science and the index of instrumental motivation in science, where no significant gender differences were found. The significant gender differences were all in favour of males, except for the indices related to responsibility for sustainable development and concern for environmental issues, where they were in favour of females. Self-concept in science, responsibility for sustainable development, concern for environmental issues, and optimism regarding environmental issues all had effect sizes around 0.20 (meaning only a small effect of these constructs on science achievement).

The impact of socioeconomic background on the various constructs in this chapter was found to have effect sizes between 0.33 and 0.72. The effect sizes were highest between socioeconomic background and self-efficacy (0.72), followed by environmental awareness (0.68). This can be interpreted as meaning that the influence of socioeconomic background on attitudes towards science was generally classed as a small to medium-sized effect.

This chapter has not compared the attitudes, motivation and engagement of Indigenous and non-Indigenous students, of students attending schools in different geographic locations, or of students from differing language backgrounds. These will be explored at a later date in more depth than is possible in this initial report.

The next chapter of this report examines Australian students´ performance in reading literacy in PISA 2006.

Chapter

5

Student Performance in Reading Literacy

In PISA 2000, reading literacy was the major domain, shifting to mathematical literacy in 2003 and scientific literacy in 2006. The assessment of a major domain provides an in-depth analysis of knowledge and skills to be reported, as shown in Chapter 3 with the description of scientific literacy and its subscales. The two remaining literacy domains (known as the minor domains) are assessed less comprehensively and take up less of the overall assessment time. The results of the minor domains are reported as a summary profile of skills only with an update on overall performance.

The first part of this chapter provides a summary of the reading literacy domain and the assessment framework; a description of how PISA measures reading literacy; and a sample of reading literacy items used in PISA[13]. The second part of the chapter focuses on the achievement of Australian students in 2006, on reading literacy. Initially Australian students' performance is compared with those of students in the other participating countries, and then results are provided for the Australian states, males and females, Indigenous students, students from different geographic locations and different socioeconomic backgrounds, and for students according to their immigrant status and language spoken at home. The final part of this chapter examines the performance of students from an international and national perspective, across the different PISA cycles.

Definition of reading literacy

The PISA concept of reading literacy emphasises skills in using written information in situations that students may encounter in their life both at and beyond school. The PISA framework (OECD, 2006) defines reading literacy as:

> … understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society.
>
> (p. 46)

This definition goes beyond the traditional notion of reading literacy as decoding information and literal comprehension. It implies that reading literacy involves understanding, using and reflecting on written information in a range of situations.

[13] Parts of this chapter have been adapted from the OECD publication, *Assessing scientific, reading and mathematical literacy: A framework for PISA 2006*.

How reading literacy is measured in PISA

PISA acknowledges that readers respond to a given text in a variety of ways as they seek to use and understand what they are reading. The concept of reading literacy in PISA is defined by three dimensions: the format of the reading material, the type of reading task or reading processes, and the situation or the use for which the text was constructed.

Text format

The text format or the structure of the reading material makes a distinction between continuous and non-continuous texts. Continuous texts are typically composed of sentences that are, in turn, organised into paragraphs. These may fit into even larger structures such as sections, chapters and books. Examples of continuous texts are narration, exposition, argumentation, instruction and hypertext. Non-continuous texts are organised differently from continuous texts and so require different kinds of reading approaches. Non-continuous texts are classified by their formats; for example, charts and graphs, diagrams, maps, and information sheets.

Processes

The PISA reading assessment measures the following five processes associated with achieving a full understanding of a text: retrieving information; forming a broad general understanding; developing an interpretation; reflecting on and evaluating the context of a text; and reflecting on and evaluating the form of a text. It is expected that all readers, irrespective of their overall proficiency, will be able to demonstrate some level of competency in each of these aspects.

For reporting purposes in PISA 2000, the five processes were collapsed into three larger categories (forming the reading literacy subscales): retrieving information, interpreting texts (combining the two processes that require students to focus on relationships within a text), and reflecting and evaluating (combining the two processes that require students to reflect on and evaluate content or form of text). In 2006, results for reading are reported on a single reading literacy scale that combines the different types of tasks.

Situations

The reading situation refers to the use for which the text was constructed and can be understood as a general categorisation of texts based on the author's intended use, on the relationship with other persons implicitly or explicitly associated with the text, and on the general content. The texts used in the assessment were drawn from a variety of situations to maximise the diversity of content included in PISA. Four situation variables are identified: reading for private use (personal), reading for public use, reading for work (occupational) and reading for education.

A more detailed description of the conceptual framework underlying the PISA reading literacy assessment is provided in the publication, *Assessing scientific, reading and mathematical literacy: A framework for PISA 2006* (OECD, 2006).

Item Types

A variety of reading literacy item formats was used in PISA. Some items were basic multiple-choice tasks, where students had to choose one answer from a set of given answers; others were complex multiple choice, where students were given a series of 'true/false' or 'yes/no' choices and one answer had to be chosen for each element in the series. There were also two kinds of constructed response items: closed-constructed responses required a clear-cut answer while open-constructed or extended responses required students to provide an extended written answer. The open-constructed responses required markers to code the students' responses.

In 2000, when reading literacy was the major focus of the PISA assessment, there were 141 items and 210 minutes of overall testing time devoted to reading literacy. In 2003 and 2006, 60 minutes of overall testing time was devoted to reading literacy and there were about 30 items. The distributions of reading literacy items for PISA 2000, 2003 and 2006 are shown in Table 5.1.

Table 5.1 Distribution of reading literacy items, by reading process and item type (OECD, 2006)

Process	Item Types									
	Multiple-choice items (%)		Complex multiple-choice items (%)		Closed-constructed response items (%)		Open-constructed response items (%)		Total[14]	
Retrieving information	8	-	2	4	6	14	13	11	29	29
Interpreting texts	32	29	2	4	2	7	13	11	49	50
Reflection and evaluation	2	-	2	-	-	-	18	21	22	21
Total	42	29	6	7	9	21	44	43	100	100

☐ PISA 2000: reading as a major domain
☐ PISA 2003 and 2006: reading as a minor domain[14]

Reporting reading literacy performance

In PISA 2000, results for reading literacy were reported on an overall scale and on three reading subscales. These subscales were retrieving information, interpreting texts, and reflecting on and evaluating texts. In PISA 2006, as was the case for PISA 2003, reading literacy results are reported against a single, overall scale. There were insufficient items included in the assessment to enable separate reporting against the three subscales.

The PISA 2006 results can be reported on the overall reading literacy scale by country, within Australia by state and by student subgroups as mean scores, as the distribution of scores around the mean, and on the basis of proficiency levels that describe levels of performance.

Mean scores and distribution of scores

The use of mean scores summarises student performance and compares the relative standing of countries. Internationally, the overall reading literacy scale was constructed in PISA 2000 to have a mean score of 500 points and a standard deviation of 100 points across the participating OECD countries.

In PISA 2003, reading literacy performance was reported on the reading literacy scale established in 2000. The mean score on the PISA 2003 reading literacy scale across participating OECD countries was 494, a decline of six points[15]. In PISA 2006, the OECD average has declined again by a small amount to 492 points.

Proficiency levels

Reporting mean scores and distribution of scores provides data on which to compare performance between countries, between states and territories, and so on. These results, however, tell us little about what skills and knowledge students actually have. To add meaning and depth to these results, PISA has also reported results on a proficiency scale, describing the progression of students' knowledge and skills in reading literacy.

[14] Data may not always add up to the total indicated because of rounding.

[15] The decrease in the OECD average was partly due to the inclusion of two new countries, the Slovak Republic and Turkey, whose performance on reading literacy was below the OECD average, and partly due to the fact that several OECD countries had decreases in reading performance between 2000 and 2003.

As described in Chapter 2 in relation to science, the described proficiency scale for reading literacy was constructed using Item Response Theory (IRT) techniques. The scores on the scale represent varying degrees of difficulty. A low score indicates that a student has very limited knowledge and skills, while a high score indicates that a student has quite advanced knowledge and skills. Students at a particular level not only demonstrate the knowledge and skills associated with that level but also the proficiencies required at lower levels. For example, a student who is judged to be at Level 4 on the reading literacy scale is proficient in Level 4 tasks as well as Level 1, 2 and 3 tasks. The average student within each level can be expected to successfully perform the average task within that level 62 per cent of the time.

The reading literacy scale established in 2000 divides students into five levels of proficiency as shown in Figure 5.1[16]. Students who scored below 335 points and are therefore placed below Level 1 are not able to perform the most basic reading literacy skills that PISA seeks to measure. Students performing at this level should not be assumed to have no reading skills at all, but a score below 335 does point to serious deficiencies in students' ability to meet the challenges of the future and adapt to societal change.

Proficiency level	General reading literacy proficiencies students should have at each level
5	At Level 5 students are able to deal with difficult texts and complete sophisticated reading tasks. They can deal with information that is difficult to find in unfamiliar texts, especially in the presence of closely competing information, show detailed understanding of these texts and sort out which information is relevant to the task. They are able to evaluate texts critically, draw on specialised knowledge to build hypotheses, and cope with concepts that may be contrary to expectations.
625.6 points	
4	At Level 4 students are able to cope with difficult tasks, such as locating embedded information, construing meaning of parts of a text through considering the texts as a whole, and dealing with ambiguities and negatively worded ideas. They show accurate understanding of complex texts and are able to evaluate texts critically.
552.9 points	
3	At Level 3 students can deal with moderately complex reading tasks, such as finding several pieces of relevant information and sorting out detailed competing information requiring consideration of many criteria to compare, contrast or categorise. They are able to make links between different parts of a text and to understand text in a detailed way in relation to everyday knowledge.
480.2 points	
2	At Level 2 students can cope with basic reading tasks, such as locating straightforward information, making low-level inferences, using some outside knowledge to help understand a well-defined part of a text, and applying their own experience and attitudes to help explain a feature of a text.
407.5 points	
1	At Level 1 students are able to deal with only the least complex reading tasks developed for PISA, such as finding explicitly stated pieces of information and recognising the main theme or author's purpose in a text on a familiar topic when the required information is readily accessible in the text. They are also able to make a connection between common, everyday knowledge and information in the text.
334.8 points	

Figure 5.1 Descriptions of the five proficiency levels on the reading literacy scale

Sample reading literacy items and responses

The sample reading literacy items set out below are included to show the types of questions included in the PISA assessment and to help with understanding the descriptions of the proficiency levels in Figure 5.1.

Only a small number of reading literacy items was released for public use following PISA 2000. The majority of reading literacy items remain secure as the linking of items between cycles enables monitoring of results across time.

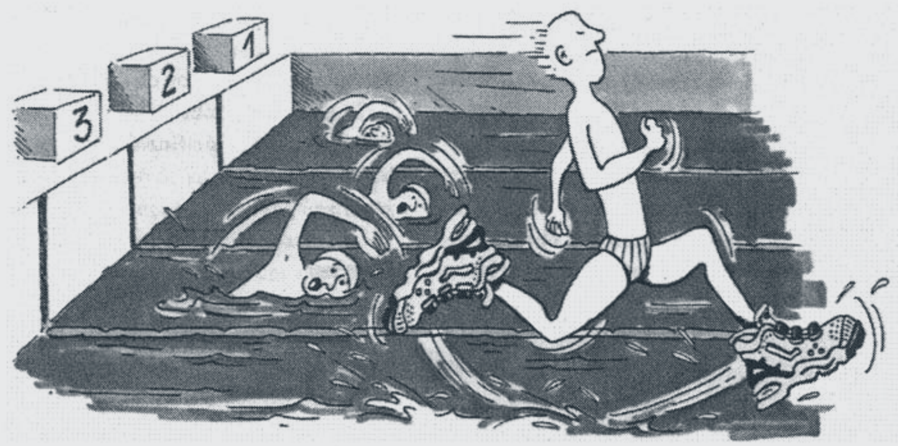
As no additional reading literacy items have been released since the publication of the PISA 2000 reports, the examples provided here are taken from the Australian national report on PISA 2000 (Lokan, Greenwood & Cresswell, 2001). They illustrate a range of proficiency levels and item types.

[16] This is unlike scientific literacy and mathematical literacy, where there are six proficiency levels.

Running Shoes

In PISA 2000 the unit 'Running Shoes' was among the easiest overall in the assessment. It consisted of the following text and four items, all of which were at Level 1.

Feel Good in your Runners



For 14 years the Sports Medicine Centre of Lyon (France) has been studying the injuries of young sports players and sports professionals. The study has established that the best course is prevention … and good shoes.

Knocks, falls, wear and tear...

Eighteen per cent of sports players aged 8 to 12 already have heel injuries. The cartilage of a footballer's ankle does not respond well to shocks, and 25% of professionals have discovered for themselves that it is an especially weak point. The cartilage of the delicate knee joint can also be irreparably damaged and if care is not taken right from childhood (10–12 years of age), this can cause premature osteoarthritis. The hip does not escape damage either and, particularly when tired, players run the risk of fractures as a result of falls or collisions.

According to the study, footballers who have been playing for more than ten years have bony outgrowths either on the tibia or on the heel. This is what is known as "footballer's foot", a deformity caused by shoes with soles and ankle parts that are too flexible.

Protect, support, stabilise, absorb

If a shoe is too rigid, it restricts movement. If it is too flexible, it increases the risk of injuries and sprains. A good sports shoe should meet four criteria:

Firstly, it must provide exterior protection: resisting knocks from the ball or another player, coping with unevenness in the ground, and keeping the foot warm and dry even when it is freezing cold and raining.

It must support the foot, and in particular the ankle joint, to avoid sprains, swelling and other problems, which may even affect the knee.

It must also provide players with good stability so that they do not slip on a wet ground or skid on a surface that is too dry.

Finally, it must absorb shocks, especially those suffered by volleyball and basketball players who are constantly jumping.

Dry feet

To avoid minor but painful conditions such as blisters or even splits or athlete's foot (fungal infections), the shoe must allow evaporation of perspiration and must prevent outside dampness from getting in. The ideal material for this is leather, which can be water-proofed to prevent the shoe from getting soaked the first time it rains.

Running Shoes Question 1

The first item in 'Running Shoes', shown below, required interpretation, but was easy because the point is made prominently near the beginning of the text.

What does the author intend to show in this text?

A That the quality of many sports shoes has greatly improved.
B That it is best not to play football if you are under 12 years of age.
C That young people are suffering more and more injuries due to their poor physical condition.
D That it is very important for young sports players to wear good sports shoes.

Overall per cent correct[17]	
Sweden (Highest achieving country)	91%
Australian females	91%
Australia	88%
Australian males	86%
OECD average	85%
Mexico (Lowest achieving country)	71%

Running Shoes Question 2

The second question asked for a single piece of information directly stated in the text to be located and reproduced. A further factor making the item relatively easy is that the information is at the beginning of a new section of text.

According to the article, why should sports shoes not be too rigid?

It restricts movement

Overall per cent correct	
Finland (Highest achieving country)	89%
Australian females	87%
Australia	81%
OECD average	79%
Australian males	77%
Mexico (Lowest achieving country)	60%

[17] The students' results for the sample reading literacy items were derived from the PISA 2000 dataset.

Running Shoes Question 3

This item also asked for information to be located, identified and reproduced. The item was a little more difficult because four pieces of information have to be correctly stated to gain a correct score. The students also had to filter out competing information.

One part of the article says, "A good sports shoe should meet four criteria."

What are these criteria?

* provide exterior protection
* support the foot
* stability
* absorb shocks

Overall per cent correct	
Korea (Highest achieving country)	89%
Australian females	86%
Australia	83%
Australian males	80%
OECD average	76%
Luxembourg (Lowest achieving country)	45%

Running Shoes Question 4

The final item about running shoes required students to reflect on the logical connection between two parts of a sentence, which are clearly indicated in the assessment item.

Look at this sentence from near the end of the article. It is presented here in two parts:

"To avoid minor but painful conditions such as blisters or even splits or athlete's foot (fungal infections),…" *(first part)*

"…the shoe must allow evaporation of perspiration and must prevent outside dampness from getting in." *(second part)*

What is the relationship between the first and second parts of the sentence?

The second part

A contradicts the first part.
B repeats the first part.
C illustrates the problem described in the first part.
D gives the solution to the problem described in the first part.

Overall per cent correct	
Spain (Highest achieving country)	85%
Australian females	85%
Australia	81%
OECD average	78%
Australian males	77%
Luxembourg (Lowest achieving country)	69%

Lake Chad

The stimulus for 'Lake Chad' comprised two graphs with a minimum of text. Students needed to have a basic understanding of how information is presented graphically, and to be able to read line graphs. Items in this unit were at levels ranging from 1 to 4, and involved all three reading processes.

LAKE CHAD

Figure 1 shows changing levels of Lake Chad, in Saharan North Africa. Lake Chad disappeared completely in about 20,000 BC, during the last Ice Age. In about 11,000 BC it reappeared. Today, its level is about the same as it was in AD 1000.

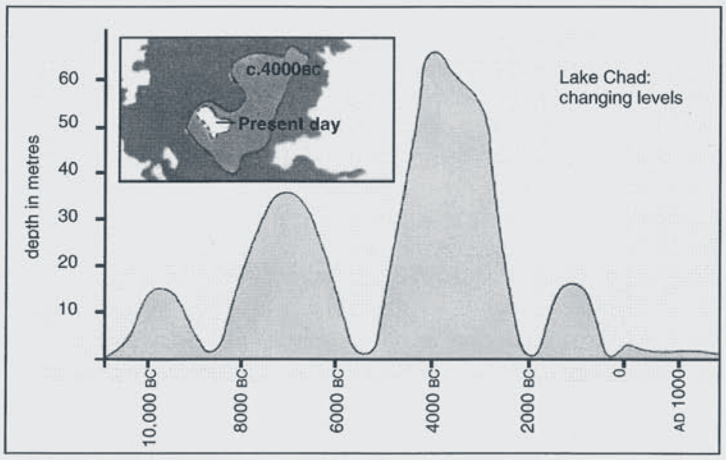


Figure 1

Figure 2 shows Saharan rock art (ancient drawings or paintings found on the walls of caves) and changing patterns of wildlife.

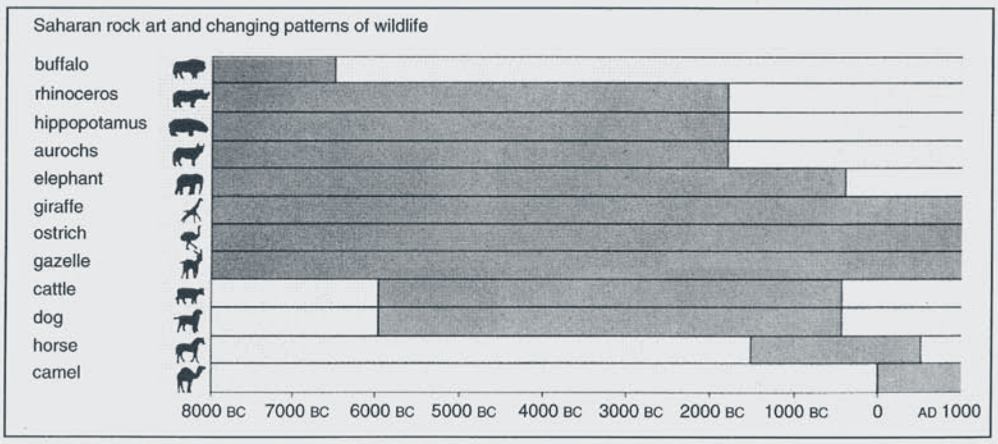


Figure 2

Lake Chad Question 1

The first item required retrieval of information. It was placed at Level 2 because of the added need to be able to locate information presented graphically.

Lake Chad Question 2

The second item also asked for some information from the graph, but was more challenging because some estimation is needed, the required value is not marked, and extra care is required because the dates are in the negative direction for 'BC'. Many students wrote 10,000 as their answer, failing to extrapolate from the scale. They were given no credit. The response below was assessed as correct – answers between 10,500 and 12,000 BC were accepted.

> In about which year does the graph in Figure 1 start?
>
> 11,000 BC

Overall per cent correct	
Finland (Highest achieving country)	71%
Australian males	60%
Australia	58%
Australian females	55%
OECD average	51%
Mexico (Lowest achieving country)	31%

Lake Chad Question 3

This question was a 'short response' item, which required students to evaluate what they had read and make an inference about the author's intention in preparing the graph. This was a Level 4 item. It was more difficult than the earlier items because of the level of reasoning involved. Students with the necessary skill could state the answer correctly and succinctly as shown in this student response.

> Why has the author chosen to start the graph at this point?
>
> because before then it disappeared completely and at that time it reappeared.

Overall per cent correct	
Finland (Highest achieving country)	49%
Australian females	37%
OECD average	37%
Australia	35%
Australian males	33%
Mexico (Lowest achieving country)	18%

Lake Chad Question 5

The last item was also a multiple-choice question, shown below. This item required interpretation skills and was more difficult than the previous item because it required consideration of the two sets of information shown in Figures 1 and 2 in the stimulus of Lake Chad.

For this question you need to draw together information from Figure 1 and Figure 2.

The disappearance of the rhinoceros, hippopotamus and aurochs from Saharan rock art happened

A at the beginning of the most recent Ice Age.
B in the middle of the period when Lake Chad was at its highest level.
C after the level of Lake Chad had been falling for over a thousand years.
D at the beginning of an uninterrupted dry period.

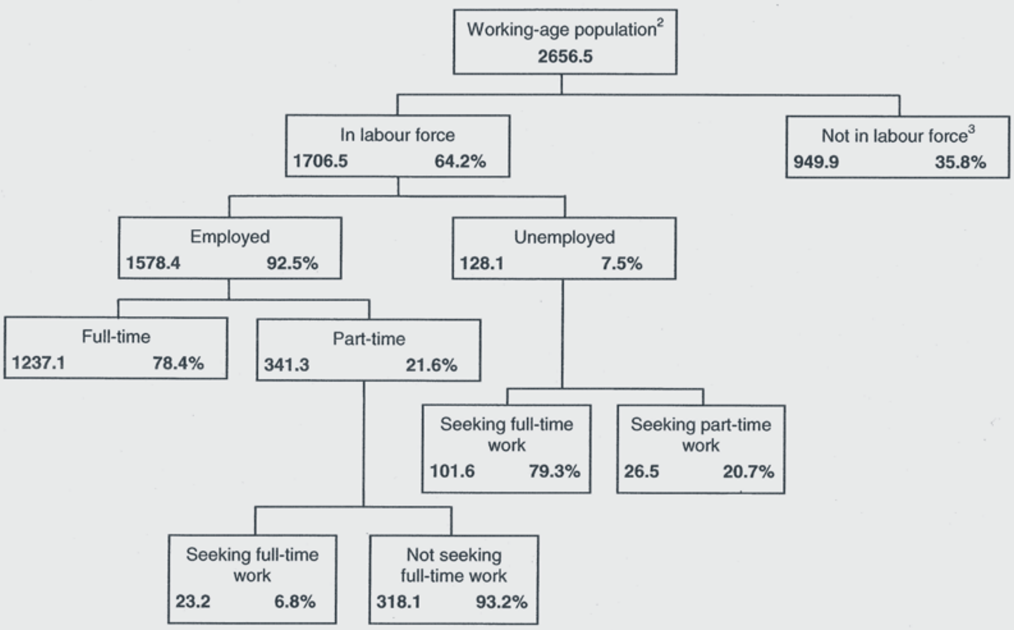
Overall per cent correct	
Finland (Highest achieving country)	71%
Australian males	63%
Australia	62%
Australian females	61%
OECD average	57%
Mexico (Lowest achieving country)	34%

Labour

Only a handful of items in the PISA 2000 reading literacy assessment were at Level 5, and most of these have not been released. A sample Level 5 item, the third item in the Labour unit, is included here. The unit is about the structure of a country's labour market, in which the information is presented as a complex tree diagram with several divisions and sub-divisions. For each branch of the tree, both numbers in thousands and percentages are given. Definitions of the 'working-age population' and 'not in the labour force' are provided.

The tree diagram below shows the structure of a country's labour force or "working-age population". The total population of the country in 1995 was about 3.4 million.

The Labour Force Structure year ended 31 March 1995 (000s)[1]



Notes

1. Numbers of people are given in thousands (000s).
2. The working-age population is defined as people between the ages of 15 and 65.
3. People "Not in labour force" are those not actively seeking work and/or not available for work.

Labour Question 3

This item assessed the 'interpreting texts' process and is an example of a 'complex multiple choice' item. All five of the people described had to be correctly categorised for the student to be given a score of 2. If three of four were correct the answer was scored 1. The item is difficult because multiple pieces of information have to be dealt with, the tree diagram interpreted and the definitions taken into account in order to identify the five correct answers.

In which part of the tree diagram, if any, would each of the people listed in the table below be included?

Show your answer by placing a cross in the correct box in the table.

The first one has been done for you.

	"In labour force: employed"	"In labour force: unem-ployed"	"Not in labour force"	Not included in any category
A part-time waiter, aged 35	☒	☐	☐	☐
A business woman, aged 43, who works a sixty-hour week	☒	☐	☐	☐
A full-time student, aged 21	☐	☐	☒	☐
A man, aged 28, who recently sold his shop and is looking for work	☐	☒	☐	☐
A woman, aged 55, who has never worked or wanted to work outside the home	☐	☐	☒	☐
A grandmother, aged 80, who still works a few hours a day at the family's market stall	☐	☐	☐	☒

Overall per cent correct*	
France (Highest achieving country)	50%
Australian females	46%
Australia	42%
Australian males	39%
OECD average	39%
Mexico (Lowest achieving country)	22%

* This item was worth two score points. The results shown are weighted percentages for the numbers of fully and partially correct answers.

Student performance in reading literacy

Australia's reading literacy performance from an international perspective

In PISA 2006, Australia achieved a mean score of 513 points in reading literacy. Five countries, of which four were OECD countries, performed significantly higher than Australia: these were Korea (556 score points); Finland (547 score points); Hong Kong-China (536 score points); Canada (527 score points) and New Zealand (521 score points). Australia's performance was equivalent to that of five other countries: Ireland (517 score points); Liechtenstein (510 score points); Poland (508 score points), Sweden (507 score points) and the Netherlands (507 score points). Australia performed significantly higher than all other countries. Figure 5.2 shows the mean reading literacy scores for participating countries in PISA 2006.[18, 19]

Korea's score was significantly higher than that for any other country and was 64 score points above the OECD average[20]. It has overtaken Finland, which was 'number one' in reading literacy in both PISA 2000 and PISA 2003.

Fifteen countries (including Australia) scored significantly higher than the OECD average; eight countries achieved means equivalent to the OECD average; while the remaining 33 countries scored significantly lower than the OECD average. The difference between the top-performing country, Korea, and the lowest-performing country, Kyrgyzstan, was 271 score points.

18 See page 65 for directions on how to read the bar charts.

19 Reading literacy results for the United States are not available because due to a printing error in the assessment booklets the mean performance in reading literacy cannot be accurately estimated.

20 Multiple comparison tables, which provide the statistical significance of differences between all countries, are provided in Appendix 4 of this report.

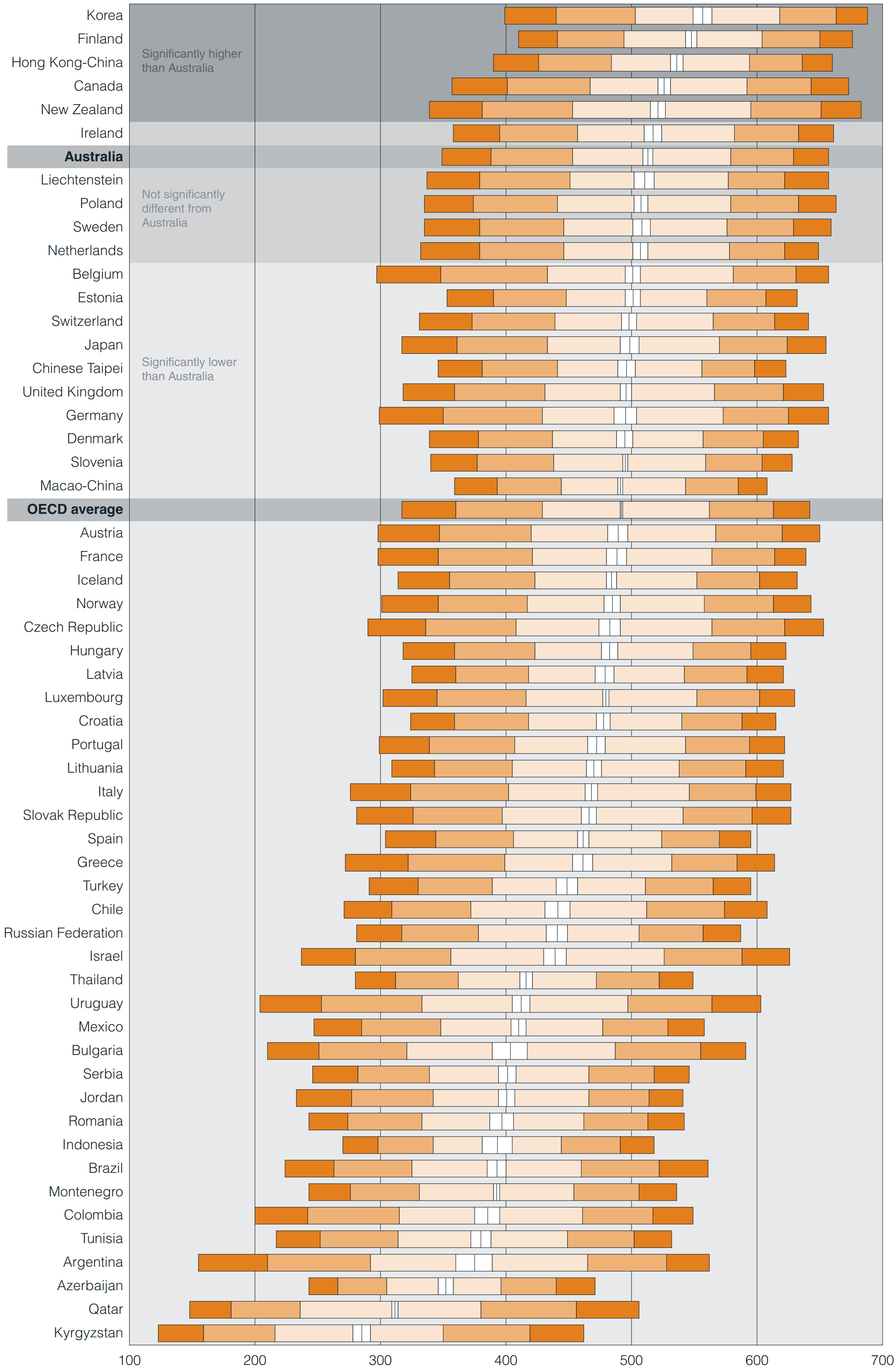


Figure 5.2 International student performance in reading literacy[21]

[21] The Bonferroni correction has not been used for these comparisons. See Reader's Guide for more information.

Figure 5.2 also shows the variation in scores between the lowest and highest performing students within each country. Examining the spread of student performance between the 5th and the 95th percentiles, the largest differences were found in the partner countries Argentina and Uruguay, with about 400 score points between students in the 5th and 95th percentiles. For OECD countries, the largest differences were in the Czech Republic, Belgium and Germany with a spread of 363, 360 and 359 score points respectively. The smallest spread of student performance was in the partner countries of Azerbaijan, Indonesia and Macao-China (with differences of between 229 and 250 score points). The highest performing countries, Finland and Hong Kong-China, had relatively narrow spreads of 265 and 270 score points respectively, and Korea had a slightly broader spread at 289 score points. The two other countries that out-performed Australia were Canada, with a similar distribution of students at 316 scores points, and New Zealand, with a wider distribution of 344 score points. Australia's spread between the highest and lowest performing students was 307 score points. Other countries with similar spreads were Ireland, Turkey, the Russian Federation, Hungary, Jordan and Switzerland. The OECD average between students in the 5th and 95th percentiles was 324 score points and United Kingdom's spread was wider at 344 score points.

In both PISA 2000 and PISA 2003 females outperformed males in reading literacy in all countries with the single exception of Liechtenstein in PISA 2003. In PISA 2006, the pattern of females achieving significantly higher than males has continued. Figure 5.3 provides the mean scores for reading literacy by gender and graphically illustrates the gender difference in reading literacy performance. The figure orders countries by the magnitude of the gender difference, from highest to lowest.

Australian females achieved a mean score of 532. This was 37 score points higher than the mean score of Australian males at 495 score points. The gender difference found in Australia was similar to the OECD average gender difference of 38 points. Australian males' mean reading literacy score was 22 score points higher than the OECD average for male performance (473 score points). Australian females scored, on average, 21 score points higher than the OECD average for females (511 score points).

Across countries, the gender differences in favour of females ranged from a low of 17 points in Chile to a high of 66 points in Qatar. Other countries that displayed small gender differences were the partner countries Indonesia (18 points), Colombia (19 points), Azerbaijan (20 points), Chinese Taipei (21 points), and OECD countries the Netherlands (24 points) and the United Kingdom (29 points). In twelve countries, of which two were OECD countries (Finland and Greece), females scored more than 50 points higher than their male counterparts.

	Females		Males	
	Mean score	SE	Mean score	SE
Qatar	346	(1.6)	280	(1.9)
Bulgaria	432	(6.9)	374	(7.7)
Greece	488	(3.5)	432	(5.7)
Jordan	428	(3.4)	373	(5.6)
Thailand	440	(3.0)	386	(4.0)
Argentina	399	(7.4)	345	(8.3)
Slovenia	521	(1.4)	467	(1.9)
Lithuania	496	(3.2)	445	(3.5)
Kyrgyzstan	308	(3.3)	257	(4.4)
Finland	572	(2.3)	521	(2.7)
Latvia	504	(3.5)	454	(4.3)
Croatia	502	(3.3)	452	(3.8)
Iceland	509	(2.3)	460	(2.8)
Norway	508	(3.3)	462	(3.8)
Estonia	524	(3.1)	478	(3.2)
Czech Republic	509	(5.4)	463	(5.0)
Uruguay	435	(3.8)	389	(4.4)
Montenegro	415	(1.8)	370	(2.0)
Liechtenstein	531	(6.3)	486	(7.7)
Austria	513	(5.5)	468	(4.9)
Romania	418	(5.2)	374	(4.5)
Turkey	471	(4.3)	427	(5.1)
Israel	460	(4.6)	417	(6.5)
Germany	517	(4.4)	475	(5.3)
Slovak Republic	488	(3.8)	446	(4.2)
Serbia	422	(4.2)	381	(3.4)
Italy	489	(2.8)	448	(3.4)
Sweden	528	(3.5)	488	(4.0)
Poland	528	(2.8)	487	(3.4)
Belgium	522	(3.5)	482	(4.1)
Hungary	503	(3.9)	463	(3.7)
OECD average	511	(0.7)	473	(0.7)
Russian Federation	458	(4.3)	420	(4.8)
Tunisia	398	(3.9)	361	(4.6)
New Zealand	539	(3.6)	502	(3.6)
Australia	532	(2.2)	495	(3.0)
Spain	479	(2.3)	443	(2.6)
Korea	574	(4.5)	539	(4.6)
France	505	(3.9)	470	(5.2)
Ireland	534	(3.8)	500	(4.5)
Mexico	427	(3.0)	393	(3.5)
Portugal	488	(3.5)	455	(4.4)
Canada	543	(2.5)	511	(2.8)
Brazil	408	(3.7)	376	(4.3)
Luxembourg	495	(2.1)	464	(2.0)
Hong Kong-China	551	(3.0)	520	(3.5)
Switzerland	515	(3.3)	484	(3.2)
Japan	513	(5.2)	483	(5.4)
Denmark	509	(3.5)	480	(3.6)
United Kingdom	510	(2.6)	480	(3.0)
Macao-China	505	(1.5)	479	(1.8)
Netherlands	519	(3.0)	495	(3.7)
Chinese Taipei	507	(4.2)	486	(4.4)
Azerbaijan	363	(3.3)	343	(3.5)
Colombia	394	(5.6)	375	(5.6)
Indonesia	402	(4.2)	384	(8.7)
Chile	451	(5.4)	434	(6.0)

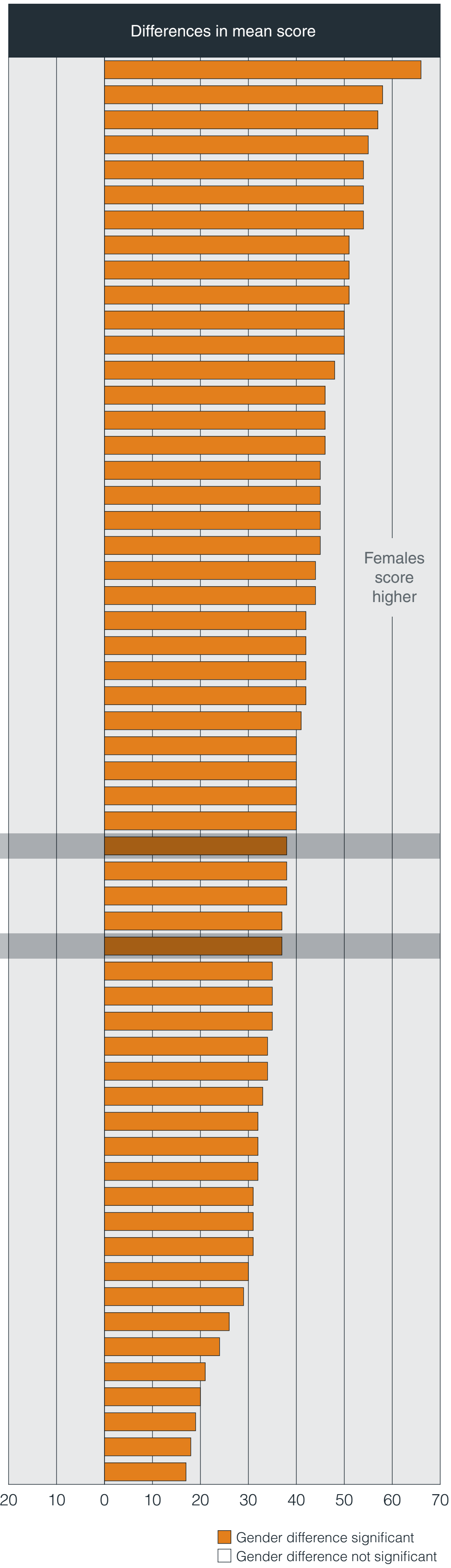


Figure 5.3 Gender differences on the reading literacy scale by country

The percentages of students at each reading literacy proficiency level, from below Level 1 to Level 5, are shown by country in Figure 5.4. In the figure, countries are ordered on the basis of the percentage of students achieving below Level 2. Generally, if a country had a relatively high percentage of students below Level 2, it tended to have a relatively low percentage at the higher proficiency levels.

On average across the OECD countries, about nine per cent of students achieved Level 5, the highest proficiency on the reading literacy scale. There was a wide variation between countries in the percentage of students at this level. Korea had the largest proportion (22%), followed by 17 per cent of Finnish students and 16 per cent of students from New Zealand. Australia, like Sweden and Belgium, had 11 per cent of students at Level 5, while 13 per cent of students from Hong Kong-China, nine per cent of Japanese students, five per cent of Chinese Taipei students and three per cent of Macao-Chinese students performed at this level. There were 12 countries, including Indonesia, Serbia, Thailand and Mexico, that had less than one per cent of students achieving at this level.

On average across the OECD, 30 per cent of students were proficient at Level 4 or higher on the reading literacy scale. More than 40 per cent of students in Canada, Hong Kong-China and Finland, and more than half the students from Korea, achieved at these two highest levels. Thirty-six per cent of Australian students were proficient at Level 4 and Level 5.

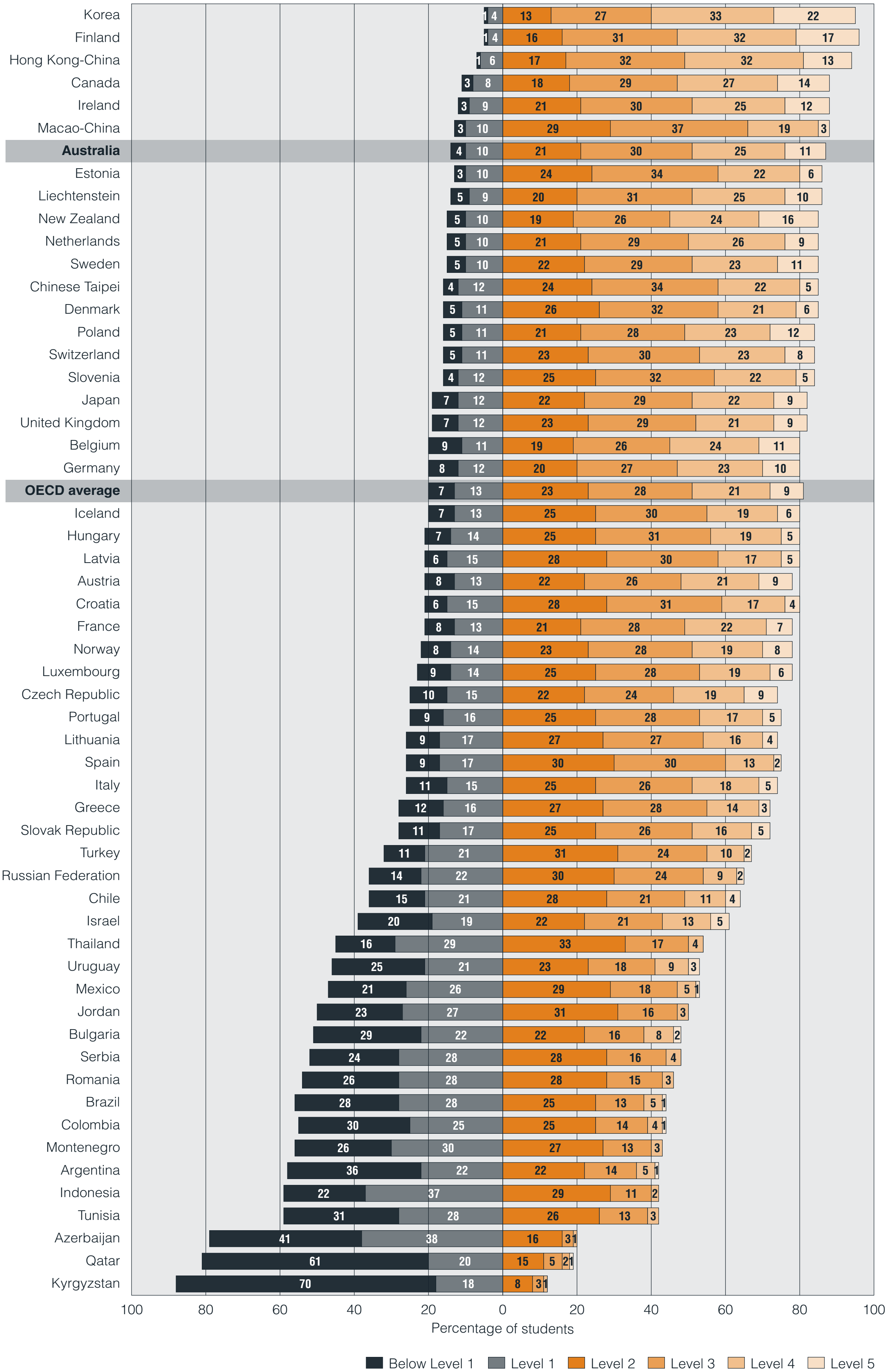


Figure 5.4 Proficiency levels for students in reading literacy by country

Proficiency Level 2, while not officially designated by the OECD as such, represents a baseline level of proficiency at which students begin to demonstrate the kind of reading literacy skills that are considered fundamental for future development, not only in reading, but also in other areas of knowledge acquisition. This chapter will report on the proportion of students failing to achieve this level.

On average a fifth of students in OECD countries performed at or below Level 2, and in Australia 14 per cent of students achieved at these levels. The highest performing countries (Korea, Finland and Hong Kong-China) had fewer than seven per cent of students achieving at these low levels, while Qatar and Kyrgyzstan had more than 80 per cent of students performing at or below Level 2.

Students performing below Level 1 have not demonstrated even the most basic type of information retrieval and understanding of text that PISA measures. These students are likely to be seriously disadvantaged in their lives beyond school and to encounter problems as they meet challenges beyond school life.

On average, seven per cent of students in OECD countries were unable to demonstrate Level 1 reading literacy skills. Finland, Hong Kong-China and Korea each had fewer than two per cent in this level while Australia had four per cent of students below Level 1. In contrast, more than 60 per cent of students from Kyrgyzstan and Qatar were placed below Level 1.

State differences in reading literacy performance

The mean performance and distributions for reading literacy in each Australian state is shown by state in Figure 5.5, along with the results for Korea, the highest performing country, and the OECD average. Students from the Australian Capital Territory achieved the highest mean score of 535 points, followed by Western Australia with a mean score of 524 points. These and four other states achieved a mean score that was significantly higher than the OECD average: New South Wales with a mean score of 519 points, South Australia (514 score points), Queensland (509 score points) and Victoria (504 score points). Tasmania's mean reading literacy score of 496 points was not statistically significantly different from the OECD average, but the Northern Territory's mean score of 460 score points was significantly below the OECD average.

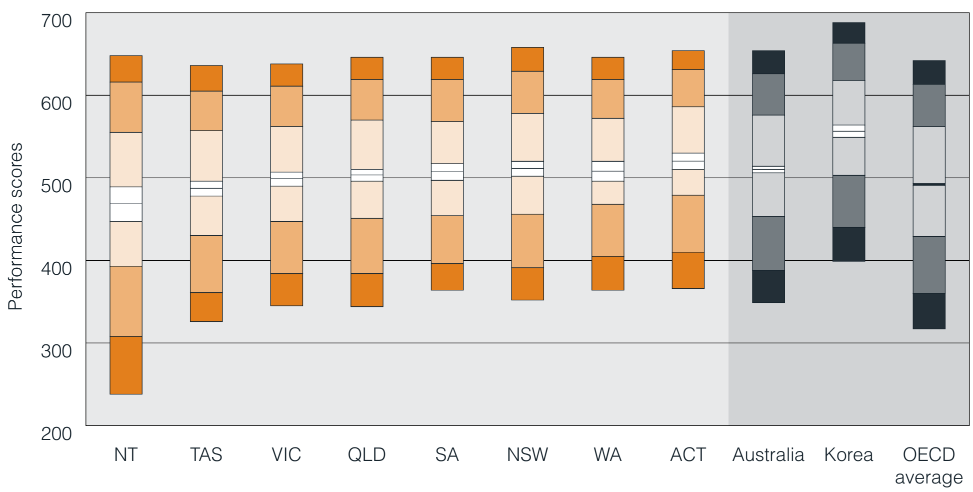


Figure 5.5 Student performance in reading literacy by state

Some states show more disparity in reading literacy performance than others. South Australia had the narrowest distribution between students in the 5th and 95th percentiles of 289 score points, while Western Australia, Victoria and the Australian Capital Territory had a spread of around 300 score points. In Queensland, New South Wales and Tasmania there were differences of 308, 313 and 319 score points respectively between the highest and lowest achievers. Of all the states, the

Northern Territory had the widest variation in reading literacy performance with 402 score points between students in the 5th and 95th percentiles (this was approximately 100 score points more than the spread for Australia as a whole).

Table 5.2 provides further insight into state-level performance by indicating significant differences in achievement between the states. The Australian Capital Territory performed similarly to Western Australia and significantly higher than all other states. Western Australia performed significantly higher than Queensland, Victoria, Tasmania and the Northern Territory, and equivalent to the Australian Capital Territory, New South Wales and South Australia. The Northern Territory performed significantly lower than all other states and significantly lower than the OECD average. Tasmania's score was similar to the OECD average, all other states performed significantly better.

Table 5.2 Multiple comparisons of mean performance on the reading literacy scale by state

			ACT	WA	NSW	SA	QLD	VIC	TAS	NT	OECD
		Mean	535	524	519	514	509	504	496	460	492
	Mean	**SE**	5.0	6.0	4.4	4.9	3.5	4.3	4.6	10.6	0.6
ACT	535	5.0		●	▲	▲	▲	▲	▲	▲	▲
WA	524	6.0	●		●	●	▲	▲	▲	▲	▲
NSW	519	4.4	▼	●		●	●	▲	▲	▲	▲
SA	514	4.9	▼	●	●		●	●	▲	▲	▲
QLD	509	3.5	▼	▼	●	●		●	▲	▲	▲
VIC	504	4.3	▼	▼	▼	●	●		●	▲	▲
TAS	496	4.6	▼	▼	▼	▼	▼	●		▲	●
NT	460	10.6	▼	▼	▼	▼	▼	▼	▼		▼

Note: Read across the row to compare a state's performance with the performance of each state listed in the column heading.
▲ Average performance statistically significantly higher than in comparison state
● No statistically significant difference from comparison state
▼ Average performance statistically significantly lower than in comparison state

The mean reading literacy score for females and males, together with the standard error and gender differences are shown by state in Figure 5.6. States are ordered from the largest to smallest gender differences in reading literacy. Females statistically significantly outperformed males in all states. New South Wales had the largest gender difference, with a 46 score point difference, representing more than half a proficiency level. Females in Tasmania, South Australia and Queensland performed 37 score points higher than males from the same states, this difference being similar to the OECD average. Gender differences in the remaining states were between 27 and 33 score points, with the smallest difference in the Australian Capital Territory.

	Females		Males	
	Mean score	SE	Mean score	SE
NSW	542	3.9	496	7.7
TAS	514	6.1	477	5.6
SA	531	5.9	494	6.1
QLD	528	5.1	491	3.9
NT	478	17.3	445	7.0
VIC	520	5.0	492	5.3
WA	539	6.0	511	8.2
ACT	549	6.1	522	10.3

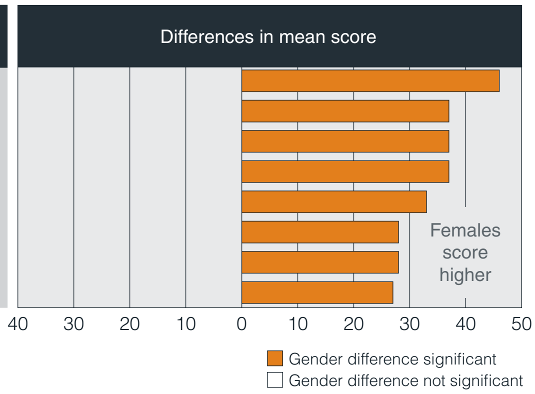


Figure 5.6 Gender differences on the reading literacy scale by state

Figure 5.7 shows the performance of the states in terms of the reading literacy proficiency levels. The performance of Korea and the OECD average are again included for comparison.

On average across Australia, 11 per cent of students achieved Level 5 in reading literacy. In the Australian Capital Territory 16 per cent of students were performing at this level, while in Victoria, Tasmania and the Northern Territory fewer than 10 per cent of students achieved at this highest level.

Almost half the students from the Australian Capital Territory were proficient at Level 4 or higher. Western Australia and New South Wales also performed strongly, with around 40 per cent of students achieving at Level 4 or higher. In the Northern Territory, however, less than one quarter of students achieved at the highest two levels.

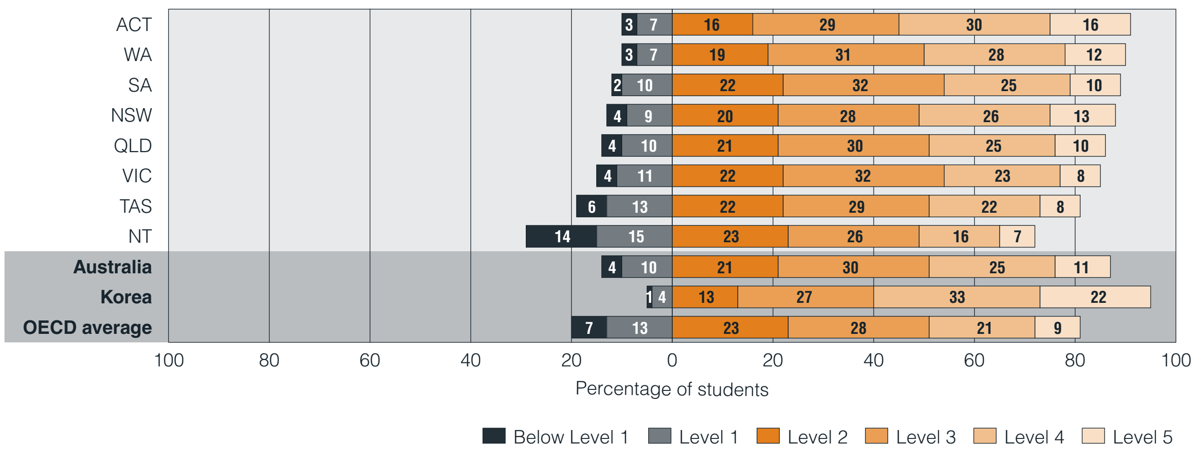


Figure 5.7 Proficiency levels in reading literacy by state

Overall, almost 14 per cent of Australian students failed to reach Level 2, the baseline level of reading literacy proficiency as described earlier. Results varied between the levels achieved in the Australian Capital Territory and Western Australia, where only ten per cent of students failed to achieve Level 2, to that of Tasmania (19%) and the Northern Territory, where 29% of students did not reach Level 2.

Gender differences on the reading literacy proficiency scale were more apparent at the higher and lower ends of the scale (Figure 5.8). Thirteen per cent of female students in Australia achieved Level 5, compared to eight per cent of males. Comparing states, there were more than twice the proportion of females as males achieving at this level in the Northern Territory and South Australia, and almost twice the proportion of females as males in New South Wales, Queensland and Tasmania. The smallest gender differences at Level 5 were found in the Australian Capital Territory (4%), Western Australia (5%) and Victoria (3%).

The largest difference in the proportion of students at the lower end of the reading literacy proficiency scale was in New South Wales, where 19 per cent of males and six per cent of females had not reached Level 2. In Tasmania there was also a large gender difference, with 25 per cent of males and 13 per cent of females failing to achieve Level 2. In the other states gender differences were significant, and ranged from 11 per cent in the Northern Territory to six per cent in Western Australia.

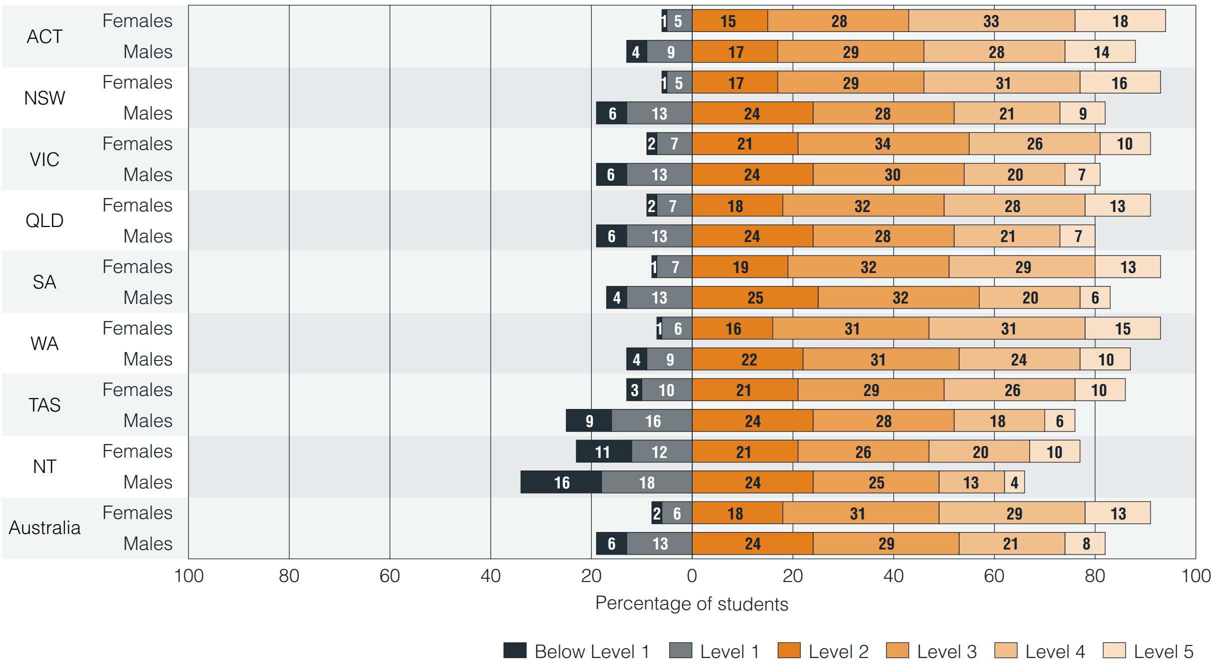


Figure 5.8 Proficiency levels for students on the reading literacy scale by state and gender

Indigenous students' performance in reading literacy

Figure 5.9 shows the large disparity between the mean reading literacy performance of Indigenous and non-Indigenous students. Indigenous students achieved a mean score of 434 points for reading literacy compared to the mean score of 515 points for non-Indigenous students. This difference of 81 score points equates to more than one proficiency level. Furthermore, the Indigenous students' mean score was more than three-quarters of a proficiency level lower than the OECD average (compared to the non-Indigenous students who performed one-third of a proficiency level higher than the OECD average).

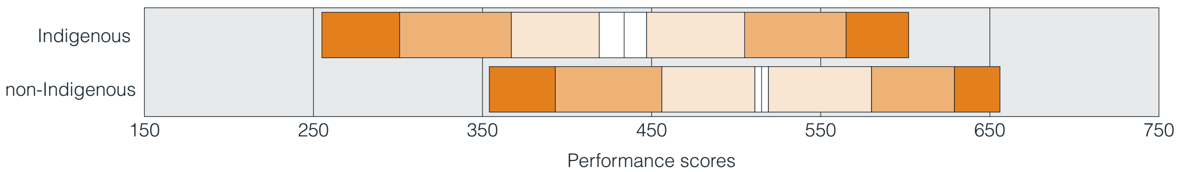


Figure 5.9 Student performance in reading literacy for Indigenous and non-Indigenous students

As Table 5.3 shows, Indigenous females performed significantly better than Indigenous males, with a difference (between mean scores) of about half a proficiency level in reading literacy (which is also similar to the difference in means between non-Indigenous females and males). The differences in performance between Indigenous and non-Indigenous students by gender is substantial with both non-Indigenous females and non-Indigenous males performing more than one proficiency level higher than Indigenous females and males respectively.

Table 5.3 Means by gender on the reading literacy scale for Indigenous and non-Indigenous students

	Females		Males		Total	
	Mean	SE	Mean	SE	Mean	SE
Indigenous	451	11.6	417	9.4	434	6.9
Non-Indigenous	534	2.1	497	3.1	515	2.1

As in PISA 2000 and PISA 2003, Indigenous students were again over-represented in the lower proficiency levels for reading literacy and under-represented in the upper proficiency levels (Figure 5.10).

At the higher end of the reading literacy proficiency scale, the proportion of non-Indigenous students achieving at Level 5 is more than four times the proportion of Indigenous students. Only three per cent of Indigenous students were able to complete sophisticated reading tasks, show detailed understanding of such texts, infer which information in the text is relevant to the task, and be able to evaluate critically and build hypotheses. Similarly, only 12 per cent of Indigenous students, compared to 36 per cent of non-Indigenous students, were able to achieve at Level 4 or higher.

At the lower end of the reading literacy proficiency scale, 16 per cent of Indigenous students compared with three per cent of non-Indigenous students failed to achieve higher than Level 1. Thirty-eight per cent of the Indigenous students did not achieve Level 2, compared to only 12 per cent of non-Indigenous students. Given that students achieving below Level 1 are the students that the OECD describes as likely to be seriously disadvantaged in their lives beyond school and that Level 2 is considered to be the baseline of demonstrating reading literacy skills that are essential for students' participation in society and meeting real-life challenges, these are alarming proportions.

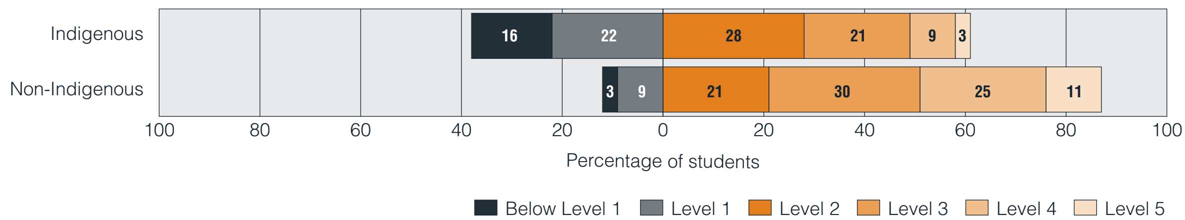


Figure 5.10 Proficiency levels for Indigenous and non-Indigenous students on the reading literacy scale

In PISA 2000, 35 per cent and in PISA 2003, 38 per cent of Indigenous students failed to achieve Level 2, compared to 12 per cent and 11 per cent of non-Indigenous students respectively. The reading literacy achievement for Indigenous students has not improved over time.

Figure 5.11 shows the performance of Indigenous and non-Indigenous students in reading literacy by gender. Almost half the Indigenous males did not reach Level 2 compared to almost one-fifth of non-Indigenous male students, while approximately one-third of Indigenous females did not reach Level 2 compared to less than one-tenth of non-Indigenous females.

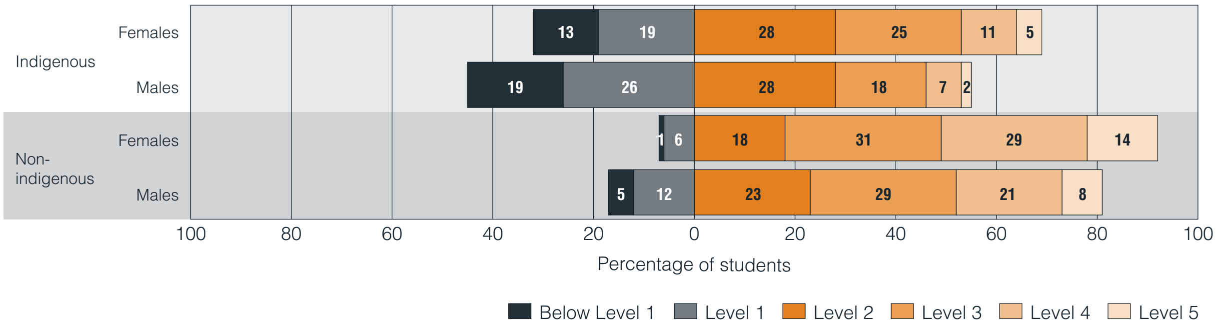


Figure 5.11 Proficiency levels for Indigenous and non-Indigenous students on the reading literacy scale by gender

At the upper end, only nine per cent of Indigenous males and 16 per cent of Indigenous females achieved at least Level 4, compared with 29 per cent of non-Indigenous males and 43 per cent of non-Indigenous females.

Reading literacy performance for students from different school locations

The mean scores and distribution of PISA 2006 students using the broad categories of geographic location from the MCEETYA Schools Geographic Location Classification, as described in the Reader's Guide, are shown in Figure 5.12.

In terms of mean scores, students who attended schools in metropolitan locations performed about 20 score points higher than students from schools in provincial areas and about 50 score points higher than students attending schools in remote locations. These differences were both statistically significant. However, although students attending schools in provincial areas achieved a higher mean score than students in schools located in remote areas, the difference was not statistically significant[22].

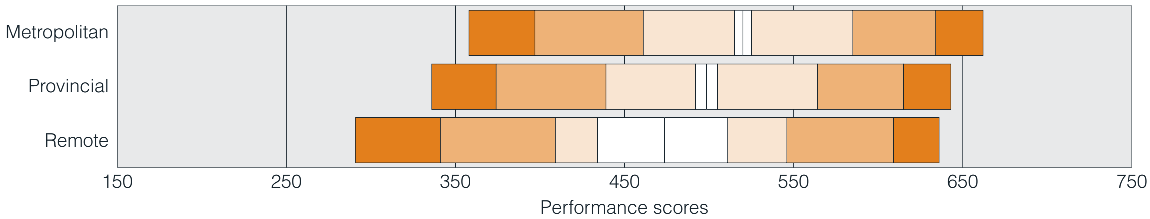


Figure 5.12 Student performance on the reading literacy scale by geographic location

Figure 5.13 shows the distribution of performance in the reading literacy proficiency levels by geographic location. Around 38 per cent of students attending metropolitan schools were achieving Level 5, compared to 30 per cent of those in provincial schools and 24 per cent of those in remote schools.

The proportion of students in remote areas not achieving at Level 2 is of some concern: approximately one-quarter of students in remote areas, compared to 17 per cent of students in provincial areas and 12 per cent of those in metropolitan areas, did not achieve this baseline level of proficiency.

[22] The confidence interval for students attending remote schools is very large, and so it is possible that this may mask any real differences.

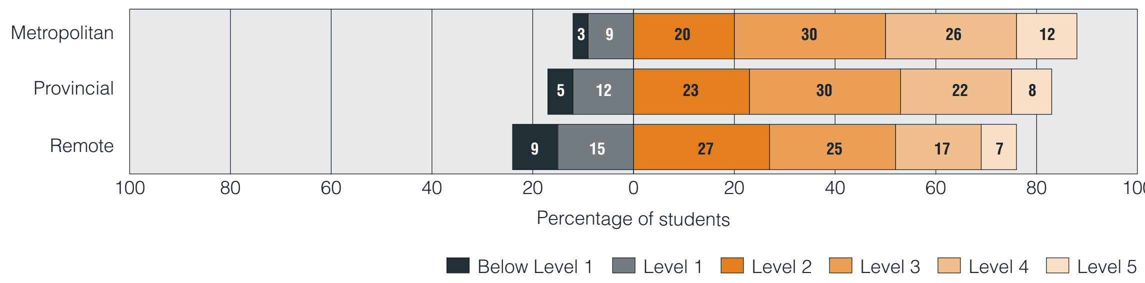


Figure 5.13 Proficiency levels on the reading literacy scale by geographic location

Reading literacy performance and socioeconomic background

As described in the Reader's Guide, an economic, social and cultural status index (ESCS) is used as the main measure of socioeconomic background in PISA and was derived from a series of student responses in relation to parental occupation status, parental education and home background.

Figure 5.14 shows that reading literacy scores varied positively with students' socioeconomic background; that is, in general terms, students with higher socioeconomic backgrounds tended to achieve higher scores in reading literacy. The mean score for students in the highest socioeconomic quartile was 557 points, with students in the lowest socioeconomic quartile performing more than one reading literacy proficiency level lower with a mean score of 473 score points. The difference in reading literacy scores between the highest and third quartiles of socioeconomic background was 0.4 of a proficiency level, 0.3 of a proficiency level between the third and second quartiles of socioeconomic background, and 0.4 of a proficiency level between the second and the lowest quartile of socioeconomic background. The differences in performance between students in each of the four quartiles of socioeconomic background are all statistically significant.

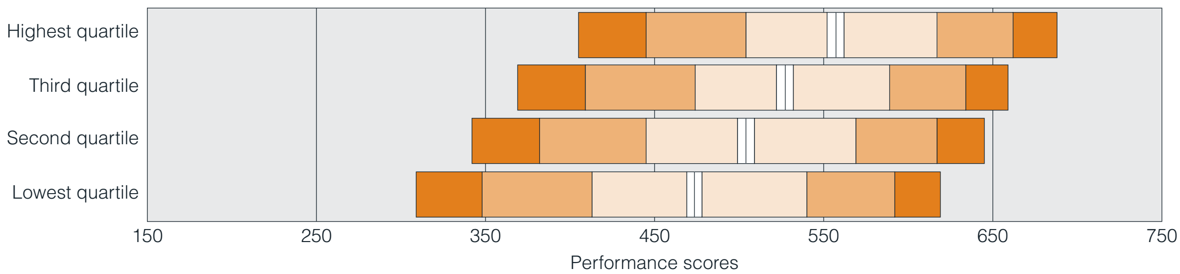


Figure 5.14 Student performance in reading literacy by socioeconomic background

Figure 5.15 shows the same pattern in terms of proficiency levels. For example, more than one-fifth of students in the highest quartile of socioeconomic background achieved Level 5 compared to 11 per cent of those in the third quartile, eight per cent in the second quartile and four per cent in the lowest quartile. At the same time, only five per cent of students in the highest socioeconomic quartile failed to achieve Level 2, compared to one-quarter (23%) of students in the lowest quartile.

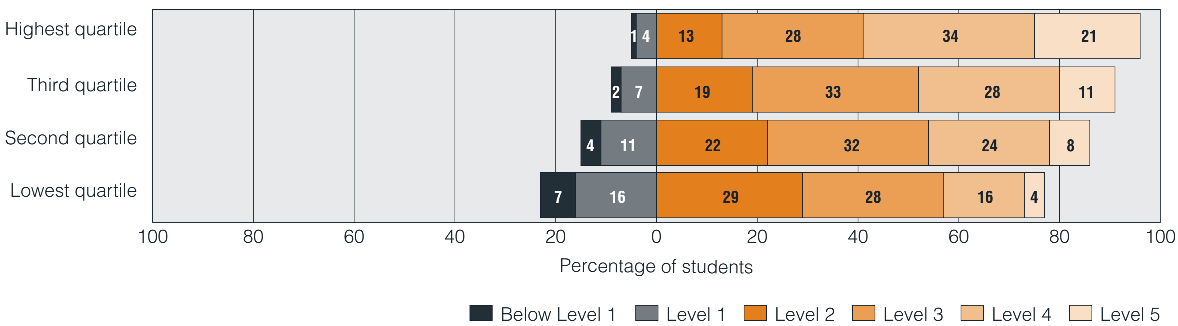


Figure 5.15 Proficiency levels in reading literacy by socioeconomic background

Reading literacy performance and immigrant status

The results for reading literacy based on students' immigrant status (in terms of country of birth) are shown in Figure 5.16. The mean score of 520 points for first-generation students (i.e. those students born in Australia with at least one parent born overseas) was statistically significantly higher than that of Australian-born students (512 score points). However, the mean score of foreign-born students (514 score points) was not statistically different from the scores for either Australian-born or first-generation students.

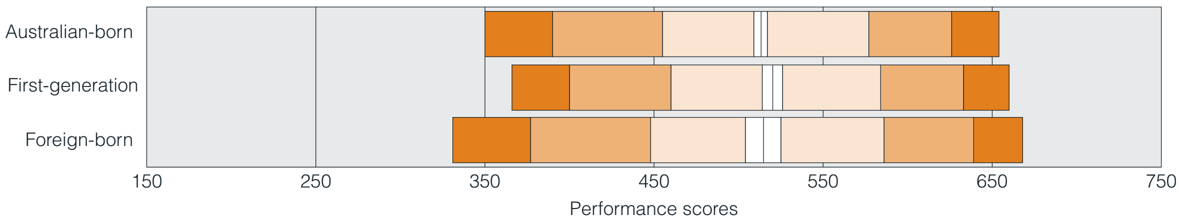


Figure 5.16 Student performance on the reading literacy scale by immigrant status

The distribution of students across the reading literacy proficiency levels is similar for each category of immigrant status (Figure 5.17). At the higher end of the reading literacy scale, there was at least 35 per cent of students achieving at Level 4 or Level 5, regardless of immigrant status. At the lower end, 14 per cent of foreign-born students had not reached Level 2, very similar to the percentage of first-generation (12%) and Australian-born (14%) students who did not achieve this level.

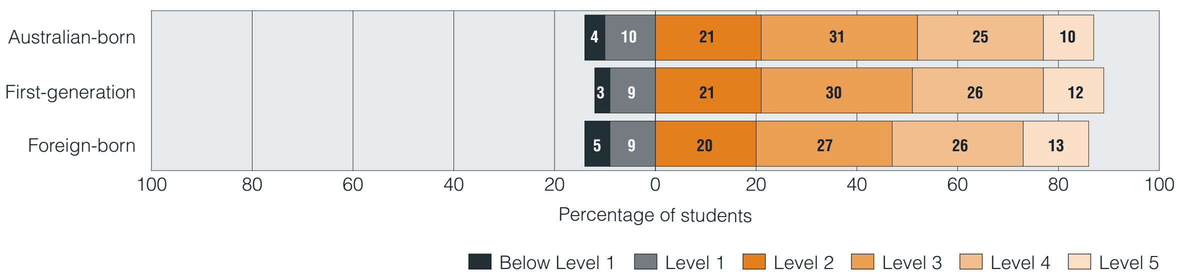


Figure 5.17 Proficiency levels in reading literacy by immigrant status

Students who spoke English as their main language at home performed significantly higher in reading literacy (with a mean score of 517 points) than those students whose main language at home was a language other than English (mean score of 497 points) (Figure 5.18). The difference in performance between those students who speak English at home and those students who speak another language at home is almost a third of a proficiency level.

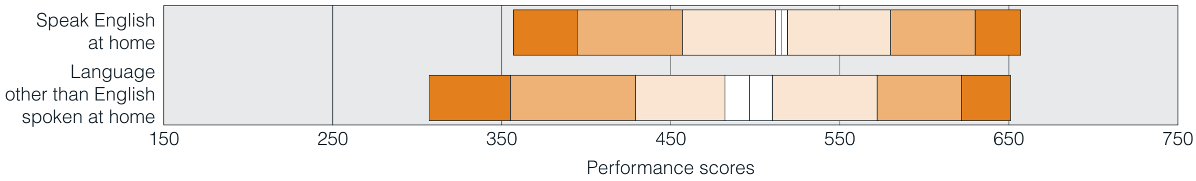


Figure 5.18 Student performance on the reading literacy scale by language spoken at home

Figure 5.19 shows there are some slight differences between these two groups in terms of proficiency levels. The proportion of students who speak a language other than English at home who did not achieve Level 2 is higher than the equivalent proportion for students whose main language at home is English (20 per cent and 12 per cent respectively). Thirty-six per cent of students who speak English at home and 32 per cent of students who speak a language other than English at home achieved at least Level 4.

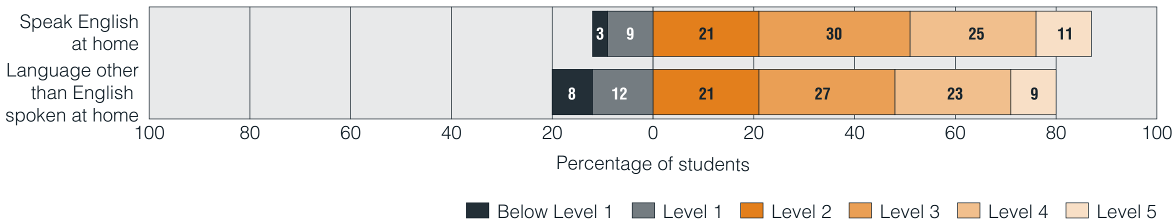


Figure 5.19 Proficiency levels on the reading literacy scale by language spoken at home

Monitoring reading literacy changes over time

One of the main aims of PISA is to examine student performance over time so that policy makers can monitor learning outcomes in both an international and national context. Although the optimal reporting of trends will occur between each full assessment of a literacy domain (for example, in reading between PISA 2000 and PISA 2009, where the major focus will again be on reading literacy), PISA has been designed so that it is possible to compare results between each three-year cycle. Nevertheless, care needs to be taken in making comparisons involving minor domains, both because of the smaller number of test items involved in minor domains and the fact that small refinements continue to be made in PISA's methodology, which may have an effect on comparability over time.

Internationally there are 36 countries in which reading literacy performance can be compared between PISA 2000 and PISA 2006. While the average OECD mean score has declined by nine points between 2000 and 2006 (from 500 score points to 492 score points), several countries have seen an improvement in their performance over this time while some countries have seen a decline and others no change (Table 5.4).

Table 5.4 Mean reading literacy scores, standard errors and differences in performance between PISA 2000 and PISA 2006 by country

Country	PISA 2000		PISA 2006		Difference	SE
	Mean	SE	Mean	SE		
Argentina	418	9.9	374	7.2	**-45**	13.2
Australia	528	3.5	513	2.1	**-15**	6.4
Austria	492	2.7	490	4.1	-2	7.0
Belgium	507	3.6	501	3.0	-6	6.8
Brazil	396	3.1	393	3.7	-3	7.0
Bulgaria	430	4.9	402	6.9	**-28**	9.8
Canada	534	1.6	527	2.4	-7	5.8
Chile	410	3.6	442	5.0	**33**	7.9
Czech Republic	492	2.4	483	4.2	-9	6.9
Denmark	497	2.4	494	3.2	-2	6.4
Finland	546	2.6	547	2.1	0	6.0
France	505	2.7	488	4.1	**-17**	7.0
Germany	484	2.5	495	4.4	11	7.1
Greece	474	5	460	4.0	-14	8.1
Hong Kong-China	525	2.9	536	2.4	11	6.3
Hungary	480	4	482	3.3	2	7.2
Iceland	507	1.5	484	1.9	**-22**	5.5
Indonesia	371	4	393	5.9	**22**	8.7
Ireland	527	3.2	517	3.5	-9	6.9
Israel	452	8.5	439	4.6	-14	10.8
Italy	487	2.9	469	2.4	**-19**	6.3
Japan	522	5.2	498	3.6	**-24**	8.1
Korea	525	2.4	556	3.8	**31**	6.7
Latvia	458	5.3	479	3.7	**21**	8.2
Liechtenstein	483	4.1	510	3.9	**28**	7.6
Mexico	422	3.3	410	3.1	-11	6.7
New Zealand	529	2.8	521	3.0	-8	6.4
Norway	505	2.8	484	3.2	**-21**	6.5
OECD average	500	0.6	492	0.6	-8	1.4
Poland	479	4.5	508	2.8	**29**	7.2
Portugal	470	4.5	472	3.6	2	7.6
Romania	428	3.5	396	4.7	**-32**	7.7
Russian Federation	462	4.2	440	4.3	**-22**	7.8
Spain	493	2.7	461	2.2	**-32**	6.1
Sweden	516	2.2	507	3.4	-9	6.4
Switzerland	494	4.2	499	3.1	5	7.2
Thailand	431	3.2	417	2.6	**-14**	6.5

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

Two OECD countries (Korea and Poland) and four partner countries (Chile, Liechtenstein, Indonesia and Latvia) showed improved reading literacy performance between PISA 2000 and PISA 2006. Korea increased its performance by 31 score points and Poland by 29 score points. Korea improved its performance by raising the performance of the better students while Poland raised its performance by improving the performance of students at the lower end of the performance distribution. For the partner countries, Chile's performance has risen by 33 score points, followed by Liechtenstein (28 score points), Indonesia (22 score points) and Latvia (21 score points).

The reading literacy performance of seven OECD countries and five partner countries declined from PISA 2000 to PISA 2006. For the OECD countries, Spain decreased its performance by

32 score points, followed by Japan (by 24 score points), Iceland (by 22 score points), Norway (by 21 score points), Italy (by 19 score points), France (by 17 score points) and Australia (by 15 score points). The partner countries that showed a decline in their reading literacy performance from PISA 2000 to PISA 2006 were Argentina (by 45 score points), Romania (by 32 score points), Bulgaria (by 28 score points), the Russian Federation (by 22 score points) and Thailand (by 14 score points).

The remaining 15 countries showed no change in their reading literacy performance between PISA 2000 and PISA 2006. This included 13 OECD countries, including some of the high performing countries in 2006 (Finland, Canada, New Zealand and Ireland) and two partner countries; Brazil and Israel.

In PISA 2000 only Finland outperformed Australia, and in 2003 Finland and Korea achieved significantly higher results than Australia. In PISA 2006, Figure 5.2 shows that five countries are now significantly outperforming Australia: Korea, Finland, Hong Kong-China, Canada and New Zealand. These changes have occurred for a combination of reasons – Australia's significant decline in score plus a large increase in the average score for Korea and a moderate increase for Hong Kong-China, and no decrease in scores in the average score for Finland, Canada and New Zealand.

At a national level, there were no statistically significant differences in the performance of reading literacy between PISA 2000 and PISA 2003 for Australia overall or for individual states as shown in Table 5.5.

From PISA 2003 to PISA 2006, there was a decrease in the reading literacy performance by 13 score points for Australia overall. The difference in mean reading literacy scores decreased in all states between PISA 2003 and PISA 2006. Statistically significant declines were found in the Northern Territory (by approximately half a proficiency level), Western Australia (by almost one-third of a proficiency level) and South Australia (by one-quarter of a proficiency level). The difference between PISA 2003 and PISA 2006 across all OECD countries was a decline of two score points.

The overall reading literacy mean for Australia declined significantly by 15 score points, from 528 to 513 score points from PISA 2000 to PISA 2006. This difference was larger than that of the OECD average, which was a decline of six score points. The difference in mean reading literacy scores decreased in all states between PISA 2000 and PISA 2006. Statistically significant declines were found in the Northern Territory (by approximately 0.4 of a proficiency level), South Australia and New South Wales (by approximately 0.3 of a proficiency level), and the Australian Capital Territory (by approximately one-quarter of a proficiency level).

Table 5.5 Mean reading literacy scores and standard errors for PISA 2000, PISA 2003 and PISA 2006, and differences between performance in cycles by state

State	PISA 2000		PISA 2003		PISA 2006		Differences between					
							PISA 2000 and PISA 2003		PISA 2003 and PISA 2006		PISA 2000 and PISA 2006	
	Mean	SE	Mean	SE	Mean	SE	Diff.	SE	Diff.	SE	Diff.	SE
ACT	552	4.6	549	6.0	535	5.0	-3	9.2	-14	9.0	**-17**	8.4
NSW	539	6.3	530	4.3	519	4.4	-9	9.3	-11	7.6	**-20**	9.2
VIC	516	7.6	514	5.0	504	4.3	-2	10.5	-10	8.0	-12	10.0
QLD	521	8.6	517	8.1	509	3.5	-4	13.0	-8	9.9	-12	10.5
SA	537	7.7	532	4.3	514	4.9	-5	10.3	**-18**	7.9	**-23**	10.4
WA	538	8.0	546	4.3	524	6.0	8	10.5	**-22**	8.7	-14	11.2
TAS	514	9.7	508	7.2	496	4.6	-6	13.2	-12	9.6	-18	11.8
NT	489	5.6	496	6.1	460	10.6	7	9.8	**-36**	13.0	**-29**	13.0
Australia	528	3.5	525	2.1	513	2.1	-3	6.7	**-13**	5.4	**-15**	6.4

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

Given that Australia was one of the countries to show a decline in reading literacy performance between 2000 and 2006, it is important to investigate further where and when this change has occurred. Table 5.6 shows the difference in percentiles between PISA cycles. There have been significant declines in the performance of students in the 75th, 90th and 95th percentiles between PISA 2003 and 2006, and between PISA 2000 and PISA 2006; that is, the best performers in reading literacy are not performing as well in PISA 2006 as they did in PISA 2000 and PISA 2003.

Table 5.6 Differences in percentiles between PISA 2000, PISA 2003 and PISA 2006 for Australia

PISA	5th		10th		25th		75th		90th		95th	
	Diff.	SE	Diff.	SE	Diff.	SE	Diff.	SE	Diff.	SE	Diff.	SE
2000 and 2003	-2	8.7	1	7.8	6	7.5	-8	7.5	-12	7.3	-13	7.6
2003 and 2006	-3	7.4	-6	6.7	-11	5.9	**-15**	5.6	**-16**	6.0	**-17**	6.0
2000 and 2006	-5	7.7	-6	7.4	-5	7.1	**-23**	7.2	**-27**	7.1	**-29**	7.2

Note: Differences in bold are statistically significant (at 95 percent confidence level)

Table 5.7 shows the mean reading literacy scores for females from PISA 2000 to PISA 2006 as well as the differences in reading literacy performance between PISA cycles. There were no statistically significant differences in reading literacy performance for females between PISA 2000 and PISA 2003 in Australia or in any of the states.

There was a statistically significant decline in the reading literacy performance of females for Australia overall and for two states (Northern Territory and Western Australia) between PISA 2003 and PISA 2006. For Australian females, reading literacy performance declined from 545 to 532 score points, a decline of 14 score points. In the Northern Territory, there was a decline of 45 score points (more than half a proficiency level), and in Western Australia the reading literacy performance for females declines by 26 score points (or one-third of a proficiency level).

Comparing the reading literacy performance between PISA 2000 and PISA 2006, there was a statistically significant decline in the female mean reading literacy score for Australia overall and for Tasmania. The mean reading literacy score for Australian females declined by 14 score points, from a mean of 546 to 532 score points, and for Tasmania, by 27 score points.

Table 5.7 Mean reading literacy scores and standard errors for PISA 2000, PISA 2003 and PISA 2006, and differences between performance in cycles by state for females

State	PISA 2000		PISA 2003		PISA 2006		Differences between					
							PISA 2000 and PISA 2003		PISA 2003 and PISA 2006		PISA 2000 and PISA 2006	
	Mean	SE	Mean	SE	Mean	SE	Diff.	SE	Diff.	SE	Diff.	SE
ACT	565	10.1	569	12.2	549	6.1	4	16.7	-20	14.4	-16	12.8
NSW	555	6.9	550	4.1	542	3.9	-5	9.6	-8	7.2	-13	9.3
VIC	532	13.3	530	5.9	520	5.0	-2	15.5	-10	9.0	-12	15.1
QLD	545	11.6	544	8.2	528	5.1	-1	15.2	-16	10.6	-17	13.6
SA	551	9.3	551	8.0	531	5.9	0	13.4	-20	10.9	-19	12.1
WA	557	9.5	565	4.8	539	6.0	8	11.9	**-26**	8.9	-18	12.3
TAS	541	9.1	532	8.0	514	6.1	-9	13.2	-18	11.0	**-27**	12.0
NT	505	7.1	523	9.0	478	17.3	18	12.6	**-45**	20.0	-27	19.3
Australia	546	4.7	545	2.6	532	2.2	-1	7.6	**-14**	5.6	**-14**	7.2

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

Table 5.8 shows the mean reading literacy scores for males from PISA 2000 to PISA 2006 as well as the differences in reading literacy performance between PISA cycles. There were no statistically significant differences in reading literacy performance for males between PISA 2000 and PISA 2003 in Australia or in any of the states.

Between PISA 2003 and PISA 2006 there were significant declines in the mean reading literacy scores in South Australia. The mean reading literacy score for males decreased 22 points, from 517 to 494 score points.

Comparing the mean reading literacy performance for males between PISA 2000 and PISA 2006 there was a statistically significant decline for Australia overall and for three states (the Northern Territory, New South Wales and South Australia). For Australia, the mean reading literacy score for males decreased by 18 points, from 513 to 495 score points. In the Northern Territory, there was a 30 point decline (or 0.4 of a proficiency level) from 475 to 445 score points. In New South Wales the mean reading literacy score for males decreased from 525 to 496 score points, a decline of 29 score points, and in South Australia there was a decline of 28 score points in the mean reading literacy score for males from 522 to 494 score points.

Table 5.8 Mean reading literacy scores and standard errors for PISA 2000, PISA 2003 and PISA 2006, and differences between performance in cycles by state for males

State	PISA 2000		PISA 2003		PISA 2006		Differences between					
							PISA 2000 and PISA 2003		PISA 2003 and PISA 2006		PISA 2000 and PISA 2006	
	Mean	SE	Mean	SE	Mean	SE	Diff.	SE	Diff.	SE	Diff.	SE
ACT	542	14.0	527	9.2	522	10.3	-15	17.6	-5	14.5	-20	18.1
NSW	525	8.9	510	6.6	496	7.7	-15	12.3	-14	11.1	**-29**	12.8
VIC	504	6.7	499	6.8	492	5.3	-5	10.9	-7	9.7	-13	9.9
QLD	498	8.6	495	8.9	491	3.9	-3	13.5	-4	10.7	-8	10.7
SA	522	10.7	517	5.9	494	6.1	-5	13.3	**-23**	9.6	**-28**	13.3
WA	523	9.6	526	5.7	511	8.2	3	12.4	-15	10.9	-12	13.5
TAS	491	12.1	487	10.0	477	5.6	-4	16.6	-10	12.3	-14	14.2
NT	475	9.0	465	7.3	445	7.0	-10	12.7	-20	11.1	**-30**	12.5
Australia	513	4.0	506	2.8	495	3.0	-7	7.2	-11	6.1	**-18**	7.1

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

The reading literacy performance of Indigenous students was also examined to determine if there have been any changes between PISA 2000, PISA 2003 to PISA 2006. Table 5.9 shows although there has been a decline in the reading literacy performance for Indigenous students, these changes are not statistically significant.

Table 5.9 Mean reading literacy scores and standard errors for PISA 2000, PISA 2003 and PISA 2006, and differences between performance in cycles for Indigenous students.

PISA 2000		PISA 2003		PISA 2006		Differences between					
						PISA 2000 and PISA 2003		PISA 2003 and PISA 2006		PISA 2000 and PISA 2006	
Mean	SE	Mean	SE	Mean	SE	Diff.	SE	Diff.	SE	Diff.	SE
448	3.1	444	8.6	434	6.9	-4	10.6	-10	11.9	-14	9.1

Summary

Australia's mean score in reading literacy in PISA 2006 was 513 score points, significantly lower than the scores achieved in both PISA 2000 and in PISA 2003. Australia was outperformed by five countries: Korea, Finland, Hong Kong-China, Canada and New Zealand, compared to the previous two cycles, in which only Finland significantly outperformed Australia. This has occurred because the average scores for Korea and Hong Kong-China have improved, and the scores for Finland, Canada and New Zealand have remained the same, while that of Australia has significantly declined.

The spread in scores between the 5th and 95th percentiles ranged from 229 score points in Azerbaijan to 406 score points in Argentina. Comparing the countries who significantly out-performed Australia, Australia's spread of 307 score points was higher than for Korea, Hong Kong-China and Finland, and lower than for Canada and New Zealand. The distribution between the lowest and highest performing students for the OECD average was 324 score points.

Significant gender differences in favour of females were found in all countries that participated in PISA 2006. In Australia the gender difference was 38 score points, which was similar to the OECD average. Both female and male students scored significantly higher than the OECD average. More females than males achieved at the higher proficiency levels, and more males than females failed to achieve at least Level 2.

New South Wales, South Australia, Queensland and Victoria all had mean scores higher than the OECD average, Tasmania's score was similar to the OECD average, while the score for the Northern Territory was significantly lower than the OECD average. The Northern Territory had the widest variation in scores of 402 score points, and their average score was significantly lower than that of all other states. The largest gender differences were found in New South Wales, and the smallest in the Australian Capital Territory.

Almost half (46%) of the students in the Australian Capital Territory achieved at Level 4 or higher, compared to only 23 per cent in the Northern Territory. The Australian Capital Territory did well not only in having a high proportion of students with high levels of attainment, but also in having the lowest proportion of students (10%) not attaining Level 2, compared with the Northern Territory in which 29 per cent failed to attain this level.

Indigenous students again performed relatively poorly in reading literacy. Their average score was 81 score points lower than that of non-Indigenous students, which represents three-quarters of a proficiency level, and is significantly lower than the OECD average. Thirty-eight per cent of Indigenous students were not achieving the baseline of Level 2.

There were also significant differences found between students in metropolitan schools and those in remote schools. The difference was 47 score points in favour of students in metropolitan schools. Also a cause for concern is that approximately one-quarter of students attending schools in remote locations were failing to achieve Level 2.

Socioeconomic background also has a strong relationship with performance in reading literacy. There was an 84 score points difference between the average scores of students in the highest and lowest socioeconomic quartiles. In addition, more than one-half of the students in the highest socioeconomic quartile were achieving at a level greater than Level 4, compared to about 20 per cent of those in the lowest socioeconomic quartile, and only five per cent of those in the highest socioeconomic quartile, compared to 23 per cent of those in the lowest socioeconomic quartile, failed to achieve at Level 2.

There were not large differences either in scores or in distribution by proficiency levels for students by immigrant status, with foreign-born students achieving similar mean scores to Australian-born students. Language background also did not appear to have a great effect, with the major difference being a larger proportion of students with a language background other than English (20%) compared to English-speaking students (12%) failing to achieve Level 2.

Australia's results in mathematical literacy are considered in Chapter 6.

Chapter

6

Student Performance in Mathematical Literacy

How well can young adults use their mathematical knowledge and understanding to participate in today's changing world? Do they have the capacity to analyse and solve everyday problems involving mathematics? Do they have the ability to communicate ideas and information from a mathematical stand point? The assessment of mathematical literacy in PISA addresses these questions through the use of 'real-world' tasks.

Mathematical literacy was the major domain of PISA 2003. This allowed the mathematical literacy framework to be expanded and mathematics performance to be assessed in far greater detail than in the first assessment of 2000 when mathematical literacy was a minor domain. Mathematical literacy was again a minor domain in this current PISA cycle. The assessment of mathematical literacy as a minor domain in PISA 2006 provides results for the mathematical literacy scale overall (but not by subscale).

This chapter[23] begins with an overview of the assessment framework for the mathematical literacy domain, a description of how mathematical literacy is reported and a selection of examples to illustrate the assessment of mathematical literacy. The next part of this chapter follows the same format in reporting student performance as in the previous chapter – firstly from an international context, and then from a national perspective. The final part of the chapter investigates mathematical literacy performance between PISA 2003 and PISA 2006.

Definition of mathematical literacy

The PISA mathematical literacy domain is concerned with the capacities of students to analyse, reason and communicate ideas effectively as they pose, formulate, solve and interpret mathematical problems in a variety of situations. The PISA assessment framework (OECD, 2006) 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.
>
> (p.72)

In this conception, mathematical literacy is about meeting life needs. Mathematical literacy is expressed through using and engaging with mathematics, making informed judgements, and understanding the usefulness of mathematics in relation to the demands of life.

[23] Parts of this chapter have been adapted from the OECD publication, Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006.

The PISA mathematics assessment directly confronts the importance of the functional use of mathematics by placing primary emphasis on a real-world problem situation, and on the mathematical knowledge and competencies that are likely to be useful to deal effectively with such a problem. The PISA mathematics framework was written to encourage an approach to teaching and learning mathematics that gives strong emphasis to the processes associated with confronting a problem in a real-world context, transforming the problem into one amenable to mathematical treatment, making use of the relevant mathematical knowledge to solve it, and evaluating the solution in the original problem context. If students can learn to do these things, they will be much better equipped to make use of their mathematical knowledge and skills throughout their lives.

How mathematical literacy is measured in PISA

The PISA framework for mathematical literacy is organised into three broad components: the situations and contexts in which problems are presented and that are used as sources of stimulus material; the mathematical content to which different problems and questions relate; and the mathematical competencies that need to be activated in order to connect the real world, in which problems are generated, with mathematics and then to solve problems. The three components and their interactions are shown in Figure 6.1.

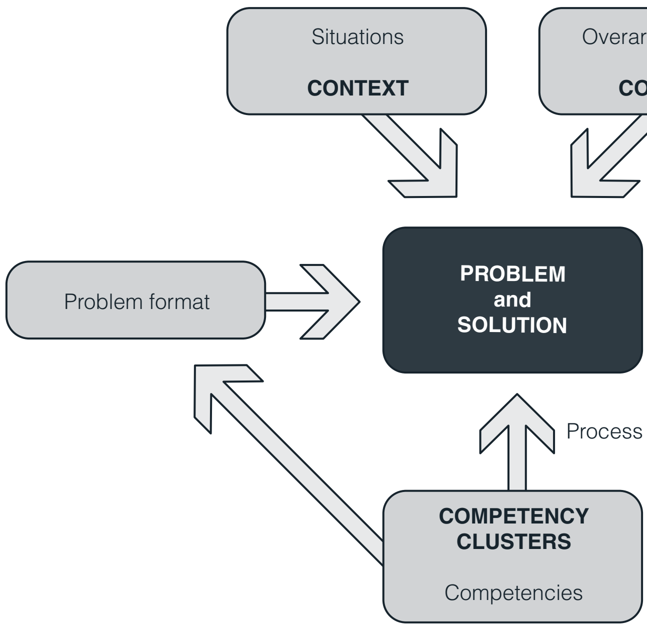


Figure 6.1 The components of the mathematical literacy framework (OECD, 2006)

Situations and Context

An important aspect of mathematical literacy is engagement with mathematics: using and doing mathematics in a variety of situations. As in previous PISA cycles, students were shown written materials that described various situations that students could conceivably confront, and which required them to apply their mathematical knowledge, understanding or skill to analyse and deal with the situation. Four situations are defined in the PISA mathematical literacy framework: personal, educational or occupational, public and scientific, and assessment items are placed within each of these contexts.

The situations differ in terms of how directly the problem affects students' lives, that is, the degree of immediacy and directness in the connection between the student and the problem context. For example, personal situations are closest to the student and are characterised by the direct perceptions involved. The situations also differ in the extent to which the mathematical aspects are explicit. Although some tasks in the assessment refer only to mathematical objects, symbols or structures, and make no reference to matters outside the mathematical world, more typically, the problems are not stated in explicit mathematical terms. This reflects the strong emphasis in the PISA mathematical literacy assessment on exploring the extent to which students can identify mathematical features of a problem when it is presented in a non-mathematical context, and can activate their mathematical knowledge to explore and solve the problem and to make sense of the solution in the context or situation in which the problem arose.

Mathematical Content

The PISA framework defines mathematical content in terms of four broad knowledge domains and includes the kinds of problems individuals come across through interaction with day-to-day phenomena and that are based on a conception of the ways in which mathematical content presents itself to people. These broad knowledge domains, referred to as overarching ideas, reflect historically well-established branches of mathematical thinking and they underpin mathematical curricula in education systems throughout the world. Together, these broad content areas cover the range of mathematics that 15-year-old students need as a foundation for life and for further extending their horizon in mathematics. There are four overarching ideas:

- *Space and shape* relates to spatial and geometric phenomena and relationships, drawing on the curriculum of geometry. Space and shape requires looking for similarities and differences when analysing the components of shapes, recognising shapes in different representations and different dimensions as well as understanding the properties of objects and their relative positions, and the relationship between visual representations (both two- and three-dimensional) and real objects.
- *Change and relationships* relates most closely to the curriculum area of algebra and recognises the world is not a constant – every phenomenon is a manifestation of change. These changes can be presented in a number of ways, including a simple equation, an algebraic expression, a graph or table. As different representations are appropriate in different situations, translation between representations is an important skill when dealing with situations and tasks.
- *Quantity* involves numeric phenomena and quantitative relationships and patterns. It relates to the understanding of relative size, the recognition of numerical patterns, and the use of numbers to represent quantities and quantifiable attributes of real world objects (counting and measuring). Furthermore, quantity deals with the processing and understanding of numbers that are represented in various ways.
- *Uncertainty* involves probabilistic and statistical phenomena and relationships. Uncertainty is present in daily life, where a great deal of information is often presented as precise and having no error, when in fact there is a varying amount of uncertainty.

Although the overarching ideas together generally encompass the range of mathematical topics that students are expected to have learned, the approach to content in PISA is somewhat different in terms of mathematical instruction and the curricular strands taught. The assessment in PISA is related more to the application of mathematical knowledge rather than what content has been learnt.

In PISA 2003, results were reported for each of these four overarching ideas, as well as for mathematical literacy overall. As noted above, separate reporting by subscale is not possible for mathematical literacy in 2006.

Competencies

While the overarching ideas define the main areas of mathematics that are assessed in PISA, they do not make explicit the mathematical processes that students apply as they attempt to solve problems. The PISA mathematics framework uses the term mathematisation to define the cycle of activity for investigating and solving real-world problems. Beginning with a problem situated in reality, students must organise it according to mathematical concepts. They progressively trim away the reality in order to transform the problem into one that is amenable to direct mathematical solution. Students can then apply specific mathematical knowledge and skills to solve the mathematical problem, before using some form of translation of the mathematical results into a solution that works for the original problem context; for example, this may involve the formulation of an explanation or justification of proof.

Various competencies are called into play as the mathematisation process is employed. The PISA mathematics framework discusses and groups the competencies in three competency clusters: reproduction, connections and reflections.

Item Types

The PISA mathematical literacy assessment items are in a variety of formats. Some of the items are basic or complex multiple-choice items and the rest of the items require students to construct a response. There are three different types of constructed response items – short response items (students were required to provide a response that was numeric or another fixed form); open-constructed response items (students had to write an explanation of their results that illustrated aspects of the methods and thought processes they had used to answer the question); and closed-response items (students had to provide the calculations they had employed to complete the answer).

The PISA 2006 assessment included a number of common items from the PISA 2003 assessment. This provides a link between the two cycles of testing and enables the monitoring 15-year-old mathematical literacy performance across and within countries over time.

Reporting mathematical literacy performance

As noted above, mathematical literacy is reported only on a single scale for 2006 along a continuum describing the skills demonstrated at various levels.

Mean scores and distribution of scores

In PISA 2003, when mathematical literacy was the major domain, the mean score across all OECD countries was set at 500 and established the benchmark against which mathematical literacy performance in PISA 2006 is compared. The OECD average in mathematical literacy is slightly lower in 2006, at 498 score points, than in PISA 2003; however, this difference is not statistically significant.

Proficiency levels

Six levels of proficiency for mathematics were defined and described in 2003. The continuum of increasing mathematical literacy is shown in Figure 6.2 along with the summary descriptions of the kinds of mathematical competencies associated with the different levels of proficiency. Students who scored below 358 points are placed below Level 1. Students performing below this level were not necessarily incapable of performing any mathematical operation, but they were unable to utilise mathematical skills in a given situation as required by the easiest PISA tasks. These students are not demonstrating skills that will enable young adults to participate fully in society beyond school.

Proficiency level	General mathematical literacy proficiencies students should have at each level
6	At Level 6 students can conceptualise, generalise, and utilise information based on their investigations and modelling of complex problem situations. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understandings along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for attacking novel situations. Students at this level can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situations.
669.3 points	
5	At Level 5 students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare and evaluate appropriate problem solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterisations, and insights pertaining to these situations. They can reflect on their actions and formulate and communicate their interpretations and reasoning.
607.0 points	
4	At Level 4 students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Students at this level can utilise well-developed skills and reason flexibly, with some insight, in these contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
544.7 points	
3	At Level 3 students can execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They can develop short communications reporting their interpretations, results and reasoning.
482.4 points	
2	At Level 2 students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures or conventions. They are capable of direct reasoning and making literal interpretations of the results.
420.1 points	
1	At Level 1 students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are obvious and follow immediately from the given stimuli.
357.8 points	

Figure 6.2 Summary descriptions of the six proficiency levels on the overall mathematical literacy scale

Sample mathematical literacy items and responses

This section provides a selection of sample items to illustrate the various aspects of the PISA mathematical literacy framework (the overarching ideas, competencies and situations), different item types and the wide range of complexity involved in such tasks. As no additional mathematical literacy items have been released since PISA 2003, the examples provided here are replicated from the national report on PISA 2003 (Thomson, Cresswell & De Bortoli, 2004).

Number Cubes

During their education students would have encountered many games and activities, whether formal or informal, that use number cubes or dice. Somewhat challenging was the problem posed below, which required spatial insight or mental visualisation technique, as students needed to imagine how the four planes of number cubes, if reconstructed into a three-dimensional number cube, obey the numerical construction rule given in the information (i.e., two opposite sides have a total of seven dots).

NUMBER CUBES

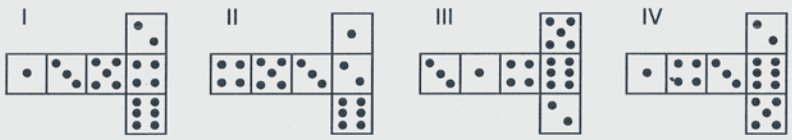
On the right, there is a picture of two dice.

Dice are special number cubes for which the following rule applies:

> The total number of dots on two opposite faces is always seven.

You can make a simple number cube by cutting, folding and gluing cardboard. This can be done in many ways. In the figure below you can see four cuttings that can be used to make cubes, with dots on the sides.

Which of the following shapes can be folded together to form a cube that obeys the rule that the sum of opposite faces is 7? For each shape, circle either “Yes” or “No” in the table below.



Full credit was given to students who correctly identified the four expected results, as shown in the example below. This complex multiple-choice item is situated in a personal context, is placed in the overarching area of Space and Shape and illustrates proficiency level 3.

Shape	Obeys the rule that the sum of opposite faces is 7?
I	Yes / No
II	Yes / No
III	Yes / No
IV	Yes / No

Overall per cent correct[24]	
Korea (Highest achieving country)	81%
Australian males	71%
Australia	69%
Australian females	66%
OECD average	63%
Mexico (Lowest achieving country)	29%

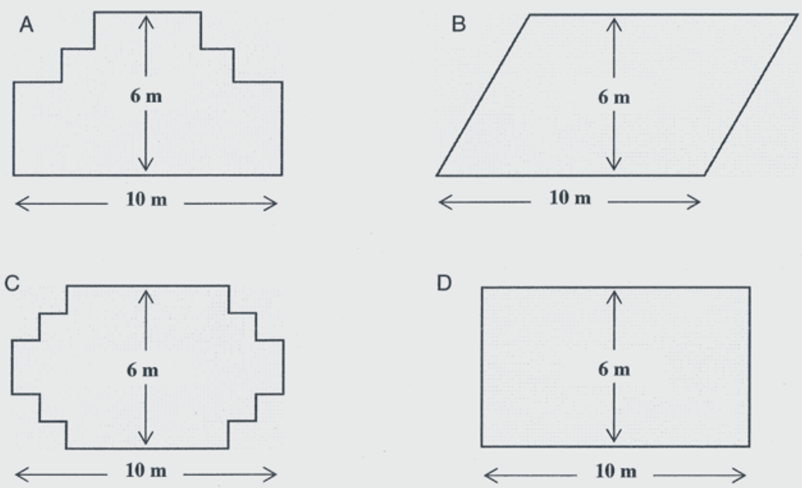
[24] The students’ results for the sample mathematical literacy items were derived from the PISA 2003 dataset.

The problem required the encoding and spatial interpretation of two-dimensional objects, interpretation of the connected three-dimensional object, and checking certain basic computational relations. Thus this item fits within the connections competency cluster.

Carpenter

'Carpenter', also a complex multiple-choice item, fits into the educational context and belongs to the Space and Shape area. Students were presented with four possible designs for garden beds and were asked to determine if each design could be made with 32 metres of timber.

A carpenter has 32 metres of timber and wants to make a border around a garden bed. He is considering the following designs for the garden bed.



To obtain full credit students had to correctly identify which of the garden beds could be constructed. Students needed to rely on their geometric knowledge, not only recognising the three rectangular shapes but also the parallelogram and that it requires more than 32 metres of timber. This use of geometric insight and argumentation skills and technical geometric knowledge makes this one of the more difficult items at Level 6.

Circle either "Yes" or "No" for each design to indicate whether the garden bed can be made with 32 metres of timber.

Garden bed design	Using this design, can the garden bed be made with 32 metres of timber?
Design A	Yes / No
Design B	Yes / No
Design C	Yes / No
Design D	Yes / No

Overall per cent correct	
Hong Kong-China (Highest achieving country)	40%
Australian males	26%
Australia	24%
Australian females	21%
OECD average	20%
Tunisia (Lowest achieving country)	5%

Walking

Reflecting on embedded mathematics from daily life is part of acquiring mathematical literacy and 'Walking' is an example of this phenomenon. Students would be familiar with seeing their footprints in sand or soil but probably would not have given much thought to the relationship between the 'number of steps taken per minute' and 'pace length'.

WALKING

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.

The two questions in this unit were open-constructed response items, in the Change and Relationships area and situated in a personal context.

Walking Question 1

The first item required problem solving by asking students to make use of a formal algebraic expression – substituting a simple formula and carrying out a routine calculation: if 70/p = 140 what is the value of p? Students needed to recognise that as the pace length increases, so the number of steps per minute will decrease, and in order to gain credit for this item students needed to carry out the actual calculation.

This item belongs to the reproduction competency cluster and illustrates Level 5 proficiency. The following example gained full credit for showing the correct substitution of numbers in the formula, along with the correct answer.

If the formula applies to Heiko's walking and Heiko takes 70 steps per minute, what is Heiko's pacelength? Show your work.

$$\frac{70}{p} \times p = 140 \times p$$

$$\frac{70}{140} = \frac{140p}{140}$$

$p = 0.5$ metres

Overall per cent correct	
Hong Kong-China (Highest achieving country)	62%
Australian males	35%
Australia	34%
Australian females	34%
OECD average	36%
Brazil (Lowest achieving country)	14%

Walking Question 2

The second item in 'Walking' also involved the relationship between 'the number of steps per minute' and 'pace length', but this time with a non-routine calculation. Students needed to calculate the number of steps per minute when the pace length is given (0.8m), which requires proper substitution: n/0.80 = 140 and the observation that this equals: n = 140 x 0.80 = 112 (steps per minute).

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.

More than routine operations were required here, with firstly substitution in an algebraic expression being used, followed by manipulating the resulting formula, in order to carry out the required calculation. The next step required going beyond the observation that the number of steps is 112, as the question also asked for the speed per minute – the subject walks 112 x 0.80 = 89.6 metres, so his speed is 89.6 metres/minute. The final step is to transform this speed in metres/minute into kilometres/hour – a more common unit of speed. Full credit for this item illustrates the high part of proficiency level 6.

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.

$\frac{n}{0.8} = 140$ $\times 0.8$ $\times 0.8$

$= n = 112$ steps

$112 \times 0.8 = 89.6$ m

∴ walking speed per minute = 89.6 m/min

89.6 m/min $\times 60$ $\times 60$

5376 m/h $\div 1000$

∴ 5.376 km/h

Overall per cent correct	
Hong Kong-China (Highest achieving country)	45%
Australian males	22%
Australia	22%
Australian females	21%
OECD average	21%
Brazil (Lowest achieving country)	6%

Students providing the above explanations were given full credit as they showed they were able to complete the conversions and provide a correct answer in both the requested units. This problem belongs to the connections competency cluster. Not only is use of a formal algebraic expression required, but also completing a sequence of different but connected calculations that need proper understanding of transforming formulae and units of measure.

Exchange Rate

The unit 'Exchange Rate' consisted of three items involving number operations (multiplication and division) set in the overarching Quantity area and a public context. The concept of foreign exchange rates, and the possibility of both increasing and decreasing movements, formed the basis of this constructed response unit. Exposure to the operation and use of exchange rates may not be common to all students but the concept can be seen as belonging to skills and knowledge required in the global economy.

EXCHANGE RATE

Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student. She needed to change some Singapore dollars (SGD) into South African rand (ZAR).

Exchange Rate Question 1

The first item in 'Exchange Rate' required students to interpret a simple, explicit mathematical relationship (the exchange rate for 1 Singapore dollar/1 South African rand), and then apply a small reasoning step to apply the relationship directly to 3000 Singapore dollars, using the calculation (3000 x 4.2). This short constructed response belongs to the reproduction competency cluster. This item, with a clearly defined question, is set in a relatively familiar context and the direct application of well-known mathematical knowledge places this item at proficiency level 1. The following student response was awarded full credit.

Mei-Ling found out that the exchange rate between Singapore dollars and South African rand was:

1 SGD = 4.2 ZAR

Mei-Ling changed 3000 Singapore dollars into South African rand at this exchange rate.

How much money in South African rand did Mei-Ling get?

Answer: 12 600

3000 SGD = x ZAR

3000 x 4.2 = 12600

Overall per cent correct	
Liechtenstein (Highest achieving country)	95%
Australian males	83%
Australia	81%
Australian females	80%
OECD average	80%
Brazil (Lowest achieving country)	37%

Exchange Rate Question 2

The second item in 'Exchange Rate' was also a short constructed response item, which required a limited form of mathematisation (understanding a simple text) as well as deciding that division was the correct procedure.

Students were required to interpret a simple, explicit mathematical relationship and only a small reasoning step was required to apply the relationship directly to 3900 South African rand using a calculation (3900/4.0). This item belonged to the reproduction competency cluster and represents proficiency level 2.

On returning to Singapore after 3 months, Mei-Ling had 3 900 ZAR left. She changed this back to Singapore dollars, noting that the exchange rate had changed to:

1 SGD = 4.0 ZAR

How much money in Singapore dollars did Mei-Ling get?

Answer: ......975......

3900 ZAR = x SGD

$\frac{3900}{4} = 975$

Overall per cent correct	
Liechtenstein (Highest achieving country)	93%
Australian males	76%
Australia	75%
Australian females	74%
OECD average	74%
Brazil (Lowest achieving country)	25%

Exchange Rate Question 3

The mathematics required to solve the problem in this open-constructed response item was more demanding as students needed to reflect on the concept of exchange rate movements and the subsequent consequences. The required procedural knowledge was more complex, and involved students applying flexible reasoning and reflection.

During these 3 months the exchange rate had changed from 4.2 to 4.0 ZAR per SGD.

Was it in Mei-Ling's favour that the exchange rate now was 4.0 ZAR instead of 4.2 ZAR, when she changed her South African rand back to Singapore dollars? Give an explanation to support your answer.

Yes it was Mei-Ling's favour because she got more than what she would have if it was at 4.2 ZAR per SGD.

example

3900 ÷ 4.2 = 928.5 SGD

or

3900 ÷ 4 = 975 SGD

Overall per cent correct	
Liechtenstein (Highest achieving country)	64%
Australian females	47%
Australia	46%
Australian males	45%
OECD average	40%
Mexico (Lowest achieving country)	13%

The student example above achieved full credit, which was awarded to students who interpreted the specified change in the exchange rate and applied basic computational skills or quantitative comparison skills to solve the problem. Students also needed to provide an explanation of their conclusion. This item belongs to the reflection cluster and represents proficiency level 4.

Robberies

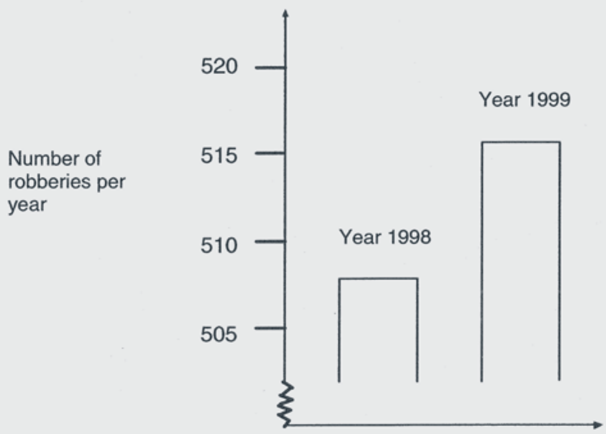
The unit 'Robberies', situated in the public context, provided a graphical representation showing the number of robberies within a two-year period, along with a statement made by a reporter. This type of item is frequently presented in the media where graphics have been used to support a pre-determined message.

The item involved data interpretation, placing it in the overarching area of Uncertainty and in the connections competency cluster, as students needed to rely on reasoning and interpretation competencies together with communication skills. Students were asked, using an open-constructed response, to consider the reporter's statement and with the use of the graph explain whether the statement fitted the data.

ROBBERIES

A TV reporter showed this graph and said:

"The graph shows that there is a huge increase in the number of robberies from 1998 to 1999."



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Give an explanation to support your answer.

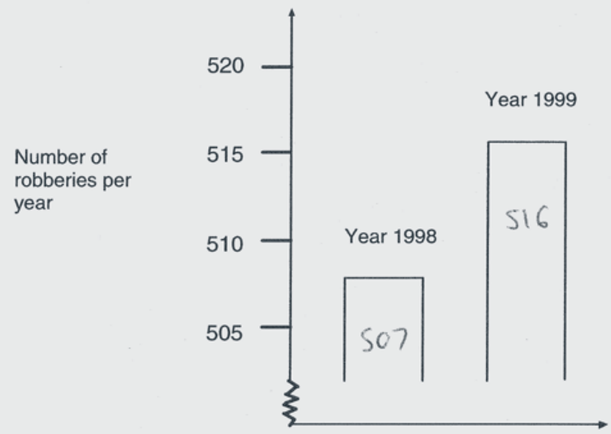
The full credit response illustrated proficiency level 6 as it required students to be able to communicate an argument based on interpretation of data, using some proportional reasoning in a statistical context.

To obtain full credit, students had to indicate that the statement was not reasonable and explain their judgment in appropriate detail. Answers had to focus on an increase given by the exact number of robberies in absolute terms and also in relative terms.

ROBBERIES

A TV reporter showed this graph and said:

"The graph shows that there is a huge increase in the number of robberies from 1998 to 1999."



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Give an explanation to support your answer.

I don't think that it is a reasonable interpretation as the robberies have only increased by 9 robberies which is only a total of a 1.7% increase.

Overall per cent correct	
Finland (Highest achieving country)	46%
Australian females	40%
Australian males	40%
Australia	40%
OECD average	30%
Indonesia (Lowest achieving country)	2%

Australia's mathematical literacy performance from an international perspective

In PISA 2006, Australia achieved a mean score of 520 points, which was significantly higher than the OECD average of 498 points[25]. The top four performing countries – Chinese Taipei (549 points), Finland (548 points), Hong Kong-China and Korea (547 points) – all achieved mean scores more than half a proficiency level above the OECD average.

Figure 6.3 shows the mean scores and distribution of scores for mathematical literacy in PISA 2006[26]. There were eight countries whose performance was significantly better than that of Australia. These were Chinese Taipei, Finland, Hong Kong-China and Korea (whose mean scores are provided above), the Netherlands (531 points), Switzerland (530 points), Canada (527 points) and Macao-China (525 points).

Australia is in a group of six countries (Liechtenstein, Japan, New Zealand, Belgium and Estonia being the other five) with mean scores ranging from 513 to 525 points whose results are not statistically different from each other. All other countries performed at a significantly lower level than Australia.

The results also show that countries can perform similarly in terms of mean score but show a great deal of variation in student performance. The variation between students performing at the 5th percentile and students at the 95th percentile (the lowest and highest performers) within a country ranged from 153 score points to 350 score points. For OECD countries, the narrowest ranges of scores were found in Finland and Ireland with a difference of around 270 points. The partner country Azerbaijan had an even narrower range of 153 points. Countries with the widest ranges of performance between the 5th and 95th percentiles were partner country Israel with 350 points and the OECD countries, Belgium and Czech Republic, each with a difference of around 340 points. Chinese Taipei, one of the top performing countries, also had a wide variation between the 5th and 95th percentiles of 333 points. Australia's range between the 5th percentile and the 95th percentile was 289 points and was similar to Chile, Iceland, Colombia, the Netherlands, Spain and Kyrgyzstan. The OECD average between the 5th percentile and the 95th percentile was 300 score points.

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25 Multiple comparison tables, which provide the statistical significance of differences between all countries, are provided in Appendix 4 of this report.

26 See page 65 for directions on how to read the bar charts.

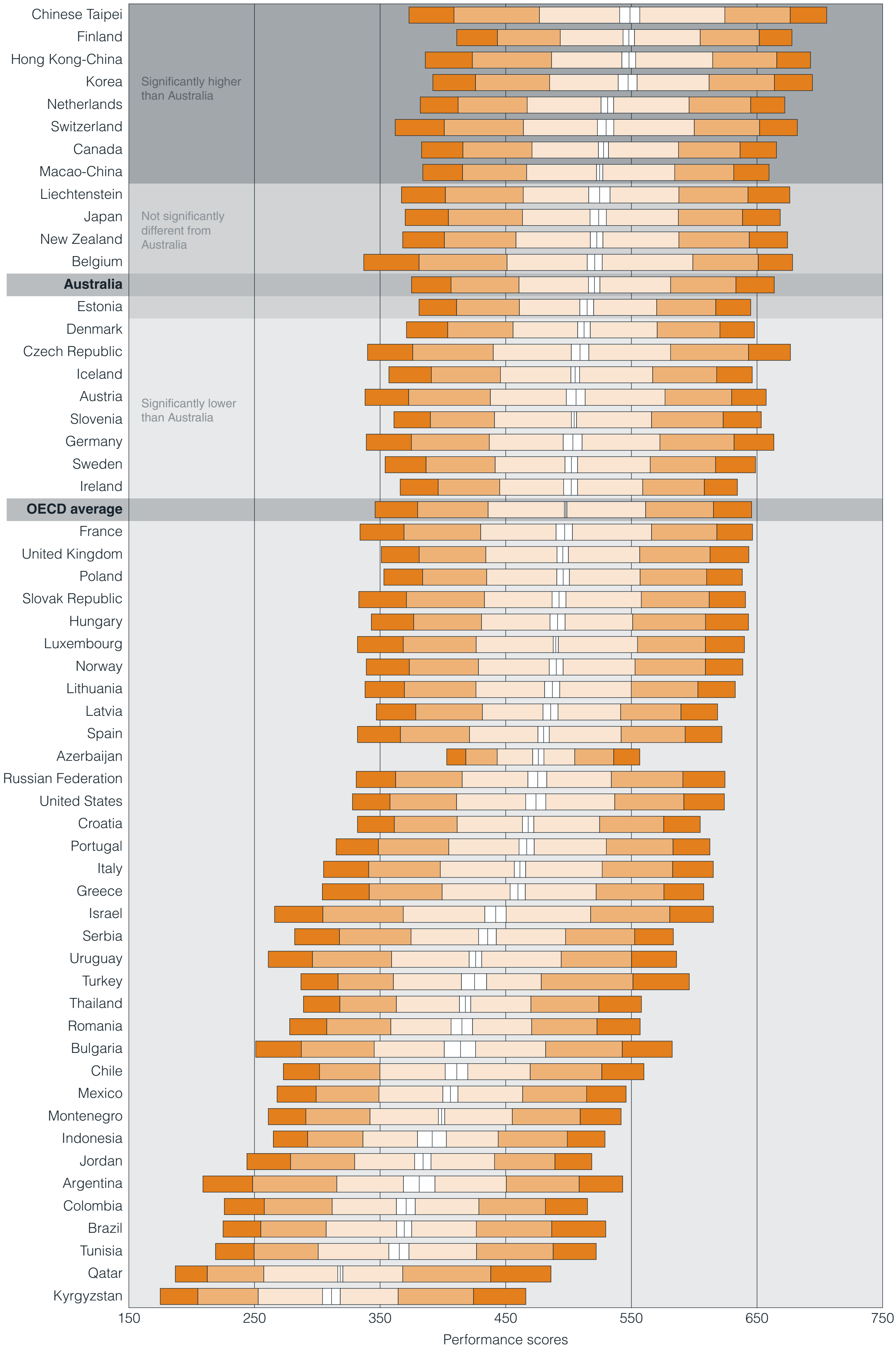

Figure 6.3 Student performance in mathematical literacy by country

Approximately eighty per cent of OECD countries and sixty per cent of partner countries had statistically significant gender differences, all but one in favour of males. Australian males achieved a mean score of 527 points and performed significantly higher than Australian females, who achieved a mean score of 513 points (Figure 6.4). This was not the case in PISA 2003, where although males achieved a mean score higher than females, the difference was not statistically significant. Further information about the performance of Australian students by gender between PISA 2003 and PISA 2006 is provided at the end of this chapter.

The highest mean scores for males were in the partner countries Chinese Taipei (556 points), Hong Kong-China (555 points), and the OECD countries Finland (554 points) and Korea (552 points). The lowest mean scores for males were from the partner countries, Kyrgyzstan (311 points), Qatar (311 points), Tunisia (373 points) and Brazil (380 points). For the OECD countries, Mexico, Turkey, Greece and Italy had the lowest mean scores for males with less than 470 score points.

Females from the OECD countries Korea and Finland and the partner country Chinese Taipei had the highest mean score of 543 points. The lowest mean scores for females were found in the partner countries Kyrgyzstan (310 score points), Qatar (325 score points) and Tunisia (328 score points), and in the OECD countries Mexico (401 score points), Turkey (421 score points) and Italy (453 score points).

The differences in favour of males ranged from 28 score points in the partner country Chile and 23 score points in Austria, to six score points in Norway and seven score points in the partner country Romania. There were 14 score points difference between Australian males and females. Qatar was the only country where females significantly outperformed males (with a mean score difference of 14 points).

	Females		Males	
	Mean score	SE	Mean score	SE
Qatar	325	(1.3)	311	(1.6)
Jordan	388	(3.9)	381	(5.3)
Thailand	420	(2.6)	413	(3.8)
Iceland	508	(2.2)	503	(2.6)
Bulgaria	415	(6.5)	412	(6.7)
Azerbaijan	477	(2.6)	475	(2.4)
Liechtenstein	525	(7.0)	525	(7.4)
Kyrgyzstan	310	(3.4)	311	(4.0)
Estonia	514	(3.0)	515	(3.3)
Lithuania	485	(3.3)	487	(3.3)
Greece	457	(3.0)	462	(4.3)
Slovenia	502	(1.8)	507	(1.8)
Sweden	500	(3.0)	505	(2.7)
Latvia	484	(3.2)	489	(3.5)
Serbia	433	(4.4)	438	(4.0)
Russian Federation	473	(3.9)	479	(4.6)
Turkey	421	(5.1)	427	(5.6)
Norway	487	(2.8)	493	(3.3)
France	492	(3.3)	499	(4.0)
Romania	412	(4.9)	418	(4.2)
Belgium	517	(3.4)	524	(4.1)
United States	470	(3.9)	479	(4.6)
Spain	476	(2.6)	484	(2.6)
Mexico	401	(3.1)	410	(3.4)
Poland	491	(2.7)	500	(2.8)
Korea	543	(4.5)	552	(5.3)
Hungary	486	(3.7)	496	(3.5)
Denmark	508	(3.0)	518	(2.9)
Czech Republic	504	(4.8)	514	(4.2)
New Zealand	517	(3.6)	527	(3.1)
Macao-China	520	(1.7)	530	(2.1)
OECD average	492	(0.6)	503	(0.7)
Ireland	496	(3.2)	507	(3.7)
Montenegro	393	(1.9)	405	(2.3)
Finland	543	(2.6)	554	(2.7)
Israel	436	(4.3)	448	(6.6)
Netherlands	524	(2.8)	537	(3.1)
Argentina	375	(7.2)	388	(6.5)
Uruguay	420	(3.1)	433	(3.6)
Chinese Taipei	543	(5.9)	556	(4.7)
Croatia	461	(2.8)	474	(3.2)
Switzerland	523	(3.6)	536	(3.3)
Canada	520	(2.0)	534	(2.4)
Slovak Republic	485	(3.5)	499	(3.7)
Australia	513	(2.4)	527	(3.2)
Portugal	459	(3.2)	474	(3.7)
Tunisia	358	(4.4)	373	(4.4)
Hong Kong-China	540	(3.7)	555	(3.9)
Luxembourg	482	(1.8)	498	(1.7)
Italy	453	(2.7)	470	(2.9)
United Kingdom	487	(2.6)	504	(2.6)
Indonesia	382	(4.0)	399	(8.3)
Brazil	361	(3.0)	380	(3.4)
Germany	494	(3.9)	513	(4.6)
Japan	513	(4.9)	533	(4.8)
Colombia	360	(5.0)	382	(4.1)
Austria	494	(4.1)	517	(4.4)
Chile	396	(4.7)	424	(5.5)

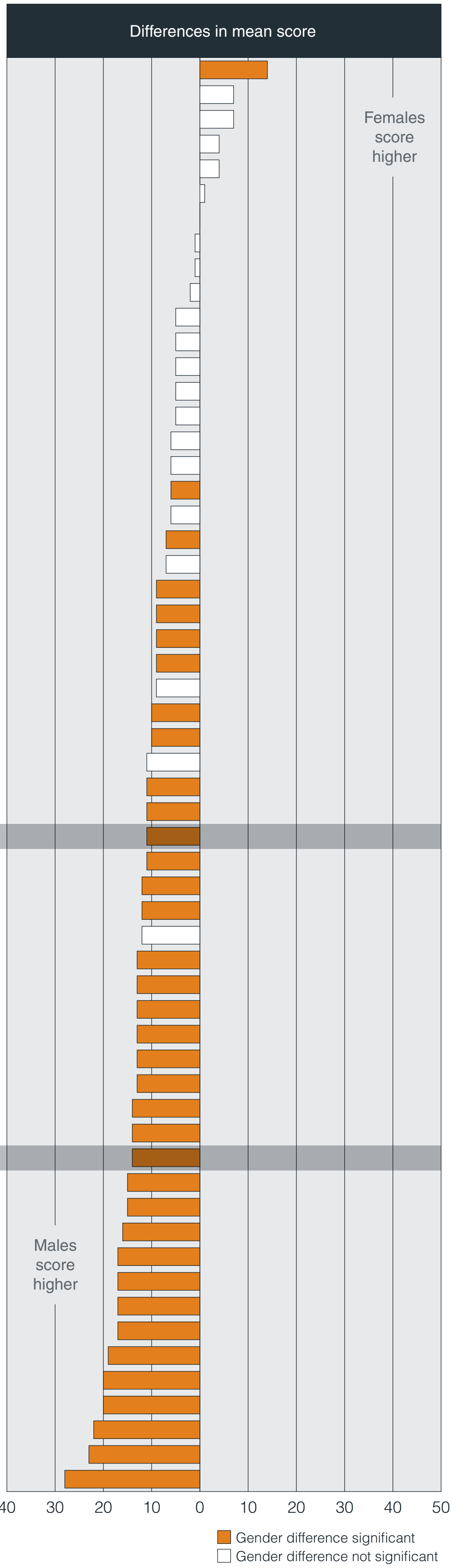

Figure 6.4 Gender differences in mathematical literacy by country

In PISA 2003, when mathematical literacy was the major focus, six levels of proficiency were defined, as described earlier in this chapter. Figure 6.5 shows the percentage of students in 2006 at each mathematical literacy proficiency level by country. The distribution of students across proficiency levels is of course influenced by the countries' mean performance and also by how much variation there is within countries. Usually, if a country had a relatively high proportion of students achieving at Level 6, it tended to have a relatively low proportion at or below Level 1.

On average across the OECD countries, three per cent of students were at Level 6, the highest level on the mathematical literacy proficiency scale. In Australia, four per cent of students achieved at this level. Almost half of the participating countries had fewer than two per cent of students at Level 6.

Chinese Taipei had the highest percentage of students (12%) who performed at Level 6. This was followed by two other top-performing countries in mathematical literacy – Korea and Hong Kong-China, each with nine per cent of students at Level 6. Finland had slightly fewer students at this level with six per cent of students.

A number of countries do very well in the proportion of students reaching at least Level 5. More than one-fifth of students from the Netherlands, Belgium, Switzerland and Finland, more than one-quarter of students from Korea and Hong Kong-China, and more than 30 per cent of students from Chinese Taipei reached Levels 5 or 6. Sixteen per cent of Australian students achieved at least Level 5, the OECD average being 13 per cent.

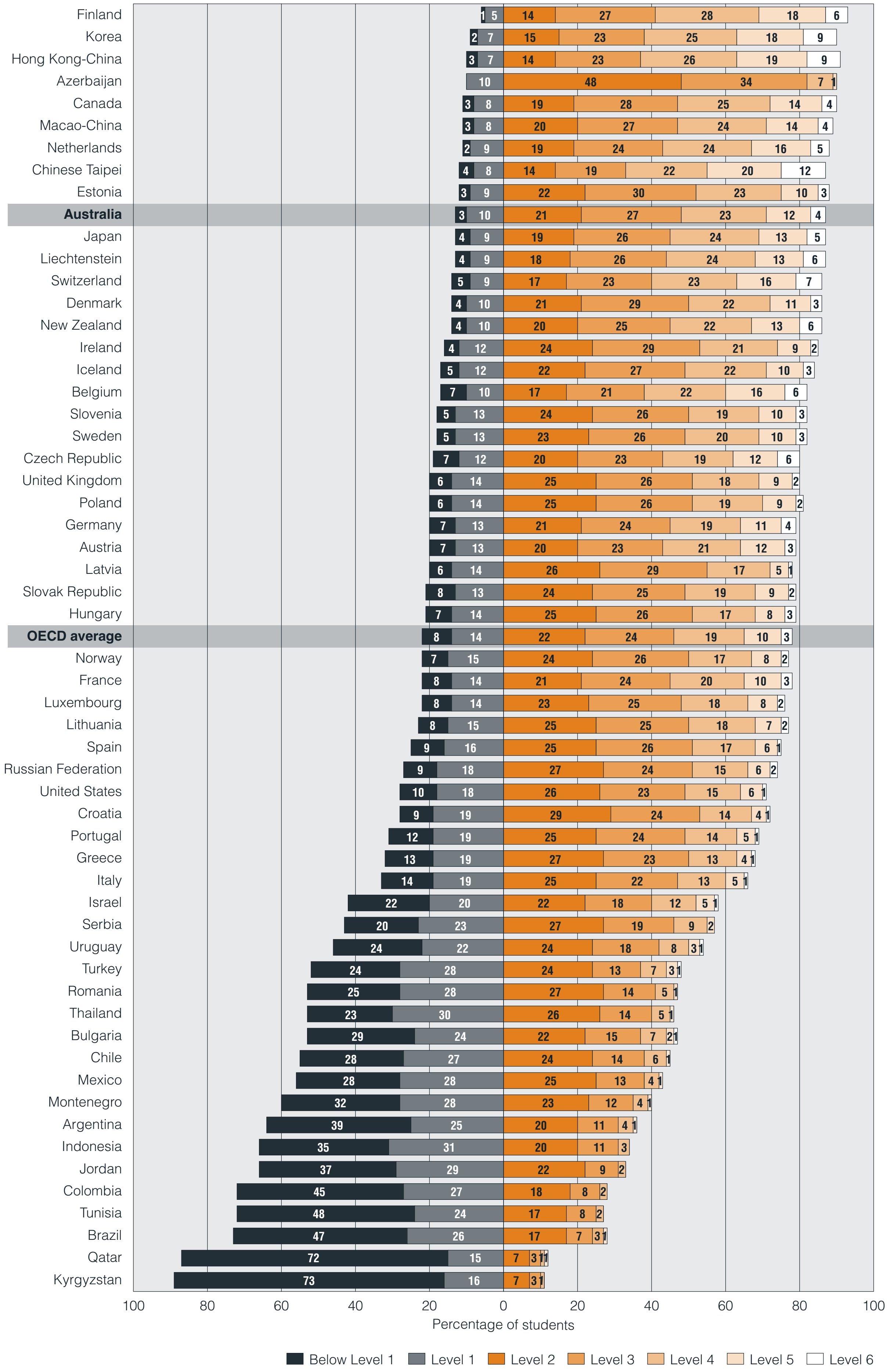

Figure 6.5 Proficiency levels for students in mathematical literacy by country

At the lower end of the performance scale, the OECD has described Level 2 as a baseline level of mathematical literacy proficiency at which students begin to demonstrate the kind of skills that enable them to actively use mathematics as stipulated by the PISA definition.

On average 78 per cent of students in OECD countries were at Level 2 or higher. In Australia, 87 per cent of the students reached at least this level. Among the highest performing countries, at least 90 per cent of students from Finland, Korea and Hong Kong-China had achieved at least Level 2. In all but two OECD countries, Mexico (43%) and Turkey (48%), at least half of the students reached at least Level 2.

In 15 countries (13 partner countries and two OECD countries), more than half the students were unable to achieve even Level 2 and in almost a fifth of countries, which included a number of European countries, plus Uruguay, Israel, the United States and the Russian Federation, between 25 and 50 per cent of students had not reached Level 2.

The top performing countries, Finland, Korea and Hong Kong-China, had fewer than ten per cent of students below Level 2. The partner country Azerbaijan had a similarly low proportion of students placed below Level 2. However, interestingly, the distribution of student performance in Azerbaijan is very different with over 80 per cent of students placed at Levels 2 and 3, and fewer students at the higher end of the scale. In Australia, 13 per cent of students were below Level 2, the OECD average being 21 per cent.

PISA does not assess mathematical skills below proficiency level 1. Students unable to demonstrate proficiency at Level 1 were not necessarily incapable of performing any mathematical operation, but were unable to utilise the mathematical skills required by the easiest PISA tasks. The OECD views these students as being at risk of not achieving the mathematical skills that will enable young adults to participate fully in society beyond school.

On average eight per cent of students across OECD countries and three per cent of students in Australia did not reach Level 1. This was comparable to the proportion in the highest performing countries. In Kyrgyzstan and Qatar more than 70 per cent of students, and in Tunisia, Brazil and Colombia more than 40 per cent of students, were placed at this category. There were five OECD countries in which more than ten per cent of students were below Level 1 – Mexico (28%), Turkey (24%), Italy (14%), Greece (13%) and Portugal (12%).

Mathematical literacy performance by state

The mean score for mathematical literacy, together with the spread of scores from the 5th to the 95th percentile for the Australian states, is shown by state in Figure 6.6. The highest performing state in mathematical literacy was the Australian Capital Territory with a mean score of 539 points, which was not significantly different from that of Chinese Taipei, the highest scoring country. Western Australia's score of 531 points was also very strong and significantly lower compared to Chinese Taipei (and not significantly different from that of the Netherlands).

The Australian Capital Territory performed significantly higher compared to the Australian mean score overall. The mean scores for Western Australia, New South Wales, South Australia, Queensland and Victoria were not significantly different from the Australian mean score, and the mean score for Tasmania and the Northern Territory was significantly lower than the Australian mean score on mathematical literacy.

All states other than Tasmania and the Northern Territory achieved mean scores higher than the OECD average of 498 points. Tasmania achieved a mean score of 502 points, which was similar to the OECD average and below the Australian overall average, while the Northern Territory performed significantly below the OECD average (and the Australian overall average) with a mean score of 481 points.

South Australia had the narrowest spread with 272 score points between the 5th and 95th percentiles of its distribution, while the Northern Territory had the widest range of scores with a range of 350 score points (Figure 6.6). The range of scores was between 280 and 290 score points for all other states.

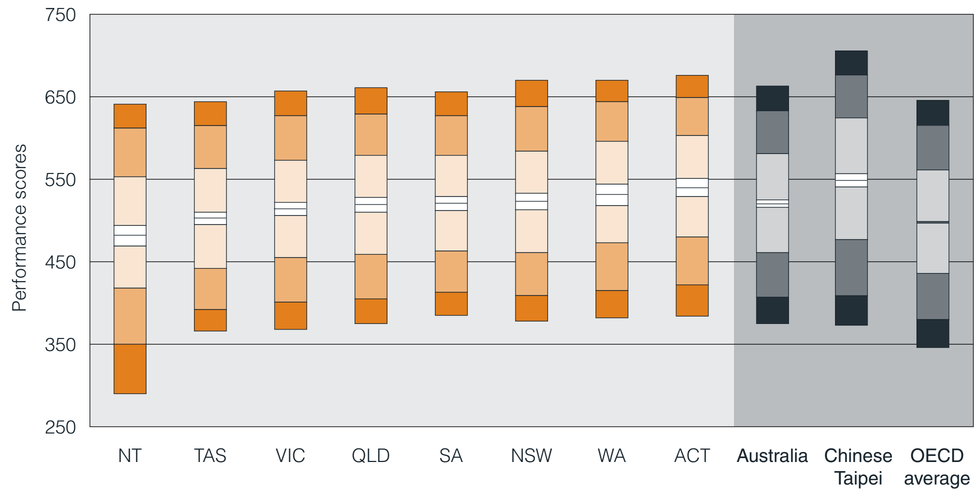

Figure 6.6 Student performance in mathematical literacy by state

Multiple comparisons of scores in mathematical literacy are shown in Table 6.1. The Australian Capital Territory outperformed all other states except Western Australia; these states performed on a par with each other (Table 6.1). Western Australia performed significantly higher than Victoria, Tasmania and the Northern Territory and not statistically different from the remaining states. The Northern Territory's score was significantly lower than any of the other states.

Table 6.1 Multiple comparisons of mean performance in mathematical literacy by state

			ACT	WA	NSW	SA	QLD	VIC	TAS	NT	OECD
		Mean	**539**	**531**	**523**	**520**	**519**	**513**	**502**	**481**	**498**
	Mean	**SE**	**5.6**	**6.5**	**5.0**	**4.3**	**4.4**	**4.0**	**3.8**	**6.2**	**0.5**
ACT	539	5.6		●	▲	▲	▲	▲	▲	▲	▲
WA	531	6.5	●		●	●	●	▲	▲	▲	▲
NSW	523	5.0	▼	●		●	●	●	▲	▲	▲
SA	520	4.3	▼	●	●		●	●	▲	▲	▲
QLD	519	4.4	▼	●	●	●		●	▲	▲	▲
VIC	513	4.0	▼	▼	●	●	●		▲	▲	▲
TAS	502	3.8	▼	▼	▼	▼	▼	▼		▲	●
NT	481	6.2	▼	▼	▼	▼	▼	▼	▼		▼

Note: Read across the row to compare a state's performance with the performance of each state listed in the column heading.
▲ Average performance statistically significantly higher than in comparison state
● No statistically significant difference from comparison state
▼ Average performance statistically significantly lower than in comparison state

As noted earlier, Australian males achieved a mean score of 527 points compared to the mean score for Australian females of 513, the difference of 14 points being statistically significant.

Although males in all Australian states achieved mean scores higher than their female counterparts, only four states had significant gender differences. The largest of these differences was in Victoria, where males outperformed females by 23 points. Males from Western Australia, Tasmania and Queensland significantly outperformed their female counterparts, with differences of 19, 16 and 13 points respectively. Figure 6.7 shows the mean scores for females and males by state and graphically represents the difference between these mean scores by gender.

	Females		Males	
	Mean score	SE	Mean score	SE
VIC	501	5.3	524	4.9
WA	522	7.3	541	8.2
ACT	529	6.6	548	8.8
TAS	494	4.4	510	5.1
QLD	513	5.8	526	4.6
SA	514	5.6	527	5.1
NT	474	10.3	487	5.4
NSW	518	4.6	527	7.9

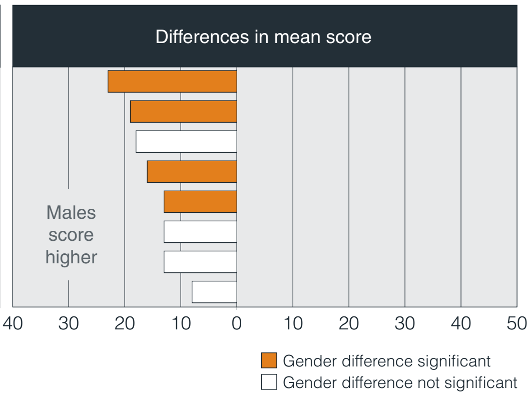

Figure 6.7 Gender differences in mathematical literacy by state

Figure 6.8 shows the proportion of students in each state at each of the mathematical literacy proficiency levels. On average, four per cent of Australian students achieved at Level 6. Six per cent of students from the Australian Capital Territory and five per cent of students from Western Australia and New South Wales achieved a proficiency of Level 6, which although much lower than the very high proportions of students in Korea and Hong Kong-China at this level, was the same as in Finland, and more than in Canada and Macao-China. In the Northern Territory and Tasmania, the proportions of students at this highest level were similar to the OECD average.

In the Australian Capital Territory, almost one-quarter (23%) and in Western Australia 21 per cent of students achieved Level 5 or higher, comparing favourably with countries such as Finland, the Netherlands and Switzerland. There were 16 per cent of Australian students overall on average who had achieved at least Level 5. As a comparison – or as something to aim for – the proportions of students achieving this very high level were in Chinese Taipei 32 per cent, in Hong Kong-China 28 per cent and in Korea 27 per cent.

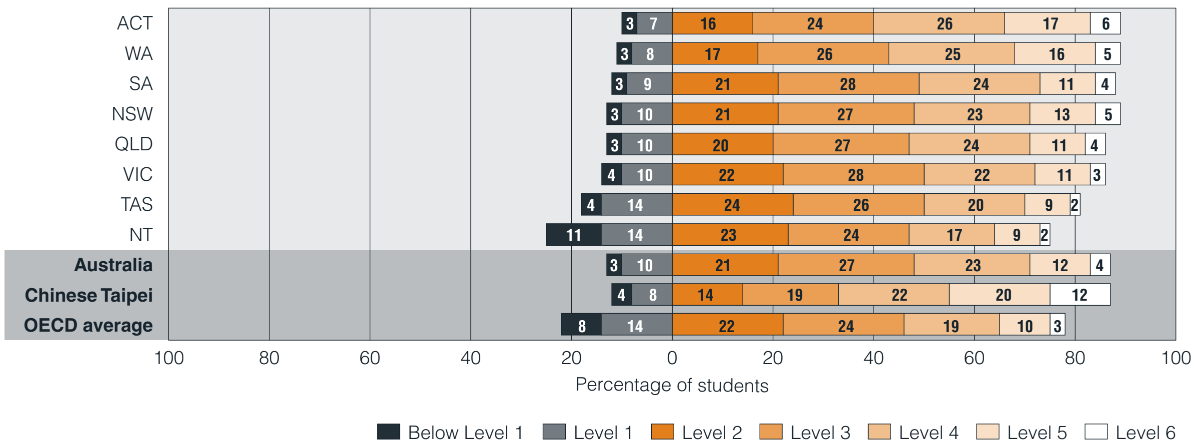

Figure 6.8 Proficiency levels for students on the mathematical literacy scale by state

Most states did well in terms of the proportion of students above the minimum proficiency levels. The Australian Capital Territory had the lowest percentage of students who had not reached Level 2 (10%), while for most other states this proportion was between 11 and 14 per cent of students. Tasmania and the Northern Territory had the highest percentages of students who had not achieved Level 2 with 18 and 25 per cent respectively.

The percentage of females and males at each proficiency level is shown by state in Figure 6.9. At the high end of the proficiency scale, the largest gender difference was found in the Australian

Capital Territory, where 29 per cent of males but only 18 per cent of females were found to be achieving at or above Level 5. In Victoria and Western Australia, there was a gap of some eight percentage points between the percentage of males and females achieving at this high level. The smallest gender difference was found in the Northern Territory, where 10 per cent of females and 12 per cent of males achieved at Level 5 or higher.

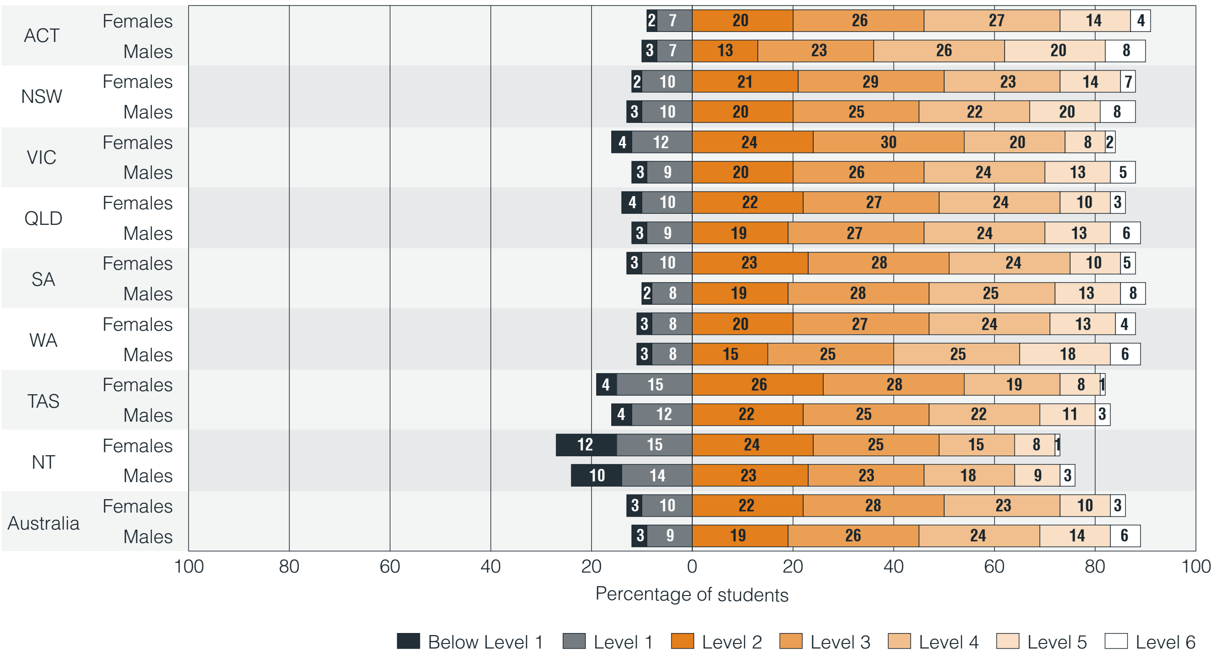

Figure 6.9 Proficiency levels for students on the mathematical literacy scale by state and gender

In most states there were few differences in the proportions of males and females not achieving Level 2. The largest gender difference at this lower level of achievement was in Victoria, where 12 per cent of males and 16 per cent of females did not achieve Level 2.

Indigenous students' performance in mathematical literacy

Figure 6.10 shows the mean scores and distributions of scores around the mean for Indigenous and non-Indigenous students in mathematical literacy. As in reading and science, there were large performance differences apparent, with Indigenous students achieving a mean score of 442 points compared to the mean score for non-Indigenous students of 522 points. This is a difference of 80 score points, which is equivalent to more than one full mathematical literacy proficiency level (or almost two and a half school years). Indigenous students also performed significantly lower than the OECD average by 56 score points, which represents more than three-quarters of a proficiency level.

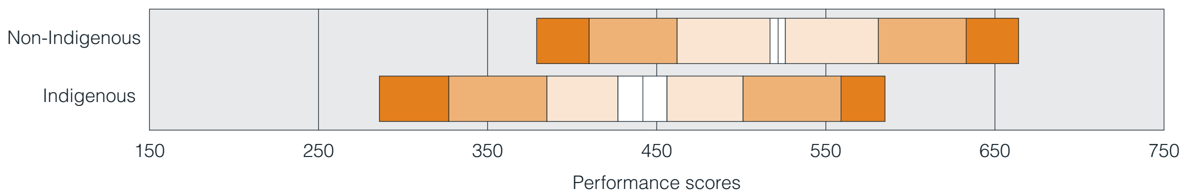

Figure 6.10 Indigenous and non-Indigenous performance in mathematical literacy

Table 6.2 shows the mean scores for Indigenous and non-Indigenous students by gender and the associated standard errors. Indigenous females performed significantly and substantially lower than their non-Indigenous counterparts (by 79 score points, or around one and a quarter of a proficiency level). Indigenous males also performed well below non-Indigenous males (by 81 score points).

While males overall in Australia achieved a statistically higher mean score than females, there was no significant difference between the mean scores of Indigenous males and females.

Table 6.2 Means by gender and gender differences in mathematical literacy for Indigenous and non-Indigenous students

	Females		Males		Total	
	Mean	SE	Mean	SE	Mean	SE
Indigenous	436	10.9	448	8.4	442	7.3
Non-Indigenous	515	2.4	529	3.2	522	2.3

Figure 6.11 shows the performance of Indigenous and non-Indigenous students in terms of mathematical literacy proficiency levels, illustrating very clearly the lower performance of Indigenous students. At the lower end of the proficiency scale, there are 39 per cent of Indigenous students compared to 12 per cent of non-Indigenous students who did not achieve Level 2. Of even more concern are the 17 per cent of Indigenous students (compared to the three per cent of non-Indigenous students) who performed below Level 1 (and achieved a mean score of less than 358 score points). Students below Level 1 are described by the OECD as not being able to successfully demonstrate the most basic types of mathematical skills and knowledge that PISA measures.

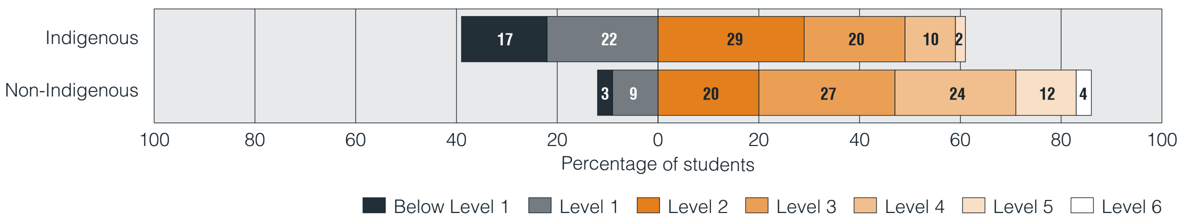

Figure 6.11 Proficiency levels for Indigenous and non-Indigenous students in mathematical literacy

The disparity between Indigenous and non-Indigenous students is also evident at the higher end of achievement. Only 0.5 per cent of Indigenous students achieved Level 6[27], compared to four per cent of non-Indigenous students. Only two per cent of Indigenous students performed at either Level 5 or 6, compared with 16 per cent of non-Indigenous students.

Figure 6.12 shows the distributions of Indigenous and non-Indigenous students at the mathematical literacy proficiency levels by gender. As in the previous figure, Figure 6.12 shows the higher percentage of Indigenous students performing at or below Level 1, but also indicates that there are few gender differences in achievement between Indigenous males and females. The percentage of Indigenous females (40%) who have not reached Level 2 is similar to that of Indigenous males (38%). There are approximately three times more Indigenous females than non-Indigenous females who have not reached Level 2. At the higher end of the proficiency level scale, less than one per cent of Indigenous males and females (0.4% of females and 0.6% of males) achieved Level 6, compared to 3 per cent of non-Indigenous females and 6 per cent of non-Indigenous males.

[27] As this is less than 1%, it does not appear on the bar for Indigenous students in Figure 6.11.

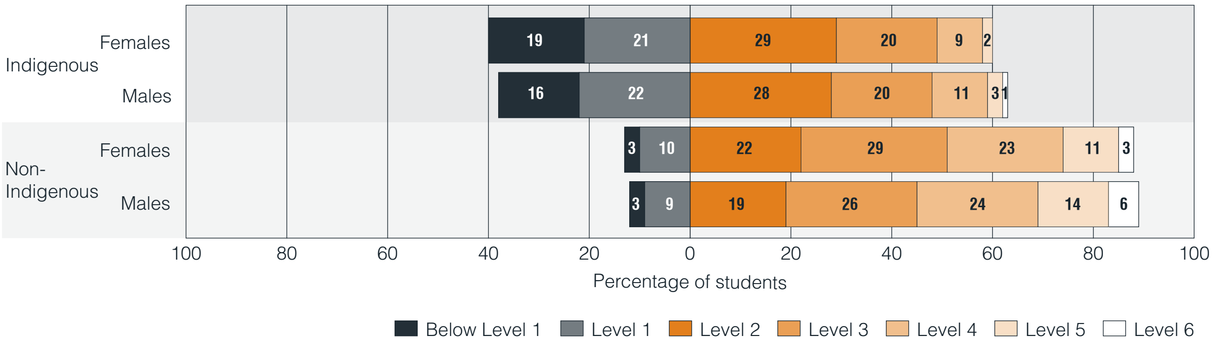

Figure 6.12 Proficiency levels for Indigenous and non-Indigenous students in mathematical literacy by gender

Mathematical literacy performance for students from different school locations

As mentioned in the Reader's Guide, geographic location is based on the MCEETYA Schools Geographic Location Classification and consists of three categories – metropolitan, provincial and remote.

Students who attended schools in metropolitan areas achieved a mean score of 526 score points, which was 18 points higher than the mean score for students from schools located in provincial areas (mean of 508 score points). Students attending metropolitan schools performed 58 score points higher than students attending schools in remote regions, whose mean score was 468 points (Figure 6.13). The differences between the mean scores of students attending schools in each of the categories of geographic location were all statistically significant.

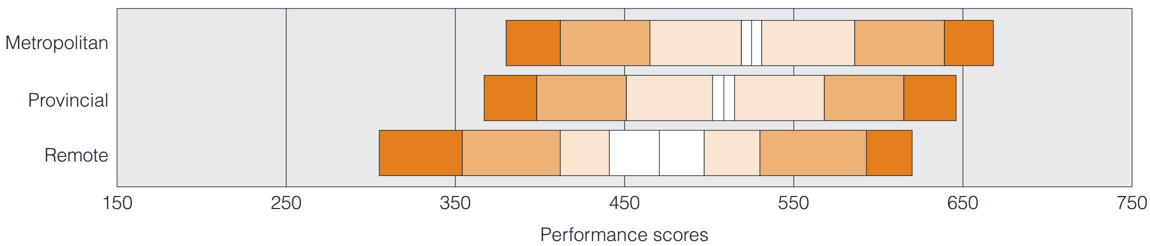

Figure 6.13 Student performance in mathematical literacy by geographic location

The difference between students attending metropolitan and remote schools is equivalent to almost one proficiency level. The difference between students attending metropolitan and provinical schools is equivalent to almost a third of a proficiency level, while the difference between students from provincial and remote schools is equivalent to more than half a proficiency level.

Figure 6.14 shows the percentages of students across the mathematical literacy proficiency scale for students attending school in different locations. The proportion of students attending schools in remote areas who had not achieved Level 2 was twice the proportion of students attending schools in metropolitan or provincial areas. At the top of the scale, the proportion of students attending metropolitan schools who achieved at Level 5 or 6 was twice the proportion of students attending schools in remote areas. There was also a higher percentage of students from provincial areas than students attending schools in remote areas achieving the highest proficiency levels.

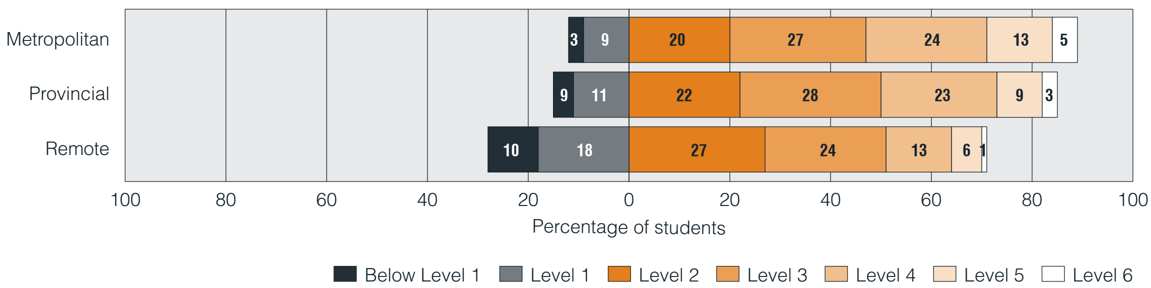

Figure 6.14 Proficiency levels in mathematical literacy by geographic location

Mathematical literacy performance and socioeconomic background

The PISA measure of socioeconomic background was derived using student responses to several questions about their home and family background in the Student Questionnaire. Figure 6.15 shows the distribution of performance in mathematical literacy for each of the socioeconomic quartiles. The differences in mathematical literacy mean scores on the basis of socioeconomic quartiles were found to be statistically significant between all of the quartiles, and the higher the level of socioeconomic background, the higher the mathematical literacy performance.

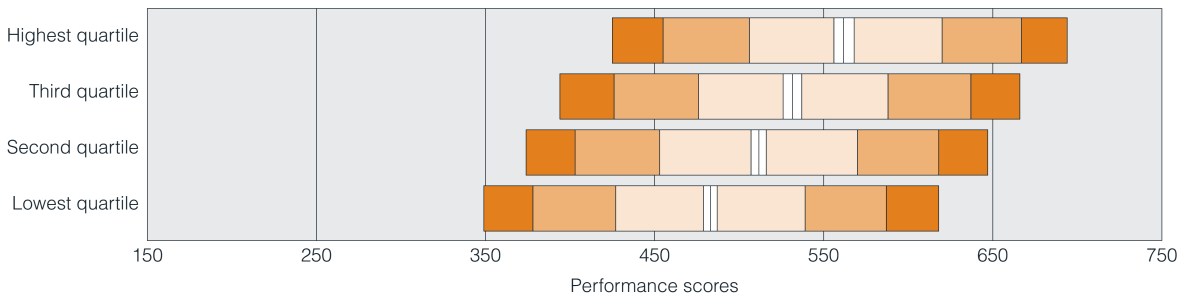

Figure 6.15 Student performance in mathematical literacy by socioeconomic background

Students in the highest quartile achieved a mean score of 561 points compared to students in the lowest quartile who achieved a mean score of 483 points, a difference of 78 points. Even students in the second quartile achieved almost 30 points higher on average than students in the lowest quartile, and students in the third quartile achieved about 30 points lower on average than students in the highest quartile. Each of these differences was statistically significant, and represent almost one year of schooling.

Figure 6.16 shows the distribution of students across the mathematical literacy proficiency levels by socioeconomic quartiles. This clearly shows that the percentage of students who did not reach Level 2 increases as the socioeconomic quartile decreases. Almost a quarter of students in the lowest socioeconomic quartile achieved only at or below Level 1, compared to 14 per cent of students in the second quartile of socioeconomic background, nine per cent of students in the third quartile, and five per cent of students in the highest quartile of socioeconomic background. At the higher end of the mathematical literacy proficiency scale 30 per cent of students in the highest quartile of socioeconomic background achieved a proficiency of at least Level 5. This was more than four times the percentage of students in the lowest socioeconomic quartile, more than twice the percentage of students in the second socioeconomic quartile and almost twice the percentage of students in the third socioeconomic quartile.

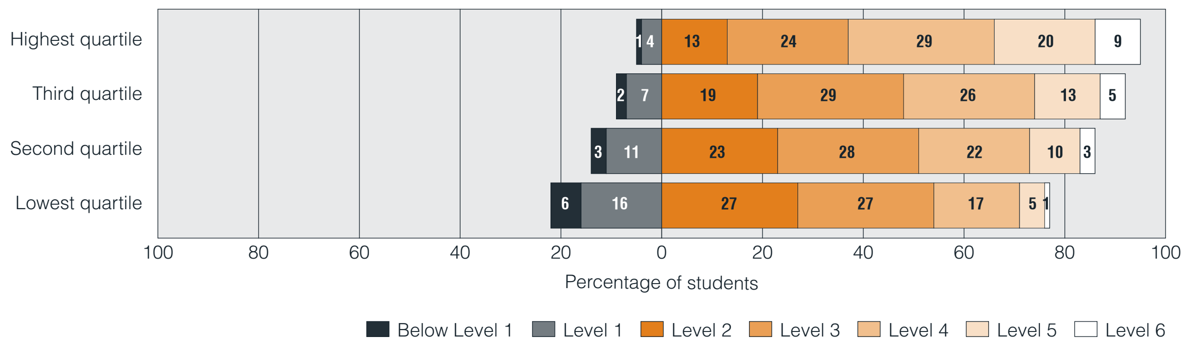

Figure 6.16 Proficiency levels in mathematical literacy by socioeconomic background

Mathematical literacy performance and immigrant status

Two constructs have been created in PISA to examine the impact of immigrant status on the performance in the literacy domains. The first construct refers to the immigrant status of the student, and the second refers to the language spoken in the home.

The mean score for Australian-born students in mathematical literacy was 518 points, statistically lower than the mean score for both first-generation students (526 points) and foreign-born students (529 points). The difference between the mean scores for first-generation students and foreign-born students was not statistically different (Figure 6.17). The variation in scores between students in the 5th and 95th percentiles show that foreign-born students have a wider spread, of 313 score points, compared to Australian-born students or first-generation students, who each have a spread of 283 score points between the highest and lowest performing students.

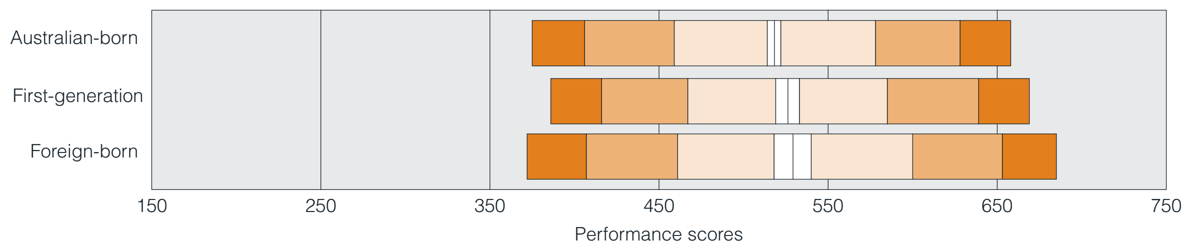

Figure 6.17 Student performance in mathematical literacy by immigrant status

Figure 6.18 shows the proportions of students in each of the mathematical literacy proficiency levels by immigrant status. Although the distributions for each of these groups of students is quite similar, there are slight differences at the higher end of the proficiency scale with 23 per cent of foreign-born students achieving at Level 5 or 6 compared to 18 per cent of first-generation students and 15 per cent of Australian-born students.

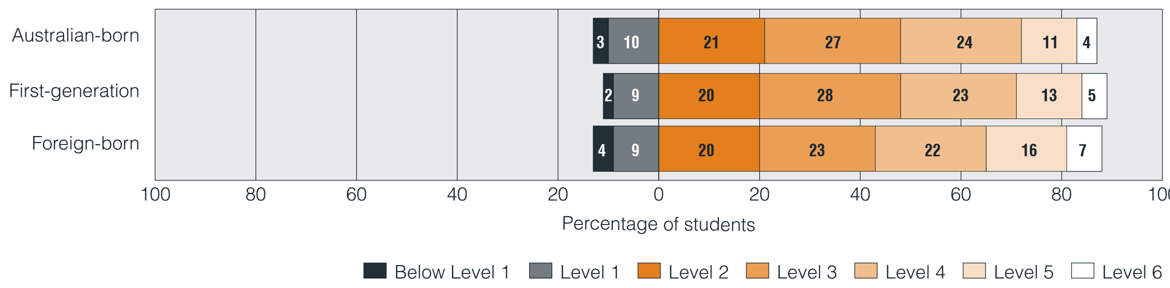

Figure 6.18 Proficiency levels in mathematical literacy by immigrant status

The mean mathematical literacy performance of those students who speak English at home and those students who speak a language other than English at home was similar, with mean scores of 521 points and 523 points respectively[28]. There is also a wider spread of performance amongst the students who speak a language other than English at home, with both higher performance than the English-speaking group at the high achieving end, and lower performance than the English-speaking group at the low achievement end (Figure 6.19).

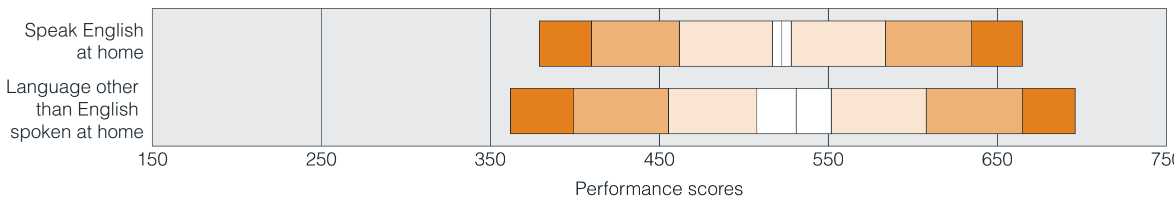

Figure 6.19 Student performance in mathematical literacy by language spoken at home

Figure 6.20 shows the proportion of students in each of the mathematical literacy proficiency levels for those students who speak English at home and those students who speak a language other than English at home. There were some differences at both ends of the achievement spectrum. At the lower end of the proficiency levels 12 per cent of students who spoke English at home and 15 per cent of students who spoke a language other than English at home did not achieve Level 2. At the higher end of the proficiency level there were 16 per cent and 22 per cent of students who spoke English at home and students who spoke a language other than English at home respectively that achieved at Level 5 or 6.

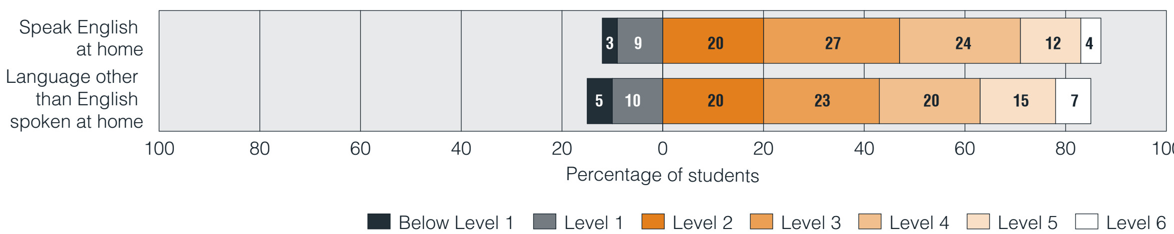

Figure 6.20 Proficiency levels in mathematical literacy by language spoken at home

[28] The confidence interval for students speaking a language other than English at home is large, and so it is possible that this may mask any real differences.

Monitoring mathematical literacy changes over time

In Chapter 5, reading literacy performance between PISA cycles was examined at both an international and a national level. The cautions that were outlined in Chapter 5 also apply when comparing student performance over time on mathematical literacy.

There is a further point to note, however, in relation to mathematical literacy. As the first major domain assessment of mathematical literacy took place in 2003, allowing for a complete development of the mathematical literacy scale, it is only possible to compare mathematical literacy from 2003 onwards. Data on mathematical literacy from PISA 2000 are therefore not included in this section.

Internationally, results for mathematical literacy performance from 39 countries can be investigated for PISA 2003 and PISA 2006, comprising 29 OECD countries and 10 partner countries. There was no significant change in the average mathematical literacy performance across all OECD countries between PISA 2003 and PISA 2006. The mean scores were 500 and 498 respectively, a difference of two score points.

Two OECD countries (Mexico and Greece) and two partner countries (Indonesia and Brazil) improved their mathematical literacy performance between PISA 2003 and PISA 2006. Mexico increased its performance by 20 score points and Greece by 14 score points. The performance of Mexico from PISA 2003 to PISA 2006 improved across all levels, and in Greece the increase in performance was due to a rise in the lower and middle range of the performance distribution and the significantly higher performance of females in PISA 2006. Indonesia's performance has risen by 31 score points (which is equivalent to half a mathematical literacy proficiency level) and is due to the higher performance of males in PISA 2006. In the case of Brazil, improvements in the lower end of the performance distribution enabled overall performance to be increased by 13 score points.

The mathematical literacy performance of four OECD countries declined from PISA 2003 to PISA 2006. The declines were in France (15 score points), Japan (11 score points), Iceland (10 score points) and Belgium (9 score points).

Overall, mathematical literacy performance has remained relatively stable between PISA 2003 and PISA 2006 for the remaining 31 countries including Australia, 22 other OECD countries and eight partner countries (Table 6.3).

Table 6.3 Mean mathematical literacy scores, standard errors and differences in performance between PISA 2003 and PISA 2006 by country

Country	PISA 2003		PISA 2006		Difference	SE
	Mean	SE	Mean	SE		
Australia	524	2.1	520	2.2	-4	3.4
Austria	506	3.3	505	3.7	0	5.2
Belgium	529	2.3	520	3.0	**-9**	4.0
Brazil	356	4.8	370	2.9	**13**	5.8
Canada	532	1.8	527	2.0	-5	3.0
Czech Republic	516	3.5	510	3.6	-7	5.2
Denmark	514	2.7	513	2.6	-1	4.0
Finland	544	1.9	548	2.3	4	3.3
France	511	2.5	496	3.2	**-15**	4.3
Germany	503	3.3	504	3.9	1	5.3
Greece	445	3.9	459	3.0	**14**	5.1
Hong Kong-China	550	4.5	547	2.7	-3	5.4
Hungary	490	2.8	491	2.9	1	4.3
Iceland	515	1.4	506	1.8	**-10**	2.7
Indonesia	360	3.9	391	5.6	**31**	7.0
Ireland	503	2.4	501	2.8	-1	4.0
Italy	466	3.1	462	2.3	-4	4.1
Japan	534	4.0	523	3.3	**-11**	5.4
Korea	542	3.2	547	3.8	5	5.2
Latvia	483	3.7	486	3.0	3	5.0
Liechtenstein	536	4.1	525	4.2	-11	6.1
Luxembourg	493	1.0	490	1.1	-3	2.0
Macao-China	527	2.9	525	1.3	-2	3.5
Mexico	385	3.6	406	2.9	**20**	4.9
Netherlands	538	3.1	531	2.6	-7	4.3
New Zealand	523	2.3	522	2.4	-1	3.6
Norway	495	2.4	490	2.6	-5	3.8
OECD average	500	0.6	498	0.5	-2	0.8
Poland	490	2.5	495	2.4	5	3.8
Portugal	466	3.4	466	3.1	0	4.8
Russian Federation	468	4.2	476	3.9	7	5.9
Slovak Republic	498	3.3	492	2.8	-6	4.6
Spain	485	2.4	480	2.3	-5	3.6
Sweden	509	2.6	502	2.4	-7	3.8
Switzerland	527	3.4	530	3.2	3	4.8
Thailand	417	3.0	417	2.3	0	4.0
Tunisia	359	2.5	365	4.0	7	4.9
Turkey	423	6.7	424	4.9	1	8.4
United States	483	2.9	474	4.0	-9	5.2
Uruguay	422	3.3	427	2.6	5	4.4

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

At a national level, while the mean scores in mathematical literacy for Australia as a whole and for most of the states have declined between PISA 2003 and PISA 2006, the decreases were significant for only two states – Western Australia (by 17 score points or about a quarter of a proficiency level) and South Australia (by 15 score points) (Table 6.4).

Table 6.4 Mean mathematical literacy scores, standard errors and differences in performance between PISA 2003 and PISA 2006 by state

State	PISA 2003		PISA 2006		Differences between PISA 2003 and PISA 2006	
	Mean	SE	Mean	SE	Mean	SE
ACT	548	3.5	539	5.6	-9	6.7
NSW	526	4.3	523	5.0	-3	6.7
VIC	511	5.1	513	4.0	2	6.6
QLD	520	6.9	519	4.4	-1	8.3
SA	535	4.9	520	4.3	**-15**	6.7
WA	548	4.1	531	6.5	**-17**	7.8
TAS	507	9.4	502	3.8	-5	10.2
NT	496	4.9	481	6.2	-15	8.0
Australia	524	2.1	520	2.2	-4	3.4

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

Table 6.5 shows the mean mathematical literacy scores and the standard errors for males and females for Australia overall and by state for PISA 2003 and 2006. For males, there were no statistically significant differences in their mathematical literacy performance between PISA 2003 and PISA 2006 in Australia or in any of the states. However, the data shows that there were significant declines in the scores of female students, for Australia overall (by 9 score points) and for two states, the Northern Territory (by 27 score points) and Western Australia (by 24 score points).

Table 6.5 Mean mathematical literacy scores, standard errors and differences in performance between PISA 2003 and PISA 2006 by gender

State	Females						Males					
	PISA 2003		PISA 2006		Differences between PISA 2003 and PISA 2006		PISA 2003		PISA 2006		Differences between PISA 2003 and PISA 2006	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
ACT	548	12.2	529	6.6	-19	14.0	548	10.2	548	8.8	0	13.6
NSW	524	3.9	518	4.6	-6	6.2	529	6.9	527	7.9	-2	10.6
VIC	503	6.2	501	5.3	-2	8.3	518	6.6	524	4.9	6	8.3
QLD	521	8.6	513	5.8	-8	10.5	518	7.7	526	4.6	8	9.1
SA	530	7.1	514	5.6	-16	9.1	540	7	527	5.1	-13	8.8
WA	546	4.3	522	7.3	**-24**	8.6	551	5.7	541	8.2	-10	10.0
TAS	508	9.9	494	4.4	-14	10.9	507	10.7	510	5.1	3	11.9
NT	501	7.7	474	10.3	**-27**	12.9	491	6.2	487	5.4	-4	8.4
Australia	522	2.7	513	2.4	**-9**	3.9	527	3.0	527	3.2	0	4.6

Note: Differences in bold are statistically significant (at 95 per cent confidence level)

The mathematical literacy performance of Indigenous students was also examined to determine if there have been any changes from PISA 2003 to PISA 2006. Table 6.6 shows the performance of Indigenous students in PISA 2006 has remained essentially the same as PISA 2003.

Table 6.6 Mean mathematical literacy scores, standard errors and differences in performance between PISA 2003 and PISA 2006 for Indigenous students

	PISA 2003		PISA 2006		Differences between PISA 2003 and PISA 2006	
	Mean	SE	Mean	SE	Mean	SE
Indigenous students	440	5.4	442	7.3	2	9.2

Summary

Australia's mean score in mathematical literacy in 2006 was 520 points, significantly better than the OECD average. Australia was in a group of six countries with similar levels of achievement. Eight countries significantly outperformed Australia, compared to seven countries in PISA 2003 (without the Bonferroni correction).

The range of scores between the 5th and 95th percentiles in Australia was 289 score points, which was lower than the highest performing country, Chinese Taipei (333 score points), and the OECD average (300 score points).

In many countries, including Australia, male students significantly outperformed female students in 2006. In Australia, this represented a change from 2003 when there was no significant difference between male and female students in mathematics.

Australia's average score remained statistically unchanged between 2003 and 2006. However, while the average score for males remained the same as in PISA 2003, the average score for females in Australia declined significantly between the two cycles.

Around 16 per cent of Australian students achieved at Level 5 or higher, compared with 13 per cent on average in OECD countries. At the other end of the achievement scale, 13 per cent of Australian students compared to the OECD average of 21 per cent failed to achieve proficiency Level 2, including some eight per cent internationally and three per cent of Australian students who were not even able to demonstrate the most basic mathematical skills that PISA assesses at proficiency Level 1.

The score for the Australian Capital Territory was not significantly different to that of Chinese Taipei, the highest scoring country. The score for Western Australia was not significantly different to that of the Australian Capital Territory, and was also significantly higher than the Australian average. Other than Tasmania and the Northern Territory, all states scored significantly higher than the OECD average. Tasmania's score was not significantly different while that for the Northern Territory was significantly lower than the OECD average. The Northern Territory's score was also significantly lower than that of all of the other states.

In the Australian Capital Territory around one-quarter of students and in Western Australia just over 20 per cent of students achieved Level 5 or higher, which compared favourably with Finland, the Netherlands and Sweden.

There were significant gender differences in favour of males in Victoria, Western Australia, Tasmania and Queensland, with the largest difference in Victoria.

Indigenous students scored, on average, 80 points lower than non-Indigenous students, and 56 score points lower than the OECD average. There was no significant gender difference in the average score. Some 17 per cent of Indigenous students, compared to three per cent of non-Indigenous students, were unable to demonstrate Level 1, and 39 per cent of Indigenous compared to 12 per cent of non-Indigenous students achieved below Level 2.

Significant differences were also found by location of school that the students attended with students in metropolitan schools outscoring those in remote schools by a significant 58 score points on average – almost a full proficiency level. There were also significant differences between metropolitan and provincial school and between provincial and remote schools.

Socioeconomic differences were also apparent, with students in the highest socioeconomic quartile outperforming those in the lowest socioeconomic quartile by 78 score points on average. This represents more than one full proficiency level. At the highest and lowest achievement proficiencies, the differences are stark. Twenty-two per cent of students in the lowest socioeconomic quartile, compared to five per cent of students in the highest socioeconomic quartile, failed to achieve Level 2. At the same time, six per cent of students in the lowest socioeconomic quartile, compared to 29 per cent of students in the highest socioeconomic quartile, achieved Level 5 or higher.

There are always interesting differences in Australia in mathematics achievement between those born in the country and those with immediate roots outside the country. In the PISA 2006 mathematical literacy assessment, Australian-born students scored at a level significantly lower than either foreign-born or first-generation students, and although the proportions of students not achieving Level 2 are around the same for all three groups, the proportions achieving at the higher levels are quite different. Fifteen per cent of Australian-born students, compared to 18 per cent of first-generation students and 23 per cent of foreign-born students, achieved Level 5 or higher.

As previously mentioned, Australia's mean score in mathematical literacy in PISA 2006 was not significantly different from the mean score achieved in PISA 2003. There were some differences evident however; the scores for males in all states remained statistically the same, while those of females in the Northern Territory and Western Australia declined by a significant 27 score points and 24 score points respectively.

The next chapter of this report will examine the influences of socioeconomic background on student achievement within Australia and the states.

Chapter

7

Quality and Equity in the Performance of Students and Schools: An Australian Perspective

Previous chapters have described student performance in the three literacy domains: scientific, reading and mathematical literacy. Student performance is, of course, affected by myriad factors – student home background, attitudes, motivations, learning preferences and the learning environment have all been shown to influence student performance. At school and system level, there are differences in the way that teaching is organised and delivered in classes, the human and financial resources available to schools as well as factors such as curricular differences and organisational policies and practices.

Students come from a wide range of backgrounds and it is important that schools are equipped to accommodate students with diverse experiences and that they seek to provide equitable educational opportunities. Previous chapters have shown that this is not always the case, and that achievement varies widely within Australia. This chapter examines the relationship between socioeconomic background and achievement in PISA, presenting the findings both in an international[29] and national context.

The overall impact of socioeconomic background on student performance was found to be similar for science, reading and mathematics in PISA 2006. Therefore to simplify the presentation and to avoid repetition most of the analysis in this chapter will relate to student performance in science, the focus of the PISA 2006 assessment, and consider the combined science scale rather than examining the competency and knowledge areas separately.

The challenge for countries is to both cater for a diverse student body and narrow the gaps in student performance. In Australia, there is little institutional differentiation, reflecting the comprehensive nature of our education system. In general, schools are required to provide all students with similar opportunities for learning by requiring each school and teacher to provide for the full range of student abilities, interests and backgrounds.

How much variation?

There are considerable differences in the extent to which science achievement varies within countries. Figure 7.1 (derived from the OECD database, Table 4.1a) shows these differences. The total length of the bars indicates the observed variance in student performance on the PISA science scale. The values are expressed as percentages of the average variance between OECD countries in student performance on the PISA science scale, which is equal to 8,971 units.

A value larger than 100 indicates that variance in student performance is greater in that country than on average among OECD countries, while a value smaller than 100 indicates below-average

[29] International charts presented in this chapter are derived from the OECD PISA 2006 database and adapted from *PISA 2006: Science Competencies for Tomorrow's World*, Volume 1.

variance in student performance. Australia's variance is 9,926 units, which is about 11 per cent higher than the OECD average. As a contrast Finland, the highest performing country, had one of the lowest levels of variation in student performance – almost 20 per cent lower than the OECD average.

For each country a distinction is made between the variation attributable to differences in student results obtained by students in different schools (between-school differences) and that attributable to the range of student results within schools (within-school differences). In Figure 7.1 the length of the bars to the left of the central line shows between-school differences, while the length of the bars to the right of the central line shows the within-school differences. Longer segments on the left of the central line indicate greater variation in the mean performance of different schools while longer segments to the right indicate greater variation among students within schools. Countries such as Finland, Canada, Australia and New Zealand not only achieve high average student performance, they also show low or modest levels of between-school variation. These results are similar to those found in PISA 2000 and PISA 2003 in reading and mathematical literacy respectively.

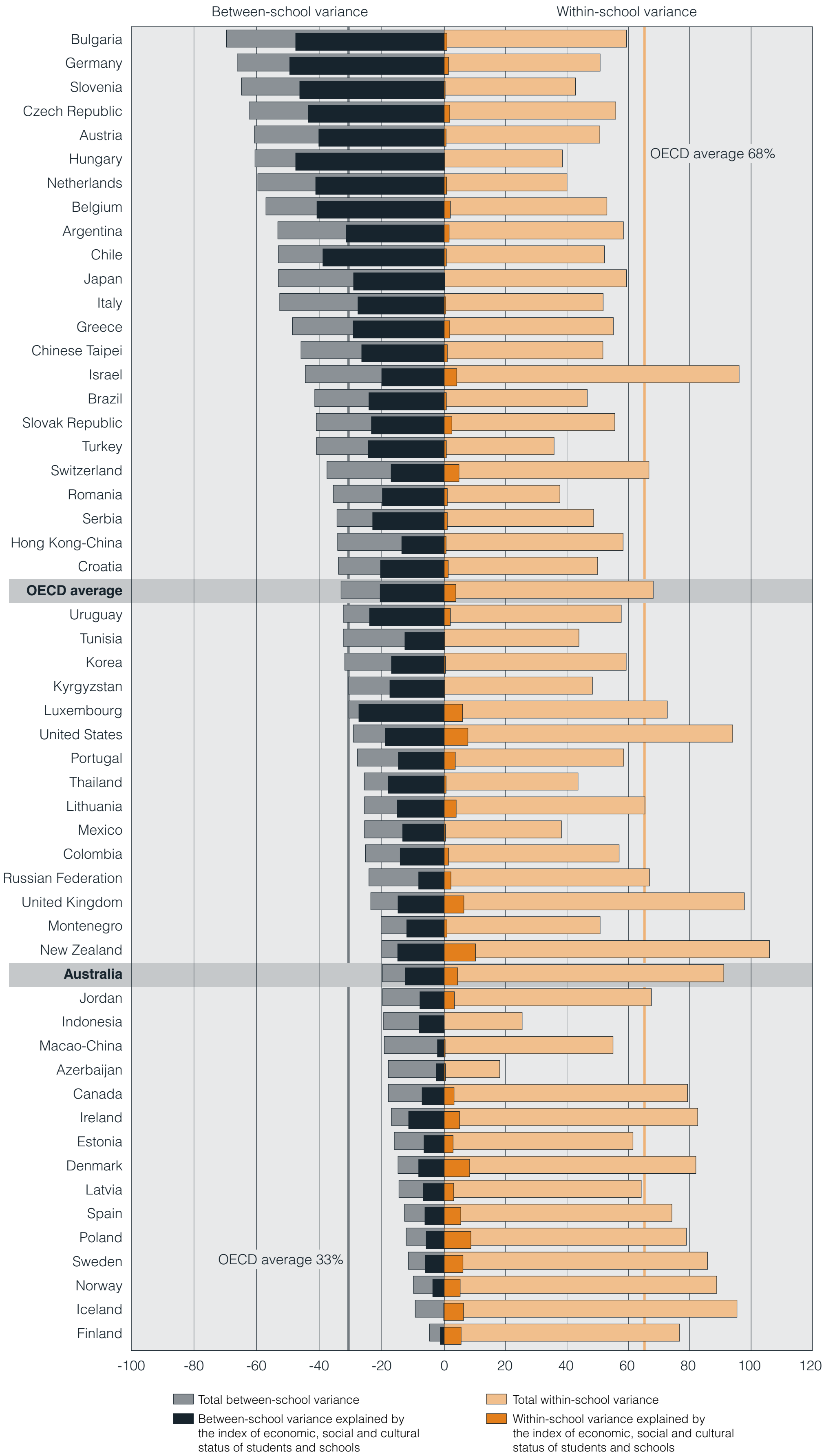

Figure 7.1 Variance in student performance between schools and within schools in scientific literacy

Also shown in Figure 7.1 is the amount of between-school variance and within-school variance that can be attributed to the socioeconomic background of students and schools. Chapter 3 has shown that although achievement in Australia is generally high, inequalities persist. The long-term social and financial costs to a society of educational inequality are high in that those who are not able to participate socially and economically in society generate higher costs for health, income support, child welfare and security.

The OECD defines the relative success of an educational system as the extent to which the system provides appropriate and equitable opportunities for a diverse student body. To do so, it uses the extent to which social background relates to student and school performance. Where students and schools perform well irrespective of their social background, learning can be considered to be more equitably distributed. If successful student and school performance depends largely on socioeconomic background, inequalities remain and student potential is unrealised.

Economic, social and cultural status

To measure wider aspects of a student's family and home background in addition to parental occupational status, the PISA index of economic, social and cultural status (ESCS) was created. PISA collected detailed information from students on various aspects of their background related to the economic, social and cultural status of their family. These included information on the occupations of the student's parents or guardians, the level of education of the parents or guardians, and an index of home possessions, which included access to educational and cultural resources at home. The composite socioeconomic background index, ESCS, was based on the occupations of the parents or guardians (using the index known as HISEI, which is described in the following section), the highest level of education of the parents converted into years of education, an index of the home educational resources, an index of cultural possessions in the home, and an index of family wealth.

ESCS can be regarded as a broader measure of socioeconomic or family background than HISEI alone. In PISA 2000, HISEI was used as the main measure of socioeconomic background in the national report (Lokan, Greenwood & Cresswell, 2001). The current international report (OECD, 2007) discusses the relationship between socioeconomic background and student performance in terms of ESCS, and we have therefore used the ESCS measure in this report for consistency.

The measures that comprise the ESCS are elaborated further in the following section.

Parents' occupational status

Students were asked in the Student Questionnaire to report (in an open-ended response) their mother's and father's occupations. The open-ended responses were then coded in accordance with the International Standard Classification of Occupations (ISCO). The resulting classifications were then used to derive a measure on the PISA International Socioeconomic Index of Occupational Status (ISEI). This index captures the attributes of occupations that relate parental education to income and is therefore indicative of socioeconomic status. In PISA a further index, HISEI, is created with values based on whichever of the father's or mother's occupation is the highest. Values on HISEI range from 0 to 90. High values on the index represent higher socioeconomic status and low values represent lower socioeconomic status. The mean value for the OECD was 48.7.

Australia had a mean of 53.0, following behind Iceland (53.9), Canada (53.5) and Norway (53.1). The scores for the United States (52.5) and New Zealand (51.6) were slightly below that of Australia. Turkey had the lowest value on the index with a mean of 39.5. Within Australia, the mean on HISEI ranged from 59.5 in the Australian Capital Territory to 48.8 in Tasmania. All states and territories other than Tasmania had a mean on the HISEI index significantly above the OECD mean. In Australia, the correlation coefficients between HISEI and student performance across each of the three (scientific, reading and mathematical literacy) domains were similar at around

0.30. This is a moderate positive correlation, indicating that there is a general tendency for students with higher levels on the index to have higher scores than students with lower levels on the index.

Parents' educational attainments

Information was collected on parents' education levels by asking students two questions. The first question asked students to indicate their parents' level of school education, from a list of statements (completed Year 12, completed Year 10 or 11, completed some secondary school but not more than Year 10, completed primary school only or none of the above). The second question asked students to indicate their mother's and father's post-school qualification from the following: a TAFE training certificate, a TAFE diploma or a university degree.

In terms of the mother's highest education levels, 26 per cent had completed some secondary school, but not more than Year 10, 15 per cent had completed Year 10 or 11 and 58 per cent of mothers had completed Year 12. Only one per cent of mothers had completed primary school only. Approximately 30 per cent of mothers had a university degree qualification, one- fifth had a TAFE training certificate, and another fifth had completed a TAFE diploma.

Similar percentages were found with the father's highest levels of education attained: 26 per cent had completed some secondary, but not more than Year 10; 17 per cent had completed Year 10 or 11; and 54 per cent of fathers had completed Year 12. One-third of fathers had a university degree qualification, 17 per cent had a TAFE diploma, and 27 per cent had a TAFE training certificate.

There was a weak (but significant) positive relationship in Australia between parents' education and student performance. The correlation coefficient was 0.25 for scientific literacy and mathematical literacy, and 0.24 for reading literacy.

In all participating countries there was a significant positive relationship between parental educational level and student performance in scientific literacy. Further information can be found in the international report (OECD, 2007).

Books in the home

Books are an important educational resource and the number of books in students' homes has been found to have an association with student performance. Eleven per cent of Australian students had more than 500 books in their home; about 20 per cent had each of 201 to 500 books and 101 to 200 books; thirty per cent had 26 to 100 books; 20 per cent had 11 to 25 books, while the remaining seven per cent had no more than 10 books in their home. The percentage of books in the home was very similar for females and males. On average, students from the Northern Territory had the lowest number of books in the home and students in the Australian Capital Territory had the highest.

There was a moderate positive relationship (correlation coefficient 0.35) between student performance in scientific literacy and the number of books a student has in their home. On average, a student whose home had more than 500 books scored 117 points higher in scientific literacy than a student who had less than 10 books in their home.

Educational resources in the home

The index on home educational resources was derived from students' indications of their access to educational items other than books in their home. Almost all Australian students had a dictionary and a calculator, 93 per cent had a desk, 89 per cent had a place to study and 86 per cent had books to help with schoolwork. Australia's mean on the home educational resources index was higher than the OECD mean at 0.04. The means for the states ranged above and below the OECD mean, with the Australian Capital Territory (0.16) and Western Australia (0.02) above the OECD mean, and Queensland (–0.04), Tasmania (–0.17) and the Northern Territory (–0.39) below the OECD mean. There was a weak positive association between educational resources in the home and performance. The correlation coefficient between educational resources in the home and performance was 0.20 for scientific literacy, 0.21 for mathematical literacy and 0.22 for reading literacy. On average, students whose home had all of the educational resources mentioned above (and were therefore placed in the highest quartile of the index) scored 38 points higher in scientific literacy than students in the lowest quartile (who had very few or no educational resources in the home).

Cultural possessions in the home

Students were asked to indicate whether they had possessions related to 'classical culture' in their home. The index was derived from the possession of three items, with 40 per cent of Australian students having classical literature (e.g. Shakespeare), 45 per cent having books of poetry, and 27 per cent having works of art (e.g. paintings) in their home. Australia's mean on the cultural possessions index was below the OECD average at –0.11. The mean in the Australian Capital Territory (at 0.18) was the only one higher than the OECD mean. The means for all other states were below the OECD mean, ranging from –0.05 in New South Wales to –0.26 in Tasmania. There was a weak positive relationship between cultural possessions and student performance. The correlation coefficients for scientific, reading and mathematical literacy were 0.23, 0.20 and 0.24 respectively. Students with higher means on the cultural possessions at home index (i.e. those students who have classical literature, books of poetry and works of art in their home) scored 59 points higher on average in scientific literacy than students with lower mean scores on the index.

Family wealth

The index on family wealth was based on items in the home. Students were asked two questions about possession of specific items in the home and about the quantity of some of these items. Almost all students reported having a DVD or VCR player and more than ninety per cent of students had a room of their own and a link to the Internet. Eighty-eight per cent of students had a digital camera, 86 per cent had a mobile phone, and 66 per cent reported having a dishwasher in their home. Fewer than half the students reported having cable or pay TV or a plasma TV in their home. Two-thirds of students had three or more televisions in their home, one- third had three or more cars, and a quarter of students participating in PISA 2006 had three or more computers in their home. Australia's mean (0.39) on the wealth index was higher than the average for all OECD countries. The Australian Capital Territory had a mean of 0.58, followed by Victoria (0.42), New South Wales and Western Australia (0.41 points), and South Australia (0.40). Queensland, Tasmania and the Northern Territory had the lowest means on the wealth index with 0.33, 0.29 and 0.22 respectively. Family wealth was not correlated with performance, with a correlation coefficient of 0.03 for scientific literacy, 0.06 for mathematical literacy and 0.05 for reading literacy. On average, students in the highest quartile of the wealth index scored nine points higher in scientific literacy compared to students in the lowest quartile.

The ESCS index

Using the various factors described above, values on the ESCS index were computed for each student, with mean scores also being calculated for each country. As for all the other indices in this report, the ESCS index was standardised to have a mean of zero and a standard deviation of 1 for all OECD countries combined. Australia's mean value on the ESCS was 0.21, which was higher than the OECD average. This is similar to the ESCS score for OECD countries Austria (0.20), Finland (0.26), the Netherlands (0.25), and Sweden (0.24), is lower than that of Canada (0.37) and Iceland (0.77), and higher than that of countries such as New Zealand (0.10) and the United States (0.14). Within Australia, the mean values for the ESCS were 0.58 in the Australian Capital Territory, 0.28 in New South Wales, 0.21 in Victoria and Western Australia, 0.16 in South Australia, 0.10 in Queensland, 0.07 in the Northern Territory, and –0.04 in Tasmania (see Figure 7.5, which shows the mean and range of ESCS scores for selected countries, and Figure 7.10, which shows the range for the Australian states).

Socioeconomic gradients

The terms 'socioeconomic gradient' or 'social gradient' refer to the relationship between an outcome and socioeconomic background. In the case of PISA the outcome considered is students' performance and the measure of socioeconomic performance is the ESCS index. PISA data show that there is a significant relationship between students' performance and their socioeconomic background as measured by ESCS. This relationship is evident in Australia and all PISA countries, although the strength of the relationship differs among countries. In a graphical representation the line of best fit for the points that represent performance against socioeconomic background (ESCS) provides information about several aspects of the relationship. The line is referred to as the social gradient.

The analysis of socioeconomic gradients is a means of characterising student performance and providing guidance for educational policy. Socioeconomic gradients can be used to compare the relationships between outcomes and student background across countries and to examine changes in gradients that occur from one cycle of PISA to another.

Four types of information are relevant to a consideration of social gradients:

- The *strength* of the relationship between science achievement and socioeconomic background. Although it is not always evident from a graphical presentation (even if individual data points for students are represented as a scatter plot) it is important to consider how closely individual results fit to the line of best fit. In other words, are the points representing the performance and ESCS measures for all the individual students situated close to the line of best fit or are they widely scattered about it? The closer all the points are to the line of best fit, the greater is the strength of the relationship. This aspect of the social gradient is represented by the percentage of the variation in performance that can be explained by the ESCS index. If the percentage is large it indicates that performance is relatively highly determined by ESCS, whereas if it is small it indicates that performance is not highly determined by ESCS. For OECD countries as a whole, the strength of the relationship between science achievement and socioeconomic background is 14.4.
- The *slope* of the gradient line is an indication of the extent of inequality in the relationship between students' results and their socioeconomic background (as measured by ESCS). A steeper slope indicates a greater difference in performance between low socioeconomic background students and high socioeconomic background students. Education systems typically aim to decrease the differences in performance between different social groups. Greater equity would thus be indicated by a flatter gradient.
- The average *level* of the line in the graph gives an indication of how well the overall population has achieved on the given assessment. Lines at higher levels indicate higher mean performance by the students.
- The *length* of the line indicates the range of ESCS. The graphs in this chapter are plotted between the 5th percentile of ESCS and the 95th percentile of ESCS, that is the graphs span the middle 90 per cent of the values of ESCS for each country. A smaller range indicates less difference in socioeconomic background between students from the highest and lowest socioeconomic backgrounds in the country. The range can be measured by projecting the starting point and finishing point of the gradient onto the horizontal axis.

The relationship between science performance and socioeconomic background as measured by ESCS for the OECD as a whole is shown in Figure 7.2. The vertical axis on the left hand side of the figure represents scores on the PISA 2006 overall scientific literacy scale. The banded horizontal regions on the graph represent the six proficiency levels (and an area below Level 1) as discussed in Chapter 2. The horizontal axis on the graph represents the index of ESCS. Each dot on the graph represents a fraction of the sampled students over the whole OECD.

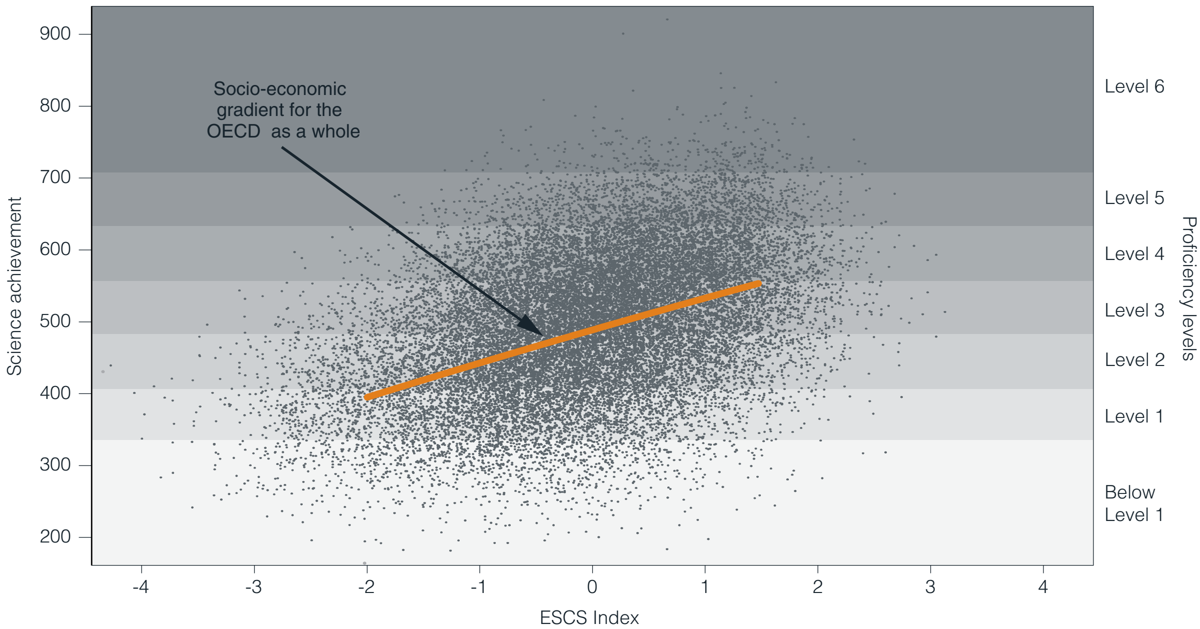

Figure 7.2 Socioeconomic gradient for the OECD in scientific literacy

Several points can be noted about the distribution of scores in this graph, and the almost straight line representing the socioeconomic gradient. Firstly, the most obvious is that students from more advantaged socioeconomic backgrounds generally perform better than those from disadvantaged backgrounds. This can be seen from the upwards slope of the line. Across OECD countries this slope represents an average rise of 40 score points in science performance for an increase of one standard deviation in socioeconomic background.

Secondly, the gradient line is almost straight, meaning that the difference in student science achievement associated with a particular change in socioeconomic background is about the same throughout the distribution of socioeconomic background. That is, the benefit for performance of socioeconomic advantage neither diminishes nor rises as socioeconomic advantage grows.

Finally, the graph shows very clearly that socioeconomic background is not deterministic. This is evidenced by the spread of the dots around the line. Some students from very disadvantaged backgrounds score well above what the gradient line would predict, while some students from highly advantaged homes, shown on the right hand side of the figure, perform at a very low level. For any group of students with similar socioeconomic backgrounds there is a large range of performance.

Figure 7.3 shows the socioeconomic gradients for Australia and the OECD. Several aspects of the graphs can be explored – how well socioeconomic background predicts performance, how well students with an average socioeconomic background perform, how wide are the differences in socioeconomic background in Australia compared with the OECD on average, and how much performance differs between students with stronger or weaker than average socioeconomic backgrounds.

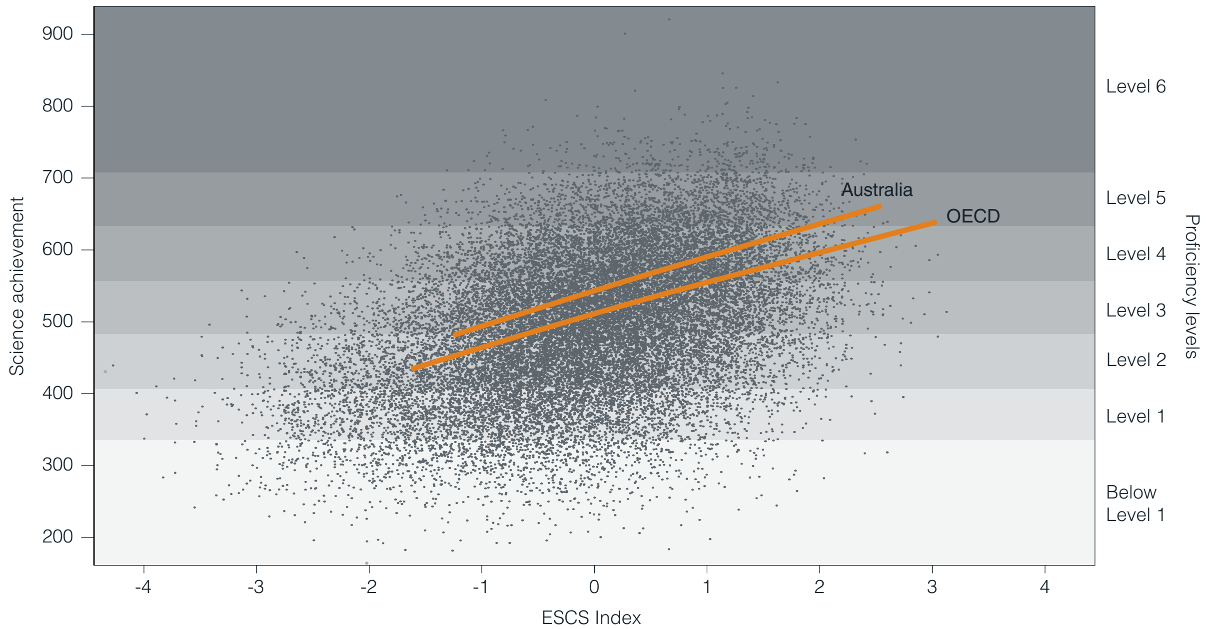

Figure 7.3 Socioeconomic gradients for Australia and the OECD in scientific literacy[30]

Examining each of the key points in turn for Figure 7.3:

- Strength: The scatter plot in Figure 7.3, which shows the relationship between socioeconomic background and scientific literacy for individual Australian students, indicates that the relationship between student performance and socioeconomic background is by no means deterministic. In the case of Australia, the strength of the relationship is 11.3, which is significantly lower than the OECD average of 14.5.
- Slope: As noted above, the slope is an indication of the extent of inequality in science performance attributable to socioeconomic factors. The slope of the socioeconomic gradient for Australia was 43, significantly higher than the slope of 40 for the OECD. This means that in Australia every additional unit increase on the index of socioeconomic background translates into an additional 43 score points on the scientific literacy scale, significantly more than the 40 score points on average over the OECD.

It is important to examine these two aspects together. The slope tells us that each additional unit, on average, of socioeconomic background translates into 43 score points, significantly higher than that of the OECD overall of 40 points. However, the association between the two variables is significantly less in Australia compared with the OECD overall, with socioeconomic background explaining some 11 per cent of the variation in scores compared to 14.5 per cent over the OECD. The strength of the relationship between socioeconomic background and science performance is used by the OECD as a proxy for equity in the distribution of learning opportunities. On the basis of Australia's higher than OECD average performance and lower than OECD average strength of relationship between socioeconomic background and performance, Australia is categorised as a high quality/high equity country in relation to science literacy performance in PISA 2006.

- Level of the lines: The Australian gradient line is higher than the OECD, reflecting the fact that Australian students performed at a higher level than on average in the OECD.
- Length of the lines: The range of ESCS scores between the 5th and 95th percentiles is smaller in Australia than over the OECD as a whole, as would be expected given the range of countries contributing to the OECD average score.

[30] Australian students are represented by the dots in the scatter plot.

Figure 7.4 plots the socioeconomic gradients for Finland, Canada, Australia, New Zealand, the United Kingdom and the United States, and the OECD average. This illustrates a number of features:

- The level of the line for Australia is above that of the United States, the United Kingdom, and the OECD average, reflecting the fact that Australia has a higher mean score than both these two countries and than the OECD average. The line for Finland is higher than the line for Australia and it is less steep than that for Australia. This indicates that not only is there higher overall achievement in Finland, but there is less difference in the scores obtained in PISA between lower socioeconomic background and higher socioeconomic background students in Finland than in Australia. In other words, the figure shows that there is a higher degree of equity in Finland.
- It is also worth noting that the lines for Finland and Canada start on the horizontal axis at a point considerably to the right of the starting points for all the other countries shown and for the OECD average. This indicates that these two countries do not have students with socioeconomic backgrounds as low as occur in Australia, New Zealand, the United Kingdom, the United States or the OECD on average.

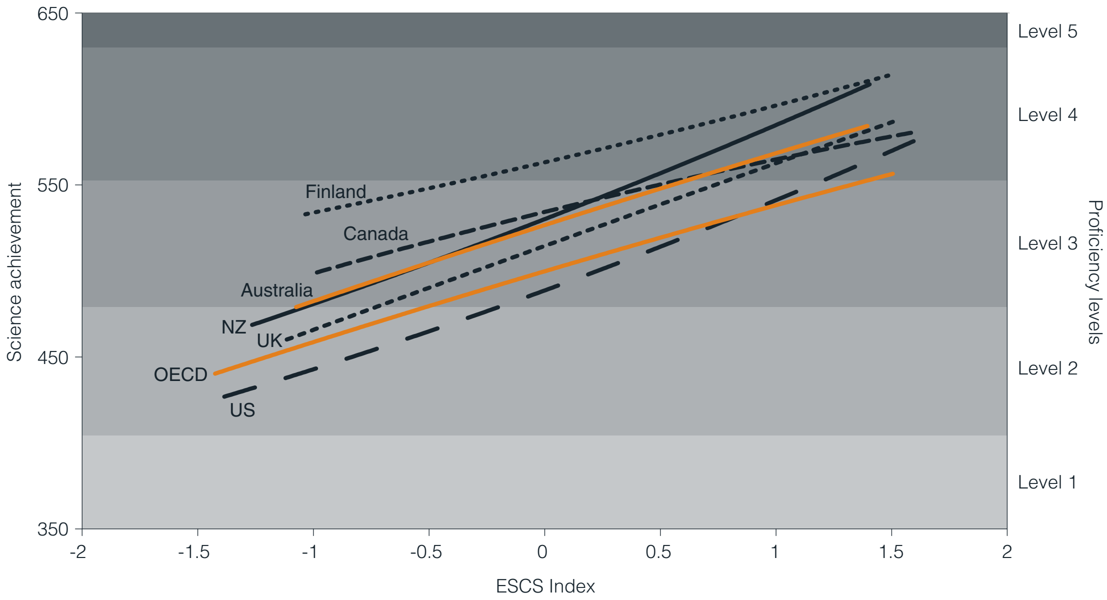

Figure 7.4 Socioeconomic gradients for selected countries in scientific literacy

The gradients for Canada, New Zealand and the United States are slightly curved. This indicates, in the case of Canada, that the added benefit of higher socioeconomic background tapers off at higher socioeconomic levels, showing that at higher levels of socioeconomic background there is progressively less advantage in student performance. In New Zealand and the United States, however, the curves rise towards the right hand end, indicating that the greater the socioeconomic advantage, the greater the advantage in terms of student achievement. At lower levels of socioeconomic background, Australia and New Zealand perform at about the same level; however, at high levels of socioeconomic background New Zealand students clearly outperform Australian students. Canada, on the other hand, appears to cater well for its lower socioeconomic background students: their achievement levels are higher than in Australia for low socioeconomic background students and closer to the achievement scores for their high achieving students. For higher socioeconomic background students, Australia's achievement level is higher than that of Canada.

An important feature illustrated by this figure is that there is less difference, generally, between countries at high levels of ESCS than there is at low levels – the slopes appear to converge slightly at higher levels of ESCS. This is also observed when the social gradients of all countries are plotted together, implying that students with high levels of socioeconomic background tend to vary less in their scientific literacy performance, from country to country, than students with relatively low levels of socioeconomic background. That is, the impact of educational experiences on student performance may be greatest for students from lower socioeconomic backgrounds.

The range of the index of ESCS spanned by the gradient lines should also be noted when comparing countries' scores. As noted above, the range is indicated by the length of the line from the 5th percentile to the 95th percentile. The ranges for selected countries are shown in Figure 7.5. For some countries the spread is quite narrow – for example in Australia the range spans less than 2.5 index points, while in others, for example Portugal, the range is much larger (4 index points). What this means is that in Australia, there is a fairly narrow distribution of socioeconomic background and the lowest level is quite high, whereas in countries such as Portugal, Mexico, Turkey and Thailand, there is a wide range of socioeconomic backgrounds and the lowest level is very low. In these countries, the education system needs to cope with students from both high and very low socioeconomic backgrounds.

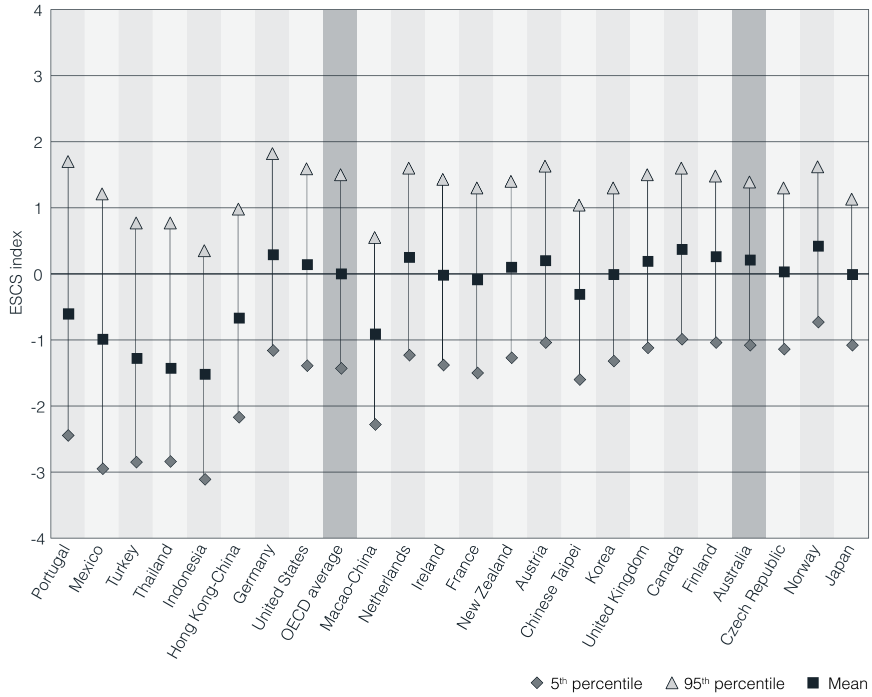

Figure 7.5 Range of ESCS index scores for selected countries for PISA 2006

Table 7.1 shows the slope and strength of the relationship between socioeconomic background and performance in scientific literacy for all participating countries in PISA 2000, PISA 2003 and PISA 2006. A bolded figure indicates that the value is significantly different from the OECD average. For Australia, both the slope and strength of the gradient were significantly lower in 2006 than in 2003, which means that the effect of socioeconomic background both declined and weakened over this period of time. Also notable is that in the United States the slope has increased and the strength has weakened between PISA 2000 and PISA 2003 and PISA 2006. Also, quite remarkably, the slope in Finland has declined.

Table 7.1 also shows that in PISA 2006:

- The strength of the relationship varies widely – from less than eight per cent of variation being explained in Iceland, Japan, Montenegro, Hong Kong-China, Azerbaijan, Qatar and Macao-China, to more than 21 per cent in France, Hungary, Luxembourg, Liechtenstein, Chile and Bulgaria. The slope for Australia was 11 per cent.

- The steepness of the slopes vary – steep slopes can be seen in France (54), New Zealand (52), the United States (49), and the United Kingdom (48) compared with gentler slopes, indicating lower impact of socioeconomic background on performance in the three highest scoring countries, Finland (31), Hong Kong-China (26) and Canada (33), as well as in a range of other countries. The slope for Australia was 43.
- Both strength and slope need to be taken into account – countries may have similar slopes, but if the strength of the relationship is quite different then the interpretation should be made carefully. For example, compare Australia with Hungary. The slopes of the socioeconomic gradients are very similar: 43 for Australia and 44 for Hungary. However, in Australia there are many students from disadvantaged backgrounds performing well and many students from advantaged backgrounds performing at a lower level than would be expected, so that the relationship only explains 11.3 per cent of the variance. In Hungary, however, performance follows the levels predicted by socioeconomic background more closely, so that socioeconomic background explains 21.4 per cent of the variance.

Table 7.1 Relationship between student performance in scientific literacy and the PISA index of economic, social and cultural status (ESCS) for PISA 2000, PISA 2003 and PISA 2006

	PISA 2000				PISA 2003				PISA 2006			
	Slope of ESCS		Strength of the relationship		Slope of ESCS		Strength of the relationship		Slope of ESCS		Strength of the relationship	
	Slope	SE	%	SE	Slope	SE	%	SE	Slope	SE	%	SE
OECD countries												
Australia	42	(2.6)	14.3	(1.75)	47	(2.1)	14.6	(1.15)	**43**	(1.5)	**11.3**	(0.78)
Austria	42	(2.7)	15.3	(1.70)	49	(2.2)	18.7	(1.48)	**46**	(3.1)	15.4	(2.02)
Belgium	**53**	(2.7)	**20.0**	(1.51)	**55**	(1.8)	**24.5**	(1.32)	**48**	(1.9)	**19.4**	(1.29)
Canada	**33**	(1.5)	**10.6**	(0.88)	**40**	(1.6)	**11.4**	(0.82)	**33**	(1.4)	**8.2**	(0.68)
Czech Republic	**56**	(2.7)	**20.9**	(1.83)	**50**	(2.2)	16.4	(1.38)	**51**	(2.6)	15.6	(1.35)
Denmark	**46**	(2.6)	16.6	(1.80)	47	(2.3)	16.3	(1.40)	39	(2.0)	14.1	(1.43)
Finland	**26**	(2.3)	**7.3**	(1.24)	**34**	(1.7)	**9.9**	(0.97)	**31**	(1.6)	**8.3**	(0.87)
France	**47**	(2.5)	18.5	(1.90)	**54**	(2.8)	**20.9**	(1.97)	**54**	(2.5)	**21.2**	(1.77)
Germany	**54**	(2.6)	**23.4**	(2.19)	**54**	(1.7)	**25.9**	(1.51)	**46**	(2.1)	**19.0**	(1.45)
Greece	**30**	(2.8)	**10.5**	(1.93)	**36**	(2.0)	**13.0**	(1.48)	37	(2.2)	15.0	(1.72)
Hungary	**60**	(3.6)	**23.3**	(2.44)	**51**	(2.4)	**21.4**	(1.75)	**44**	(1.8)	**21.4**	(1.58)
Iceland	**22**	(2.4)	**5.7**	(1.19)	**31**	(2.1)	**6.8**	(0.95)	**29**	(1.8)	**6.7**	(0.80)
Ireland	**34**	(2.3)	12.8	(1.62)	44	(2.1)	17.8	(1.62)	39	(2.2)	12.7	(1.37)
Italy	**30**	(2.4)	**9.3**	(1.34)	**40**	(2.2)	14.1	(1.32)	**31**	(1.6)	**10.0**	(0.94)
Japan					48	(4.5)	10.6	(1.67)	39	(2.7)	**7.4**	(0.95)
Korea	**27**	(2.8)	**8.4**	(1.70)	39	(3.3)	**10.9**	(1.75)	**32**	(3.1)	**8.1**	(1.49)
Luxembourg					40	(1.6)	17.7	(1.27)	41	(1.2)	**21.7**	(1.12)
Mexico	**26**	(2.2)	16.2	(2.67)	**28**	(1.9)	15.1	(1.82)	**25**	(1.3)	16.8	(1.72)
Netherlands					47	(2.4)	17.3	(1.62)	44	(2.2)	16.7	(1.65)
New Zealand	44	(2.5)	16.2	(1.60)	46	(1.7)	16.8	(1.13)	**52**	(1.8)	16.4	(1.11)
Norway	38	(2.2)	13.1	(1.44)	47	(2.3)	**12.9**	(1.21)	36	(2.5)	**8.3**	(1.10)
Poland	42	(3.5)	14.1	(2.11)	**52**	(2.1)	17.5	(1.29)	39	(1.8)	14.5	(1.13)
Portugal	**33**	(2.2)	15.6	(2.23)	**29**	(1.6)	15.1	(1.55)	**28**	(1.4)	16.6	(1.50)
Slovak Republic					58	(3.6)	**21.8**	(2.29)	**45**	(2.6)	**19.2**	(1.96)
Spain	**35**	(2.1)	15.3	(1.71)	**36**	(2.0)	**13.3**	(1.38)	**31**	(1.3)	13.9	(1.21)
Sweden	**33**	(2.3)	**9.3**	(1.20)	46	(2.4)	14.2	(1.36)	38	(2.1)	**10.6**	(0.97)
Switzerland	**52**	(2.3)	**23.0**	(1.92)	**56**	(2.5)	**19.4**	(1.54)	**44**	(1.8)	15.7	(1.20)
Turkey					41	(4.4)	22.2	(3.76)	**31**	(3.2)	16.5	(2.96)
United Kingdom									48	(1.9)	13.9	(1.12)
United States	46	(3.6)	**21.2**	(2.93)	48	(1.7)	18.5	(1.33)	**49**	(2.5)	**17.9**	(1.63)
OECD average	*40*	*(0.5)*	*15.1*	*(0.38)*	*45*	*(0.5)*	*16.4*	*(0.30)*	*40*	*(0.4)*	*14.5*	*(0.26)*
Partner countries												
Argentina									38	(2.4)	**19.5**	(2.33)
Azerbaijan									**11**	(2.0)	**4.7**	(1.71)
Brazil	**28**	(2.9)	12.2	(2.29)	**30**	(2.6)	**11.6**	(1.84)	**30**	(1.9)	17.1	(1.92)
Bulgaria									52	(3.6)	24.1	(2.76)
Chile									38	(1.8)	23.3	(1.92)
Chinese Taipei									42	(2.1)	12.5	(1.19)
Colombia									23	(1.6)	11.4	(1.57)
Croatia									34	(1.9)	12.3	(1.21)
Estonia									31	(2.0)	9.3	(1.12)
Hong Kong-China	**32**	(3.0)	**9.4**	(1.93)	**30**	(2.5)	**6.7**	(1.20)	**26**	(2.3)	**6.9**	(1.26)
Indonesia	**18**	(3.5)	**5.6**	(1.97)	**19**	(2.2)	**8.0**	(1.62)	**21**	(2.6)	10.2	(2.31)
Israel									43	(2.7)	**10.9**	(1.10)
Jordan									27	(1.8)	11.2	(1.35)
Kyrgyzstan									27	(2.6)	8.2	(1.42)
Latvia	36	(4.7)	**8.9**	(2.17)	**38**	(3.0)	**9.5**	(1.53)	**29**	(2.3)	**9.7**	(1.41)
Liechtenstein	43	(7.6)	19.2	(6.74)	**61**	(6.7)	23.0	(4.47)	49	(5.5)	20.4	(4.42)
Lithuania									38	(2.0)	15.2	(1.33)
Macao-China					10	(3.1)	0.9	(0.59)	**13**	(1.5)	**2.2**	(0.49)
Montenegro									24	(1.4)	7.5	(0.90)
Romania									35	(3.4)	16.6	(3.15)
Russian Fed.	38	(3.3)	**8.0**	(1.29)	40	(2.3)	**9.0**	(1.01)	**32**	(2.6)	**8.1**	(1.23)
Serbia									33	(1.8)	13.2	(1.27)
Slovenia									46	(1.6)	16.7	(1.11)
Thailand	**22**	(2.7)	**7.0**	(1.70)	**28**	(2.2)	12.8	(1.85)	**28**	(1.6)	15.9	(2.00)
Tunisia					19	(2.5)	7.2	(1.83)	**19**	(2.2)	**9.5**	(2.11)
Uruguay					37	(2.3)	12.7	(1.47)	**34**	(1.4)	**18.3**	(1.23)

Note: Figures in bold are significantly different to the OECD average

Differences among domains

Table 7.2 shows the average score, slope and strength of the relationship between socioeconomic background and achievement in each of science, reading and mathematics for Australia as a whole in each of the three cycles of PISA. In previous years some of this information was presented graphically; however, with three cycles this is not now ideal.

Table 7.2 Mean scores, slope and strength of the relationship between ESCS and achievement in science, reading and mathematics, PISA 2000, PISA 2003 and PISA 2006 for Australia

	Scientific literacy			Reading literacy			Mathematical literacy		
	Score	Slope	Strength	Score	Slope	Strength	Score	Slope	Strength
PISA 2000	528	42	14.3	528	50	17.4	533	44	17.1
PISA 2003	525	47	14.6	525	44	14.2	524	42	13.7
PISA 2006	527	43	11.3	**513**	**41**	**11.8**	520	38	**11.5**

Note: Figures in bold are significantly different to the PISA 2000 figures

The slope for reading has declined significantly from that measured in PISA 2000, meaning that Australia's reading literacy, although significantly lower than in PISA 2000, is also more equitably distributed in terms of socioeconomic background. The strength of the relationship has also decreased over the time period – only 11.8 per cent of variation in students' scores can be explained by socioeconomic background in 2006 compared to 17.4 per cent in 2000.

The slope for mathematics has also decreased, but not significantly. The strength of the relationship has significantly decreased from PISA 2000 to PISA 2006, explaining around 17 per cent of the variation in 2000 and 11.5 per cent of the variation in 2006.

Figure 7.6 shows the socioeconomic gradients for the three assessed areas in PISA 2006.

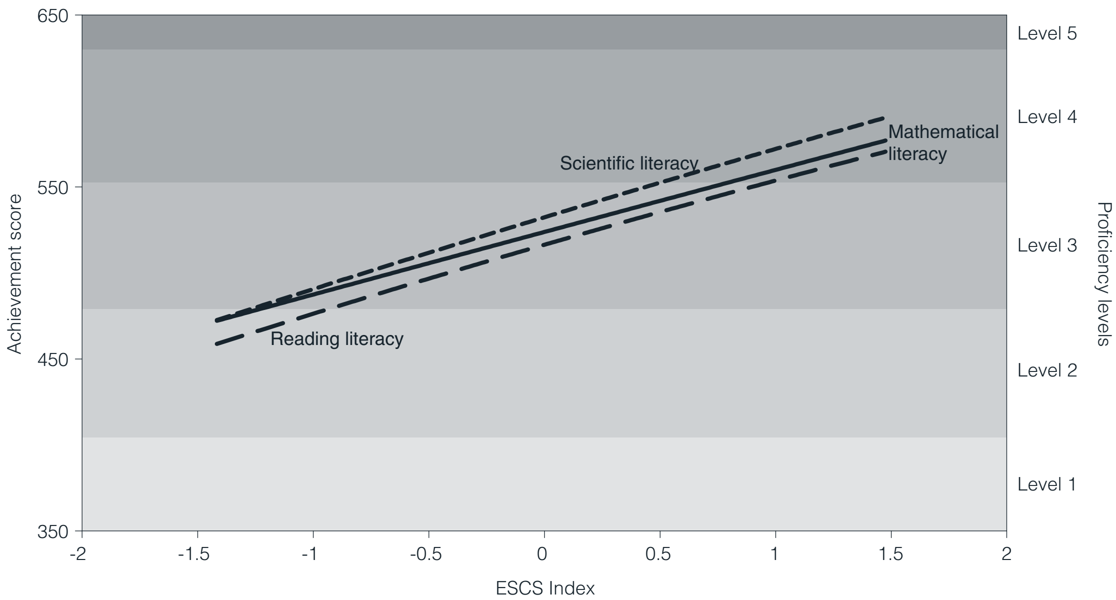

Figure 7.6 Socioeconomic gradients for scientific, reading and mathematical literacy, PISA 2006

As also shown in Table 7.2, these data indicate that the slopes for each of the domains are very similar. There is a slightly lower impact of socioeconomic background on mathematics achievement than either scientific or reading literacy achievement, as indicated by the slightly flatter line for mathematical literacy.

Relationships by state

Analysis carried out for Australia suggests that the vast majority of the variation in student scores across the country is due to variation between students within schools (81 per cent), with 18.4 per cent due to differences between schools, and only 0.6 per cent due to differences between states.[31]

As there is so little variation between states in terms of the impact of socioeconomic background on science achievement, an extensive analysis of the reasons for between-state differences will not be carried out; however, Figure 7.7 shows that there is variation in the relationship between socioeconomic background and science achievement, some of which have already been explored in Chapter 3.

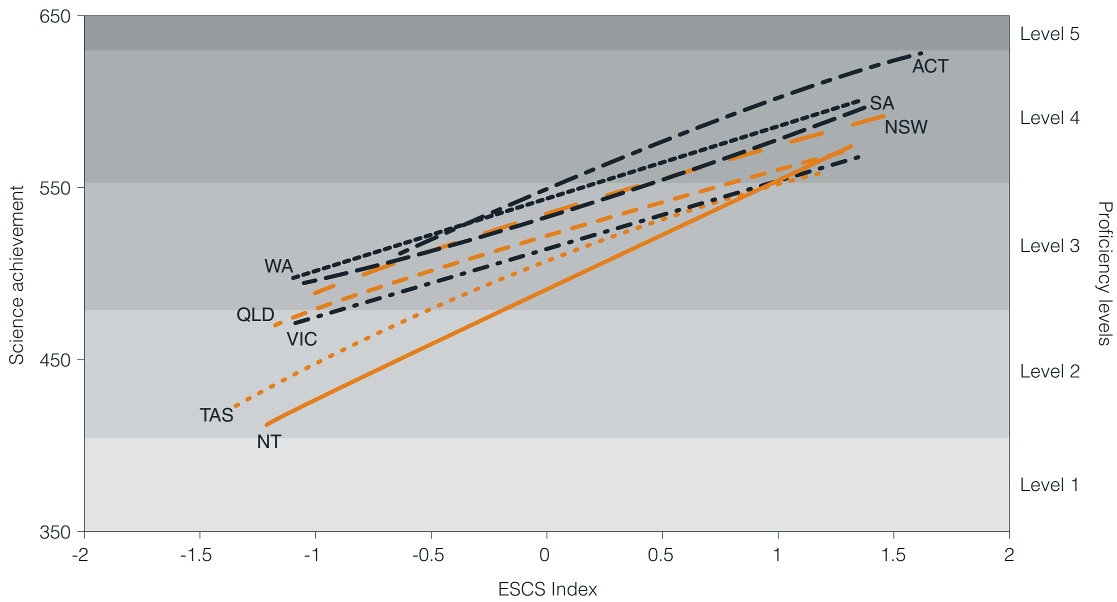

Figure 7.7 Socioeconomic gradients in scientific literacy for the states, PISA 2006

The graph illustrates the following:

- The gradient for the Northern Territory is the steepest, with the Australian Capital Territory almost as steep, while Victoria has the flattest slope.
- The graphs for Tasmania and the Australian Capital Territory have a negative curvilinearity (the curvature of the line), indicating that the influence of socioeconomic background on science achievement 'flattens out' at higher levels, i.e. that there is a decreasing return on achievement for socioeconomic background past a certain point. South Australia's slope on the other hand shows a positive curvilinearity, indicating a higher rate of increase in science scores for students in high socioeconomic backgrounds than for students with low socioeconomic backgrounds.
- The average socioeconomic background for the Australian Capital Territory is generally higher than that of other states. Performance is also generally higher than that of students in other states.

[31] A three-level multilevel regression analysis was carried out with students at the first level, schools at the second level and states at the third level. Whilst not technically correct, as random selection is assumed at each level for multilevel analysis, this mimics the analysis conducted internationally with countries at the third level. Partitioning the variance found that of the total variation in science achievement scores in Australia, 0.6 per cent of the variance was at the third level, i.e. between states, 18.4 per cent was between-school variance, and the remaining 81 per cent was within-school variance, i.e. variation between students within schools.

- Performance across the states at the lower levels of ESCS has a wider range than at the higher levels; as was found internationally the range of the states' performance converges at higher levels of ESCS.

Figure 7.8 shows the socioeconomic gradient lines for reading in PISA 2006. Some similar patterns can be seen in reading as for science – there is less dispersion at the higher ESCS levels than at the lower levels, and Tasmania, the Australian Capital Territory and the Northern Territory show a negative curvilinearity (that of Tasmania is a little more pronounced).

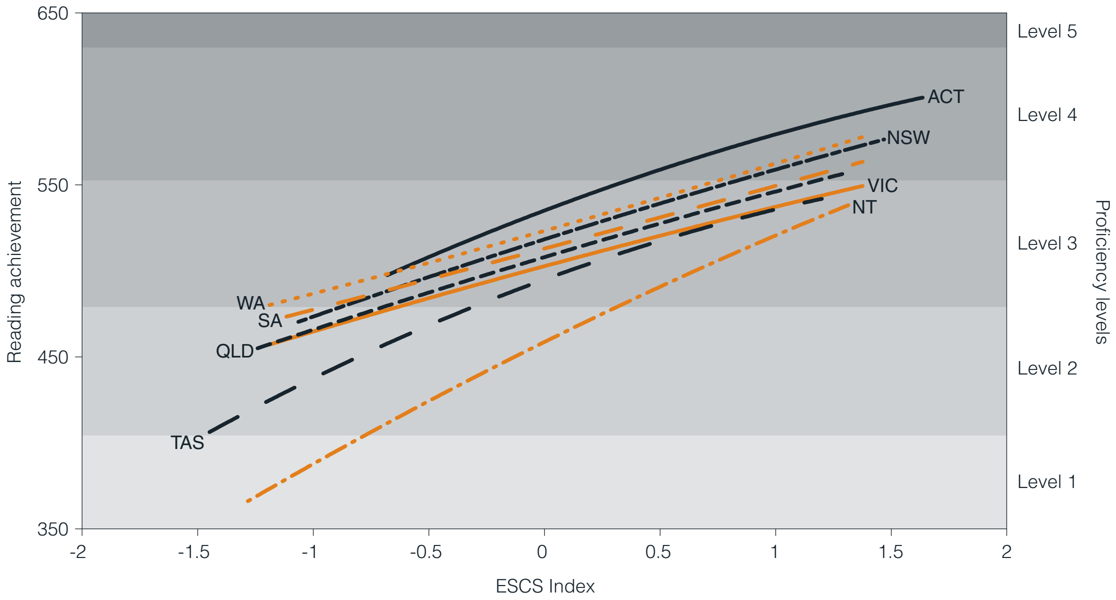

Figure 7.8 Socioeconomic gradients in reading literacy for the states, PISA 2006

A similar pattern can be seen in the socioeconomic gradients for mathematics in PISA 2006, as shown in Figure 7.9. There is more convergence at the higher levels of ESCS, and the slopes are generally flatter. In other words socioeconomic background appears to be less of an influence on achievement in mathematics than in the other two literacy domains.

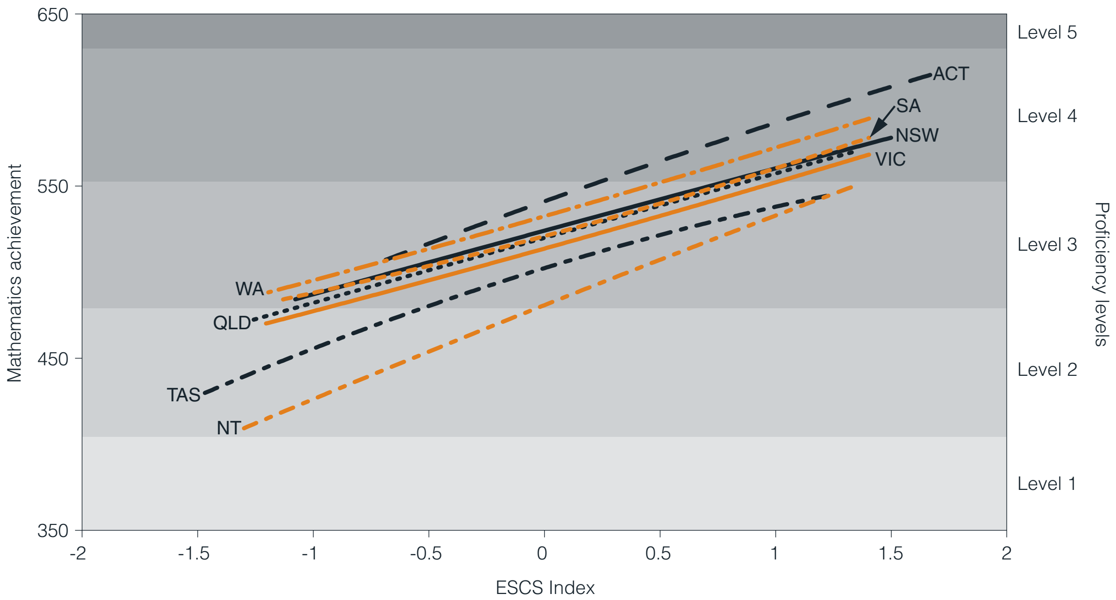

Figure 7.9 Socioeconomic gradients in mathematical literacy for the states, PISA 2006

Figure 7.10 shows the spread of ESCS between the 5th and 95th percentiles for the states. These are all very similar, ranging from 2.24 index points in the Australian Capital Territory to 2.51 in the Northern Territory and 2.55 in Tasmania.

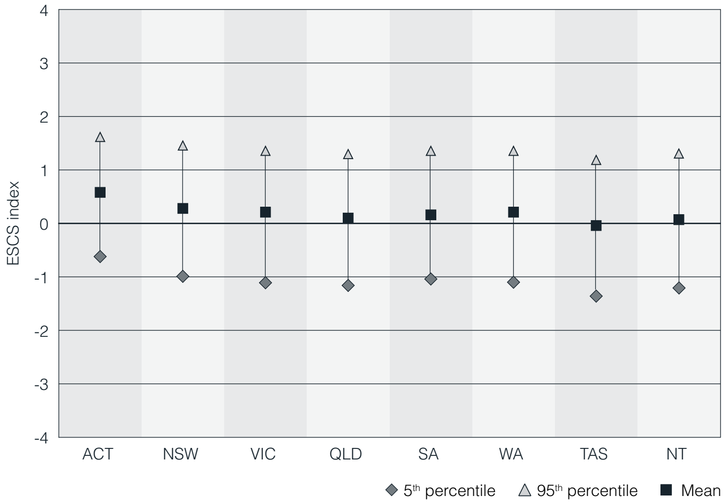

Figure 7.10 Range of ESCS for states, PISA 2006

Figure 7.10 shows the spread of ESCS between the 5th and 95th percentiles for the states. These range from 2.24 index points in the Australian Capital Territory to 2.51 in the Northern Territory and 2.55 in Tasmania. The average socioeconomic background in the Australian Capital Territory is higher than that in other states, while the average socioeconomic background in Tasmania is generally lower. The range of ESCS is also shorter than for other states, starting higher and finishing higher.

The impact of socioeconomic background

The socioeconomic gradient for a country can be broken down into two parts: a within-school gradient and a between-school gradient, as shown in Figure 7.11. The within-school gradient describes how a student's socioeconomic background is related to their performance within a common school environment. The between-school gradient describes how schools' average level of performance is related to the average socioeconomic background of their student intake. Figure 7.11 shows the within-school and between-school slopes across countries. The lengths of the bars represent the differences in scores on the PISA scientific literacy scale that are associated with a difference of one-half of a standard deviation on the PISA ESCS index for the individual student (dark grey bar) and for the average of the student's school (orange bar).

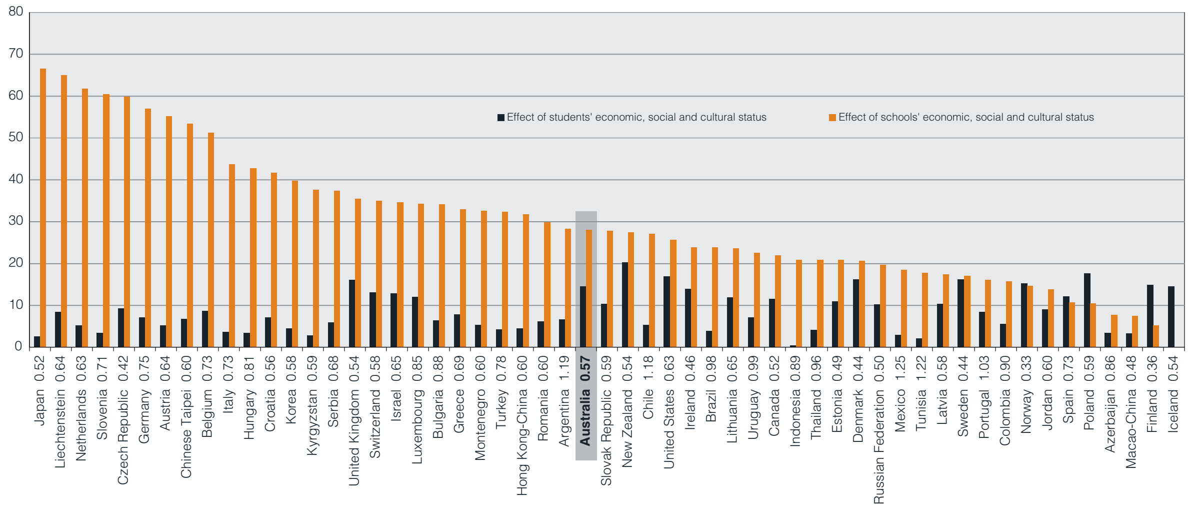

Figure 7.11 Effects of students' and schools' socioeconomic background on student performance in scientific literacy

In almost all countries, the relatively long bars representing the school's effect on achievement show a clear advantage in attending a school whose students are, on average, from higher socioeconomic backgrounds. Regardless of their own socioeconomic background, students attending schools in which the average socioeconomic background is high tend to achieve better than if they were attending schools with a below-average socioeconomic intake. In most OECD countries the effect of the average ESCS of students in a school outweighs the effects of the student's own socioeconomic background.

In some countries this difference is very large. In Japan, for example, a student of average family socioeconomic background attending a school in which the average socioeconomic background is one-quarter of a standard deviation above the OECD average is likely to score about 64 points higher on the PISA science literacy scale than if he or she attended a school whose average socioeconomic background was one-quarter of a standard deviation lower than the OECD average. In Australia, the differences are not as great, with the score difference being about 28 score points for a student in the same situation. However, given that 34 score points represents a full school year, this is not an insignificant advantage.

Socioeconomic differences at the student level are not as predictive of performance as those at the school level in most countries. Consider the case of two students living in the same country, whose family scores on the ESCS place them one-quarter of a standard deviation above, and one-quarter of a standard deviation below the mean. If these students attend the same school, with an average socioeconomic profile, the predicted difference in their scores would be about 15 score points in Australia, compared to just 3 score points in Japan and 20 score points in New Zealand.

The positive effect on performance of attending a school with a higher average socioeconomic status is likely due to many factors, including a better learning environment and access to better resources at school. Research has found that schools with a higher average socioeconomic level tend to have fewer disciplinary problems, better teacher–student relations, higher teacher morale and an environment that is oriented towards higher performance (e.g. Baker, Goesling & Letendre, 2000). Some of the contextual effect may also be due to higher levels of peer interaction as higher achieving students work together, while some, no doubt, is due to factors not measured in PISA, such as the engagement of students and their parents with learning.

Summary

Figure 7.12 summarises the findings from this chapter by contrasting average performance in science (shown on the y-axis) with the strength of the relationship between socioeconomic background and science performance, which is used as a proxy for equity in the distribution of learning opportunities (shown on the x-axis). The Australian states have been included in this figure.

Australia and most of the states lie in the top right quadrant of this figure, as was the case for mathematical literacy in PISA 2003. Australia, along with countries such as Finland, Hong Kong-China, Japan and Canada, in the top right-hand quadrant of the graph, is an example of countries with above average performance in science and a below-average impact of socioeconomic background on performance. New South Wales, Western Australia, South Australia, Queensland and Victoria are similarly characterised. Countries such as New Zealand, the Netherlands and Germany, as well as the Australian Capital Territory and Tasmania, are countries and states with high levels of student performance and an above-average impact of socioeconomic background on student performance in science (top left quadrant of the graph). Countries such as the United States and France, as well as the Northern Territory, have a below-average level of performance in science and an above-average impact of socioeconomic background on performance. Countries such as Italy and Norway, in the bottom right quadrant of the figure, are countries in which performance is relatively low but not strongly related to students' socioeconomic background.

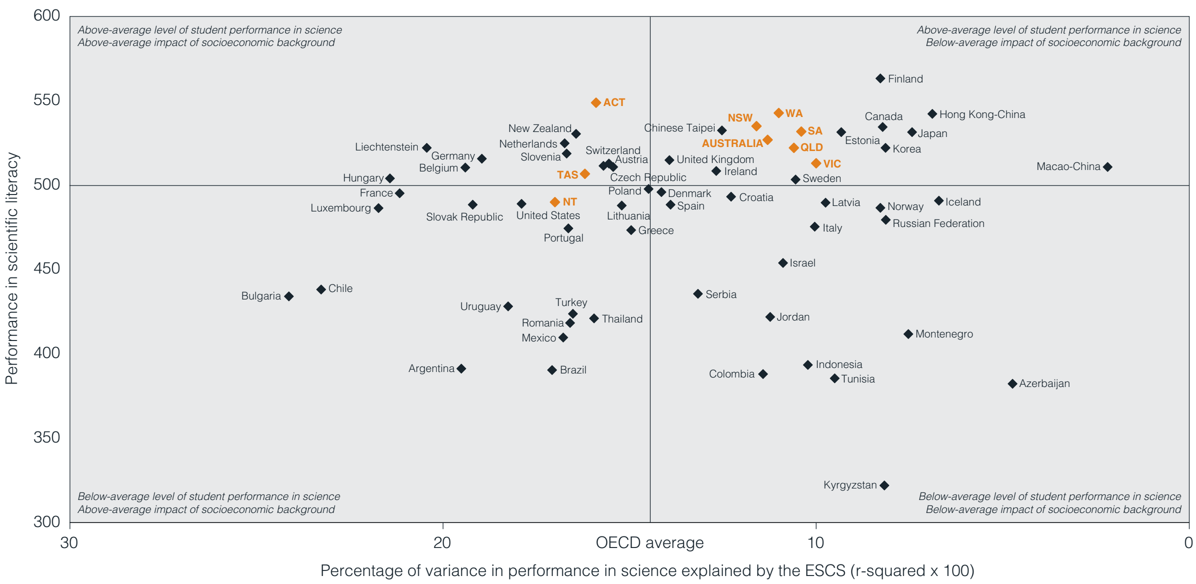

Figure 7.12 Performance in scientific literacy and the impact of socioeconomic background

The final chapter of this report provides an overall summary of the findings of this report.

Chapter

8

PISA 2006: Summary and Policy Implications

Many education systems monitor student performance at various points in schooling to provide information about how well young people are being prepared for life. Developing the knowledge and skills of young people is important to a society in terms of both future prosperity and future wellbeing, and education systems play a vital role not only in developing students' knowledge and skills, but also in strengthening students' disposition for learning both at school and over their lifetimes. Science has played an increasingly important role in terms of economic development for countries in an information technology age, and for development to progress quickly it is important that all students should be encouraged to study science and to see the relevance of it to their worlds.

The first national tests in literacy and numeracy will be conducted in 2008 for Years 3, 5, 7 and 9, and comparative international studies can provide a context within which to interpret national results. PISA is an initiative by governments within the OECD (with many non-OECD countries also participating) to monitor the outcomes of education systems in terms of student performance on a regular basis within a common framework. PISA goes beyond reporting on the relative performance of countries. Using the data from PISA we are able to examine differences in performance between males and females, Indigenous and non-Indigenous students, students in different geographic locations and from different socioeconomic backgrounds, and students from different language backgrounds. Examining these differences on an internationally comparative basis can draw attention to variations in relationships considered to be immutable within any one national context. PISA explores some of the factors associated with the development of knowledge and skills and the implications for policy and practice. PISA also examines issues such as students' attitudes and motivation to learn, and their beliefs about themselves.

PISA began as an initiative of the OECD in Paris in 1997, and its first international assessment was carried out in 2000. The core domains of learning chosen for assessment were reading, mathematical and scientific literacy. Data on each of these three domains are gathered in each testing cycle, but within each cycle there is about four times the emphasis on the major domain, in terms of testing time, than on each of the other domains.

The PISA assessment materials focus 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 possess. The emphasis is on whether students, faced with problem situations that might occur in real life, are able to analyse, reason and communicate their ideas, arguments or conclusions effectively. The term 'literacy' as used in PISA reflects the focus on these broader skills, not just the ability to read and write. In the way that the term is used, it holds more meaning than the traditional sense of being able to read and write. The OECD considers that mathematics, science and technology are so pervasive in modern life that it is important for students to be 'literate' in these areas as well. The student population chosen for PISA is students aged 15 years, who are typically in their final year of compulsory schooling in most OECD countries. The measures obtained from the assessments undertaken in PISA, as well as the information collected about students' home backgrounds, beliefs and attitudes, provide an assessment of the cumulative 'yield' of education systems. Procedures in place ensure that the data collected for PISA is both reliable and comparable across countries in terms both of the measurements and the student sample. These steps are detailed in Appendix 1.

In the first PISA study in 2000, reading literacy was the major domain, with less emphasis on the testing of mathematical and scientific literacy. PISA 2000 revealed wide differences in the extent to which countries succeed in equipping young adults with knowledge and skills in reading literacy as well as other key subject areas. It also highlighted the extent of variation within countries in performance and the distribution of learning outcomes. The second cycle of PISA, carried out in 2003, was conducted in 41 countries with a little over a quarter of a million students, and the major domain was mathematical literacy. As in PISA 2000, it found wide differences in performance in mathematics, in the variation between countries, and in the distribution of learning outcomes.

The third cycle of PISA was conducted in 2006. Over 400,000 students in 57 countries took part. This report has examined the performance of Australian students in PISA 2006. The main focus of the assessment was scientific literacy, with mathematics and reading forming the minor assessment domains. This report compared the performance of Australian students with the performance of students in other OECD countries and other participating countries, and presented results for each of the states in the major and minor assessment areas. Results for scientific literacy, as the major domain, have been further reported against the PISA science knowledge domains (*knowledge of science* and *knowledge about science*) and the scientific competencies defined in the framework: *identifying scientific issues, explaining phenomena scientifically* and *using scientific evidence*. Information on student attitudes and beliefs about science has been presented, along with information about the relationships between these factors and student achievement in science.

The report also examined performance within Australia of various subgroups: males and females, Indigenous and non-Indigenous students, students in different geographic locations and from different socioeconomic backgrounds, and students from different language backgrounds.

It is important that Australia has a strong pool of talented scientists to push forward the technological and scientific boundaries – to tackle problems associated with global warming and drought for example. However in terms of human capital in a society strongly dependent on and influenced by science and technology, all citizens, not just those destined to become scientists and engineers, need to be scientifically literate.

PISA in Australia

In Australia, 356 schools and 14,170 students participated in PISA 2006. The Australian students undertook the assessment between late July and early September 2006. Students in Northern Hemisphere countries undertook the assessment a few months earlier to ensure that students in all countries were assessed at around the same stage of their school year. Australia sampled a larger number of students than the minimum required by the international PISA project. This was done for two major reasons:

- Students in the smaller states, and Indigenous students, were oversampled so that reliable estimates could be drawn for each of the individual states and for Indigenous students nationally; and
- The PISA 2006 sample will be used as a cohort of the Longitudinal Surveys of Australian Youth (LSAY). These students will be surveyed in future years about their progress through school and entry into further education and the work force. A large initial sample is needed for LSAY because a proportion of the original sample will lose contact with the project over time.

International performance in scientific, reading and mathematical literacy

Australia's performance in PISA 2006 was significantly higher than the OECD average in each of the three assessment areas: scientific, reading and mathematical literacy. Australia performed very well in science overall, being significantly outscored by only three countries: Finland, Hong Kong-China and Canada, and achieving a similar score to seven other countries, including Japan, New Zealand and the Netherlands. Australia significantly outperformed the remaining 46 countries, including the United Kingdom and the United States. In 2003 three countries also achieved better results than Australia in scientific literacy – Finland, Japan and Korea. In PISA 2000, only Korea and Japan outperformed Australia.

Australia's score was also significantly higher than the OECD average in reading literacy. In PISA 2006, Australia was outperformed by five countries: Korea, Finland, Hong Kong-China, Canada and New Zealand, compared to the previous cycles, in which Finland and Korea significantly outperformed Australia in PISA 2003, and PISA 2000 in which only Finland outperformed Australia[32]. Five countries scored at a similar level to Australia in 2006, and Australia's 2006 score was significantly lower than its score in PISA 2000 and in PISA 2003. This was a result of a decline in scores at the high end of achievement; the national score at the 90th percentile declined by 12 score points between PISA 2000 and PISA 2003 and by a further 16 points between PISA 2003 and PISA 2006. The score at the 75th percentile declined by 8 score points and a further 15 score points between PISA 2000 and 2003 and PISA 2003 and 2006 respectively. There was no compensatory improvement at the lower end of the achievement scale.

Data on reading literacy achievement by state and gender over the period from 2000 to 2006 show that there was a statistically significant decline in the reading literacy performance of females for two states (Northern Territory and Western Australia) between PISA 2003 and PISA 2006 and for Tasmania between PISA 2000 and PISA 2006. There were also significant declines for males in South Australia and the Northern Territory between 2003 and 2006, and in the Northern Territory, New South Wales and South Australia between 2000 and 2006.

In mathematical literacy in 2006, Australia was in a group of six countries with similar levels of achievement. Eight countries significantly outperformed Australia (including Chinese Taipei, which participated in PISA for the first time in PISA 2006), compared to seven countries in PISA 2003. There was no statistically significant difference in Australia's overall mean score between PISA 2003 and PISA 2006, although there were statistically significant declines in the mean scores in three states – Western Australia (by 17 score points), the Northern Territory (by 16 score points) and South Australia (by 14 score points). There was also a significant decline in the average score for females.

It is important that mean scores are not looked at in isolation. Analysis of the international data showed that countries with similar mean scores may have very different profiles of performance and both the profiles and the overall mean score are important for considering policy directions. Based on the content of the PISA assessment measures together with a consideration of students' performances across all of the participating OECD countries, the continuum of increasing scientific literacy was divided into six proficiency levels. Thus six levels of scientific literacy proficiency were defined with descriptions of the scientific competencies associated with each level. In addition to having students grouped by their mean scores, it is also therefore possible to obtain a picture of the skills and knowledge that students at each level typically possess. Reading and mathematical literacy proficiency levels were also developed when these domains were the major assessment domain; there are five proficiency levels defined for reading and six for mathematics.

Level 6 is the highest proficiency level in scientific and mathematical literacy and throughout this report summaries have been made of the proportion of students at Level 5 or 6. For reading literacy Level 5 is the highest proficiency level, and reporting is presented for the proportion of

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[32] These comparisons are made without the Bonferroni correction to be consistent with current OECD reporting.

students at Level 4 or 5. These are the students who do exceptionally well on the PISA assessment, showing facility in interpreting and utilising competencies in real world settings. However, also in each country there were students who were unable to do even the simplest items in the PISA assessment. These students are classified as not reaching Level 1. Three per cent of Australia's students were not achieving at this level in scientific literacy, compared with five per cent in the OECD as a whole. Level 2 has been established by the OECD as a baseline level of proficiency in mathematical and scientific literacy, defining this as the level on the PISA scale at which students begin to demonstrate the competencies that will enable them to participate actively in life situations. Although it has not been officially described as such by the OECD, Level 2 represents a similar baseline proficiency level in reading. As such we have referred to it this way in this report. Summaries will reflect the proportion of students below this OECD baseline.

In scientific literacy, 15 per cent of Australian students achieved a score that placed them in proficiency level 5 or higher, while 13 per cent failed to achieve Level 2. This compares favourably with the OECD averages of nine and 19 per cent respectively. In reading literacy, 11 per cent of Australian students compared to the OECD average of 9 per cent were proficient at Level 5, and 36 per cent of Australian students compared to 30 per cent on average for the OECD were proficient at Level 4 or higher. Around 14 per cent of Australian students compared to an OECD average of 20 per cent did not achieve the baseline proficiency of Level 2. In mathematical literacy, around 16 per cent of Australian students achieved proficiency level 5 or higher, compared with an OECD average of 13 per cent, and 13 per cent of Australian students compared with an OECD average of 21 per cent failed to achieve proficiency level 2. So in all domains, Australia has more students in the higher proficiency levels and fewer in the lower proficiency levels than on average in the OECD.

Performance in the science knowledge domains and scientific competencies

There were two knowledge domains defined in PISA scientific literacy – *knowledge about science* and *knowledge of science*. Australian students scored significantly higher than the OECD average in both domains, scoring 533 points for *knowledge about science* and 528 points for *knowledge of science*, compared to the OECD average of 500. The *knowledge of science* domain can be divided into four content areas, three of which are able to be reported. An overall view of the strengths and weaknesses of students in these areas is valuable for relating the science results to curricula.

Australia performed at a level higher than the OECD average in all three of the PISA knowledge content areas: Earth and space systems, living systems, and physical systems. Physical systems is a relative weakness nationally, with achievement in this domain a significant 12 points lower than the average overall science performance score for Australia. The score for living systems was also relatively lower than the overall average score for scientific literacy, while the score for Earth and space systems was slightly higher than the overall average score.

Australia scored relatively well in two of the three competencies identified in the science framework, *identifying scientific issues* and *using scientific evidence*, but relatively less well in *explaining phenomena scientifically*. A particular area of concern identified through this analysis is the relatively poor performance of students in most states on *explaining phenomena scientifically*, which points to a lack of mastery of scientific knowledge and facts.

Australian students performed very well in the *identifying scientific issues* competency, scoring second only to Finland. This was our strongest competency area, with an average score eight points higher than the overall Australian science average. Australian females, as was the case in almost all participating countries, scored significantly higher than males in this competency.

Australian students demonstrated a relative weakness in the competency *explaining phenomena scientifically*. The average score was seven score points lower than the overall average for science. However, the performance of Australian students in this competency still compared well internationally, with Australian students outperformed by students from only five other countries.

Gender differences internationally were almost all in favour of males, and Australian males outscored their female counterparts by a significant 14 score points.

In the competency, *using scientific evidence*, Australian students performed well. The average score was four points higher than the overall science average, and Australian students were only outperformed by four other countries. There were fewer gender differences in this competency than in the other two, and most were in favour of females. In Australia the gender difference was not significant.

Gender differences

Internationally there was a gender difference in science scores in 20 countries: in 12 countries females outscored males and in eight countries males outscored females. In Australia there was no gender difference apparent in the overall scientific literacy score, but there were some differences in performance in content areas and between the scientific competencies. Australian female students performed at a significantly lower level than Australian male students in both Earth and space systems and physical systems, but at a similar level in living systems. In both areas the average scores for Australian females was significantly higher than the OECD average, but in physical systems the average score for females was not significantly different to the OECD average. Australian males also significantly outscored Australian females in the competency *explaining phenomena scientifically*; however, in the competency *using scientific evidence*, there was no significant gender difference and in *identifying scientific issues* females outscored males.

In reading literacy, gender differences were apparent in all countries, all in favour of females. In Australia the gender difference was 37 score points, which is about the OECD average, and represents about one school year of learning. This is at about the same level as the gender differences in reading in Australia for PISA 2000 (34 score points) and PISA 2003 (39 score points).

In mathematical literacy there were 36 countries with a significant gender difference in favour of males and one (Qatar) in which females outperformed males. In Australia the difference was a significant 14 score points compared to the OECD average of 11 points. The gender difference in Australia, which was not apparent in 2003, is the result of a significant decline in females' scores.

Performance within Australia

This report sets the context for achievement nationally within an international framework. It is useful to be able to benchmark Australian students' achievement against that of students in other countries using a standard instrument and standard procedures. The report also examines the results for each of the states of Australia.

In terms of overall scientific literacy, students in the Australian Capital Territory, Western Australia, New South Wales, South Australia, Queensland and Victoria scored at a level significantly higher than the OECD mean, while the scores of students in Tasmania and the Northern Territory were equivalent with the OECD mean. Students in Western Australia and the Australian Capital Territory achieved the highest mean scores, with students in the Northern Territory achieving a mean score significantly below the mean scores of students in all other states. Students in Western Australia and the Australian Capital Territory also performed at an exceptionally high level in the *identifying scientific issues* competency, scoring at a level statistically similar to students in Finland, the highest achieving country.

Relative strength was measured by comparing the score in a competency with the overall science score. Students from all states other than the Australian Capital Territory performed relatively strongly in the competency area requiring students to identify the problem and other than Tasmania and the Northern Territory in interpreting findings in relation to the real world. All of the states were found to have a relative weakness in the area that requires students to apply their scientific knowledge and theories. This set of findings is consistent with a constructivist way of teaching (which is generally the approach used in science teaching in Australia) in which the focus is more on identifying and interpreting than on learning facts, and consistent with findings from the 1999 TIMSS science video study.

All states achieved a higher proportion of students at Level 5 or above in scientific literacy than the OECD average. The Australian Capital Territory and Western Australia had a similar proportion of students in these two levels as Finland, and 17 per cent of students in New South Wales and 15 per cent of students in South Australia also achieved this very high level of scientific literacy. In the Northern Territory, 13 per cent of students, around one in six, achieved at this proficiency level.

The Australian Capital Territory and Western Australia also had high proportions of students achieving beyond the minimum proficiency levels in scientific literacy: only around one in ten was unable to complete tasks at Level 2. Similar proportions below Level 2 were found also for New South Wales and South Australia, while in Queensland (14%), Victoria (16%) and Tasmania (19%) the proportions were higher. In the Northern Territory, however, more than one-quarter (26%) were unable to complete tasks at Level 2.

In reading literacy, students in the Australian Capital Territory, Western Australia, New South Wales, South Australia, Queensland and Victoria all scored at a level higher than the OECD average, Tasmania's score was not different to the OECD average, and the score for the Northern Territory was significantly lower. In terms of proficiency levels, almost half (46%) of the students in the Australian Capital Territory achieved at Level 4 or Level 5; the proportion in other states with the exception of the Northern Territory ranged from 30 per cent (Tasmania and Victoria) to 40 per cent (Western Australia), while only 23 per cent in the Northern Territory achieved this level. The Australian Capital Territory and Western Australia had the lowest proportions of students not attaining proficiency level 2 (10% in each state), compared to the Northern Territory in which 29 per cent failed to attain this level. In other states the proportion ranged from 12 per cent in South Australia to 19 per cent in Tasmania. The OECD average was 20 per cent not achieving proficiency level 2.

In mathematical literacy the Australian Capital Territory was the highest achieving Australian state, with a score not significantly different to that of Chinese Taipei, the highest scoring country. Students in Western Australia also achieved at a level significantly higher than the Australian average. Other than Tasmania and the Northern Territory, all of the other states scored significantly higher than the OECD average – the score for Tasmania was not significantly different from the OECD average, while that for the Northern Territory was significantly lower than the OECD average. The Northern Territory's score was also significantly lower than that of all of the other states. In the Australian Capital Territory around one-quarter of students and in Western Australia just over 20 per cent of students achieved at least proficiency level 5. Most states did well in terms of proportions of students above the minimum proficiency levels. The Australian Capital Territory had the lowest percentage of students who did not achieve Level 2, and for most other states this proportion was between 11 and 14 per cent of students. Tasmania and the Northern Territory had the highest percentage of students who had not achieved proficiency level 2 with 18 and 25 per cent respectively. The OECD average was 21 per cent not achieving proficiency level 2.

Performance of equity groups

The performance level of Indigenous students is an enduring concern. In PISA 2006, Indigenous students' performance in scientific literacy was found to be the equivalent of 86 score points (which is equivalent to one full proficiency level, or two and a half years of formal schooling) below that of non-Indigenous students on the overall scientific literacy scale. In reading literacy the average score of Indigenous students was 81 score points below that of non-Indigenous students. In mathematical literacy, Indigenous students scored an average 80 points lower than their non-Indigenous counterparts. In all three domains Indigenous students are under-represented in the higher proficiency levels and over-represented in the lower proficiency levels.

The difference in achievement levels between students attending metropolitan schools and those attending schools in remote locations is large: students in metropolitan schools scored 57 score points higher in scientific literacy, 50 score points higher in reading literacy and 58 score points higher in mathematical literacy. Students attending schools in provincial areas also performed at a lower level than those attending schools in metropolitan areas; however, these differences were not as large as those between remote and metropolitan areas.

Socioeconomic background was found to be closely related to achievement in all three domains. In scientific literacy students in the lowest quartile of socioeconomic background scored significantly lower than those in the next highest quartile, and the difference between those in the highest and lowest socioeconomic quartiles was 87 score points – representing about two and a half school years of formal schooling. Furthermore, almost one-quarter of students in the lowest socioeconomic quartile were not achieving at proficiency level 2, compared with just five per cent of those in the highest socioeconomic quartile. In reading literacy the difference in scores between students in the highest and lowest quartiles was 84 points and in mathematical literacy 79 points. In terms of proportion of students failing to reach the baseline proficiency levels, 23 per cent of students in the lowest quartile compared to just 5 per cent of students in the highest quartile did not achieve Level 2 in reading literacy, and 22 per cent and five per cent of students respectively did not achieve Level 2 in mathematical literacy.

There were no significant differences in the mean scores in scientific literacy for Australian-born, first-generation or foreign-born students; however, a much larger proportion of students with a language background other than English was found to be achieving below Level 2, and a much smaller percentage performing at Level 5 or greater. In reading literacy, foreign-born students and those with a language background other than English were found to be achieving similar scores to those born in Australia; however, a larger proportion of students with a different language background were failing to achieve at proficiency level 2 (20% compared to 12% of English-speaking students). Otherwise, the proportion of students at each proficiency level in reading literacy was almost identical for Australian-born, foreign-born and first-generation students. In mathematical literacy, Australian-born students scored at a level significantly lower than either foreign-born or first-generation students, and the proportion of students achieving at least Level 5 was higher for foreign-born and first-generation students than for Australian-born students.

Beliefs and motivation

One of the aims of schooling is to engender an underlying love of learning, so that all students leave school competent, confident and willing to undertake further learning. In science in particular, in addition to student performance, important outcomes for students are their attitudes to science, their confidence in handling scientific tasks and demonstrating strong scientific abilities, their interest in learning science at and beyond school, and their motivation to pursue a science-related course or career. Information on student attitudes and motivations was collected through the student questionnaire and also through embedded attitudinal items in the cognitive assessment.

Australian students had higher levels of self-efficacy in science than the OECD average. There were significant gender differences in Australia, with males scoring significantly higher than females; however, both were higher than the OECD average.

Students from New South Wales had the highest levels of self-efficacy in science. Students in the Australian Capital Territory, Western Australia, South Australia and the Northern Territory had higher levels of self-efficacy in science that were slightly higher than the OECD average, while students in Victoria, Tasmania and Queensland had means that were slightly lower than the OECD average. Males from all states showed higher levels on the self-efficacy in science index than females. The largest gender differences were found in Western Australia and Victoria, with differences of approximately 0.25 points. There was a large positive relationship between self-efficacy in science and scientific literacy performance for Australian students. Students in the highest quartile scored 130 points on average higher than students in the lowest quartile on the self-efficacy in science index, which is equivalent to almost four years of schooling or almost two proficiency levels on the scientific literacy scale.

The average for Australia for self-concept in science was –0.03, which was not significantly different to the OECD average. There was a significant gender difference in Australia, with males generally more confident in science than the OECD mean for males, while females were on average less confident than the OECD mean for females. Western Australia had a mean score that was just higher than the OECD mean; all other states scored below the OECD average, indicating lower levels of self-concept in science than students on average in OECD countries. The largest gender differences were in the Northern Territory and Western Australia. Self-concept in science has a moderately strong positive relationship with scientific literacy performance. There were 113 points on average between students in the highest quartile of the self-concept in science index and students in the lowest quartile.

In general for Australian students there was a positive association between scientific literacy performance and most of the constructs. An exception to this was optimism regarding environmental issues, where students with high levels of optimism about future environmental issues scored lower than students with low levels of optimism.

Significant gender differences were found for all indices in Australia except in the index of general interest in learning science and the index of instrumental motivation in science, where no significant gender differences were found. The significant gender differences were all in favour of males, except for the indices related to responsibility for sustainable development and concern for environmental issues, where they were in favour of females.

Socioeconomic background

As noted above, PISA 2006 results showed that socioeconomic background was again closely related to achievement in all three domains.

Socioeconomic background was also found to have a moderate to strong relationship with most of the attitudinal constructs defined, and most particularly with self-efficacy and environmental awareness. In general, students from higher socioeconomic levels held more positive views about themselves as learners of science, were more interested in scientific issues, were more likely to pursue a career in a science-related field, and were more environmentally aware.

The preceding chapter of this report examined questions of equity and quality in the performance of students and schools. In Australia there is little institutional variation: most of the variance in scientific literacy scores is due to differences within schools. These results are similar to those found in PISA 2000 and PISA 2003 in reading and mathematical literacy respectively.

To examine equity the OECD uses the extent to which social background relates to student and school performance, using the measure of economic, social and cultural status (ESCS). Socioeconomic gradients describe graphically the relationship between ESCS and student performance in terms of the strength of the relationship, the slope of the gradient line (indicating the extent of inequality), the average level of the line (indicating how well the overall population has achieved), and the length of the line (indicating the range of ESCS).

The strength of the relationship between socioeconomic background and scientific literacy was found to be significantly weaker for Australia than for the OECD on average, but the slope of the gradient is significantly higher than for the OECD. The slope shows that the relationship between socioeconomic levels and scores in scientific literacy is stronger for Australia, so that each additional unit of socioeconomic background translates into 43 score points compared to 40 for the OECD. However, the strength of the relationship is weaker than for the OECD, only explaining around 11 per cent of the variance compared to 14.5 per cent over the OECD.

The socioeconomic gradients for Australia for science, reading and mathematics were compared with each other. The slopes were very similar, with just a slightly lower impact of socioeconomic background on mathematics achievement than either science or reading literacy.

The socioeconomic gradient for each country can be broken down into a within-school gradient and a between-school gradient. The within-school gradient describes how a student's socioeconomic background is related to their performance within a common school environment. The between-school gradient describes how schools' average level of performance is related to the average socioeconomic background of their student intake.

This analysis found that for almost all countries, including Australia, there is a clear advantage in students attending a school in which the average socioeconomic background is high. A student from an average socioeconomic background attending a school with a higher than average socioeconomic background results in an advantage of almost one full school year over a similar student attending a school with lower than average socioeconomic background. The effect of the average ESCS of students in a school outweighs the effect of the student's own socioeconomic background.

A country's average performance in a domain can be contrasted with the strength of the relationship between socioeconomic background and performance, with the latter relationship being used as a proxy for equity in the distribution of learning opportunities. Australia was characterised as high performance but low equity in PISA 2000 in reading literacy, and as high performance and high equity in PISA 2003 in mathematical literacy. In 2006, scientific literacy in Australia is again high performance and high equity. Among the states, New South Wales, Western Australia, South Australia, Queensland and Victoria also demonstrated a below-average impact of socioeconomic background on performance and an above average performance in science, placing these states in the high performance-high equity quadrant.

Policy issues

The approach to assessing scientific literacy used in PISA differs from more traditional assessments in which mastery of science content is tested. Instead, the PISA assessment focuses on students' ability to extrapolate from what they have learned and to apply their knowledge and skills in novel situations. This focus reflects the recognition amongst educators that globalisation and computerisation are changing labour markets and societies, and that a different set of skills will be needed by those entering such markets. The greatest decline in jobs over the past decade has not been in manual labour, but in tasks that are described as routine cognitive tasks – those that can easily be done at less cost by computer. Students preparing for the work force of the future will need to be able to solve problems for which there are no clear solutions, and to be able to communicate their ideas effectively.

Australia is well placed to continue its tradition of producing high quality scientists. The average score in scientific literacy is significantly higher than the OECD average, and either statistically similar to, or significantly higher than, most trading partners and other countries to which we would usually compare ourselves. Fifteen per cent of our young people scored in the top two proficiency levels, comparing favourably internationally.

The 'gap' in achievement between the best and the weakest students varies by subject domain. In science, there is a relatively wide gap, narrower than that of the United States and the United Kingdom, but wider than the OECD average and that of most other countries. In reading and mathematical literacy, however, it is narrower than the OECD average and also narrower than the spread for 60 per cent of the other countries in reading and for 70 per cent of the other countries in mathematics.

Analysis of Australia's performance in terms of equity and achievement places us in the category of above-average level of student performance and below-average impact of socioeconomic background in scientific literacy; in other words, high quality and high equity. In terms of the slope and strength of the association between socioeconomic background and achievement in science, both have decreased significantly since PISA 2003. Australia's outcomes have become more equitable, as shown by a flatter gradient, and less deterministic, as shown by the smaller proportion of variance explained by socioeconomic background. In reading literacy, the slope and strength have also significantly declined, while in mathematics only the strength of the relationship has decreased. However, the increase in equity in reading literacy may be an artefact of declining achievement in the higher levels rather than because achievement at the bottom end has improved.

Australia's results in scientific, reading and mathematical literacy are laudable. However, average scores do not paint the complete picture of a country's performance, and that has been the primary aim of this report. There are a number of areas in which Australia's performance is not as good as would be hoped.

Decline in reading achievement

The results from the first three cycles of PISA indicate that the performance levels of Australian students, while comparing reasonably well internationally, are generally not improving. TIMSS 2003 found that scores in science at Year 8 had improved significantly; however, this improvement in scores has not really translated to an improvement in scientific literacy in the manner in which it is presented in PISA. There had also been no evidence previously of any decline in performance, but the PISA 2006 results now point to a significant decrease in performance in reading literacy since PISA 2000. While some caution should be exercised in interpreting these results, as reading literacy was only assessed as a minor domain in PISA 2006, there is evidence of a decline in performance primarily at the upper end of the achievement scale without any compensatory improvement at the lower end. The decline was found for both male and female students. While there is no evidence of any decrease in overall achievement levels in mathematical or scientific literacy, there was a significant decline in the mathematics achievement of Australian females.

PISA 2009 will provide the first opportunity to measure achievement in reading literacy from major domain to major domain.

Gender

In terms of gender, there was no difference overall in scientific literacy; however, males performed significantly better than females in both *Earth and space systems* and *physical systems*, and while the performance of females in the first two areas was higher than the OECD average, for the latter females scores were not different to the OECD average. In reading literacy the gender gap continued to favour females, and there is no evidence of any significant gains being made by males to close the gap. Around 19 per cent of males, compared to 8 per cent of females, failed to achieve the baseline of proficiency level 2 for reading.

In the PISA 2003 assessment, gender differences in favour of males in mathematics were evident in a large number of countries; however, this was not the case in Australia, and it was noted that "Australia seems to have been able to contain [the] widening of gender disparity with age in mathematics" (Thomson et al., 2004, p. 32). However in PISA 2006, there is evidence of a decline in the scores of 15-year-old females and no associated decline in the score for males, resulting in a significant gender difference and one that is higher than the OECD average. The decline in scores for females appears to have come from the higher end of achievement; 18 per cent of females achieved at Level 5 or 6 in 2003, compared to 13 per cent in 2006. For males the corresponding proportions were 22 per cent and 20 per cent respectively.

The performance of males in reading literacy relative to females has not improved, and there is now a gender difference in mathematics in favour of males that has not existed for many years. Perhaps gender needs to be reconsidered as an issue for Australian education.

Indigenous students

The achievement of Australia's Indigenous students continues to be a concern. Average scores for Indigenous students place them on a par with students in a country such as Chile, one of the lower performing countries, and two and a half years behind the average for their non-Indigenous contemporaries. While some individual Indigenous students performed very well on the PISA assessment, with 15 per cent achieving at least proficiency level 4 in science, less than four per cent, compared with 15 per cent of non-Indigenous students, achieved at Level 5 or 6. At the other end of the achievement spectrum, 40 per cent of Indigenous students (compared to 12% of non-Indigenous) in science, 45 per cent of Indigenous students (compared to 7% of non-Indigenous) in reading, and 33 per cent of Indigenous students (compared to 12% of non-Indigenous) in mathematics are failing to achieve the baseline proficiency set by the OECD. There is no doubt that many Indigenous students will continue to need extra support.

Students attending schools in remote locations

The relatively poor performance of students attending schools in remote areas is also evident from these analyses, and requires further investigation. Students attending schools in remote areas were found to be achieving at a level about a year and a half lower than their counterparts in metropolitan schools in all of the assessment areas. It is recognised that schools in remote areas face problems such as attracting and retaining qualified teachers, maintaining services and providing resources, and in their capacity to send staff to participate in professional development, which may impinge on the quality of student outcomes.

Students and schools with low socioeconomic levels

This report also examined differences in achievement by quartiles of socioeconomic background. Students in the lowest socioeconomic quartile scored, on average, two and a half years lower than students in the highest socioeconomic quartile, across all three domains. Of the students in the lowest socioeconomic quartile around one-quarter failed to achieve the baseline proficiency levels in scientific, reading or mathematical literacy. Few achieved the highest levels in any domain.

Achievement differences in Australia are much larger within schools than they are between schools. However, the discussion of the PISA findings in scientific literacy in Chapter 7 indicates that the average socioeconomic background of a school outweighs a student's own socioeconomic background, and that the impact of schooling is greatest for students from disadvantaged backgrounds or those attending schools with a low average socioeconomic background.

Nevertheless, students from low SES backgrounds are a diverse group encompassing the full range of learning abilities. They can and do achieve high standards.

In conclusion

Students who are confident in their own abilities and well motivated tend to do better at school. Positive approaches not only help to explain student performance but also are themselves important outcomes of education. Students who have become effective learners by the time they leave school, and particularly those who have learned to regulate their own learning, are often considered more likely to learn throughout life.

Australia remains committed to the principle of equity and social justice in education, to the goal of allowing and encouraging all children to fulfil their full educational potential. This is articulated in detail in the National Goals for Schooling in the 21st Century (MCEETYA, 1999) to which all governments are committed.

To a large extent, these goals are realised; evidenced by the high average achievement levels in all three assessment domains in PISA. However, there is some evidence from this cycle that Australia appears to be standing still while other countries improve their levels of performance. This report has also shown that behind the higher than average scores, significant levels of educational disadvantage exist in Australia, and that the gap between students of the same age can be equivalent to several years of schooling. This gap places an unacceptable proportion of 15-year-old students at serious risk of not achieving levels sufficient to allow them to adequately participate in the 21st century work force and contribute as a productive citizen.

> Looking back, such disadvantage at school can be seen to be strongly linked to disadvantage at home. Looking forward, it may be predicted that the disadvantage is likely to perpetuate itself through educational under-achievement and a greater likelihood of economic marginalisation and social exclusion.
>
> (UNICEF, 2002, p. 3)

Educational inequality is not a given. Some schools, some school systems, and some countries do more to mitigate inequality than others. Using PISA to monitor national outcomes on a regular basis provides Australian educators at all levels with the opportunity to step back and see where we stand in terms of educational outcomes.

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Appendix

1

PISA's Procedures

To assist readers to understand the scope and operations of PISA, a brief account of some of its procedures is provided in this Appendix. A thorough account will be available in 2008 in the Technical Report of the project. Most of the operational procedures have both international and national components.

Information on how PISA operated internationally and implementing the assessment in 2006 is given first, followed by details of its implementation in Australia.

PISA internationally

International consortium

PISA 2006 was implemented through an international consortium managed by the Australian Council for Educational Research (ACER). Other members are the Netherlands National Institute for Educational Measurement (CITO), Westat Inc. in the United States, and the National Institute for Educational Policy Research (NIER) in Japan.

Collaborative development

PISA is an international assessment that has been jointly developed by the OECD's participating countries. Through their National Project Managers (NPM) and National Advisory Committees (NAC), countries have been able to contribute to the survey by providing sample assessment material to the consortium and offering comment on many aspects of the project to the international bodies described below – Network A, the PISA Governing Board and Functional Expert Groups.

The OECD set up several networks to undertake specific tasks relating to PISA. Network A focuses on educational outcomes and is responsible for the *Education at a Glance* project. Network A's work during the mid-1990s led to the development of the initial specifications for PISA.

Each OECD country taking part in PISA has one member, usually from an education ministry, as a representative on the PISA Governing Board (PGB). This group sets the policy objectives of the assessment and the policy priorities for the implementation of the survey. This includes endorsing the assessment frameworks, approving the bank of items developed for the assessment, and agreeing to the plans for international reporting of results. The PGB also considers advice from the PISA Technical Advisory Group (TAG) on technical aspects of design; for example, concerning the balance of multiple choice and open-ended items, the number of assessment booklets, and the design for rotation of material in the assessment booklets. Aspects such as these require the PGB's endorsement.

The three Subject Matter Expert Groups (SMEGs) for PISA 2006 consisted of subject matter and technical experts from participating countries. Each assessment domain – that is, each of mathematical, scientific and reading literacy – had its own SMEG. These groups, together with the TAG, linked the policy objectives specified by the PGB with expertise in the field of international comparative assessment, to provide input into the frameworks for the assessment and to monitor the quality of assessment items prepared. The expert groups typically contain between eight and ten members each. The members are not intended to represent countries as such, but rather to provide a cross-section of the world's most renowned experts in each area. A smaller group of consultants assisted with the PISA 2006 questionnaire development. All of these groups provide advice and recommendations to the consortium, and, through the consortium, to the PGB.

Operational stages

Very high standards are set for sampling, assessment materials and operational procedures in PISA to ensure that the data will be comparable across countries. Many of the operational steps are briefly referred to here. More detail is provided later on how the various procedures worked in Australia.

Framework and item review

The development of the assessment frameworks has been a continuous effort since the inception of PISA. In PISA 2006, an expanded framework for the assessment of scientific literacy as a major domain was undertaken. The assessment framework was circulated for comment, with the aim of reaching consensus on the nature and detail of the assessment domains. Similarly, drafts of assessment items were sent to each country, for review by local experts. Countries had the opportunity to provide feedback and suggestions on the items, which were then revised and subjected to a Field Trial. The reading and mathematical literacy frameworks remained essentially the same for PISA 2006.

Field Trial

The Field Trial was an instrumental part of the study, not only to refine the assessment materials but also to try out the operational procedures. Internationally, many thousands of students took part, including approximately 1,200 from Australia. Twelve assessment booklets were used, as practice for the Main Study, and there were four questionnaire forms in order to achieve a greater coverage of material than would be possible in one form. The Field Trial took place from March to June 2002.

Main Study

For most countries, the PISA Main Study was administered between March and August 2006. For many northern hemisphere countries, where the academic year begins in September and ends in June, the assessment was conducted between March and the end of the academic year. For countries in the southern hemisphere, that typically have an academic year extending from early February until December, the assessment was conducted between mid-May and the end of August.

Within the majority of countries, between 4,000 and 9,000 students were tested. In a few small countries, such as Iceland, Liechtenstein, and Luxembourg, the whole cohort of age-eligible schools and students was assessed. In some countries, the sample size was increased so that regions could be adequately represented (e.g. Italy, Spain and the United Kingdom), sub-national comparisons made (e.g. Mexico, Indonesia and Belgium), or to combine PISA with another national study (e.g. Australia and Canada). Details of the Field Trial and Main Study in Australia are provided later in the Appendix. The remainder of this section describes some of the more technical features of PISA's assessment design.

Design aspects

Assessment booklets

In PISA 2006, a pen-and-paper-based assessment was prepared in booklet style. Both 'closed' and 'open-ended' assessment items were used. Closed items have only one correct answer and open-ended items require students to construct their own response. Open-ended items allow a wider range of skills to be assessed.

Each PISA assessment task takes the form of some stimulus material followed by a series of questions (items) relating to the material. The stimulus material and its associated items are called a 'unit'. For both the Field Trial and the Main Study, each unit in the pool is allocated to a test cluster. The clusters typically contain about four units and are designed to take 30 minutes to complete. In PISA 2006 there were seven scientific literacy clusters, four mathematical literacy clusters and two reading literacy clusters.

Use of such a design allows a large amount of material to be covered, with different students completing different combinations of the items. The booklets were allocated to students in turn, from a random starting point in each school.

Questionnaires

As well as the assessment booklets, there were two context questionnaires. Principals each completed a School Questionnaire and students each completed a Student Questionnaire. These were designed to enable analysis of achievement data in relation to different backgrounds, living conditions, educational programs and other factors that might have an impact on performance.

As well as gathering information about students and their family background, academic environments and self-regulated learning, the Student Questionnaire also included optional sections to assess Educational Career Paths and Familiarity with Information Technology. These optional components were placed at the end of the Student Questionnaire. There was also an opportunity for countries to include additional items of national interest. In Australia, questions for LSAY were included as a national option.

Ensuring a high quality assessment

Quality monitoring is an integral part of PISA, and the implementation of checking procedures within all components and stages of the survey have ensured that PISA has produced data of a very high standard. The quality monitoring procedures have been reviewed and endorsed by the PGB.

The International Project Centre (IPC), set up by the lead member of the consortium, ACER, was designed to manage the implementation of PISA internationally. Staff of the IPC were always available to give advice to countries as requested. They continuously monitored countries' progress and were proactive in offering assistance with procedures if this seemed to be warranted.

Translation procedures

Experts in translation procedures ensured that translated materials were as equivalent in meaning and level of complexity as possible. Translation of the assessment booklets, questionnaires and manuals involved extensive and thorough processes. Materials from the IPC were provided to countries in both English and French. In countries where the language is neither English nor French, the countries were required to translate the assessment materials separately from both versions. A reconciliation of these independent translations then took place at country level and the resulting translation was then reviewed by the team of tri-lingual verifiers working for the IPC.

Sampling procedures

Ensuring the quality of sampling in PISA was the responsibility of Westat. A senior staff member was appointed to be the International Sampling Referee for the project. A team of sampling experts at Westat and ACER employed rigorous procedures for the random selection of schools and students to represent their country. Countries were assisted in the preparation of a series of sampling forms, including the school sampling frame 'i.e. the list of all schools containing students in the PISA target population'. Countries were required to use the KeyQuest software developed by the consortium for the selection of the student sample within schools. Stringent criteria for adequate response rates were specified at the school and student level. Participating countries agreed to meet the international criteria for response rates; otherwise their data could not be included fully in reports. The sampling procedures helped to ensure that the data would be of a high standard, so that valid comparisons of results between countries could be made.

Test administration procedures

Criteria for Test Administrators were set internationally. It was required that the Test Administrator not be the reading, mathematics, or science instructor of any students in the sessions he or she would be administering. It was further recommended that the Test Administrator not be a member of the staff of any school where he or she would be administering PISA, nor of any school in the PISA sample. These criteria were set partly to minimise the burden on schools, but mostly to establish PISA as a valid and unbiased assessment with uniformly administered test sessions.

Standardised administration procedures were developed by the consortium and were brought together in a Test Administrator's Manual. Comprehensive training sessions were held covering administration procedures, both for the Field Trial and again for the Main Study. Training sessions were held firstly for National Project Managers (NPMs) or their designated staff, who were then responsible for training the Test Administrators in their country. In that way it was hoped that standardised administration of the PISA tests could be achieved.

Monitoring of procedures

The IPC set up a two-stage process of monitoring the implementation of PISA in each country. Prior to the Main Study, National Centre Quality Monitors (NCQMs), one per country, visited the national centres responsible for implementing PISA. The NCQMs were drawn from staff of the various consortium members. They travelled to each of the PISA countries to ensure that procedures were being followed correctly in national centres and to offer assistance if this seemed needed. This process was also carried out during the Main Study.

A second kind of monitor was used during the Main Study. These monitors, known as PISA Quality Monitors (PQMs), were nominated by national project teams, but were employed by and worked on behalf of the consortium. They were not allowed to be connected in any way to a National Centre. PQMs were used to observe testing sessions to ensure that testing procedures were being implemented according to the specifications in the Test Administrator's Manual. They were trained nationally in PISA's procedures by the visiting NCQM (see above) and then went to a subset of schools, unannounced, during the assessment sessions.

Coding of responses to open-ended items

Approximately 40% of items from each of the three domains (scientific, reading and mathematical items) were open-ended, necessitating coding. Standardised Coding Guides were developed by consortium staff and reviewed by PISA national project staff before being finalised. In countries where languages other than English or French were used, these Guides had to be translated and the translations verified by the consortium (double translations were not required, however). The same approach to training coders was used as for Test Administrators, in that NPMs or their designated staff first attended international training sessions and then trained the coders in their country.

Reliability studies were carried out to ensure that coders were applying the criteria consistently, and to quantify any variation between coders. Monitoring of consistency in applying the coding criteria was required to be done on a daily basis so that systematic errors could be corrected. In the Main Study, four coders in each country were required to code all of the items in their subject area from 100 each of four assessment booklets. A cross-national study of coder reliability was also undertaken. Within a country, 180 booklets (60 of each of three booklet types) that had already been coded four times were sent to be coded a fifth time by an experienced coder in another same-language country. These data were collected to ensure the reliability of coding across PISA.

Data entry procedures

Another step in ensuring the high quality of PISA data was the provision to countries of specially developed software for entering and validating data. It was important that data were submitted to the IPC in a standard format so that they could readily be combined into a single international data set. Many data cleaning procedures were carried out before data were considered to be ready for analysis.

PISA nationally

Project management

A National Project Manager (NPM) is appointed by each participating country to ensure that the survey is implemented according to the international timeline and that all duties are carried out according to the specified procedures and standards. NPMs play a role in evaluating survey results in a national context and a large role in ensuring the operational success of the survey in their country. Countries are encouraged by the OECD to set up one or more committees, to monitor the progress of the project, to assist with reviewing materials, and to provide a forum for discussion of issues of implementation at the national level. In Australia, a National Advisory Committee (NAC) guides all aspects of the project. The Committee's members are from many areas of Australian education and include subject matter experts to advise the NPM and the national PGB representative on the content and methods of the assessment. Each of the state and territory Education Departments has a representative on the NAC.

The Committee's involvement in policy decisions relating to international and national options, commenting on frameworks, and providing input into assessment materials and dissemination of results, ensures that any issues of concern in Australia are not overlooked by the consortium. Members are listed at the front of this book, immediately prior to the first chapter.

Item review

Members of the NAC reviewed items for their relevance and appropriateness for Australian 15-year-old students.

Field Trial

In Australia, the Field Trial took place during early-May to mid-June 2005. A summary of its scope is presented here.

In addition to PISA, Australia participated in the international option of the Computer Based Assessment of Science (CBAS) to assess students' scientific literacy skills and knowledge using a computer-based assessment. The computer assessment was undertaken on lap top computers, which were brought in by Test Adminstrators. An additional 20 students were randomly selected to take part in CBAS. The format of the assessment was similar to the PISA assessment, except the assessment session involved students participating in both a paper-based assessment and a computer-based assessment, which took one hour each to complete. All CBAS students completed the Student Questionnaire.

Schools

The selection of schools for the Field Trial was much less rigorous than school sampling for the Main Study. Schools were chosen by convenience, and were representative of schools from a range of communities and socioeconomic areas. In all, 40 Australian schools from four states – New South Wales, Victoria, Queensland and South Australia – took part in the Field Trial.

Students

The target population for the Field Trial was 'students born between 1 February 1989 and 31 January 1990'. The School Contact was asked to provide a list of all age-eligible students, regardless of year level. In accordance with the international sampling manual, ACER staff randomly selected 50 students from each school. For the PISA assessment, of the approximately 1,900 age-eligible students selected, 1,400 students participated in the PISA Field Trial. For the CBAS assessment, about 500 students participated in the computer-based assessment out of approximately 750 students.

Adaptations to manuals, assessment booklets and questionnaires

Minimal adaptations for Australia were required to the administrative manuals, Coding Guides, assessment booklets and questionnaires. Amendments to assessment booklets, such as vocabulary, were submitted to and approved for use by the IPC.

Test administration

Each student was asked to complete an assessment booklet (consisting of multiple choice and open-ended items) and a questionnaire. Two hours plus administration time were required for the assessment booklet and about 30 minutes required for the questionnaire. There was provision for a short break to be taken after students had worked on their assessment booklet for an hour, and a break of five to 10 minutes to be taken before starting the questionnaire. A total of 15 experienced teachers were employed by ACER to conduct the Field Trial sessions. Half of the test administrators were involved with the PISA assessment, while the other half was involved with the CBAS assessment. Training of test administrators took place at the ACER offices in Melbourne and Sydney in mid-April 2005.

Coding

Almost half of the field trial items were open-ended and required coders to code the students' responses to the scientific literacy items. Training of the coding procedures using internationally prepared Coding Guides was conducted during mid-June and involved eight experienced coders. The coding process also included multiple coding from three assessment booklets, as specified internationally.

Data entry

All data were entered using KeyQuest, the specially developed software provided to national centres by the IPC.

Main Study

Assessment dates in Australia

In Australia, the Main Study assessment took place from late July to early September, 2006.

Schools and students

Full details of the Australian school and student samples are presented in Appendix 2, and hence are not included here. Australia satisfied the international response rate criteria fully, with 98.9 per cent of the selected schools and 86.3 per cent of the selected students taking part.

Obtaining the school sample

PISA was included as part of the National Assessment Program in 2006. Liaison officers were appointed from state and territory Education Departments, Catholic Education Offices and Associations of Independent Schools to inform schools that they had been randomly selected to participate in PISA. Schools were approached in late November 2005 and were sent an information package about PISA.

Response rates and the sampling of students are discussed in Appendix 2.

Contact persons in schools

Participating schools were asked to nominate an experienced staff member to take on the role of PISA School Contact. School Contacts assisted by making administrative arrangements for the assessment session in their school – for example, setting the date for the session, finding a room in which the session could be conducted, arranging for lists of age-eligible students to be sent to the national centre, and so on.

National options

Countries were permitted to introduce additional aspects of national relevance into PISA, subject to approval from the IPC. Australia chose to include optional material to the Student Questionnaire, as described in the following paragraphs.

Additional questionnaire items

Information was sought on Indigenous origin and time spent in a range of out-of-school activities. The questions on language spoken at home and on parents' and respondent's countries of birth were adapted in the Australian questionnaire. It was felt, for example, that responses to the international format question of 'Were you born in Australia?' (Yes/No) would not be accurate as an indication of ethnic background.

One quarter of the Student Questionnaire was devoted to questions related to LSAY. Students were asked about courses at school, plans after secondary school, and work experience. Students were also asked to complete their contact details so they could be contacted to follow their career and educational pathways.

Test Administrators

Forty-three Test Administrators external to the schools administered all test sessions. All were employed by ACER on a casual basis and most had also been involved in previous PISA cycles. All were highly experienced, trained teachers, many of whom were also experienced in conducting test sessions according to standardised procedures.

All Test Administrators attended full-day training sessions, which were held in Melbourne, Sydney, Perth, Adelaide and Brisbane during June 2006. The sessions were highly useful – to establish a sense of common purpose among the diverse group of Test Administrators, especially for those who had not met each other before; to ensure that they were appropriately briefed for conducting the sessions; and to apportion the test sessions and establish travelling schedules in what was a complex logistical operation.

Scheduling of sessions: logistics

The assessment booklets and questionnaires were mostly administered in a single morning session, except in a handful of schools where the test took place in the morning and the questionnaire session took place in the afternoon. The amount of time required was about three hours, arranged the same way as in the Field Trial.

A muesli bar snack was provided for each student during the break between the assessment booklet and the questionnaire. Students were allowed to talk to each other during the breaks, though they were asked not to talk about the assessments.

Altogether, 356 regular and 120 follow-up testing sessions took place. Assessment sessions were mostly carried out in classrooms, although the school library, the school hall, or areas such as common or meeting rooms or the computer room were also used as an assessment venue.

Coding processes

Eighteen mathematical/scientific literacy coders and five reading literacy coders were used for the whole duration of the coding. All coders were experienced secondary teachers, not currently teaching. The coders were trained in the use of the Coding Guide, with the initial training session beginning in late August, two weeks before the end of the testing. The coding rotation developed by the IPC enabled all three literacy domains to be coded simultaneously using different assessment booklets.

Following the procedures specified by the IPC, coding was done by clusters rather than by booklet. Before a new cluster was started, further training and practice on the new clusters was carried out. Within clusters, coding was done by item. The specified procedures for randomly allocating booklets to coders were followed.

Two mathematical and scientific literacy table leaders[33] and one reading literacy table leader were used to field queries from individual coders, to review with individual coders any issues that needed to be drawn to their attention, to document difficulties that needed resolution from the NPM or the IPC, and to monitor the coding process generally.

The coding across all domains was completed in approximately six weeks. In addition to improved Coding Guides, revised after the Field Trial, the expertise and experience of the table leaders ensured that the work progressed well.

Data entry

Up to eleven operators were used to enter the assessment data from the booklets and the multiple coding sheets, and the questionnaire data. All data were entered in approximately seven weeks, using KeyQuest. Checking and cleaning steps, which took a further two to three weeks, were then undertaken prior to the Australian data being sent to the IPC.

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[33] Very experienced coders.

Ensuring quality in national operations

Monitoring of operations and procedures was built into every stage of PISA in Australia, from the selection of the school and student samples, initiating and maintaining contact with schools, through to the preparation of materials, printing, packing, mailing, receiving and tallying returns. Other aspects of quality assurance included the detailed training of Test Administrators in the internationally laid-down procedures, and the training and monitoring of coders and the entry of data.

PISA Quality Monitors, on behalf of the IPC, visited a sample of 15 Australian schools when the testing was taking place to ensure that procedures were followed accurately and instructions were adhered to.

Appendix

2 Sampling

Australian sampling results

Sampling in PISA was carried out in two stages in most countries, including Australia. First, schools were selected with a probability proportional to enrolment size of 15-year-olds. Thus, large schools had a greater chance than small schools of being selected.

Internationally, the minimum required sample for each country was 150 schools and 4,500 students. In Australia, a larger sample was drawn to enable results to be reported by State and Territory and for Indigenous students, and for PISA 2006 to become a cohort of the Longitudinal Surveys of Australian Youth (LSAY) 2006. Table A2.1 gives the details of the Australian sample design.

Table A2.1 Designed PISA school sample by state and sector

State	Sector			Total
	Catholic	Government	Independent	
NSW	8	15	3	26
VIC	20	50	13	83
QLD	12	35	11	58
SA	11	38	10	59
WA	8	27	9	44
TAS	8	24	9	41
NT	5	25	5	35
ACT	4	16	7	27
TOTAL	76	230	67	373

Stratification variables used in Australia when selecting the sample were state and sector (government, Catholic and independent).[34] School geographic location (as described in the Reader's Guide) was also taken into account in the sampling.

Following PISA procedures, schools were randomly selected with probability proportional to estimated enrolment size of PISA age-related students within strata, using the latest available data in ACER's sampling frame. To define the PISA population, estimates of the numbers of 15-year-olds were made by sector within each state, from information obtained from each State and Territory Education Department and previous PISA data on the proportion of 15-year-old students. Permission was granted from the International Sampling Referee to exclude a number of categories of schools from the sample. These included hospital and correctional schools, distance education

[34] The stratum codes for sector were necessary for accuracy of sampling. They are not used for reporting purposes in PISA 2006 and are not included in the PISA databases.

schools, remote off-shore and very remote mainland schools, and schools instructing in a language other than English. In addition, institutions in the Technical and Further Education (TAFE) sector were also excluded, because there was a very small percentage of 15-year-olds enrolled.

Achieved Sample

Main Sample

Of the 373 schools sampled for PISA 2006, 16 schools were not eligible and therefore not included in the school sample (on the basis there were two or fewer age-eligible students[35], or the school had closed). An additional two schools chose not to participate. One of the schools was undergoing extensive construction work (making it difficult to hold an assessment that would involve 50 students) and the replacement school participated in PISA.

PISA was included as part of the National Assessment Program in 2006 and the support provided by schools produced the highest school response rate in any PISA cycle. In all, 356 schools participated in the study (including one replacement school). The achieved Australian PISA school sample is included as Table 1.1 in Chapter 1.

The 356 schools represented a weighted response rate of 98.9 per cent and the weighted student participation rate after replacement was 86.3 per cent. Both these figures met the international standards on response rates as specified by the Technical Advisory Group.

Special Indigenous sample

The National Advisory Committee again recommended a process of oversampling Indigenous students to reliably report results for this minority group in PISA 2006. To achieve this, all age-eligible Indigenous students in the sampled PISA schools were invited to participate in the survey.

All age-eligible Indigenous students were sampled by inviting any additional Indigenous students if they had not been sampled within the initial sampling of 50 students per school, resulting in 1,080 Indigenous students participating in PISA 2006.

Absentees

Of the eligible students participating in PISA, 2,307 students were absent on the day of the assessment session. Overall, the absentee rate was 12.9 per cent. Of the sampled students, the Northern Territory had the highest absentee rate of 20.6 per cent while Victoria and New South Wales had the lowest, at 11.4 and 11.3 per cent respectively. The number of students who were absent on the day of the assessment are shown by state in Table A2.2.

Table A2.2 Non-participation in Australia by state

	Absentees	Refusals	Exclusions	Other
NSW	462	80	44	109
VIC	315	66	28	71
QLD	424	50	37	156
SA	283	51	53	112
WA	236	14	21	175
TAS	192	34	20	86
NT	237	20	6	119
ACT	158	37	26	42
TOTAL	2307	352	235	870

[35] Schools with two or fewer students are considered ineligible and do not participate in PISA.

Refusals

In addition to the students who were absent from school, there were 352 whose parents refused permission for them to participate, or they chose themselves to refuse. The Student Tracking Form did not distinguish between parent and student refusal. These students constituted two per cent of the sampled students, considerably lower than the six per cent from the PISA 2003 study. This lower rate could partially be explained by PISA becoming part of the national testing program from the 2006 study. The lowest refusal rate was less than one per cent in Western Australia, with the highest rate of three per cent in the Australian Capital Territory. The details are listed in Table A2.2.

Exclusions

In all, there were 235 students excluded by the School Contact from the PISA assessment. In PISA 2003, 25 students were excluded on the basis of a functional disability (exclusion 1); 168 students were excluded because of an intellectual disability (exclusion 2), and 42 students were excluded because of language (exclusion 3). Exclusions at student level accounted for fewer than two per cent of the designed sample. Students with exclusions were spread throughout the country (Table A2.2).

Exclusion categories used were equivalent to those in the international PISA manual, though with wording changed to reflect current terminology in Australia.

The three types of exclusion were:

1 = Functional disability – student has a moderate to severe permanent physical disability

2 = Intellectual disability – student has a mental or emotional disability and has either been tested as cognitively delayed or is considered in the professional opinion of qualified staff to be cognitively delayed

3 = Limited assessment language experience – student is not a native speaker of any of the languages of the assessment in the country and has limited proficiency in these languages

Other non-participants

Table A2.2 shows there was also a group of 870 students who were eligible and selected to participate in the survey, but who had left school before the testing, had transferred to another school, were temporarily suspended from the school, or were age ineligible. (The number of not applicable students may have been fewer had some schools provided current school lists of their eligible students).

International sampling results

Internationally, the desired minimum number of students to be assessed per country was specified as 4,500. Some countries, including Australia, sampled more students so that language groups or regions within the country could be adequately represented. In small countries, such as Iceland, Liechtenstein and Luxembourg, the whole cohort of age-eligible students was assessed.

Table A2.3 PISA 2006 target populations and samples

	Population and Sample Information				
	Total population of 15-year-olds	Total enrolled population of 15-year-olds at grade 7 or above	Total in national desired target population	Total school-level exclusions	Total in national desired target population after all school exclusions and before within-school exclusions
	(1)	(2)	(3)	(4)	(5)
Argentina	662 686	579 222	579 222	2 393	576 829
Australia	270 115	256 754	255 554	1 371	254 183
Austria	97 337	92 149	92 149	401	91 748
Azerbaijan	139 119	139 119	131 235	780	130 455
Belgium	124 943	124 557	124 216	2 957	121 259
Brazil	3 390 471	2 374 044	2 357 355	0	2 357 355
Bulgaria	89 751	88 071	88 071	1 733	86 338
Canada	426 967	428 876	424 238	5 141	419 097
Chile	299 426	255 459	255 393	2 284	253 109
Chinese Taipei	334 391	318 691	318 691	2 972	315 719
Colombia	897 477	543 630	543 630	2 814	540 816
Croatia	54 500	51 318	51 318	548	50 770
Czech Republic	127 748	124 764	124 764	1 124	123 640
Denmark	66 989	65 984	65 984	1 871	64 113
Estonia	19 871	19 623	19 623	569	19 054
Finland	66 232	66 232	66 232	1 257	64 975
France	809 375	809 375	777 194	19 397	757 797
Germany	951 535	1 062 920	1 062 920	6 009	1 056 911
Greece	107 505	110 663	110 663	640	110 023
Hong Kong-China	77 398	75 542	75 542	678	74 864
Hungary	124 444	120 061	120 061	3 230	116 831
Iceland	4 820	4 777	4 777	16	4 761
Indonesia	4 238 600	3 119 393	2 983 254	9 388	2 973 866
Ireland	58 667	57 648	57 510	50	57 460
Israel	122 626	109 370	109 370	1 770	107 600
Italy	578 131	639 971	639 971	16	639 555
Japan	1 246 207	1 222 171	1 222 171	16 604	1 205 567
Jordan	138 026	126 708	126 708	0	126 708
Korea	660 812	627 868	627 868	3 461	624 407
Kyrgyzstan	128 810	94 922	92 109	1 617	90 492
Latvia	34 277	33 659	33 534	932	32 602
Liechtenstein	422	362	362.00	0	362
Lithuania	53 931	51 808	51 761	613	51 148
Luxembourg	4 595	4 595	4 595	0	4 595
Macao-China	8 835	6 648	6 648	6	6 642
Mexico	2 200 916	1 383 364	1 383 364	0	1 383 364
Montenegro	9 190	8 973	8 973	155	8 818
Netherlands	197 046	193 769	193 769	57	193 712
New Zealand	63 800	59 341	59 341	451	58 890
Norway	61 708	61 449	61 373	412	60 961
Poland	549 000	546 000	546 000	10 400	535 600
Portugal	115 426	100 816	100 816	0	100 816
Qatar	8 053	7 865	7 865	0	7 865
Romania	341 181	241 890	240 661	2 943	237 718
Russian Federation	2 243 924	2 077 231	2 077 231	43 425	2 033 806
Serbia	88 584	80 692	80 692	1 811	78 881
Slovak Republic	79 989	78 427	78 427	1 355	77 072
Slovenia	23 431	23 018	23 018	228	22 790
Spain	439 415	436 885	436 885	3 930	432 955
Sweden	129 734	127 036	127 036	2 330	124 706
Switzerland	87 766	86 108	86 108	2 130	83 978
Thailand	895 924	727 860	727 860	7 234	720 626
Tunisia	153 331	153 331	153 331	0	153 331
Turkey	1 423 514	800 968	782 875	970	781 905
United Kingdom	779 076	767 248	767 248	12 879	754 369
United States	4 192 939	4 192 939	4 192 939	19 710	4 173 229
Uruguay	51 119	40 815	40 815	97	40 718

Population and Sample Information							Coverage Indices		
Percentage of all school-level exclusions	Number of participating students	Weighted number of participating students	Number of excluded students	Weighted number of excluded students	Within-school exclusion rate (%)	Overall exclusion rate (%)	Coverage Index 1: Coverage of national desired population	Coverage Index 2: Coverage of national enrolled population	Coverage Index 3: Coverage of 15-year-old population
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
0.41	4 339	523 048	4	636	0.12	0.53	0.99	0.99	0.79
0.54	14 170	234 940	234	2 935	1.23	1.76	0.98	0.98	0.87
0.43	4 927	89 925	94	1 586	1.73	2.16	0.98	0.98	0.92
0.59	5 184	122 208	0	0	0.00	0.59	0.99	0.94	0.88
2.38	8 857	123 161	28	401	0.32	2.70	0.97	0.97	0.99
0.00	9 295	1 875 461	19	6 438	0.34	0.34	1.00	0.99	0.55
1.97	4 498	74 326	0	0	0.00	1.97	0.98	0.98	0.83
1.21	22 646	370 879	1 681	20 339	5.20	6.35	0.94	0.93	0.87
0.89	5 235	233 526	28	1 259	0.54	1.43	0.99	0.99	0.78
0.93	8 815	293 513	21	922	0.31	1.24	0.99	0.99	0.88
0.52	4 478	537 262	2	541 743	0.03	0.55	0.99	0.99	0.60
1.07	5 213	46 523	38	382	0.81	1.87	0.98	0.98	0.85
0.90	5 932	128 827	8	203	0.16	1.06	0.99	0.99	1.01
2.84	4 532	57 013	170	1 960	3.32	6.07	0.94	0.94	0.85
2.90	4 865	18 662	50	23 580	1.10	3.97	0.96	0.96	0.94
1.90	4 714	61 387	135	1 650	2.62	4.47	0.96	0.96	0.93
2.50	4 716	739 428	28	3 876	0.52	3.00	0.97	0.93	0.91
0.57	4 891	903 512	37	6 017	0.66	1.22	0.99	0.99	0.95
0.58	4 873	96 412	65	1 397	1.43	2.00	0.98	0.98	0.90
0.90	4 645	75 145	1	21	0.03	0.93	0.99	0.99	0.97
2.69	4 490	106 010	31	1 103	1.03	3.69	0.96	0.96	0.85
0.33	3 789	4 624	95	96	2.04	2.37	0.98	0.98	0.96
0.31	10 647	2 248 313	0	0	0.00	0.31	1.00	0.95	0.53
0.09	4 585	55 114	93	59 792	1.67	1.76	0.98	0.98	0.94
1.62	4 584	93 347	72	1 339	1.41	3.01	0.97	0.97	0.76
0.00	21 773	520 055	363	8 984	1.70	1.70	0.98	0.98	0.90
1.36	5 952	1 113 701	0	0	0.00	1.36	0.99	0.99	0.89
0.00	6 509	90 267	73	1 042	1.14	1.14	0.99	0.99	0.65
0.55	5 176	576 669	4	625	0.11	0.66	0.99	0.99	0.87
1.76	5 904	80 674	42	521	0.64	2.39	0.98	0.95	0.63
2.78	4 719	29 232	26	33 980	0.44	3.21	0.97	0.96	0.85
0.00	339	353	3	3	0.84	0.84	0.99	0.99	0.84
1.18	4 744	50 329	28	264	0.52	1.70	0.98	0.98	0.93
0.00	4 567	4 733	193	9 493	3.92	3.92	0.96	0.96	1.03
0.09	4 760	6 417	0	0	0.00	0.09	1.00	1.00	0.73
0.00	30 971	1 190 420	49	1 221 440	0.27	0.27	1.00	1.00	0.54
1.72	4 455	7 734	0	0	0.00	1.72	0.98	0.98	0.84
0.03	4 871	189 576	7	227	0.12	0.15	1.00	1.00	0.96
0.76	4 823	53 398	222	58 443	3.84	4.58	0.95	0.95	0.84
0.67	4 692	59 884	156	1 764	2.86	3.51	0.96	0.96	0.97
1.90	5 547	515 993	18	1 685	0.33	2.22	0.98	0.98	0.94
0.00	5 109	90 079	112	95 300	2.05	2.05	0.98	0.98	0.78
0.00	6 265	7 271	3	3	0.04	0.04	1.00	1.00	0.90
1.22	5 118	223 887	0	0	0.00	1.22	0.99	0.98	0.66
2.09	5 799	1 810 856	60	20 576	1.12	3.19	0.97	0.97	0.81
2.24	4 798	73 907	6	78 713	0.12	2.36	0.98	0.98	0.83
1.73	4 731	76 201	11	193	0.25	1.98	0.98	0.98	0.95
0.99	6 595	20 595	45	27 236	0.48	1.46	0.99	0.99	0.88
0.90	19 604	381 686	557	401 848	2.65	3.52	0.96	0.96	0.87
1.83	4 443	126 393	122	3 471	2.67	4.46	0.96	0.96	0.97
2.47	12 193	89 651	186	842	0.93	3.38	0.97	0.97	1.02
0.99	6 192	644 125	5	353	0.05	1.05	0.99	0.99	0.72
0.00	4 640	138 491	2	52	0.04	0.04	1.00	1.00	0.90
0.12	4 942	665 477	1	130	0.02	0.14	1.00	0.98	0.47
1.68	13 152	732 004	229	12 033	1.62	3.27	0.97	0.97	0.94
0.47	5 611	3 578 040	254	142 517	3.83	4.28	0.96	0.96	0.85
0.24	4 839	36 011	5	39	0.11	0.34	1.00	1.00	0.69

Population coverage

All countries attempt to maximise the coverage of eligible 15-year-old students in their national sample. According to the PISA sampling standards, countries are permitted to exclude a total of five per cent of the total relevant population either by excluding schools or by excluding students within schools.

Table A2.3 describes the target population of the countries participating in PISA 2006. Further information on the target population and the implementation of PISA sampling standards can be found in the *PISA 2006 Technical Report* (OECD, forthcoming).

- **Column 1** shows the **total number of 15-year-olds** according to the most recent available information, which in most countries was the year 2005 as the year before the assessment.
- **Column 2** shows the number of 15-year-olds enrolled in schools in Grades 7 or above, that is referred to as the **eligible population**.
- **Column 3** shows the **national desired target population**. As part of the school-level exclusions, countries were allowed to exclude up to 0.5 per cent of students a priori from the eligible population, essentially for practical reasons.
- **Column 4** shows the number of students enrolled in schools that were excluded from the national desired target population, either from the sampling frame or later in the field during data collection.
- **Column 5** shows the size of the national desired target population after subtracting the students enrolled in excluded schools. This is obtained by subtracting Column 4 from Column 3.
- **Column 6** shows the percentage of students enrolled in excluded schools. This is obtained by dividing Column 4 by Column 3 and multiplying by 100.
- **Column 7** shows the **number of students participating in PISA 2006**. Note that this number does not account for 15-year-olds assessed as part of additional national options.
- **Column 8** shows the **weighted number of participating students**, i.e. the number of students in the nationally defined target population that the PISA sample represents.
- **Column 9** indicates the total number of **excluded students**. Each country attempted to maximise the coverage of PISA's target population within the sampled schools. In the case of each sampled school, all eligible students, namely those 15 years of age, regardless of grade, were first listed. Sampled students who were to be excluded had still to be included in the sampling documentation, and a list drawn up stating the reason for their exclusion.
- **Column 10** indicates the **weighted number of excluded students**, i.e. the overall number of students in the nationally defined target population represented by the number of students excluded from the sample.
- **Column 11** shows **the percentage of students excluded within schools**. This is calculated as the weighted number of excluded students (Column 10) divided by the weighted number of excluded and participating students (Column 8 plus Column 10) then multiplied by 100.
- **Column 12** shows the **overall exclusion rate**, which represents the weighted percentage of the national desired target population excluded from PISA either through school-level exclusions or through the exclusion of students within schools. It is calculated as the school-level exclusion rate (Column 6 divided by 100) plus within-school exclusion rate (Column 11 divided by 100) multiplied by 1 minus the school-level exclusion rate (Column 6 divided by 100).
- **Column 13** presents an index of the **extent to which the national desired target population is covered by the PISA sample**.
- **Column 14** presents an index of the **extent to which 15-year-olds enrolled in schools are covered by the PISA sample**. The index measures the overall proportion of the national enrolled population that is covered by the non-excluded portion of the student sample. The

index takes into account both school-level and student-level exclusions. Values close to 100 indicate that the PISA sample represents the entire education system as defined for PISA 2000. The index is the weighted number of participating students (Column 8) divided by the weighted number of participating and excluded students (Columns 8 plus Column 10), times the nationally defined target population (Column 5) divided by the eligible population (Column 2) national desired target population (times 100).

- **Column 15** presents an index of the **coverage of the 15-year-old population**. This index is the weighted number of participating students (Column 8) divided by the total population of 15-year-old students (Column 1).

Sampling procedures and response rates

The accuracy of any survey results depends on the quality of the information on which national samples are based as well as on the sampling procedures. Quality standards, procedures, instruments, and verification mechanisms were developed for PISA that ensured that national samples yielded comparable data and that the results could be compared with confidence. Statistics in this report are, however, associated with standard errors that reflect the uncertainty associated with sample survey statistics. Where confidence intervals are provided, these indicate that the true value is, in 95 out of 100 replications of the study, within the interval indicated. Experts from the PISA International Consortium monitored the sample selection process in each participating country.

Data quality standards in PISA required minimum participation rates for schools as well as for students. These standards were established to minimise the potential for response biases. In the case of countries meeting these standards, it is likely that any bias resulting from non-response will be negligible, i.e. typically smaller than the sampling error.

A minimum response rate of 85 per cent was required for the schools initially selected. Where the initial response rate of schools was between 65 and 85 per cent, however, an acceptable school response rate could still be achieved through the use of replacement schools. This procedure brought with it a risk of increased response bias. Participating countries were, therefore, encouraged to persuade as many of the schools in the original sample as possible to participate. Schools with a student participation rate between 25 and 50 per cent were not regarded as participating schools, but data from these schools were included in the database and contributed to the various estimations. Data from schools with a student participation rate of less than 25 per cent were excluded from the database.

PISA 2006 also required a minimum participation rate of 80 per cent of students within participating schools (original sample). This minimum participation rate had to be met at the national level, not necessarily by each participating school. Follow-up sessions were required in schools in which too few students had participated in the original assessment sessions. Student participation rates were calculated over all original schools, and over all schools whether original sample or replacement schools, and from the participation of students in both the original assessment and any follow-up sessions.

Appendix

3 Highlights from PISA 2000 and PISA 2003

This appendix provides readers with a brief background on Australia's results from PISA 2000 and PISA 2003[36]. Australia's results are reported for the country as a whole, along with the highest performing country, as well as the performance of Australian students by gender, across states and for selected student subgroups.[37]

Figures within brackets refer to the standard error for the associated mean score. Means provided are in score points on the relevant PISA scales.

PISA 2000: Scientific literacy

Internationally

- Australia achieved a mean performance score of 528 (3.5) for scientific literacy in PISA 2000 and was outperformed by two countries – Korea with a mean score of 552 (2.7), and Japan with a mean score of 550 (5.5). (The Bonferroni correction was used in this cycle.[38])
- Australia's performance was equivalent to that of six countries: Finland; the United Kingdom; Canada; New Zealand; Austria; and Ireland. Australia performed significantly higher than 22 other countries.
- There were no gender differences for Australian students, consistent with the international trend with only seven countries showing significant gender differences. The OECD average for females and males was the same at 501 (0.8 and 0.9 respectively).

Nationally – performance by State and gender

- Within Australia, the Australian Capital Territory had the highest mean score of 553 (5.9), while the Northern Territory had the lowest mean score of 490 (7.6).
- None of the mean scores were significantly different by gender in any state.

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36 Further details on PISA 2000 and PISA 2003 can be found in the International and National reports, listed in the Reference section.

37 It is not possible to solely use the mean scores and standard errors in this appendix to determine if there is statistical difference between PISA cycles as comparisons cannot be compared without taking into account a linking error.

38 Throughout this appendix, results at the international level have been reported with or without the Bonferroni correction, and are in keeping with what the OECD has reported. In PISA 2000, the OECD reported mean performance between countries with the Bonferroni correction. In PISA 2003, the OECD reported mean performance between countries both with and without the Bonferroni correction.

Nationally – performance of specific groups within Australia

- The performance of Indigenous students was significantly lower compared to non-Indigenous students with mean scores of 448 (5.5) and 529 (1.9) respectively.
- There was a significantly higher mean performance in science for students whose main language was English, with a mean of 534 (1.8) compared with students whose main language spoken at home was not English, with a mean score of 497 (5.1).
- Results on geographic location in PISA 2000 were based on relative remoteness and on distance and access to services and facilities. Using the ARIA Plus classification, students who attended schools in major cities of Australia achieved a mean score of 532 (4.8) compared to students who attended schools in remote or very remote areas, with a mean score of 481 (10.4).

PISA 2003: Scientific literacy

Internationally

- Australia's mean performance score for scientific literacy in PISA 2003 was 525 points (2.1).
- With the Bonferroni correction used, three countries outperformed Australia (Finland, Japan and Korea), while Australia outperformed 28 other countries including France, Ireland and the United States. Eight countries: Hong Kong-China; Liechtenstein; Macao-China; the Netherlands; the Czech Republic; New Zealand; Canada; and Switzerland had similar achievements in mean scores. Without the Bonferroni correction being applied, an additional country (Hong Kong-China) outperformed Australia, while Australia in turn outperformed an additional two countries (Canada and Switzerland).
- Australia, along with 24 other countries, showed no significant gender differences in performance in science. The OECD average for females was 497 points (0.8) and for males the mean score was 503 points (0.7).

Nationally – performance by State and gender

- Within Australia, the Australian Capital Territory had the highest mean score of 553 (4.7), whilst the Northern Territory had the lowest mean score of 495 (5.8).
- Gender differences were not statistically significant in any of the states.
- Indigenous students achieved a mean score of 434 (7.7), which was significantly lower than that of non-Indigenous students who achieved a mean of 527 (2.0).
- Students whose home language was English achieved a mean score of 529 (2.0), compared to those students whose home language was not English, who achieved a mean score of 505 (6.1).
- Performance scores were significantly higher for students attending schools in metropolitan areas than in provincial and remote schools, with mean scores of 529 (2.6), 516 (4.2) and 486 (6.8) respectively.

PISA 2000: Reading literacy

Internationally

- Australia achieved a mean score of 528 (3.5) and was outperformed by only one country, Finland, with a mean of 546 (2.6).
- Australia's performance was equivalent to that of eight other countries: Canada; New Zealand; Ireland; Korea; the United Kingdom; Japan; Sweden; and the United States. Twenty-one

countries performed significantly lower than Australia. (The Bonferroni correction was used in this cycle.)

- Twelve per cent of Australian students performed below Level 2, compared with seven per cent in Finland and 18 per cent across all OECD countries. Forty-three per cent of Australian students achieved at Level 4 or Level 5, compared with half the students from Finland and 32 per cent across all OECD countries.
- Females from all countries performed significantly higher than males. The mean for Australian females was 546 points (4.7) and for Australian males the mean was 513 points (4.0), compared to the OECD average for females and males of 517 points (0.7) and 485 points (0.8) respectively.

Nationally – performance by State and gender

- The Australian Capital Territory had the highest mean score of 552 (4.6), while the Northern Territory had the lowest mean score of 489 (5.6).
- For the Australian Capital Territory, 11 per cent of students scored below Level 2 but 51 per cent scored at Level 4 or higher, compared with 23 per cent and 30 per cent for the Northern Territory respectively.
- All states and territories except the Australian Capital Territory had significantly higher performance scores for females than males.

Nationally – performance of specific groups within Australia

- The mean score for Indigenous students was 448 (3.1), significantly lower than the mean score for non-Indigenous students, whose mean score was 531 (1.8). Thirty-five per cent of Indigenous students had a proficiency level below Level 2, compared with 12 per cent of non-Indigenous students. Fifteen per cent of Indigenous students performed at least at Level 4, compared to 45 per cent of non-Indigenous students.
- Students for whom English was the main language spoken at home scored significantly higher than those with a language background other than English. The mean score for the former group was 535 (1.8) and the mean score for the latter group was 506 (4.1). Eleven per cent of students whose main language at home was English scored below Level 2, and 46 per cent of students scored at Level 4 and above, compared with 18 per cent of students below Level 2 and 33 per cent of students at Level 4 and above for those who use another language.
- Using the ARIA Plus classification, students in major cities achieved a mean score of 541 (4.8) compared to a mean score of 495 (8.8) for those students located in remote or very remote areas of Australia.

PISA 2003: Reading literacy

Internationally

- Australia's mean score was 525 (2.1) in the 2003 study and with the Bonferroni correction applied Finland was again the only country to outperform Australia, with a mean score of 543 (1.6). Five countries (Korea, Canada, Liechtenstein, New Zealand and Ireland) performed at equivalent levels to Australia. Thirty-three countries performed significantly lower than Australia.
- When the Bonferroni correction was not applied, Korea also outperformed Australia, with a mean score of 534 (3.1). Only three countries (Canada, Liechtenstein and New Zealand) performed at an equivalent level of performance, and 34 countries performed at a lower level.
- Females performed significantly higher than males (with an OECD average of 511 [0.7] and 477 [0.7]), a consistent finding in all countries with the exception of Liechtenstein where no

difference was found. The mean score for Australian females was 545 (2.6) and for Australian males 506 (2.8).

- Twelve per cent of Australian students performed below Level 2 compared to the OECD average of 19 per cent and six per cent of Finnish students, while 42 per cent of Australian students performed at Level 4 or Level 5 compared to the OECD average of 30 per cent and 38 per cent of Finnish students.

Nationally – performance by State and gender

- Australian Capital Territory students again showed the highest performance with a mean score of 549 (6.0), with eight per cent of students performing below Level 2, while 52 per cent performed at Level 4 and above.
- Northern Territory students showed the lowest average performance with a mean score of 496 (6.1), with 20 per cent of students performing below Level 2, while 33 per cent of students performed at Level 4 and above.
- Females consistently performed significantly better in all states and territories.

Nationally – performance of specific groups within Australia

- Indigenous students had a mean score of 444 (8.6), with 38 per cent below Level 2, and 15 per cent at Level 4 or above. Non-Indigenous students in comparison had a mean score of 527 (2.0), with 11 per cent below Level 2 and 42 per cent at Level 4 or above.
- Australian-born students had the highest mean score of 529 (2.2), compared to first-generation students with a mean score of 525 (4.6), and foreign-born students with a mean score of 517 (5.0). Twelve per cent of Australian-born students did not achieve a proficiency of Level 2 compared to 13 per cent of first-generation students and 14 per cent of foreign-born students. Forty-three per cent of Australian-born students achieved at proficiency of Level 4 or Level 5 compared to 41 per cent of first-generation students and 39 per cent of foreign-born students.
- Students living in metropolitan areas had the highest mean score with a mean of 530 (2.6), compared with a mean score of 514 (4.6) for provincial students and a mean score of 489 (7.5) for students in remote areas.

PISA 2000: Mathematical literacy

Internationally

- Australia achieved a mean score of 533 (3.5) and was outperformed by only one country, Japan, with a mean of 557 (5.5).
- Australia's performance was equivalent to that of eight other countries: Korea; New Zealand; Finland; Canada; Switzerland; the United Kingdom; Belgium; and Liechtenstein. Australia significantly outperformed 21 other countries on mathematics literacy. (The Bonferroni correction was used in this cycle.)
- Although 16 countries had significant differences between the performance of females and males, there were no significant differences found between Australian females and males. The OECD average for females was 495 (0.9) and for males the mean score was 506 (1.0).

Nationally – performance by State and gender

- Within Australia, the Australian Capital Territory students had the highest mean score of 548 (6.2) for mathematics, while the Northern Territory had the lowest mean score of 502 (6.7).
- None of the mean scores were significantly different by gender in any state.

Nationally – performance of specific groups within Australia

- Indigenous students achieved a mean score of 449 (5.3), which was significantly lower than that of non-Indigenous students who achieved a mean score of 535 (1.9).
- Those students who had English as the main language at home achieved a mean score of 537 (2.0), which was significantly higher than that of students whose main language at home was not English, who achieved a mean score of 522 (4.0).
- Based on the ARIA Plus classification, students in major cities achieved a mean score of 537 points (4.4) compared to a mean score of 514 points (11.8) for those students located in remote or very remote areas of Australia.

PISA 2003: Mathematical literacy

Internationally

- Australia's mean performance of 524 points (2.1) in the PISA 2003 study meant that when the Bonferroni correction was used, four countries (Hong Kong-China, Finland, Korea and the Netherlands) had significantly higher mean scores. When the Bonferroni correction was not applied, three additional countries (Lichtenstein, Japan and Canada) also outperformed Australia. There were 26 countries (27 without Bonferroni correction) that were outperformed by Australia, while countries such as New Zealand, Switzerland and Belgium showed equivalent scores.
- Twenty-one per cent of students across all OECD countries did not achieve Level 2, while 15 per cent of students achieved at Level 5 or Level 6.
- There was no difference in performance between males and females in Australia, defying the trend of 27 countries where scores for females were lower than for males. The OECD average for females was 488 (0.8) and 505 (0.8) for males.

Nationally – performance by State and gender

- Students in the Australian Capital Territory had the highest mean score of 548 (3.5), while those in the Northern Territory had the lowest mean score of 496 (4.9).
- There were no significant gender differences by state.
- Within Australia, 14 per cent of students performed below Level 2, whilst 20 per cent performed at Level 5 and above.
- Eleven per cent of students from the Australian Capital Territory performed below Level 2 and 27 per cent of students performed at Level 5 and above. In the Northern Territory, 22 per cent of students performed below Level 2 and 15 per cent performed at Level 5 and above.

Nationally – performance of specific groups within Australia

- Indigenous students had a mean score of 440 (5.4), with 43 per cent below Level 2, and five per cent at Level 5 or above. This compared to non-Indigenous students who had a mean score of 526 (2.1), with 14 per cent below Level 2 and 20 per cent at Level 5 and above.
- Australian-born students had the highest mean score of 527 (2.1), followed by foreign-born students who had a mean score of 525 (4.9), and then first-generation students who had a mean score of 522 (4.7).
- Students who spoke English at home achieved a mean score of 529 (2.0) compared to students who spoke a language other than English at home with a mean score of 505 (6.1).
- Students attending schools in metropolitan areas achieved a mean score of 528 (2.5), which was significantly higher than the mean for students attending schools in provincial or remote areas whose mean scores were 515 (4.4) and 493 (9.6) respectively.

Appendix 4

Statistical Tables

The data referred to in this report and presented in Figures and Tables are available as online documents from the ACER PISA National website (http://www.acer.edu.au/ozpisa/reports.html).

The international multiple comparison tables are included in this appendix.

Table A4.1: Multiple comparisons of mean performance on the scientific literacy scale

Scientific literacy scale	Mean	S.E.	Finland	Hong Kong-China	Canada	Chinese Taipei	Estonia	Japan	New Zealand	Australia	Netherlands	Liechtenstein	Korea	Slovenia	Germany	United Kingdom	Czech Republic	Switzerland	Macao-China	Austria	Belgium	Ireland	Hungary	Sweden	Poland	Denmark	France	Croatia	Iceland	Latvia	United States	Slovak Republic	Spain	Lithuania	Norway	Luxembourg	Russian Federation	Italy	Portugal	Greece	Israel	Chile	Serbia	Bulgaria	Uruguay	Turkey	Jordan	Thailand	Romania	Montenegro	Mexico	Indonesia	Argentina	Brazil	Colombia	Tunisia	Azerbaijan	Qatar	Kyrgyzstan
Mean			563	542	534	532	531	531	530	527	525	522	522	519	516	515	513	512	511	511	510	508	504	503	498	496	495	493	491	490	489	488	488	488	487	486	479	475	474	473	454	438	436	434	428	424	422	421	418	412	410	393	391	390	388	386	382	349	322
S.E.			(2.0)	(2.5)	(2.0)	(3.6)	(2.5)	(3.4)	(2.7)	(2.3)	(2.7)	(4.1)	(3.4)	(1.1)	(3.8)	(2.3)	(3.5)	(3.2)	(1.1)	(3.9)	(2.5)	(3.2)	(2.7)	(2.4)	(2.3)	(3.1)	(3.4)	(2.4)	(1.6)	(3.0)	(4.2)	(2.6)	(2.6)	(2.8)	(3.1)	(1.1)	(3.7)	(2.0)	(3.0)	(3.2)	(3.7)	(4.3)	(3.0)	(6.1)	(2.7)	(3.8)	(2.8)	(2.1)	(4.2)	(1.1)	(2.7)	(5.7)	(6.1)	(2.8)	(3.4)	(3.0)	(2.8)	(0.9)	(2.9)
Finland	563	(2.0)	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	542	(2.5)	▼	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	534	(2.0)	▼	▼	■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	532	(3.6)	▼	▼		■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	531	(2.5)	▼	▼			■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	531	(3.4)	▼	▼				■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	530	(2.7)	▼	▼					■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	527	(2.3)	▼	▼	▼					■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	525	(2.7)	▼	▼	▼						■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	522	(4.1)	▼	▼	▼							■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	522	(3.4)	▼	▼	▼	▼	▼						■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	519	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	516	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼				■								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	515	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼					■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	513	(3.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼						■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	512	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	511	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	511	(3.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	510	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	508	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	504	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼				■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	503	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼			■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	498	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	496	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	495	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	493	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	491	(1.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	490	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	489	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	488	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	488	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	488	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	487	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	486	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	479	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼				■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	475	(2.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	474	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	473	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	454	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	438	(4.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	436	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	434	(6.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	428	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■			▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Turkey	424	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Jordan	422	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Thailand	421	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Romania	418	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■			▲	▲	▲	▲	▲	▲	▲	▲
Montenegro	412	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■		▲	▲	▲	▲	▲	▲	▲	▲
Mexico	410	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■	▲	▲	▲	▲	▲	▲	▲	▲
Indonesia	393	(5.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■						▲	▲
Argentina	391	(6.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■					▲	▲
Brazil	390	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■			▲	▲	▲
Colombia	388	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■			▲	▲
Tunisia	386	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■		▲	▲
Azerbaijan	382	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▼			■	▲	▲
Qatar	349	(0.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■	▲
Kyrgyzstan	322	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■

▲ Mean performance statistically significantly higher than in comparison country
☐ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average

Table A4.2: Multiple comparisons of mean performance on the *identifying scientific issues* scale

Identifying scientific issues scale	Mean	S.E.	Finland	New Zealand	Australia	Netherlands	Canada	Hong Kong-China	Liechtenstein	Japan	Korea	Slovenia	Ireland	Estonia	Belgium	Switzerland	United Kingdom	Germany	Chinese Taipei	Austria	Czech Republic	France	Sweden	Iceland	Croatia	Denmark	United States	Macao-China	Norway	Spain	Latvia	Portugal	Poland	Luxembourg	Hungary	Lithuania	Slovak Republic	Italy	Greece	Russian Federation	Israel	Chile	Serbia	Uruguay	Turkey	Bulgaria	Mexico	Thailand	Romania	Jordan	Colombia	Montenegro	Brazil	Argentina	Indonesia	Tunisia	Azerbaijan	Qatar	Kyrgyzstan
Mean			555	536	535	533	532	528	522	522	519	517	516	516	515	515	514	510	509	505	500	499	499	494	494	493	492	490	489	489	489	486	483	483	483	476	475	474	469	463	457	444	431	429	427	427	421	413	409	409	402	401	398	395	393	384	353	352	321
S.E.			(2.3)	(2.9)	(2.3)	(3.3)	(2.3)	(3.2)	(3.7)	(4.0)	(3.7)	(1.4)	(3.3)	(2.6)	(2.7)	(3.0)	(2.3)	(3.8)	(3.7)	(3.7)	(4.2)	(3.5)	(2.6)	(1.7)	(2.6)	(3.0)	(3.8)	(1.2)	(3.1)	(2.4)	(3.3)	(3.1)	(2.5)	(1.1)	(2.6)	(2.7)	(3.2)	(2.2)	(3.0)	(4.2)	(3.9)	(4.1)	(3.0)	(3.0)	(3.4)	(6.3)	(2.6)	(2.5)	(3.6)	(2.8)	(3.4)	(1.2)	(2.8)	(5.7)	(5.6)	(3.8)	(3.1)	(0.8)	(3.2)
Finland	555	(2.3)		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	536	(2.9)	▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	535	(2.3)	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	533	(3.3)	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	532	(2.3)	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	528	(3.2)	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	522	(3.7)	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	522	(4.0)	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	519	(3.7)	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	517	(1.4)	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	516	(3.3)	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	516	(2.6)	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	515	(2.7)	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	515	(3.0)	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	514	(2.3)	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	510	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	509	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	505	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	500	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	499	(3.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	499	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	494	(1.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	494	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	493	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	492	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	490	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	489	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	489	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	489	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	486	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	483	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	483	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	483	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	476	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	475	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	474	(2.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	469	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	463	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	457	(3.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	444	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	431	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	429	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Turkey	427	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	427	(6.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Mexico	421	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Thailand	413	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				▲	▲	▲	▲	▲	▲	▲	▲	▲
Romania	409	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲
Jordan	409	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲
Colombia	402	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲
Montenegro	401	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲
Brazil	398	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲
Argentina	395	(5.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲
Indonesia	393	(5.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲
Tunisia	384	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				▲	▲	▲
Azerbaijan	353	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▲
Qatar	352	(0.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▲
Kyrgyzstan	321	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	

▲ Mean performance statistically significantly higher than in comparison country
☐ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average

Table A4.3: Multiple comparisons of mean performance on the *explaining phenomena scientifically* scale

Explaining phenomena scientifically scale			Finland	Hong Kong-China	Chinese Taipei	Estonia	Canada	Czech Republic	Japan	Slovenia	New Zealand	Netherlands	Australia	Macao-China	Germany	Hungary	United Kingdom	Austria	Liechtenstein	Korea	Sweden	Switzerland	Poland	Ireland	Belgium	Denmark	Slovak Republic	Norway	Lithuania	Croatia	Spain	Iceland	Latvia	United States	Russian Federation	Luxembourg	France	Italy	Greece	Portugal	Bulgaria	Israel	Serbia	Jordan	Chile	Romania	Turkey	Uruguay	Thailand	Montenegro	Azerbaijan	Mexico	Indonesia	Brazil	Argentina	Tunisia	Colombia	Qatar	Kyrgyzstan
	Mean		566	549	545	541	531	527	527	523	522	522	520	520	519	518	517	516	516	512	510	508	506	505	503	501	501	495	494	492	490	488	486	486	483	483	481	480	476	469	444	443	441	438	432	426	423	423	420	417	412	406	395	390	386	383	379	356	334
		S.E.	(2.0)	(2.5)	(3.7)	(2.6)	(2.1)	(3.5)	(3.1)	(1.5)	(2.8)	(2.7)	(2.3)	(1.2)	(3.7)	(2.6)	(2.3)	(4.0)	(4.1)	(3.3)	(2.9)	(3.3)	(2.5)	(3.2)	(2.5)	(3.3)	(2.7)	(3.0)	(3.0)	(2.5)	(2.4)	(1.5)	(2.9)	(4.3)	(3.4)	(1.1)	(3.2)	(2.0)	(3.0)	(2.9)	(5.8)	(3.6)	(3.1)	(3.1)	(4.1)	(4.0)	(4.1)	(2.9)	(2.1)	(1.1)	(3.0)	(2.7)	(5.1)	(2.7)	(6.0)	(2.9)	(3.4)	(1.0)	(3.1)
Finland	566	(2.0)		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	549	(2.5)	▼			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	545	(3.7)	▼				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	541	(2.6)	▼	▼			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	531	(2.1)	▼	▼	▼	▼				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	527	(3.5)	▼	▼	▼	▼								▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	527	(3.1)	▼	▼	▼	▼								▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	523	(1.5)	▼	▼	▼	▼	▼										▲			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	522	(2.8)	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	522	(2.7)	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	520	(2.3)	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	520	(1.2)	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	519	(3.7)	▼	▼	▼	▼	▼														▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	518	(2.6)	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	517	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	516	(4.0)	▼	▼	▼	▼	▼	▼	▼														▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	516	(4.1)	▼	▼	▼	▼	▼	▼	▼														▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	512	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	510	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	508	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	506	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	505	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	503	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	501	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	501	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	495	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	494	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	492	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	490	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	488	(1.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	486	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	486	(4.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	483	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	483	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	481	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	480	(2.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	476	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	469	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	444	(5.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	443	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	441	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Jordan	438	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	432	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Romania	426	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Turkey	423	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	423	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Thailand	420	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲
Montenegro	417	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼				▲	▲	▲	▲	▲	▲	▲	▲
Azerbaijan	412	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				▲	▲	▲	▲	▲	▲	▲
Mexico	406	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▲	▲	▲	▲	▲	▲	▲
Indonesia	395	(5.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲
Brazil	390	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲	▲	▲
Argentina	386	(6.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲
Tunisia	383	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲
Colombia	379	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				▲	▲
Qatar	356	(1.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲
Kyrgyzstan	334	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	

▲ Mean performance statistically significantly higher than in comparison country
☐ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average

Table A4.4: Multiple comparisons of mean performance on the *using scientific evidence* scale

Using scientific evidence scale	Mean	S.E.	Finland	Japan	Hong Kong-China	Canada	Korea	New Zealand	Liechtenstein	Chinese Taipei	Australia	Estonia	Netherlands	Switzerland	Slovenia	Belgium	Germany	United Kingdom	Macao-China	France	Ireland	Austria	Czech Republic	Hungary	Sweden	Poland	Luxembourg	Iceland	Latvia	Croatia	Denmark	United States	Lithuania	Spain	Russian Federation	Slovak Republic	Norway	Portugal	Italy	Greece	Israel	Chile	Uruguay	Serbia	Thailand	Turkey	Bulgaria	Romania	Montenegro	Jordan	Mexico	Indonesia	Argentina	Colombia	Tunisia	Brazil	Azerbaijan	Qatar	Kyrgyzstan
	Mean		567	544	542	542	538	537	535	532	531	531	526	519	516	516	515	514	512	511	506	505	501	497	496	494	492	491	491	490	489	489	487	485	481	478	473	472	467	465	460	440	429	425	423	417	417	407	407	405	402	386	385	383	382	378	344	324	288
		S.E.	(2.3)	(4.2)	(2.7)	(2.2)	(3.7)	(3.3)	(4.3)	(3.7)	(2.4)	(2.7)	(3.3)	(3.4)	(1.3)	(3.0)	(4.6)	(2.5)	(1.2)	(3.9)	(3.4)	(4.7)	(4.1)	(3.4)	(2.6)	(2.7)	(1.1)	(1.7)	(3.4)	(3.0)	(3.6)	(5.0)	(3.1)	(3.0)	(4.2)	(3.3)	(3.6)	(3.6)	(2.3)	(4.0)	(4.7)	(5.1)	(3.1)	(3.7)	(2.6)	(4.3)	(7.5)	(6.0)	(1.3)	(3.3)	(3.1)	(7.3)	(7.0)	(3.9)	(3.7)	(3.6)	(4.0)	(1.2)	(3.8)
Finland	567	(2.3)		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	544	(4.2)	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	542	(2.7)	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	542	(2.2)	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	538	(3.7)	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	537	(3.3)	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	535	(4.3)	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	532	(3.7)	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	531	(2.4)	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	531	(2.7)	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	526	(3.3)	▼	▼	▼	▼	▼	▼							▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	519	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	516	(1.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	516	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	515	(4.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	514	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	512	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	511	(3.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	506	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	505	(4.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	501	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								▲	▲		▲	▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	497	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	496	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	494	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	492	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	491	(1.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼												▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	491	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼														▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	490	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	489	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼													▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	489	(5.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼															▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	487	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	485	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	481	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼											▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	478	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	473	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	472	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	467	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	465	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	460	(4.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	440	(5.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	429	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	425	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Thailand	423	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Turkey	417	(4.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	417	(7.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼										▲	▲	▲	▲	▲	▲	▲	▲
Romania	407	(6.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							▲	▲	▲	▲	▲	▲	▲	▲
Montenegro	407	(1.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲
Jordan	405	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲
Mexico	402	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲	▲	▲	▲	▲	▲
Indonesia	386	(7.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲
Argentina	385	(7.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲
Colombia	383	(3.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲
Tunisia	382	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲
Brazil	378	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▲	▲	▲
Azerbaijan	344	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲
Qatar	324	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲
Kyrgyzstan	288	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	

▲ Mean performance statistically significantly higher than in comparison country
☐ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average

Table A4.5: Multiple comparisons of mean performance on the reading literacy scale

Reading literacy scale	Mean	S.E.	Korea	Finland	Hong Kong-China	Canada	New Zealand	Ireland	Australia	Liechtenstein	Poland	Sweden	Netherlands	Belgium	Estonia	Switzerland	Japan	Chinese Taipei	United Kingdom	Germany	Denmark	Slovenia	Macao-China	Austria	France	Iceland	Norway	Czech Republic	Hungary	Latvia	Luxembourg	Croatia	Portugal	Lithuania	Italy	Slovak Republic	Spain	Greece	Turkey	Chile	Russian Federation	Israel	Thailand	Uruguay	Mexico	Bulgaria	Serbia	Jordan	Romania	Indonesia	Brazil	Montenegro	Colombia	Tunisia	Argentina	Azerbaijan	Qatar	Kyrgyzstan
Mean			556	547	536	527	521	517	513	510	508	507	507	501	501	499	498	496	495	495	494	494	492	490	488	484	484	483	482	479	479	477	472	470	469	466	461	460	447	442	440	439	417	413	410	402	401	401	396	393	393	392	385	380	374	353	312	285
S.E.			3.8	2.1	2.4	2.4	3.0	3.5	2.1	3.9	2.8	3.4	2.9	3.0	2.9	3.1	3.6	3.4	2.3	4.4	3.2	1.0	1.1	4.1	4.1	1.9	3.2	4.2	3.3	3.7	1.3	2.8	3.6	3.0	2.4	3.1	2.2	4.0	4.2	5.0	4.3	4.6	2.6	3.4	3.1	6.9	3.5	3.3	4.7	5.9	3.7	1.2	5.1	4.0	7.2	3.1	1.2	3.5
Korea	556	(3.8)	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Finland	547	(2.1)	▼	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	536	(2.4)	▼	▼	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	527	(2.4)	▼	▼	▼	■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	521	(3.0)	▼	▼	▼		■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	517	(3.5)	▼	▼	▼	▼		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	513	(2.1)	▼	▼	▼	▼	▼		■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	510	(3.9)	▼	▼	▼	▼	▼			■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	508	(2.8)	▼	▼	▼	▼	▼	▼			■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	507	(3.4)	▼	▼	▼	▼	▼	▼				■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	507	(2.9)	▼	▼	▼	▼	▼	▼					■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	501	(3.0)	▼	▼	▼	▼	▼	▼	▼					■								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	501	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼					■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	499	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼					■							▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	498	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼						■									▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	496	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■								▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	495	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	495	(4.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■						▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	494	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼								■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	494	(1.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	492	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	490	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	488	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼									■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	484	(1.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	484	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼	▼				■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	483	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	482	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	479	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	479	(1.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼					■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	477	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	472	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼				■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	470	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	469	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	466	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	461	(2.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	460	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Turkey	447	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	442	(5.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	440	(4.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	439	(4.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Thailand	417	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	413	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Mexico	410	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	402	(6.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■								▲	▲	▲	▲	▲
Serbia	401	(3.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■					▲	▲	▲	▲	▲	▲	▲
Jordan	401	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲	▲	▲	▲	▲	▲
Romania	396	(4.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■					▲	▲	▲	▲	▲
Indonesia	393	(5.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■					▲	▲	▲	▲
Brazil	393	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						■			▲	▲	▲	▲	▲
Montenegro	392	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼				■		▲	▲	▲	▲	▲
Colombia	385	(5.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼					■			▲	▲	▲
Tunisia	380	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼		■		▲	▲	▲
Argentina	374	(7.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■	▲	▲	▲
Azerbaijan	353	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■	▲	▲
Qatar	312	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■	▲
Kyrgyzstan	285	(3.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■

▲ Mean performance statistically significantly higher than in comparison country
☐ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average

Table A4.6: Multiple comparisons of mean performance on the mathematical literacy scale

Mathematical literacy scale	Mean	S.E.	Chinese Taipei	Finland	Hong Kong-China	Korea	Netherlands	Switzerland	Canada	Macao-China	Liechtenstein	Japan	New Zealand	Belgium	Australia	Estonia	Denmark	Czech Republic	Iceland	Austria	Slovenia	Germany	Sweden	Ireland	France	United Kingdom	Poland	Slovak Republic	Hungary	Luxembourg	Norway	Lithuania	Latvia	Spain	Azerbaijan	Russian Federation	United States	Croatia	Portugal	Italy	Greece	Israel	Serbia	Uruguay	Turkey	Thailand	Romania	Bulgaria	Chile	Mexico	Montenegro	Indonesia	Jordan	Argentina	Colombia	Brazil	Tunisia	Qatar	Kyrgyzstan
Mean			549	548	547	547	531	530	527	525	525	523	522	520	520	515	513	510	506	505	504	504	502	501	496	495	495	492	491	490	490	486	486	480	476	476	474	467	466	462	459	442	435	427	424	417	415	413	411	406	399	391	384	381	370	370	365	318	311
S.E.			4.1	2.3	2.7	3.8	2.6	3.2	2.0	1.3	4.2	3.3	2.4	3.0	2.2	2.7	2.6	3.6	1.8	3.7	1.0	3.9	2.4	2.8	3.2	2.1	2.4	2.8	2.9	1.1	2.6	2.9	3.0	2.3	2.3	3.9	4.0	2.4	3.1	2.3	3.0	4.3	3.5	2.6	4.9	2.3	4.2	6.1	4.6	2.9	1.4	5.6	3.3	6.2	3.8	2.9	4.0	1.0	3.4
Chinese Taipei	549	(4.1)	■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Finland	548	(2.3)		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	547	(2.7)			■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	547	(3.8)				■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	531	(2.6)	▼	▼	▼	▼	■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	530	(3.2)	▼	▼	▼	▼		■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	527	(2.0)	▼	▼	▼	▼			■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	525	(1.3)	▼	▼	▼	▼				■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	525	(4.2)	▼	▼	▼	▼					■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	523	(3.3)	▼	▼	▼	▼						■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	522	(2.4)	▼	▼	▼	▼	▼						■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	520	(3.0)	▼	▼	▼	▼	▼	▼						■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	520	(2.2)	▼	▼	▼	▼	▼	▼	▼	▼					■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	515	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	513	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼		■		▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	510	(3.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	506	(1.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	505	(3.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	504	(1.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	504	(3.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	502	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	501	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	496	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■							▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	495	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼			■				▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	495	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼				■			▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	492	(2.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■						▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	491	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	490	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼			■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	490	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼							■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	486	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	486	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	480	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Azerbaijan	476	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	476	(3.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	474	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	467	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	466	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■			▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	462	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	459	(3.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	442	(4.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	435	(3.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■	▲		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	427	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Turkey	424	(4.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■					▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Thailand	417	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■				▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Romania	415	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■				▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	413	(6.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■			▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	411	(4.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼					■		▲	▲	▲	▲	▲	▲	▲	▲	▲
Mexico	406	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼				■	▲	▲	▲	▲	▲	▲	▲	▲	▲
Montenegro	399	(1.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■		▲	▲	▲	▲	▲	▲	▲
Indonesia	391	(5.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲	▲	▲	▲
Jordan	384	(3.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■		▲	▲	▲	▲	▲
Argentina	381	(6.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■			▲	▲	▲
Colombia	370	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		■			▲	▲
Brazil	370	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■		▲	▲
Tunisia	365	(4.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼			■	▲	▲
Qatar	318	(1.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■	▲
Kyrgyzstan	311	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	■

▲ Mean performance statistically significantly higher than in comparison country
☐ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average