Facing the Future:

>> A Focus on Mathematical Literacy Among Australian 15-year-old Students in PISA 2003

Sue Thomson
John Cresswell
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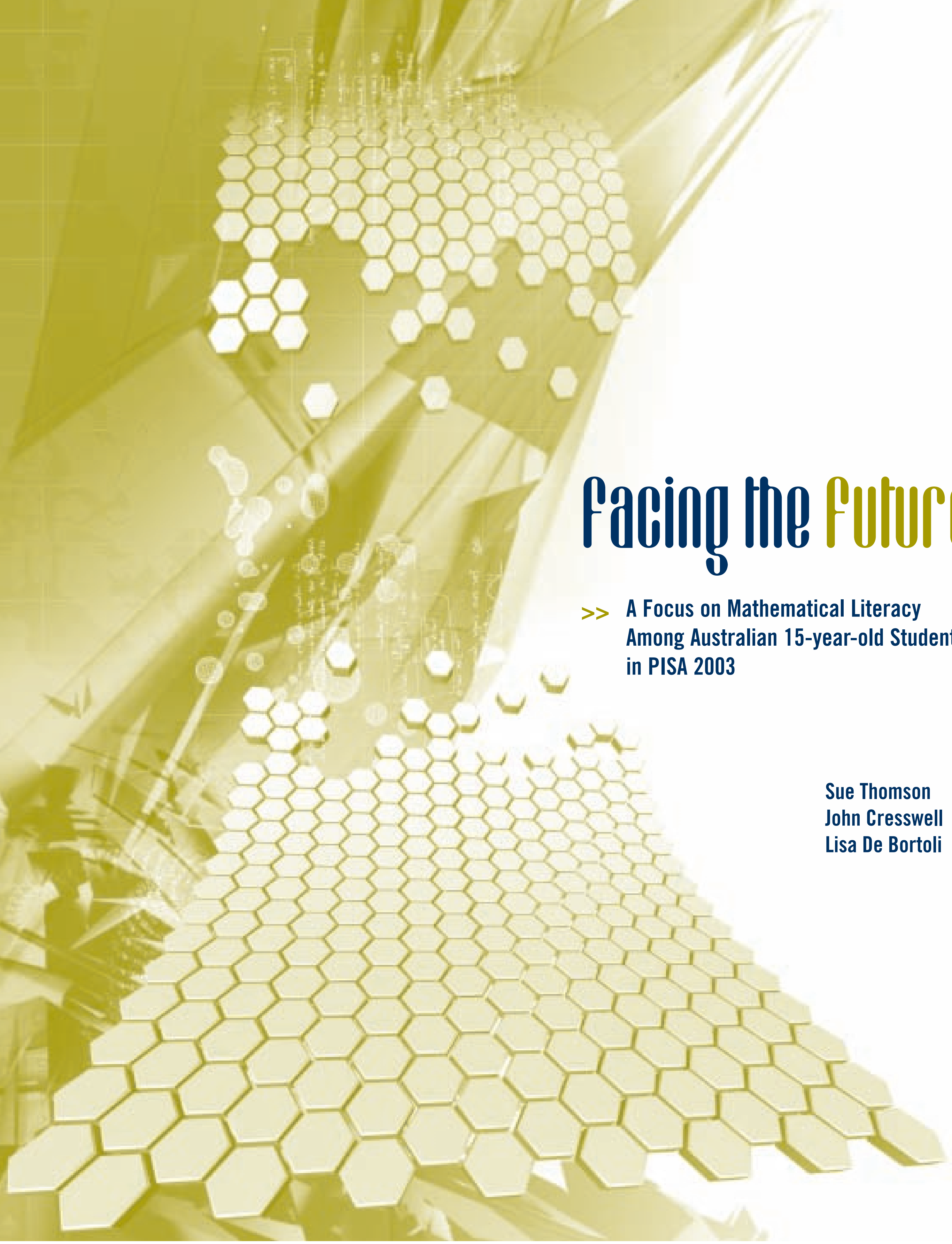
Programme for
International Student
Assessment



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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 4500 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, the results of which are reported in this volume, 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 Australia, 321 schools and just over 12 500 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 can be inferred for those populations, and

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[1] Although the Netherlands participated in PISA 2000, and the United Kingdom in PISA 2003, neither country's results are reported, as they were unable to meet sampling requirements.

- The PISA 2003 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.

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, scientific and problem solving 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 2003 items were multiple choice, but for others, students had to construct and write in 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, and *mathematical literacy* in PISA 2003. *Scientific literacy* will be the major focus of the PISA 2006 survey.

What did participants need to do?

Students who participated in PISA completed an assessment booklet which contained questions from the major domain and one or more of the minor domains being tested – in PISA 2003 they were assessed on *mathematical literacy* (the major domain), *scientific literacy*, *reading literacy* and problem-solving skills. 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 also completed a short questionnaire, which collected information about their schools.

How are results reported?

Results are reported on each of *mathematical*, *scientific*, *reading literacy* and problem solving separately, and also on four subscales of mathematics: *quantity*, *space and shape*, *change and relationships*, and *uncertainty*. For each of the major domains, a scale was defined that had a mean of 500 and a standard deviation of 100. The means of the *mathematical literacy* subscales differed slightly from 500 because the scales were constructed with reference to the overall scale, not as separate scales.

Results from countries are reported as average scores, as distributions of scores, and, in mathematics and reading, as percentages of students who attain each of a set of defined levels of proficiency. The mathematics proficiency scales contain descriptions of the skills typically shown by students achieving at each level, and were defined especially for PISA 2003 by international mathematics experts.

How is PISA managed?

PISA 2003 was implemented internationally by a consortium led by the Australian Council for Educational Research (ACER). Other members of the consortium were the National Institute for Educational Measurement (CITO) in the Netherlands, Westat and the Educational Testing Service (ETS) 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 2003 in Australia

- Just over 12 500 students from 321 schools participated, from all states and territories and all sectors of schooling.
- Data were gathered between mid-July and the end of August 2003.
- 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. Thirty-nine teachers, referred to as Test Administrators, all of whom were required to attend a training session of PISA procedures, were involved in this way.
- A further 31 teachers marked 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 2003

Australia's students acquitted themselves very well in PISA 2003. 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 *mathematical, scientific and reading literacy*, as well as in problem solving, and in each of the *mathematical literacy* subscales.
- Four countries outperformed Australia in *mathematical literacy* in PISA 2003 —Hong Kong-China, Finland, Korea, and the Netherlands. In PISA 2000 only two countries performed better than Australia —Japan and Hong Kong-China, and Australia's results were statistically similar to those of Finland and Korea. Australia's results were statistically not different to those of Japan. (Comparisons cannot be made with the Netherlands, as their data were excluded from the 2000 report because of an insufficient sample.)
- As in PISA 2000, only one country achieved significantly better results than Australia in *reading literacy* —Finland.
- Three countries achieved better results than Australia in *scientific literacy* —Finland, Japan and Korea. In PISA 2000, only Korea and Japan outperformed Australia.
- Four countries performed significantly better than Australia in problem solving —Korea, Hong Kong-China, Finland and Japan.

In terms of distribution of scores –

- In Australia, the range of scores between the 5th and 95th percentile is narrower than the OECD average for all the domains, that is for *mathematical literacy, reading literacy, scientific literacy*, and problem solving. A lower spread in scores means that there is a smaller gap in performance between the highest- and lowest-achieving students.
- Similarly, the range of scores between the 5th and 25th percentile, or the 'tail' for Australia was less than the average for the OECD, suggesting progress in Australia bringing the mathematics skills of the lowest achieving students closer to that of the higher achievers.

In terms of proficiency levels in mathematical literacy and its subscales –

- Six per cent of Australia's students achieved the highest *mathematical literacy* proficiency level (Level 6), which was slightly above the OECD average of four per cent. The country with the highest proportion of students achieving proficiency Level 6 was Hong Kong-China, with 11 per cent of its students at Level 6.

- In Australia, seven per cent of students reached proficiency Level 6 in *space and shape* (highest were Korea and Hong Kong-China, with 16 per cent), *change and relationships* (highest was Belgium with 12 per cent), and *uncertainty* (highest was Hong Kong-China with 13 per cent), and five per cent reached this level in *quantity* (highest were Hong Kong-China and Belgium, with nine per cent).
- Students at Level 6 in *mathematical literacy* succeeded in doing some very sophisticated mathematics tasks. They were able to conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations. Students at this level are capable of advanced mathematical thinking and reasoning, and can apply their insight and understanding along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for attacking novel situations.
- Twenty per cent of Australian students were placed at Level 5 or higher in *mathematical literacy*, just over 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 15 per cent at Level 5 or higher, 34 per cent at Level 4 or higher, and 58 per cent at Level 3 or higher.
- Only 14 per cent of Australian students did not reach at least Level 2, compared with the OECD average of 21 per cent.
- Four per cent of Australia's students were not achieving at the basic PISA proficiency level, Level 1, compared with eight per cent in the OECD as a whole. Students performing below proficiency Level 1 were not necessarily incapable of performing any mathematical operation, but were unable to utilise mathematical skills in a given situation, as required by the easiest PISA tasks.
- In relative terms, Australian students' performance on the *uncertainty* subscale is slightly better than their performance on the other three subscales, and performance on the *quantity* subscale is not as strong as on the other three.

In terms of proficiency levels in reading literacy and problem solving[2] *–*

- Fifteen per cent of Australian students were achieving at the highest level of *reading literacy*, which was significantly higher than the OECD average of eight per cent. The country with the highest proportion of students achieving at this level was New Zealand, with 16 per cent of students achieving at Level 5.
- Australia ranked third in terms of the percentage of students performing at least at Level 4 in *reading literacy* (42 per cent), behind Finland (48 per cent) and Korea (43 per cent).
- About 12 per cent of Australian students were performing below proficiency Level 2 in reading, lower than the OECD average (19 per cent), but higher than that of the highest performing country, Finland (six per cent).
- Just four per cent of Australian students were performing at the basic PISA proficiency level, Level 1, compared with seven per cent for the OECD as a whole.

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[2] No proficiency levels have yet been defined for *scientific literacy*.

- In problem solving, more than 25 per cent of Australian students were performing at the highest proficiency level. The OECD average was 18 per cent. Nine per cent of Australian students, compared to an OECD average of 17 per cent, were not achieving at Level 1, the most basic problem-solving level.

Between 2000 and 2003 –

- For those domains in which comparisons can be made – *mathematical literacy*, *scientific literacy* and *reading literacy*, Australia's performance did not change significantly. This was the case for most of the participating countries, although there were exceptions to this – some countries improved overall in one or more domains, and in some countries performance declined for one or more domains.

In terms of results for the Australian states and territories -

- 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 *mathematical literacy*, the average performance of students in the Australian Capital Territory was significantly higher than the average achieved by students in New South Wales, Queensland, Victoria, Tasmania and the Northern Territory, and students from the Australian Capital Territory, Western Australia, South Australia, New South Wales and Queensland attained a higher average score than students in the Northern Territory. However, the performance of students in Victoria and Tasmania was not significantly different from the performance of students in the Northern Territory. These differences are more pronounced than those in maths in PISA 2000, perhaps because this measure of *mathematical literacy* is better defined, being the focus of PISA 2003.
- In *reading literacy*, the Australian Capital Territory, Western Australia, South Australia and New South Wales achieved means which were statistically similar while Queensland, Victoria, Tasmania and the Northern Territory also were statistically similar with each other in terms of their mean scores. Students in the Australian Capital Territory and Western Australia performed on average significantly better than students in Queensland, Victoria, Tasmania and the Northern Territory, while students in South Australia performed on average significantly better than students in the last three - named states. These results are very similar to those for PISA 2000, with the only change being that the Northern Territory performed better in relation to the other states in PISA 2003. In PISA 2000, all states other than Tasmania performed significantly better than the Northern Territory.
- In the Australian Capital Territory and Western Australia, more than 20 per cent of students were performing at the highest proficiency level in *reading literacy*.
- In *scientific literacy*, the Australian Capital Territory and Western Australia achieved means that were statistically similar. While the Australian Capital Territory performed significantly better than the remaining states, Western Australia performed significantly better than Queensland, Victoria, Tasmania and the Northern Territory but not significantly better than South Australia or New South Wales. Victoria, Tasmania and Northern Territory also were statistically

similar to each other in terms of their mean scores in *scientific literacy*. These findings were similar to those reported for PISA 2000.

- In problem solving, the average performance of students in the Australian Capital Territory and Western Australia was significantly higher than the average achieved by students in all other states with the exception of South Australia. Students from the Australian Capital Territory, Western Australia, South Australia and New South Wales attained a higher average score than students in the Northern Territory, however the performance of students in Victoria and Tasmania was not significantly different from the performance of students in the Northern Territory.

In terms of males' and females' results –

- There was no gender difference in the mean scores for *mathematical literacy* in Australia. While this was the case for six other OECD countries and five partner countries, it was not found to be the general case internationally. In 27 of the 41 countries, and for the OECD as a whole, males significantly outperformed females, by as much as 29 scale points in Liechtenstein. The only country in which there were significant gender differences in favour of females was Iceland.
- While there were no significant differences on the mean scores for *mathematical literacy*, almost twice as many Australian males as females achieved the highest PISA proficiency level.
- There were no gender differences shown in overall *mathematical literacy* within the states of Australia.
- Gender differences were found in the subscales *space and shape* and *uncertainty*, in which males scored higher than females, but not in *quantity* or *change and relationships*.
- As in PISA 2000, the gender difference in favour of females in *reading literacy* was large, about 0.4 of a standard deviation (40 scale points), and this was larger than the OECD average.
- Males were under-represented at the higher proficiency levels in *reading literacy.* Nineteen per cent of females and eleven per cent of males were performing at Level 5, while seven per cent of females and 17 per cent of males were performing below proficiency Level 2.
- There was no evidence of a gender gap in Australia for *scientific literacy* in either PISA 2003 or PISA 2000. While there was a large number of countries for which this was also the case, the OECD average for *scientific literacy* was significantly higher for males than females.
- There was no gender difference in Australia for performance in problem solving, and this was also the case for most other countries, and for the OECD as a whole. The largest gender difference was in Iceland, where females scored just over 30 score points higher than males, and the only significant gender difference in favour of males was a difference of 12 scale points, in Macao-China.

In terms of Indigenous students' results –

- Altogether, 815 Indigenous students were assessed in PISA 2003. On average, the performance of Indigenous Australians in *mathematical literacy* was about half a standard deviation (50 scale points) below the OECD average, while non-Indigenous students achieved, on average, a little more than one-quarter of a standard deviation (25 scale points) above the OECD average. That is, Indigenous students score around one proficiency level lower than non-Indigenous Australians.
- Similar results were evident for *reading* and *scientific literacy* and for problem solving.
- Indigenous students were over-represented in the lowest categories of mathematics proficiency and under-represented in the highest category. However, 30 per cent of them demonstrated skills at least at proficiency Level 3, and around one per cent demonstrated skills at the very highest proficiency level.

For other student groups –

- There were no significant differences in *mathematical literacy* in Australia based on the country of birth of the student or their parents.
- Students who mainly spoke English at home performed significantly better in *mathematical literacy* than those whose main home language was other than English.
- Students in a metropolitan area performed at a significantly higher level than students in a provincial city, who in turn performed at a significantly higher level than students in rural areas.

>> *In relation to socioeconomic background*

- Two measures of socioeconomic background were defined and used in this report. HISEI, based on the status of parents' occupations, was significantly related to student performance in all domains in Australia. ESCS, a broader measure based on parents' education and occupation, books in the home, number of possessions, and number of educational resources available, was also significantly related to student performance in all domains in this country.
- The relationship between socioeconomic background (as measured by ESCS) and performance is described in terms of the slope and scatter of the social gradient curve. The slope indicates on average how much difference in performance is associated with a given difference in socioeconomic background. Scatter refers to the extent to which results for individuals are scattered around the average line rather than being close to it. It indicates the strength of the relationship and is measured by the percentage of the variation in performance accounted for by socioeconomic background.
- For *mathematical literacy* in PISA 2003 the slope of Australia's social gradient was just a little less than for the OECD average (although the difference was not significant). The slope for Australia was less steep than that, for example, of Hungary and Belgium but steeper than for Finland, Iceland or Canada. In PISA 2000 the corresponding slope for Australia was a little steeper than (but still not

significantly different from) the slope for the OECD average.

- In Australia for PISA 2003 the strength of the relationship between socioeconomic background and performance in *mathematical literacy* was less than for the OECD on average. The strength of this relationship was less strong in Australia than in countries such as the United States, Germany and Belgium, indicating that student background as reflected in the ESCS was not so strong a determinant of *mathematical literacy* in Australia as in these countries. The relationship was stronger in Australia than in Finland, Iceland and Hong Kong-China, for example. In PISA 2000 the strength of the corresponding relationship in Australia was not significantly different from that of the OECD average for *mathematical literacy*.

In terms of students' attitudes and beliefs –

- *Attitudes towards school* among Australian students were more positive than for the OECD average. Australian females had significantly more positive attitudes towards school than males.
- Australian students reported more favourable *student-teacher relationships* than the OECD average. Australian females scored higher on this index than males, indicating more positive relationships.
- Australian students' score on the *sense of belonging* index was around the OECD average. Australian females had a greater sense of belonging to their school than males.
- Australia's mean on the *teacher support* index was significantly higher than the OECD average. There was no gender difference in Australia on this index.
- Australian students' perceptions of the *classroom disciplinary climate* was similar to the OECD average. Australian females had more positive views of the disciplinary climate than males.
- Australia's mean on the *interest and enjoyment* index for mathematics was not different to that of the OECD average. Australian males reported higher levels of *interest and enjoyment* in mathematics than females.
- Australian students scored higher on the *instrumental motivation* index than the OECD average, indicating stronger beliefs in the value of learning mathematics for external reasons such as getting a job in the future. Australian males had a much stronger sense of instrumental motivation than females.
- *Self-efficacy* had the strongest association for Australian students with *mathematical literacy* among the student attitudinal and belief factors examined in PISA 2003. The average for Australian students was slightly higher than the OECD average, and males' scores on the index were significantly higher than females' scores.
- Australian students had a higher sense of *self-concept* in mathematics than the OECD average, and Australian males had significantly stronger self-concept than females. Mathematics *self-concept* had a moderately strong relationship with mathematics performance in Australia.
- The level of *anxiety in mathematics* was around the same for Australian students as for the average across the OECD. However the level of anxiety reported by females in Australia was significantly higher than that of males.
- In PISA 2003, countries which had a higher average performance in mathematics

were also countries which had a flatter slope in relation to socioeconomic background. Australia was a high performing country in which the slope was a little less steep than the average for the OECD and where the strength of the relationship (as reflected in the dispersion of scores about the line) was somewhat less than the average for the OECD.

What affects mathematics performance in Australia?

- When included together with measures of many other factors in multilevel analyses of contextual factors, it was found that, all other things equal:
- Students' *educational intentions* was the strongest of the student background influences on Australian students' mathematics performance, with those students who intend completing higher levels of educational qualifications tending to do better in *mathematical literacy*. Gender was not a significant effect. Other significant student background influences were ESCS, books in the home, and computer resources in the home.
- Good *student-teacher relationships* had a positive effect on *mathematical literacy* performance.
- *Sense of belonging* had a negative effect on *mathematical literacy* – students who reported higher levels on the *sense of belonging* index performed at a lower level in *mathematical literacy* than students who reported lower levels of *sense of belonging*.
- In the classroom, mathematics performance was increased in an environment that is quiet and orderly, and where students are eager to learn.
- Among all the variables considered, the strongest relationships in Australia were found between *mathematics self-efficacy* and mathematics performance and between *mathematics self-concept* and mathematics performance.
- *Mathematics anxiety* was negatively related to performance in mathematics, with those students having high levels of anxiety performing at lower levels than students with low levels of anxiety.
- The use of *elaboration*, *memorisation* or *cooperative learning* strategies was also negatively related to performance.

>> *Implications for Australian schools and school systems*

Several of the PISA results have policy implications. While the relationship between socioeconomic background and performance in *mathematical literacy* was less strong than for the OECD on average, there still exists a distinct advantage for those students with higher socioeconomic backgrounds, no matter which way this is defined. While schools are not able to influence students' socioeconomic backgrounds, they are able to introduce policies that help to counteract the effects of disadvantage. Although many schools already do this there is work to be done because the differences observed are greater than would be considered desirable in relation to our national aspirations.

The low level of performance by most Indigenous students continues to be a concern. While some Indigenous students performed well in PISA *mathematical literacy*, this was a very small proportion of the overall sample and many more were performing at the lower end of the proficiency levels. It is important for Indigenous students to continue to receive additional support to raise their performance levels.

While no overall gender differences were apparent in mathematics performance, males tend to be over-represented at the upper levels of achievement, although equally represented in the lower levels, and males performed at a significantly higher level than females in two of the four mathematics subscales.

Even though the differences between males and females in overall mathematics performance were not significant, it is evident from PISA there are differences in the attitudes and beliefs held by females towards mathematics. Females appear to retain, to a much greater extent than males, a negative attitude towards mathematics and towards their own abilities in the subject. This is reflected in their lesser tendency to study mathematics and related disciplines at tertiary level. PISA suggests a reason for this, finding that there are much larger gender differences at age 15 in approaches to learning mathematics than in performance itself. Females appear to be less engaged, more anxious, and less confident in mathematics than males. This finding suggests that approaches to reducing these gender differences need to start at an early age in order to increase females' engagement in mathematics and build their confidence in their mathematical abilities.

A goal of Australia's education systems is to provide equal and high quality opportunities in learning for all of our students. The PISA survey helps to indicate how well we are succeeding in this respect in comparison with other countries, providing benchmarks over time against which we can measure improved student performance.

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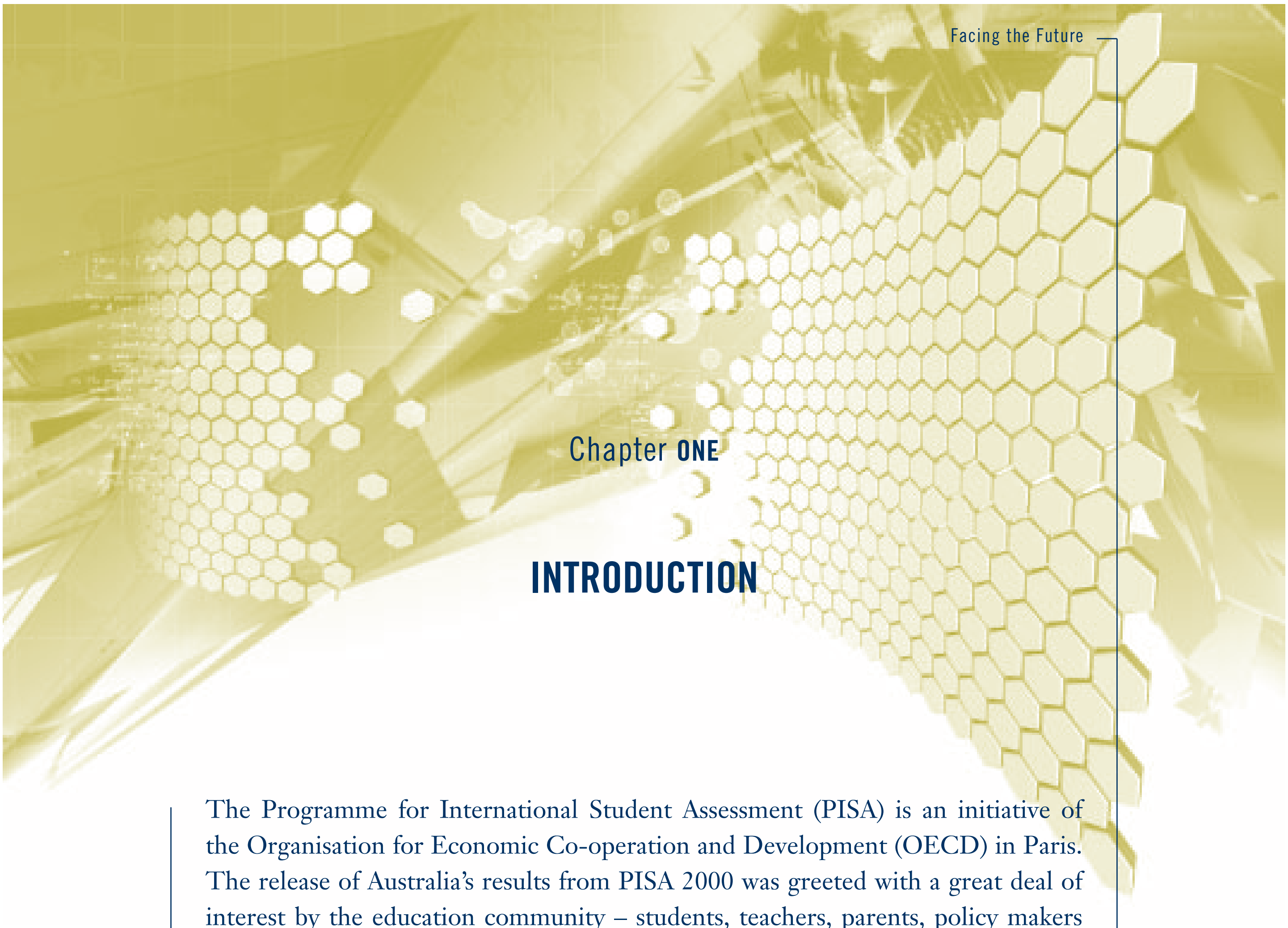


Chapter ONE

INTRODUCTION

The Programme for International Student Assessment (PISA) is an initiative of the Organisation for Economic Co-operation and Development (OECD) in Paris. The release of Australia's results from PISA 2000 was greeted with a great deal of interest by the education community – students, teachers, parents, policy makers and researchers alike. Australia has participated in most major international surveys of educational achievement in the past four decades including the First International Mathematics Study in 1964, the Third International Mathematics and Science Study in 1994/95 and its repeat in 1998/99 and the Trends in International Mathematics and Science Study in 2002/03. In 2000, Australian students participated in the first cycle of PISA, which took place in 32 countries. Subsequent to this first cycle of PISA a further 11 countries carried out the same assessment, leading to a database which has results from over a quarter of a million students. The full details of Australia's sample and results from PISA 2000 can be found in the first national report (Lokan, Greenwood & Cresswell, 2001).

In 2003, Australian students participated in the second cycle of PISA, and this second national report describes the details of their participation and results in both the national and international context. In addition this report makes comparisons where possible between results obtained in PISA 2000 and PISA 2003.

This first chapter focuses on the development of PISA, the nature of the assessment, the target population details and the implementation of the survey. Following chapters will describe Australia's results in the international context, examine associations of those results with national characteristics such as Indigenous status, language background and geographic location and explore the major factors associated with performance.

How did PISA come about?

The OECD launched the Programme for International Student Assessment (PISA) in 1997. PISA represents 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. An international consortium, led by the Australian Council for Educational Research (ACER), manages the design and implementation of PISA. Other consortium partners are the National Institute for Educational Measurement (CITO) in the Netherlands, Westat and the Educational Testing Service (ETS) in the United States, and the National Institute for Educational Policy Research (NIER) in Japan.

The first PISA assessment was conducted in 2000 and revealed wide differences in the extent to which countries succeed in equipping young adults with knowledge and skills in key subject areas. In some countries, the results were well received, showing that their 15-year-olds were well prepared to meet the challenges of the future. In other countries, the results were disappointing, showing that their 15-year-olds' performance was considerably behind that of other countries, in some instances by the equivalent of several years of schooling.

The main goals of PISA

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 focuses on the following issues:

- 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?

PISA was designed to help governments not only understand but also enhance the effectiveness of their educational systems. PISA collects reliable information on a regular basis (every three years) and derives educational indicators that can monitor differences and similarities over time.

What skills does PISA assess?

With its goal of measuring competencies that will equip students to participate productively and adaptively in their life beyond school education, 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 also mathematically, scientifically and technologically literate.'*
>
> (p. 9, OECD, 2000)

PISA assesses competencies in each of three core domains - reading literacy, mathematical literacy and scientific literacy. During each PISA cycle, taking place on a three yearly basis, one domain is tested in detail. The remaining time is allocated to assessing the 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. Problem solving was incorporated into the assessment for this cycle. In 2006, the major focus will be on 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 core assessments have been based on the assessment frameworks, which provide a common language and a vehicle for discussing the purpose of the assessment and what it is trying to measure. The construction of the frameworks has been a collaborative effort between the participating countries in the project, through the PISA Governing Board (PGB) established by the OECD. Working groups consisting of subject matter experts were formed to develop the assessment frameworks, and these have evolved since PISA began in 1997. Each of the three literacies and problem solving are described briefly in the following section, and in more detail in the relevant chapter of this report.

>> PISA 2000 – summary of Australia's results

The retention of assessment items from one cycle to the next provides the opportunity to measure not only changes in student performance but also changes in the effects of student background on performance characteristics and attitudes to school and learning in general. Throughout this report comparisons will be made between Australia's results in PISA 2000 and PISA 2003. Very briefly, this section summarises some of the key findings from PISA 2000.

Australia's mean scores were significantly above the OECD means of 500 for PISA 2000 in all three domains (528 in reading literacy, 533 in mathematical literacy and 528 in scientific literacy). These results placed Australia in a small group of countries which had similar results, and just below the highest performing countries – Finland in reading literacy, Hong Kong-China and Japan in mathematical literacy and Japan and Korea in scientific literacy.

Each of the Australian states, individually, also performed on average at a level that was either at or above the OECD average.

As in all countries that participated in PISA 2000, there was a significant difference between females and males in reading literacy in Australia (females 546, males 513). Females were also significantly more engaged in reading, spending more time reading a more diverse range of material than males in Australia. No significant differences were found in terms of mathematical or scientific literacy.

Similar to other countries, Australia exhibited a significant association between socioeconomic status (based on parents' occupations) and student performance in all four domains. The relationship was stronger in reading than in mathematics, science or problem solving.

In PISA 2000, Australia's Indigenous students scored at a much lower level than non-Indigenous students in each of the four assessment areas – reading, mathematical and scientific literacy, as well as problem solving.

>> *Impact of PISA in Australia*

A great deal of interest followed the release of results from PISA 2000 in Australia. The various federal, state and territory government authorities, teacher associations, parent groups, and principals have all shown a desire to use the information to improve education standards. PISA now provides an element of the national assessment framework in school education.

It has been proposed that PISA will be used as the data source for national Key Performance Measures (KPMs) for the performance of 15-year-old school students in reading, mathematical and scientific literacy. The Australian and state and territory governments[1], through the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) will decide shortly whether this is to be the case. These measures complement literacy and numeracy KPMs for students in Years 3, 5 and 7 that are based on states' own tests, and the KPM for other curriculum areas that are based on national sample surveys of achievement (such as for primary science based on a national sample assessment at Year 6, civics and citizenship at Year 6 and Year 10, and information and communication technology at Year 6 and Year 10).

The national KPMs allow for nationally comparable reporting of student outcomes against the *National Goals for Schooling in the Twenty-First Century* agreed by MCEETYA in 1999. Reporting on the KPMs is undertaken through the annual *National Reports on Schooling* as well as through monographs and reports on particular assessments.

Given the length of its cycle, PISA will enable reporting every three years of comparable performance data by state, by sex within state, and at the national level on the basis of Indigenous status, geographic location, language background and socioeconomic background.

>> *The PISA 'literacy' approach*

The concept of literacy in the PISA framework is defined as the 'knowledge and skills that reflect the current changes in curricula, moving beyond the school-based approach towards the use of knowledge in everyday tasks and challenges'

---

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

(p.9, OECD, 2003). This implies that literacy addresses questions like: 'Are students well prepared for the challenges of the future? Are they able to analyse, reason and communicate their ideas effectively? Do they have the capacity to continue learning throughout their life?' (p.3, OECD, 2001).

PISA measures 'knowledge and skills for life' with students at the age of 15 as they approach the end of compulsory schooling. Measuring 'literacy skills' is seen as important because they 'reflect the ability of students to continue learning throughout their lives by applying what they learn in school to non-school environments, evaluating their choices and making decisions' (p.9, OECD, 2003).

Mathematical literacy

PISA defines *mathematical literacy* as:

> *an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.*
>
> (p.24, OECD, 2003)

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*. Mathematical processes are defined by mathematical skills or competencies. The *mathematical literacy* questions have been organised in terms of the type of thinking skill required. 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*.

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.*
>
> (p.108, OECD, 2003)

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* in which the text was constructed. PISA makes the distinction between two types of text formatting: continuous texts that are organised in sentences and paragraphs and non-continuous texts that present information, for example, charts and graphs, forms and information sheets. PISA recognises five processes that are required for full understanding of texts: retrieving information; forming a broad general understanding; developing an interpretation; reflecting on and evaluating the content of a text; and reflecting on and evaluating the form of a text. 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 are not 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*.

Scientific literacy

In PISA, *scientific literacy* is defined as:

> *the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.*
>
> (p.133, OECD, 2003)

As such, it relates to the ability to think scientifically in a world in which science and technology are increasingly shaping our lives. It 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 important skill is to be able to think scientifically about evidence and the absence of evidence for claims that are made in the media and elsewhere, as part of daily life.

Scientific literacy is concerned with: *scientific knowledge* (including knowledge of concepts), *scientific processes* and *scientific situations* (or contexts). As *scientific literacy* is not a major domain in PISA 2003 only a sample of its scope has been assessed. The scientific knowledge that has been assessed was selected from the areas of physics, chemistry and biological science as well as Earth and space science according to three criteria: relevance to everyday situations; relevance to life throughout the next decade; and knowledge required for understanding scientific processes. The interaction of these criteria with the content of the science areas produced a selection of scientific themes such as chemical and physical changes; biodiversity; genetic control; and geographical change. Scientific processes, according to the PISA framework, involve the ability to acquire, interpret and act upon evidence. PISA identifies three process skills: *describing, explaining and predicting scientific* *phenomena; understanding scientific investigation*; and *interpreting scientific evidence and conclusions*. The *scientific literacy* framework identifies three main scientific situations or contexts for assessments: *science in life and health*; *science in Earth and environment*; and *science in technology*.

Problem Solving

The aim of PISA is to collect information on the abilities students have in real-life situations that rely on applying their knowledge of reading, science and mathematics. In PISA 2003, problem solving was incorporated as part of the assessment, so as to describe students' cross-disciplinary problem-solving capabilities.

Problem solving in PISA is defined as:

> *the capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricular areas that might be applicable are not within a single domain of mathematics, science or reading.*
>
> (p.156, OECD, 2003)

The assessment of problem solving focuses on three areas: *problem types*; *problem solving processes*; and *situations or problem contexts*. The assessment of problem types has been limited to: *decision making; system analysis and design;* and *trouble shooting*. Problem solving processes involve *understanding the problem; characterising the problem; representing the problem; solving the problem; reflecting on the solution;* and *communicating the problem solution.* The situations or contexts in problem solving require students to apply their knowledge and skills in a real-life setting in which the problem types may be applied.

Other domains

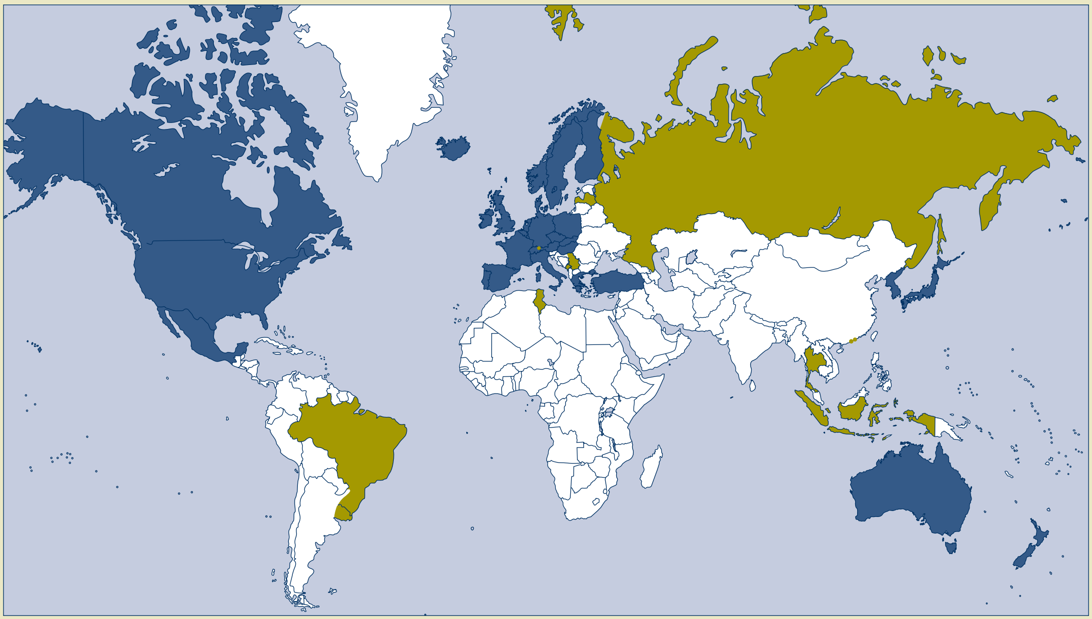
In an attempt to define the skills and knowledge that are essential for full participation in society, PISA also focused on cross-curricular areas. In PISA 2000, and again in PISA 2003, an assessment of competencies in self-regulated learning and familiarity with Information Technology were investigated. An assessment of students' ability to organise their learning process, their self-concept in relation to learning in academic areas and their confidence and attitudes, including self-efficacy, were measured.

>> Who participates in PISA?

Countries

Thirty-two countries participated in PISA 2000, including all OECD member countries other than Turkey, and four non-OECD countries (Brazil, Latvia, Liechtenstein and the Russian Federation). Results from this assessment were published in the initial international report (OECD, 2001). In 2002, a further 11 countries participated in the PISA Plus project, using the same assessment as PISA 2000. These non-OECD countries were Albania, Argentina, Bulgaria, Chile, Hong Kong-China, Indonesia, Israel, Macedonia, Peru, Romania and Thailand. Results of all countries were subsequently published in 2003 (OECD/UNESCO, 2003).

In 2003, 41 countries participated in the PISA, which included all OECD countries (including the Slovak Republic, which became a member of the OECD in December, 2000). The partner countries[2] participating in PISA 2003 were Brazil, Hong Kong-China, Indonesia, Latvia, Liechtenstein, Macao-China, the Russian Federation, Serbia[3], Thailand, Tunisia and Uruguay. The coverage of countries is shown in Figure 1.1.



OECD countries

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom*
United States of America

Partner countries

Brazil
Hong Kong-China
Indonesia
Latvia
Liechtenstein
Macao-China
Russian Federation
Serbia
Thailand
Tunisia
Uruguay

* The United Kingdom did not meet the required sample criteria. Results are not reported for the United Kingdom or included in OECD average.

Figure 1.1 Countries Participating in PISA 2003

Schools

In most countries 150 schools 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 to allow for meaningful comparisons to be made between different sectors of the population.

In Australia, a larger sample was gathered for three main reasons:

- In order that comparisons can be made between states it is necessary to 'oversample' the smaller states because a random sample proportionate to state

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[2] Partner countries are those that are non-OECD countries.

[3] For the country Serbia and Montenegro, data for Montenegro are not available. The latter accounts for 7.9 per cent of the national population. The name "Serbia" is used as a shorthand for the Serbian part of Serbia and Montenegro.

populations would not yield sufficient students in the smaller states to give a result that would be sufficiently precise;

- A special focus in PISA 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. Based on the results of PISA 2000, a detailed report of Indigenous students' results was published in a separate report (De Bortoli & Cresswell, 2004); and
- The PISA 2003 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.[4]

In PISA 2000 there were 231 schools in the achieved Australian sample, and in PISA 2003 the sample of schools increased to 321 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 the government, Catholic and independent sectors. Table 1.1 shows the distribution of the schools that participated in the Australian PISA for the main sample in 2003. Details of the designed sample can be found in Appendix 2.

Table 1.1 Australian PISA 2003 Schools by State and Sector

	Catholic	Government	Independent	Total
NSW	17	48	9	74
VIC	13	39	10	62
QLD	7	32	9	48
SA	7	20	7	34
WA	8	27	7	42
TAS	4	14	2	20
NT	2	11	3	16
ACT	5	18	2	25
Total	63	209	49	321

Eighty four per cent of the Australian PISA schools were coeducational. There were more all-female schools (9 per cent) than all-male schools (7 per cent). Of single-sex schools one-fifth were government schools, almost half were Catholic schools and a third were independent schools. Single-sex schools were distributed unevenly by state.

The PISA participating schools were coded with respect to the recently developed MCEETYA Schools Geographic Location Classification. For the analysis in this report, only the broadest categories are used:

- Metropolitan – including mainland state capital cities and major urban districts with population of 1,000,000 or more (eg. Queanbeyan, Cairns, Geelong, Hobart)

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[4] 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 Council for Educational Research (ACER) and the Australian Government Department of Education, Science and Training (DEST).

- Provincial – including provincial cities and other non-remote provincial areas (eg Darwin, Ballarat, Bundaberg, Geraldton, Tamworth)
- Remote – Remote areas and Very remote areas.

In PISA 2003, 70 per cent of schools were located in a metropolitan area, 27 per cent were from provincial areas and three per cent of schools were in remote areas.

Students

The target population for PISA is students who are 15 years old and enrolled at a school, either full- or part-time, at the time of testing. 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. 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 between Australian states.

In most countries, a random sample of 35 students is selected with equal probability from each school from a list of all 15-year-old students submitted by the school. In PISA 2003, the Australian student sample was increased to 50 students per school[5]. Further information on sampling can be found in Appendix 2.

Internationally, 4500 is the desired minimum number of students to be assessed per country. In some countries, including Australia, the sample size was increased so that language groups or regions could be adequately represented. 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.

The PISA 2003 sample of 12,551 Australian 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.

In an age-based sample these students will come from various grade levels, but 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.

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 students (which could not exceed 5 per cent of the population). Westat and ACER worked in close consultation to draw the PISA samples based on a design agreed upon by each country.

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) was required as well as a rate of a minimum of 80 per cent (weighted) of selected students. Countries who 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 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. The United Kingdom was the only country which did not meet these requirements.

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[5] To accomodate the LSAY sample.

Table 1.2 Number of Students in PISA 2003 Sample and Population, by Country

Country	Sample *N*	Population *N*	Country	Sample *N*	Population *N*
Australia	12 551	235 591	Luxembourg	3 923	4 080
Austria	4 597	85 931	Macao-China*	1 250	6 546
Belgium	8 796	111 831	Mexico	29 983	1 071 650
Brazil*	4 452	1 952 253	Netherlands	3 992	184 943
Canada	27 953	330 436	New Zealand	4 511	48 638
Czech Republic	6 320	121 183	Norway	4 064	52 816
Denmark	4 218	51 741	Poland	4 383	534 900
Finland	5 796	57 883	Portugal	4 608	96 857
France	4 300	734 579	Russian Federation*	5 974	2 153 373
Germany	4 660	884 358	Serbia*	4 405	68 596
Greece	4 627	105 131	Slovak Republic	7 346	77 067
Hong Kong-China*	4 478	72 484	Spain	10 791	344 372
Hungary	4 765	107 044	Sweden	4 624	107 104
Iceland	3 350	3 928	Switzerland	8 420	86 491
Indonesia*	10 761	1 971 476	Thailand*	5 236	637 076
Ireland	3 880	54 850	Turkey	4 855	481 279
Italy	11 639	481 521	Tunisia*	4 721	150 875
Japan	4 707	1 240 054	United Kingdom	9 535	698 579
Korea	5 444	533 504	United States	5 456	3 147 089
Latvia*	4 627	33 643	Uruguay*	5 835	33 775
Liechtenstein*	332	338			
			TOTAL	**276 165**	**19 155 865**

* Partner country

Table 1.3 Australian PISA 2003 Students by State and Sector

Sector	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	TOTAL
Government									
N students*	1942	1420	1273	699	1146	546	355	601	7982
Weighted N#	48869	31983	29670	10515	15260	3721	1208	2682	143908
Catholic									
N students*	694	568	275	274	361	167	86	201	2626
Weighted N#	16832	15094	8219	3669	6303	1091	205	1216	52629
Independent									
N students*	346	366	386	261	260	91	142	91	1943
Weighted N#	8867	9772	7496	6906	4630	480	353	552	39056
TOTALS									
N students*	2982	2354	1934	1234	1767	804	583	893	12551
Weighted N#	74568	56849	45385	21090	26193	5292	1766	4450	235593

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

Table 1.4 Distribution of Students by Year Level and State#

State	Year level (%)					
	7	8	9	10	11	12
NSW		△	8	84	7	
VIC		△	16	79	5	
QLD			3	57	40	△
SA	△		3	79	18	△
WA				43	56	△
TAS		△	30	70	△	
NT			5	78	17	△
ACT		△	10	87	3	
AUS	△	△	8	72	19	△

\# The percentages are based on weighted data; state totals may not add to 100 because of rounding.
△ Percentage < 1

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 was usually between March and May, for sampled students born in 1987. The testing in Australia occurred during a six-week period in July and August, 2003, and was completed by sampled students born between 1 May 1987 and 30 April 1988 – so that the students in Australia were both at a comparable age and at a comparable stage in the school year to those in the Northern Hemisphere who had been tested earlier in 2003.

Skills for life?

Without follow-up of future educational and occupational outcomes of the students assessed in PISA it is not yet 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.

Australian perspectives from LSAY

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.

There is also evidence from LSAY 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, to whether students complete their secondary schooling (Fullarton, 2002; Marks, Fleming, Long & McMillan, 2000). This evidence lends support to PISA's inclusion of items on a range of psychological constructs in the Student Questionnaire, as discussed in Chapter 6.

A new link between LSAY and PISA

The PISA 2003 sample became a commencing cohort for the Longitudinal Surveys of Australian Youth (LSAY). LSAY is a series of surveys that 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 well being. More detailed investigations examine the links between social characteristics, education and training, and employment. The link between LSAY and PISA will provide a basis for investigating the enduring effects of the skills and knowledge measured in PISA.

>> Implementing PISA

What did PISA 2003 participants do?

Students who participated in PISA completed an assessment booklet which contained questions from the major domain and one or more of the minor domains being tested – in the case of PISA 2003 they were assessed on *mathematical literacy* (the major domain), *scientific literacy*, *reading literacy* and problem-solving skills.

As mentioned earlier, each cycle of PISA focuses on one assessment domain (*mathematical literacy* in 2003), with the other domains (*reading literacy*, *scientific literacy* and problem solving) being covered to a lesser extent. This means that the majority of items in PISA 2003 were *mathematical literacy* items.

Each participating student completed an assessment booklet 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 mathematics items with a rotation system ensuring that the reading, science and problem solving items appeared equally several times 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 formats: 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 Student Questionnaire sought information on students and their family background, aspects of learning and instruction in mathematics and context of instruction including instructional time and class size. In PISA 2000, Australia participated in the two international options - self-regulated learning and familiarity with Information Technology. In PISA 2003, self-regulated learning became incorporated into the Student Questionnaire. Familiarity with Information Technology and Educational Career were offered as international options. Australia participated in both these international options with questions from these areas incorporated into the Student Questionnaire.

The School Questionnaire, answered by the principal (or the 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 PISA centre) 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

Levels of assessment items for each of the domains in PISA are guided by a framework which is created and developed by a group of international experts in the relevant field and agreed 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 2003, in addition to the Mathematics Expert Group, the OECD initiated the formation of a Mathematics Forum, to which all countries could send representatives and could provide input to the development of the items.

The development of the assessment items is an interactive process, including 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 2002, a final set of items was chosen to reflect the intentions of the frameworks for the Main Study in 2003.

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 the like 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 difficulties 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, five proficiency levels were defined in PISA 2000 for reading overall and for the three sub-scales of reading: retrieving information; interpreting texts; and reflecting on and evaluating texts. Six levels of proficiency have been defined in PISA 2003 for mathematics overall and for the four sub-scales of mathematics: *quantity*; *space and shape*; *change and relationship*; and *uncertainty*. The small numbers of assessment items in science in PISA 2000 and 2003 do not make it possible to define specific proficiency levels, but broad levels of high, medium and low proficiency have been outlined. However, in the next cycle of PISA, science will be the major domain and as the majority of testing time will be related to science, specific proficiency levels will be available when the 2006 assessment is reported. Further details on the proficiency scales are provided in Chapter 2 and Chapter 3 for *mathematical literacy*, Chapter 4 for *reading literacy* and *scientific literacy*, and Chapter 5 for problem solving.

>> *Summary*

PISA provides an assessment of 15-year-olds' knowledge and the skills that they will need beyond school life. Many procedures are used to ensure that the PISA instruments are internationally comparable and reliable and that the data are collected and processed in standardised ways (Appendix 1).

The results from PISA 2000 provided important outcomes for educational systems, allowing policy makers, researchers, school principals and teachers to compare the performance of educational systems within Australia as well as between countries. Australia performed well in PISA and Australian students' results were significantly above the OECD average in all domains. The innovative use of descriptive proficiency scales in each of the assessment domains provided further insight into the acquired skills and knowledge of students. Almost a fifth of Australian students achieved the highest proficiency level (Level 5) on the overall reading proficiency scale, compared with the OECD average of ten per cent. Increasing the sample size in Australia has enabled results to be reported by state, which performed on average either at or above the OECD average with few statistically significant differences.

The results from PISA 2000 reinforced current concerns about the performance of males compared to females in *reading literacy*. In all countries, significant gender differences were found in overall *reading literacy*. These gender differences were also evident within the subscales, except for one country in the interpreting text subscale and four countries in the retrieving information subscales. A range of student characteristics including their attitudes, their enjoyment of reading and their determination to do well were found to be significantly related to their reading performance. The relationship between performance and student characteristics also revealed the lower performance of Australian Indigenous students and students from disadvantaged backgrounds. Multilevel analysis showed that in Australia, differences in performance within schools (that is, between students) were larger than the differences between schools.

PISA has made a significant contribution to providing national key performance measures for the performance of 15-year-old school students in *reading*, *mathematical* and *scientific literacy*. The data from the first cycle of PISA will serve as a baseline profile of the knowledge, skills and competencies of students near the end of their compulsory schooling, in key domains of learning. Results from PISA 2003 and subsequent assessments will enable educational outcomes to be monitored to provide indicators on trends.

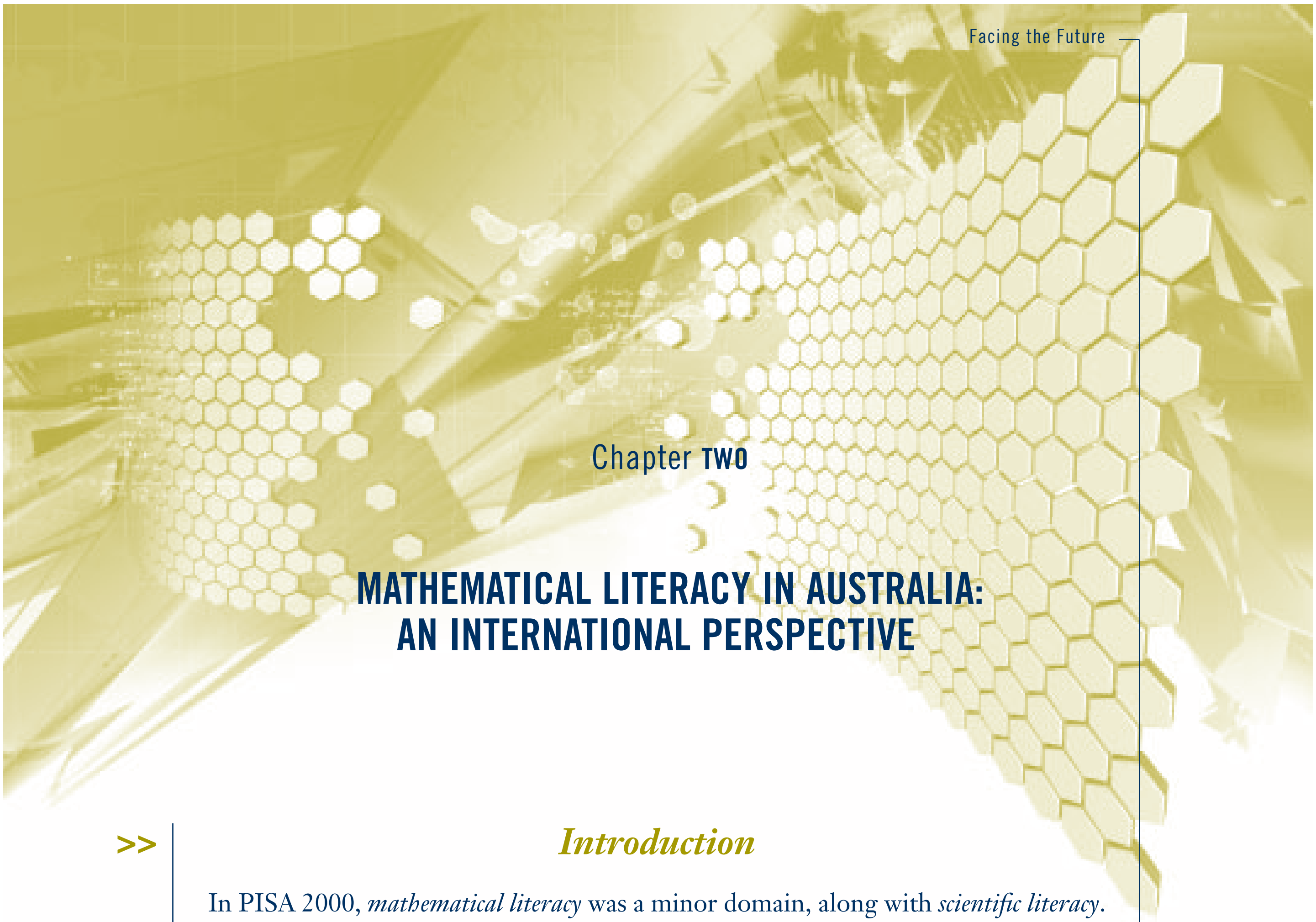
>> *Organisation of the report*

This report focuses on Australia's results from PISA 2003 in the areas of *mathematical literacy*, *reading literacy*, *scientific literacy* and problem solving, with Chapters 2, 3, 4 and 5 devoted to each of these (Chapter 4 focuses on reading and science together, as they were minor domains in 2000). These chapters contain a description of the Australian sample, a discussion of results in an international context, both in terms of average scores and distribution, and the achievement of proficiency levels (except for science), as well as a comparison between results obtained in each of the domains in both PISA 2000 and PISA 2003. These comparisons are also set in an international context.

Chapter 3 is concerned with results within Australia, including comparisons between the states in each of the domains. Consideration is also given to the results of some of the main sub-groups of students within the Australian sample, based on immigrant status, Indigenous status and home language background.

Analysis of Australia's results and the significant factors associated with performance are discussed in Chapter 6, and Chapter 7 along with a multilevel analysis of school and student factors related to performance in Australia.

Chapter 8 summarises the findings from PISA 2003, placing Australia's results in the international context and giving comparisons with PISA 2000. This chapter also raises some questions for Australian educational policy based on the PISA results from PISA 2000 and 2003.



Chapter TWO

MATHEMATICAL LITERACY IN AUSTRALIA: AN INTERNATIONAL PERSPECTIVE

Introduction

In PISA 2000, *mathematical literacy* was a minor domain, along with *scientific literacy*. Results for *mathematical literacy* were reported on a single scale, based on all of the items in that domain, and only a small proportion of the testing time was allocated to these items. In PISA 2003 *mathematical literacy* became the major domain, providing an opportunity to expand and extend the domain. In PISA 2003, the majority of the two-hour time for testing was, on average, devoted to the assessment of students' *mathematical literacy*.

This chapter focuses on the results obtained by Australian students in *mathematical literacy* in PISA 2003 in the context of the international results. The chapter first provides a detailed description of the PISA *mathematical literacy* framework that was used as a basis for the assessment. Next, Australia's results are reported both for the overall *mathematical literacy* scale and for each of the subscales, and comparisons are made with the results of the other countries that participated in PISA 2003. Australia's results are also discussed in terms of the six proficiency levels for *mathematical literacy*.

The construct of 'mathematical literacy' in PISA[1]

The PISA framework (OECD, 2003) 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. 24)

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[1] Parts of this chapter were contributed by Ross Turner, and his assistance and expertise are gratefully acknowledged.

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. In Australia, the term 'numeracy' is widely used to describe *mathematical literacy*. When thinking about what *mathematical literacy* might mean for individual students, indeed for any individual person, the most central issues and questions relate to the extent to which the students possess mathematical knowledge and understanding, and an armoury of mathematical competencies that can assist them to meet the challenges of their lives. That is, it addresses to what extent individuals can activate whatever mathematical competencies they possess to solve the kinds of problems they confront in their lives where mathematics might be of genuine assistance in solving those problems. PISA therefore presents students with problems most of which are set in some real-world situation. The problems are crafted in such a way that aspects of mathematics would be of genuine benefit in solving them. The objective of the PISA assessment is to obtain measures of the extent to which students presented with these problems can activate their mathematical knowledge and competencies to successfully solve the problems.

Mathematical concepts, structures and ideas have been invented as tools to organise phenomena in the natural, social and mental worlds. In the real world, the phenomena that lend themselves to mathematical treatment do not come organised as they are in school curriculum studies. If mathematics is seen as a science that helps us solve real problems, it makes sense to use a phenomenological approach to describe mathematical concepts, structures and ideas.

Steen (1990) suggested that we should seek inspiration in the developmental power of five deep mathematical ideas: *dimension*, *quantity*, *uncertainty*, *shape* and *change*. Taking into account several other suggestions in the literature, PISA adapted the mathematical ideas as suggested by Steen into four phenomenological categories: *quantity*, *space and shape*, *change and relationships* and *uncertainty*. They are the 'overarching ideas' that describe the content of mathematics in the PISA framework (OECD, 2003).

The PISA mathematics assessment directly confronts the importance of the functional use of mathematics by placing primary emphasis on the real-world problem situation, and on the mathematical knowledge and competencies that are likely to be useful to deal effectively with the problem. The PISA mathematics framework has been 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. They will be mathematically literate.

>> *Mathematical content – the four 'overarching ideas'*

The PISA mathematics framework conceives and defines mathematical content in terms of four very broad knowledge domains that it labels overarching ideas: *quantity*;

space and shape; *change and relationships*; and *uncertainty*. These four 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. Each of these ideas is elaborated in the following paragraphs.

Quantity

Quantity involves both 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. An important aspect of dealing with *quantity* is also *quantitative reasoning*, which involves number sense, representing numbers, understanding the meaning of operations, mental arithmetic, and estimating. The most common branch of mathematics with which quantitative reasoning is associated is arithmetic.

Space and shape

Space and shape relates to spatial and geometric phenomena and relationships, drawing on the curricular area 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. The recognition of patterns is an important component of this overarching idea – this includes not only geometric patterns but also patterns that may occur in language, music, art and the natural world.

Change and relationships

Change and relationships relates most closely to the curriculum area of algebra. The world is not a constant – every phenomenon is a manifestation of change. The growth of organisms, differing weather conditions, inflation and improvement of a student's score in a school subject are all examples of change. Some changes are simple and easy to observe, while other changes may need complex statements of the relationships between variables. In all cases of change a set of conditions can be described as undergoing development to a new set of conditions – the difference between the two sets of conditions is an indicator of the size of change that has occurred. These changes may be represented in a number of ways, including a simple equation, an algebraic expression, a graph, or a table. As different representations are appropriate in different situations, translation between representations is an important skill when dealing with situations and tasks.

Uncertainty

Today we have access to a great deal of information, which is often presented as precise and having no error. In truth, of course, there is a varying amount of *uncertainty* in the weather forecasts we see, the predictions about interest rates that experts make and the measurements that might be taken by a road traffic 'speed camera'. The two related areas that contribute to uncertainty are data and chance, and studies of statistics and probability.

The four ideas in summary

The PISA 2003 mathematics assessment sets out to ensure that these four overarching ideas are all included in the assessment; it allows for a comparison of levels of student performance among these areas. The overarching ideas provide familiar divisions of the knowledge domain, and using them as a basis for reporting permits a focus on the extent to which growth in mathematical competencies occurs uniformly across these conceptually distinguishable sub-domains. Table 2.1 shows the breakdown by mathematical content area of the 85 test items used in the PISA 2003 assessment.

Table 2.1 Count of PISA 2003 Mathematics Items by Overarching Idea

Overarching idea	Number of items
Quantity	23
Space and shape	20
Change and Relationships	20
Uncertainty	22
Total	**85**

In 2000, the areas of *space and shape*, and growth and change (now *change and relationships*) were those covered in the *mathematical literacy* assessment.

The competencies

While the four overarching ideas may define the main areas of mathematics that are assessed in PISA, they do not list the skills that a student needs to address problems in those areas. Typically, investigating and solving real-world problems involves a cycle of activity that the PISA mathematics framework calls *mathematisation* (a term coined by Freudenthal in the 1960s). Beginning with a problem situated in reality, students must organise it according to mathematical concepts. They must identify the relevant mathematical concepts. They progressively trim away the reality in order to transform the problem into one that is amenable to direct mathematical solution, by making simplifying assumptions, by generalising and formalising, by imposing useful ways of representing aspects of the problem, by understanding the relationships between the language of the problem and the symbolic and formal language needed to understand it mathematically, by finding regularities and patterns and linking it with known problems or other familiar mathematical formulations, and by identifying or imposing a suitable mathematical model.

Once the problem has been turned into a familiar or directly amenable mathematical form, the student's armoury of specific mathematical knowledge and skills can then be applied to solve the mathematical problem. This might involve a simple calculation, or using symbolic, formal and technical language and operations, switching between representations, using logical mathematical argument, and generalising. The final steps in the mathematisation process involve some form of translation of the mathematical result into a solution that works for the original problem context, a reality check of the completeness and applicability of the solution, a reflection on the outcomes, and communication of the results, which may involve explanation and justification or proof.

Various competencies are called into play as the mathematisation process is employed. The PISA mathematics framework defines those mathematical competencies in line with work done by Niss and the PISA Mathematics Expert Group. Central to this is a set of eight competencies of which seven have particular relevance to the PISA mathematics assessment: thinking and reasoning; argumentation; communication; modelling; problem posing and solving; representation; and using symbolic, formal and technical language and operations. Students activate these competencies to a greater or lesser extent as they confront their world and as they attempt to solve problems. Whilst it is generally true that these competencies operate together, and there is some overlap between the definitions of the competencies, PISA mathematics tasks can be constructed to call particularly on one or more of these competencies. In a short pencil and paper test to be taken in conditions that are required to be uniform across a large number of participating countries, it is realistic to employ test items that focus on certain aspects of the mathematisation process. PISA items are designed to do this.

The PISA mathematics framework discusses and groups the competencies in three *competency clusters* that are labelled the *reproduction* cluster; the *connections* cluster; and the *reflection* cluster. These groupings have been found to provide a convenient way to discuss the way in which different competencies are called into play in response to the different kinds and levels of cognitive demands imposed by different mathematical problems:

- The *reproduction* cluster of competencies is called into play in those items that are relatively familiar, and that require essentially the reproduction of knowledge which is likely to have been practised in most countries – knowledge of facts and of common problem representations, recognition of equivalents, recollection of familiar mathematical objects and properties, performance of routine procedures, application of standard algorithms and technical skills, manipulation of expressions containing symbols and formulae in familiar and standard form, and carrying out straight-forward computations.
- The *connections* cluster of competencies is called on by those items that build on the *reproduction* cluster competencies in taking problem solving to situations that are not simply routine, but still involve somewhat familiar settings or that extend and develop beyond the familiar to only a relatively minor degree. Problems typically involve greater interpretation demands, and require making links between different representations of the situation, or linking different aspects of the problem situation to work towards a solution.
- The *reflection* cluster of competencies builds further on the *connections* cluster. These competencies are called into play by items that require some insight and reflectiveness on the part of the student or even creativity in identifying relevant mathematics or in linking relevant knowledge to create solutions. The problems typically involve more elements, and additional demands typically arise for

students to generalise and to explain or justify their results.

Table 2.2 shows the breakdown by competency cluster of the 85 mathematics test items used in the PISA 2003 assessment.

Table 2.2 Count of PISA 2003 Mathematics Items by Competency Cluster

Competency cluster	Number of items
Reproduction	26
Connections	40
Reflection	19
Total	**85**

Situation

Stimulus material is prepared for PISA mathematics test items that represent a situation that students could conceivably confront, and for which activation of their mathematical knowledge, understanding or skill might be required or might be helpful in order to analyse or deal with the situation. The mathematics framework requires these situations to include a mixture of specified situation types: *personal*; *educational* and *occupational*; *public*; and *scientific*.

Personal situations include all kinds of contexts that directly relate to student's personal day-to-day activities. These situations have at their core the way in which the context immediately affects that individual and the way the individual perceives the context. They require the student to activate his or her mathematical understandings, knowledge and skills in some way to appreciate or interpret some aspect of the situation, and to respond to the question posed.

Educational and *occupational* situations include the contexts that appear in a student's life at school, or in a work setting. These situations have at their core the way the school or work setting might require a student or employee to confront some particular problem that requires a mathematical solution.

Public situations include contexts that require students to observe some aspect of their broader surroundings. These are generally situations located in the community that have at their core the way in which students understand relationships among elements of their surroundings. They require the student to activate his or her mathematical understandings, knowledge and skills in some way to evaluate aspects of an external situation that might have some relevant consequences for public life.

Scientific situations include more abstract contexts that might involve understanding some technological process, some theoretical situation, or some explicitly mathematical problem. The PISA mathematics framework includes in this category those relatively abstract mathematical situations with which students are frequently confronted in a mathematics classroom, which entirely consist of explicit mathematical elements, and where no attempt is made to place the problem in some broader context. These are sometimes referred to as '*intra-mathematical*' contexts. These six situation types vary in two important respects.

First, there are differences in the distance between the student and the situation – the degree of immediacy and directness in the connection between the student and the problem context. Personal situations are closest to the student, being characterised by the direct perceptions involved. Educational and occupational situations typically involve some imposition on the individual through their daily activities, then public situations typically involve a slightly further removed observation of some external events in the community. Finally, scientific contexts tend to be the most abstract and therefore involve the greatest separation between the student and the situation. The PISA mathematics framework assumes that a mathematically literate student is able to activate his or her mathematical understandings, knowledge and skills in a wide variety of such situations. All of these situation types are represented in the assessment.

Second, there are differences in the extent to which the mathematical nature of the situation is apparent. Some tasks refer only to mathematical objects, symbols or structures, and make no reference to matters outside the mathematical world (the 'intra-mathematical' contexts). A small number of such tasks are included in the PISA assessment. More typically, problems encountered in the day-to-day experiences of the student are not stated in explicit mathematical terms. They refer to real world objects, and the student must translate these problem contexts into a mathematical form. The PISA mathematics assessment has a strong emphasis 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.

Table 2.3 shows the breakdown by situation type of the 85 mathematics test items used in the PISA 2003 assessment.

Table 2.3 Count of PISA 2003 Mathematics Items by Situation Type

Context	Total
Distribution of mathematics items by situations or contexts	
Personal	18
Educational	15
Occupational	1
Public	5
Scientific	29
Intra-mathematical	17
Total	**85**

To summarise, the blueprint for constructing the PISA mathematics assessment tasks includes a perspective about the range of situations and contexts to be used as sources of stimulus materials and in which problems will be posed; it includes a perspective about the kinds of mathematical content that should be called on by different problems and questions that are posed; and a perspective about the different mathematical competencies that may be activated as students confront problems and the ways in which those competencies typically operate together to permit students to effectively respond to different problem situations and to answer the questions that are asked.

The structure of the assessment

Item response formats

In both the 2000 and 2003 PISA assessments, pencil and paper tests have been used. Under this constraint, certain types of item response format are possible and convenient. 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 capabilities.

Items were used that required students to construct a response to the stimulus and question. Some of these items involved students in writing down their calculations in order to expose something of the methods and thought processes they used in producing an answer. Other items required students to write an explanation of their results, which again exposed aspects of the methods and thought processes they had employed to answer the question. These relatively open, constructed response items could not easily be machine-scored; they required the professional judgement of trained expert markers.

Other items required students to construct a response, but the focus in evaluating the responses was limited to the response itself. For many of these relatively closed, constructed response items, the response was in numeric or other fixed form, and could be captured directly for evaluation using a well-defined algorithm. Such item responses generally did not require intervention of an expert, but were capable of analysis by computer.

Items were also used for which students were required to select one or more responses from a number of given possible responses. This format category includes both standard multiple choice items, for which students were required to select one correct response from a number of given response options; and complex multiple choice items, for which students were required to select a response from given optional responses to each of a number of propositions or questions. Responses to these items could be captured automatically for processing and analysis.

Of the 85 mathematics test items used in the PISA 2003 assessment:

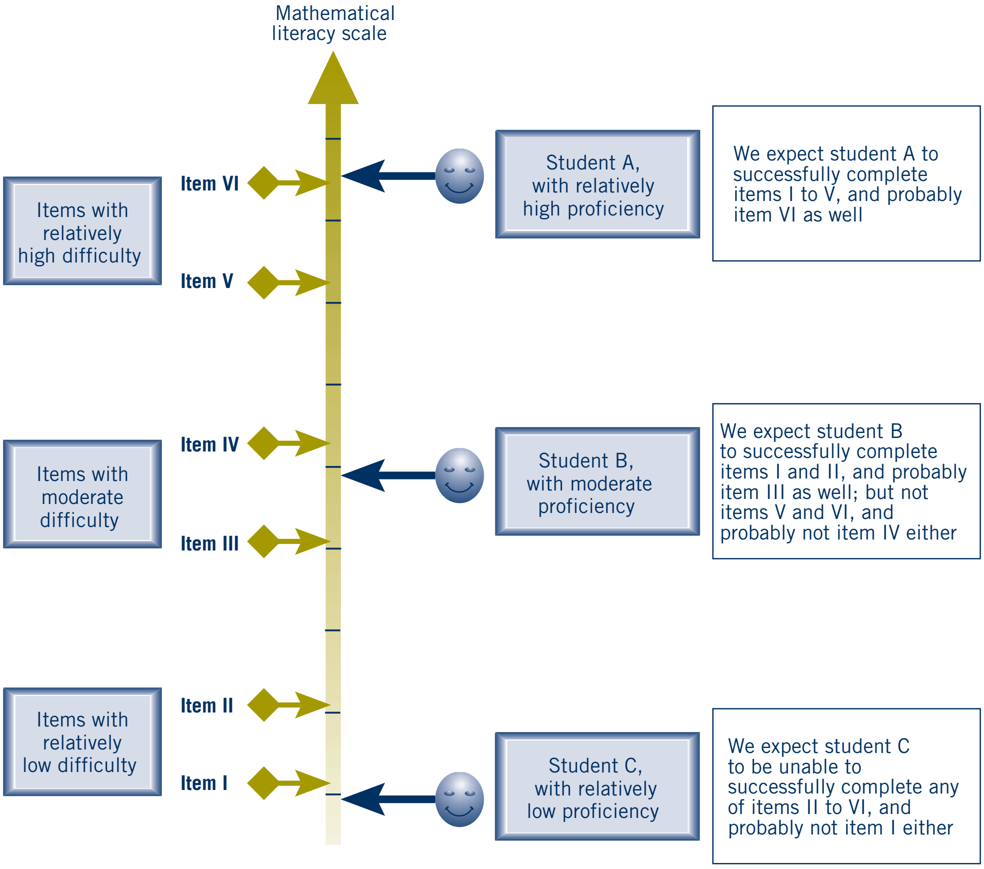
- 17 were multiple-choice items;
- 11 were complex multiple-choice items;
- 13 were closed-constructed response items;
- 21 were open-constructed response items; and
- 23 were short response items.

Allocating the items to test booklets

In total, 85 *mathematical literacy* tasks were constructed to ensure that the broadest possible coverage of *mathematical literacy* was achieved. Of course not all participating students were asked to attempt all 85 of the mathematics items. The mathematics items, together with the items from the other test domains that were included in the PISA 2003 assessment (reading, science, problem solving), were placed in *item clusters* each designed to occupy 30 minutes of test time, and 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, and that each cluster appeared in each of the four possible positions in the booklets.

Scaling the mathematical literacy tasks

A student whose ability estimate places him or her at a certain point on the PISA *mathematical 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. The scale – and the relationship between students and test items – depicted in Figure 2.1.



We expect student A to successfully complete items I to V, and probably item VI as well

We expect student B to successfully complete items I and II, and probably item III as well; but not items V and VI, and probably not item IV either

We expect student C to be unable to successfully complete any of items II to VI, and probably not item I either

Figure 2.1 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 precise 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 was 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 definition used for PISA 2000 was essentially retained for PISA 2003, with some modifications to accommodate the features particular to PISA mathematics. The definitions used for the proficiency scale developed for *mathematical literacy* in PISA 2003 are described later in the chapter.

New items for PISA 2003

Following PISA 2000, a number of *mathematical literacy* items was released. Releasing items gives a public indication of the types of questions that students face when they participate in the PISA assessment. The released items are described in *Sample tasks from the PISA 2000 assessment: reading, mathematical and scientific literacy* (OECD, 2002). A description of Australian students' responses is found in the first Australian PISA national report (Lokan, Greenwood, & Cresswell, 2001). The release of these items and the fact that *mathematical literacy* became the major domain necessitated the creation of many new items for inclusion in the 2003 assessment. A large number of items was trialled in the Field Trial in 2002 and then the final set was chosen for PISA 2003. Importantly, the items retained from 2000 allowed links to be made between the two cycles of testing so that monitoring of trends could begin. Link items will be retained to be included in each cycle of PISA.

Interpreting the results of PISA 2003

In keeping with the practice of PISA 2000 and other major international studies, the results in PISA 2003 have been standardised across the OECD countries to have a mean score of 500 and a standard deviation of 100. The choice of these values means that about two-thirds of the students across OECD countries have scored between 400 and 600 points. In constructing the scale, countries' results were weighted so that they contributed equally to it, regardless of sample size or population size. The means and standard deviations of the four *mathematical literacy* subscales vary slightly from 500 and 100, respectively, because the scales were constructed with reference to the overall scale, not as separate scales.

Each of the means mentioned in the above paragraph is referred to by the OECD as a 'country average' and can be used appropriately to compare a country's performance with the performance of a 'typical' OECD country on the same indicator. In the Australian report the term 'OECD average' is used to refer to these means. Some countries not belonging to the OECD participate in PISA, so that the OECD average is not the same as the average score of all the countries who participate.

Summaries of achievement are displayed graphically in this report. This section provides an explanation of how the bar charts are constructed, and how to read the charts. The charts can be used as a guide as to whether a country's or state's mean score is different from the mean of another country or state, and this is also described.

Standard errors and confidence intervals

In PISA, the unknown mean score of the whole population is estimated from the mean score obtained by a sample of students from the population. For this reason, each mean score estimate is accompanied by a statement of the associated error of that estimate. This error, which is labelled the standard error, is an indication that there is some *uncertainty* involved in estimating the characteristics of a population of students by measuring the characteristics of a sample of those students. The accuracy of the estimate provided by the mean score varies according to sample size and to how the sampling was done. Larger standard errors typically result from lower response rates or from differences in sample sizes.

In this report estimates of population parameters (such as mean scores) are often presented within the 95 per cent confidence intervals. This means that there is a 95 per cent chance that the estimate of a population parameter lies within plus or minus 1.96 standard errors of the sample estimate. For example, if a region's mean student performance is 520 with a standard error of 4 then sampling theory indicates that we can be 95 per cent confident that the mean in the population from which the sample was drawn is between 512 (=520-1.96x4) and 528 (=520+1.96x4). The 95 per cent confidence interval is 512 to 528.

How to read the bar charts

The charts each contain a series of coloured bars and use these to display:

- the mean (average) score in a domain for each country;
- an indication of how much reliance can be placed on the mean score as an accurate estimate of the population result;
- the range of achievement for the middle half of each distribution;
- the range of achievement for all but the lowest and highest five per cent of students in each case;
- a visual picture of countries placed in order of increasing mean performance from left to right.

As is typical in large-scale international achievement studies, the results on each of the tests reveal substantial differences both in mean achievement between the highest and lowest performing countries' and also in the spread of scores *within* countries.

A thin vertical bar is used to show the mean and range of performance in each country for 90 per cent of the students. The highest point on the bar is the 95th percentile (the point on the scale above which the highest-scoring 5 per cent of the country's students are located) and the lowest is the 5th percentile (the point below which the lowest-scoring 5 per cent are located). The white block with a black line across it, located in the middle region of each bar, denotes the mean country score and shows its 95% confidence interval. This gives an indication, through the length of the block, of the level of accuracy with which the mean was measured (the smaller the block, the more accurate the measurement).

To show more information about the distributions of results, each bar is divided into five regions, shaded differently to indicate the middle half of the students (those scoring between the 75th and 25th percentiles); the 30 per cent who scored either between the 75th and 90th or between the 25th and 10th percentiles; and the 10 per cent who scored either between the 90th and 95th percentiles or between the 10th and the 5th percentiles.

Between-country similarities and differences

The charts can be used as a guide to whether a country's mean score is significantly different from another country's mean score. For the means to be significantly different, the white blocks (the confidence intervals) on the countries' bars should not overlap on the vertical (the scores) scale.

Each country will no doubt wish to judge between-country results with itself as the main reference point. To facilitate comparisons for Australia we have included shaded background zones on each of the figures that show comparative performance for all countries, as follows:

- Countries in the lighter shaded zone on the left-hand side of each chart are the countries whose PISA students performed significantly less well, on average, than the Australian PISA students;
- Countries against the green background are those whose students performed at an equivalent level to the Australian students; and
- Countries in the dark-shaded zone at the right-hand end of each chart are the countries whose students performed significantly better, on average, than the Australian students.

The full international multiple comparison charts, from which the charts in this Australian report were derived, are included in Appendix 3.

>> *Australia's comparative results in summary*

Before a detailed discussion of the bar charts representing performance, an overview of Australia's results is included here in Table 2.4, which shows Australia's mean and standard deviation on each scale and subscale. The table also shows the results for the lowest-scoring country, the lowest-scoring OECD country, the highest-scoring country, and the highest-scoring OECD country if an OECD country was not the highest-scoring country (which occurred in three instances).

Australia's means were consistently and significantly higher than the international means. The standard deviations were within five points of the OECD standard deviation for all of the results, and for all of the scales and subscales other than *mathematical literacy – space and shape*, and *scientific literacy*, the spread of Australia's results was narrower than the spread of the OECD results.

While a gap of at least 18 score points in mean results between the highest-scoring country and Australia is evident from Table 2.4, there were generally only a few countries that achieved results higher than Australia's in absolute terms. These countries are identified in the figures and discussions in this chapter for *mathematical literacy*, in Chapter 4 for *reading* and *scientific literacy*, and in Chapter 5 for *problem solving*. Each figure is discussed from an Australian perspective.

Table 2.4 Overview of Australia's Performance in PISA 2003

Domain	OECD Average	Lowest-scoring country	Lowest-scoring OECD country	Highest-scoring country	Highest-scoring OECD country*	Australia
Mathematical literacy	500 (100)	356 (100)	385 (85)	550 (100)	544 (84)	**524 (95)**
Quantity	501 (102)	360 (109)	394 (95)	549 (83)		**517 (97)**
Space and shape	496 (110)	350 (96)	382 (87)	558 (4.8)	553 (110)	**521 (104)**
Change and relationships	499 (109)	333 (124)	364 (98)	551 (94)		**525 (98)**
Uncertainty	502 (99)	363 (71)	390 (80)	558 (101)	549 (90)	**531 (98)**
Reading literacy	494 (100)	375 (96)	400 (95)	543 (81)		**525 (97)**
Scientific literacy	500 (105)	385 (87)	405 (87)	548 (109)		**525 (102)**
Problem solving	500 (100)	345 (80)	384 (96)	550 (86)		**530 (91)**

*If highest-scoring country is not an OECD country
Standard deviations are shown in parentheses

Australia's results in mathematical literacy

Australia's mean score in *mathematical literacy* of 524 is significantly above the OECD average of 500. This is shown in Figure 2.2. There were four countries that scored significantly higher in PISA 2003 than Australia: Hong Kong-China, Finland, Korea and the Netherlands[2]. Comparisons with PISA 2000 are not possible for the Netherlands as their data were excluded from the 2000 report because of an insufficient sample. Australia's performance was statistically similar to that of Korea and Finland in PISA 2000. It is also interesting to note the change in Japan's performance relative to Australia's from 2000, when Japan outperformed Australia, to 2003, when the two countries' scores are on a par.

All of the countries from Hong Kong-China through to Sweden scored significantly higher than the OECD average. Five countries – Austria, Germany, Ireland, the Slovak Republic and Norway – had means statistically the same as the OECD average, and the group of countries from Luxembourg through to Tunisia all scored significantly below the OECD average. The difference between the performance scores for Hong Kong-China and Tunisia was almost 200 score points, or two standard deviations.

Australia is in a group of 10 countries whose results are considered statistically similar – as well as Australia, the group consists of Liechtenstein, Japan, Canada, Belgium, Macao-China, Switzerland, New Zealand, the Czech Republic and Denmark.

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[2] The standard error for Australia's mean was 2.4. The confidence interval is therefore equal to the mean plus 1.96 x standard error to the mean minus 1.96 x standard error. In this case, then, we are 95% confident that the mean for Australia lies between a score of 519.3 and a score of 528.7. Similarly, the score for Hong Kong-China was 550 with a standard error of 4.5, producing a confidence interval of 541.2 – 558.8. As the two confidence intervals do not overlap, the means are said to be significantly different. When we are comparing many countries in such a manner, a statistical adjustment for multiple comparisons has been made (Bonferroni adjustment). The tables of multiple comparisons, and their adjusted and unadjusted differences, are reproduced in Appendix 3 from the PISA 2003 International Report (OECD, 2004a). This is the same technique that was used in the PISA 2000 National Report (Lokan, Greenwood, Cresswell, 2001).

Dispersion of results in performance in mathematical literacy

Changes in mean performance scores are typically used to assess improvements in the quality of schools and education systems. However, mean performance does not provide a full 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. Both parents and the public at large are aware of the gravity of low performance and the fact that school-leavers who lack fundamental skills face poor prospects of employment. A high proportion of students at the lower end of the mathematics scale may give rise to concern that a large proportion of tomorrow's workforce and voters will lack the skills required for the informed judgements that they must make.

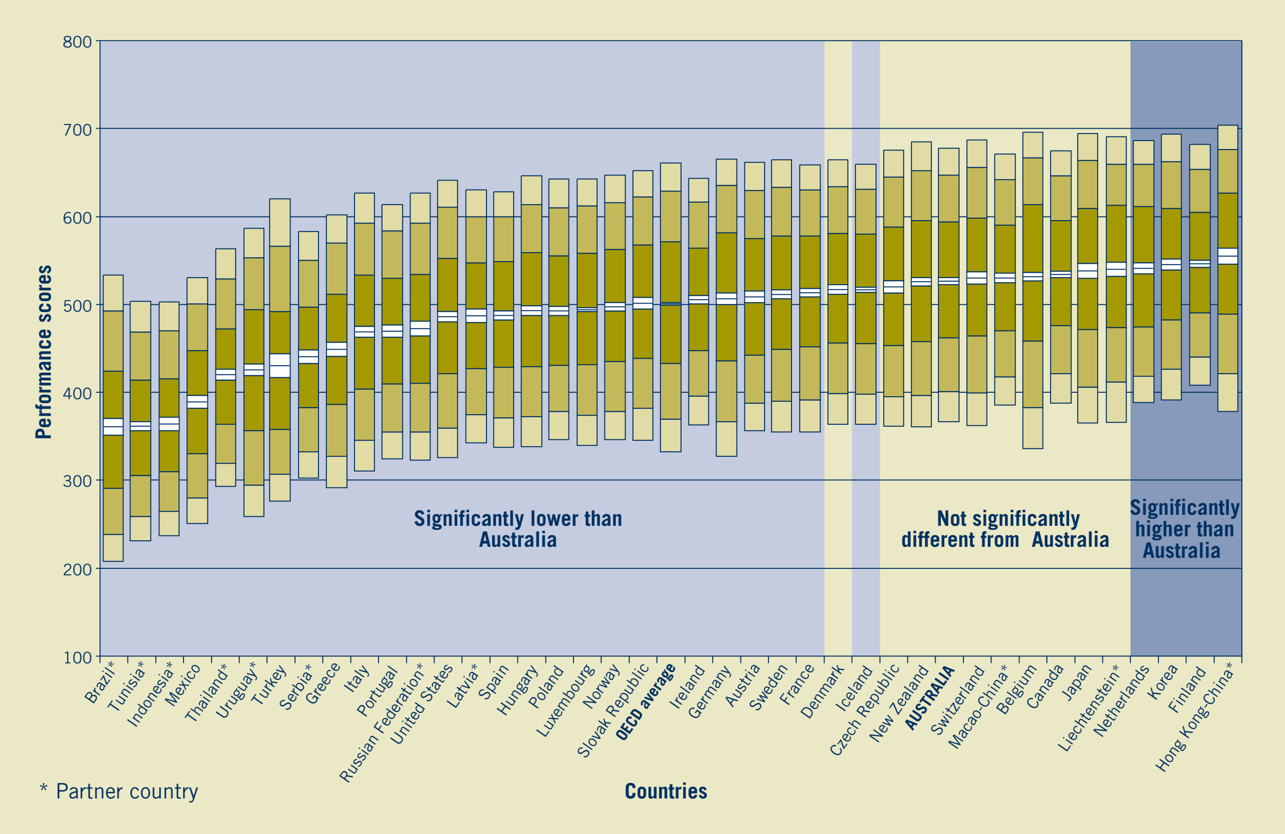
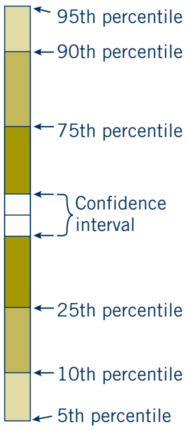


Figure 2.2 Performance in Overall *Mathematical Literacy* for all Countries



READING THE GRAPHS

Each country's results are represented in vertical bars with various colours. The bottom 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 bottom 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 center of the white band is the mean. The lines above the white band indicate the 75th, 90th and 95th percentiles.

Figure 2.2 also shows that there is indeed a great deal of variation within most countries, and that some countries with similar levels of average performance show a considerable variation in student performance. For example in Australia – the range between the 5th percentile and the 95th percentile is 312 score points, whereas Belgium, a country with a similar mean score to Australia, had the widest range of scores with a difference of 360 score points between the 5th percentile and the 95th percentile. Indonesia had the shortest range of scores, with 266 points between the 5th and 95th percentile.

Germany and Ireland both had a range between the 5th and 95th percentile which was similar to the OECD average range of 328 score points; however while Ireland had one of the narrowest range of scores between the 5th and 95th percentile (280 score points), Germany had one of the widest (338 score points). The highest scoring country, Hong Kong-China, had a spread of scores from the 5th to 95th percentile of 326 score points, while Tunisia, the lowest scoring country, had a spread of 272 score points.

Another way to look at the dispersion of scores is to examine the 'tail' of the scores, that is the gap between the 5th and 25th percentiles. The 'tail' for the highest scoring country, Hong Kong-China was 111 score points, while that for the lowest scoring country, Tunisia, was 74 score points. The best students in Belgium achieved very high results, well above the OECD average for the top five per cent of students, but the 'tail' of 122 score points was much larger than for any other country. Australia's 'tail' of 95 score points was lower than the OECD average of 101 score points, or just less than one standard deviation. The shortest 'tails'were for Indonesia and Thailand, both of which were low scorers on the overall *mathematical literacy* scale.

>> *Gender differences in mathematical literacy*

With mathematics as the primary focus of PISA 2003, it is of particular interest to examine PISA results in mathematics by gender. Internationally and in Australia, a vast body of research has investigated gender differences in mathematics over several decades, and changes in gender patterns have been noted in previous large-scale studies.

A great deal of progress has been made towards gender equity in terms of academic achievement, particularly in Australia, and today young women are more likely than in the past to progress to tertiary education and complete further qualifications. However recent research on school subject selection and subsequent study and work participation in Australia (Thomson, in press) has found that males are still much more likely than females to be taking advanced mathematics and science at senior secondary school, and much more likely than females to move into mathematics and science-related courses in higher education. Internationally, gender differences in possession of university qualifications remain persistently high. The proportion of women among university graduates in mathematics and computer science is only 30 per cent, on average among OECD countries, and in some OECD countries it is much lower (OECD, 2004a).

In the Third International Mathematics and Science Study (TIMSS) 1994/95 (Beaton, Mullis, Martin, Gonzales, Kelly & Smith, 1996), statistically significant gender differences in mathematics were found for Year 4 students in only three of the

16 participating OECD countries (Japan, Korea and the Netherlands), all in favour of males. However in the same study, gender differences all in favour of males were found for Year 8 students in six of the 16 participating OECD countries, and in the final year of schooling gender differences in favour of males were large and statistically significant in 14 of the 16 participating OECD countries. This suggested that gender differences become more pronounced and pervasive at later year levels.

Australia seems to have been able to contain this widening of gender disparity with age in mathematics. In TIMSS 1994/95 Australia was one of the six countries that had no gender differences in mathematics for Year 8 students, and also were one of the countries that had equivalent results by gender in advanced mathematics at Year 12, despite there still being a substantial gap in physics (Lokan, Ford & Greenwood, 1996). In TIMSS 1998/99, carried out with junior secondary students only, Australia was again one of the few countries (four in 39) with no significant gender differences in mathematics (Zammit, Routitsky & Greenwood, 2002).

On the overall *mathematical literacy* scale, with a mean of 500 and a standard deviation of 100, the males' mean score was 12 scale points above the females' for the OECD as a whole (males' score 506, females 494), which although statistically significant is only a little more than one-eighth of a standard deviation. The gender differences seen in PISA 2000 in *reading literacy* were substantially larger, with a mean difference over the OECD in favour of girls of 32 points - almost one-third of a standard deviation.

The next figure presented in this section (Figure 2.3) represents gender differences in all countries in PISA on the overall *mathematical literacy* scale. Bars above the x-axis represent higher scores by males, and solid bars represent significant differences. Bars below the axis represent higher scores by females, and bars that are not shaded represent non-significant differences. Most of the gender differences that can be seen in Figure 2.3 are statistically significant in favour of males. Only in one country, Iceland, was there a statistically significant difference in favour of females, of the order of 15 points. Australia was one of seven OECD countries (the others being Austria, Norway, Poland, Belgium, Japan and the Netherlands) and five partner countries (Hong Kong-China, Indonesia, Latvia, Serbia and Thailand) in which there were no statistically significant gender differences.

The differences in favour of males range from 29 scale points in Liechtenstein, where the mean for males of 550 was half a student standard deviation higher than the OECD average. As well as Liechtenstein, in both Korea and Macao-China gender differences were more than 20 scale points in favour of males.

The highest mean scores for males were in Hong Kong-China and Korea (552 score points), and Liechtenstein (550 score points). The lowest mean score for males was in Indonesia (362 score points), followed by Brazil and Tunisia (365). The range between highest and lowest country means for males was 190 score points, equivalent to almost two standard deviations, in terms of individual students' scores.

The highest mean score for females was also found in Hong Kong-China (548 score points), with the next highest being Finland (541 score points). The lowest mean score (353 score points) was found in Tunisia. The difference between highest and lowest country means was again close to 200 score points, or the equivalent of two standard deviations of student scores.

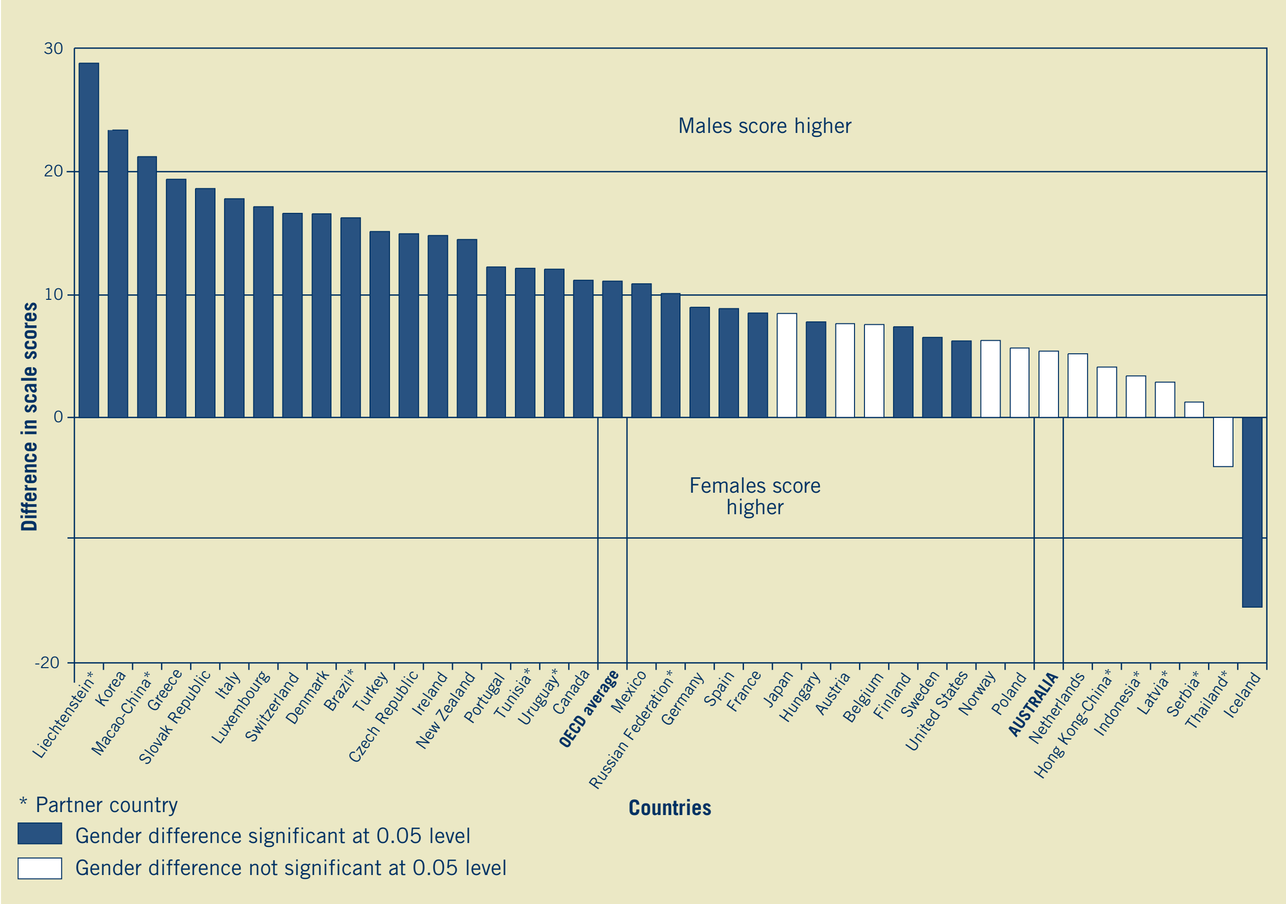


Figure 2.3 Gender Differences on the Overall *Mathematical Literacy* Scale

>> *Mathematical literacy results by subscale*

In addition to the overall *mathematical literacy* scale, results are also available for each of the four overarching ideas: *quantity*, *space and shape*, *change and relationships*, and *uncertainty*. The results from the subscales can provide valuable information to countries on the relative strengths and weaknesses of their students in the different areas of mathematics. This information could be used to provide direction for future development of mathematics courses.

Quantity

One-quarter of the mathematical tasks given to students in PISA 2003 related to numeric phenomena and quantitative relationships and patterns. The performances of all countries on this subscale are shown in Figure 2.4.

Differences among countries on the quantity subscale

Australia's score of 517 on the *quantity* subscale was significantly higher than the OECD average of 501, and statistically similar to that of the Netherlands, the Czech Republic, Japan, Denmark, Sweden, Germany, Iceland, Austria, the Slovak Republic, New Zealand and France. The countries that performed significantly better than Australia on this subscale were Finland, Hong Kong-China, Korea, Liechtenstein, Macao-China, Switzerland, Belgium and Canada.

The highest mean scores were those of Finland (549) and Hong Kong-China (545), which were significantly higher than those of other countries, and the lowest mean scores were those of Indonesia (357), Brazil (360) and Tunisia (364). The difference of scores between highest and lowest country means was again almost two standard deviations of student scores. Within Australia, the difference between the 5th and 95th percentiles was 319 score points. As the PISA 2000 assessment did not include the *quantity* subscale, no comparisons between 2000 and 2003 can be made.

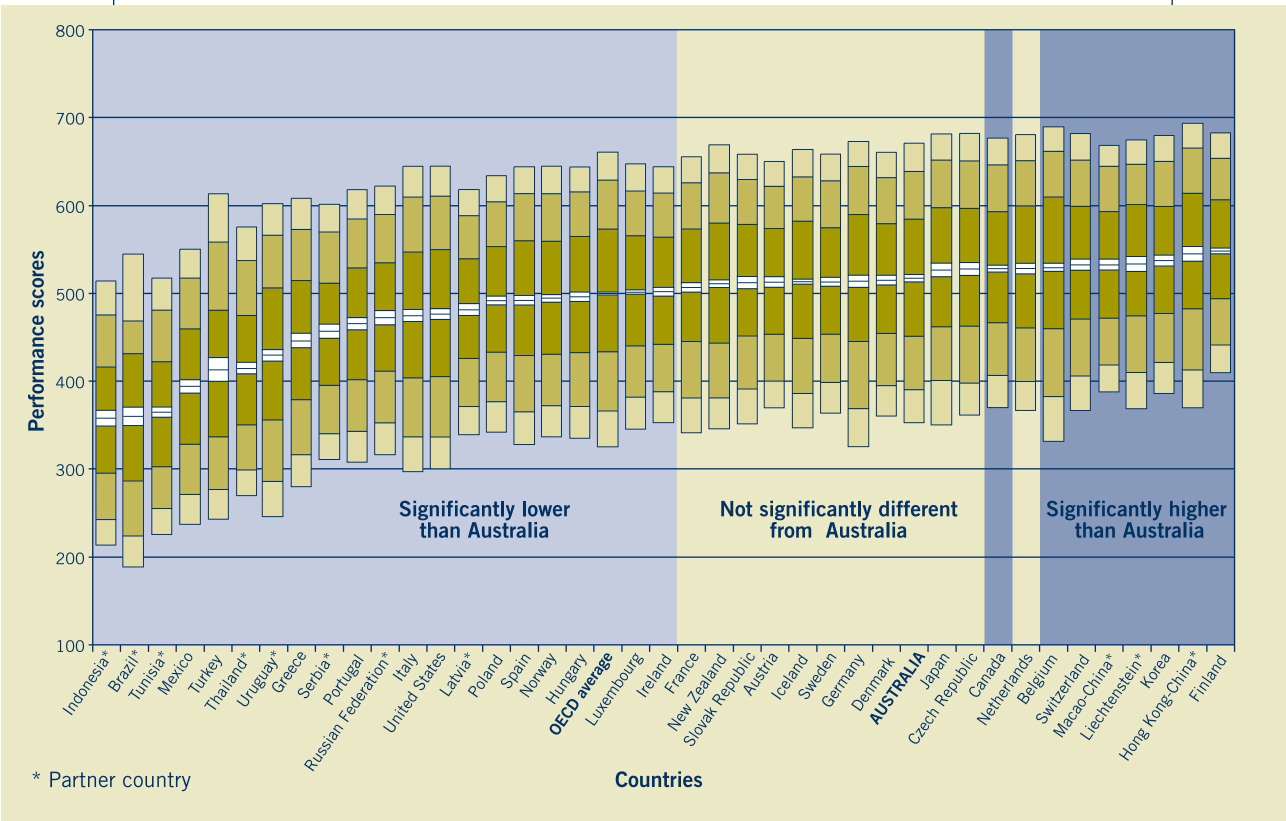


Figure 2.4 Performance on the *Quantity* Subscale for all Countries

Gender differences on the quantity subscale

Figure 2.5 shows the gender differences internationally on the *quantity* subscale. The graph is interpreted as previously described. Gender differences are not as apparent on this subscale as on overall *mathematical literacy*, and are generally quite small. The average gap was six score points. There were 22 countries, including Australia, in which there were no significant gender differences, 18 for which there were significant gender differences in favour of males, and one (Iceland) in which there was significant gender differences in favour of females. The largest gender difference is that of Iceland, of 28 score points, then Greece with a 23 score point gap, Korea with a 22 score point gap and Liechtenstein with a 21 score point gap.

Space and shape

One-quarter of the mathematical tasks given to students in PISA 2003 were related to spatial and geometric phenomena and relationships. The performance of students in all countries can be seen in Figure 2.6.

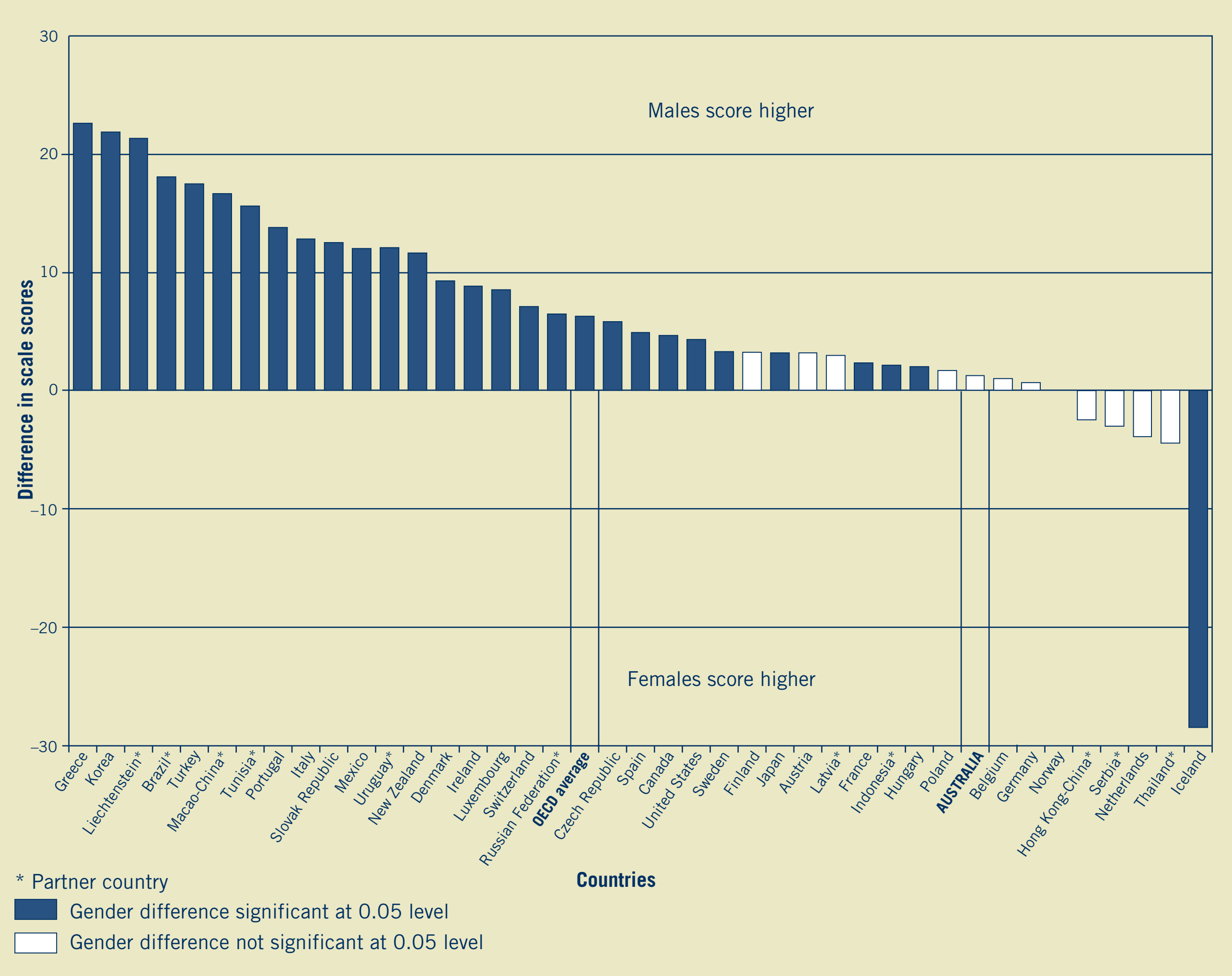


Figure 2.5 Gender Differences on the *Quantity* Subscale

Differences among countries on the space and shape subscale

The highest scoring countries in *space and shape* were Hong Kong-China (558), Japan (553) and Korea (552), which scored significantly higher than any other country. The lowest scoring countries were Brazil (350), Tunisia (359) and Indonesia (361). The range of mean scores was a little more than two standard deviations in terms of student scores. Within Australia, the mean score was 521, and the difference between the 5th and 95th percentiles was 340 score points. The OECD mean was 496 on the *space and shape* subscale.

Australia again scored significantly higher than the OECD average, statistically similar to the group of countries consisting of Belgium, the Czech Republic, Macao-China, the Netherlands, New Zealand, Canada, Austria and Denmark. Scoring significantly better than Australia were Hong Kong-China, Japan, Korea, Switzerland, Finland and Liechtenstein.

It is also possible to estimate how much mathematics performance on the mathematics *space and shape* subscale has changed since the last PISA survey in 2000. However, such differences need to be interpreted with caution. First of all, since data are only available from two points in time, it is not possible to assess to what extent the observed differences are indicative for longer-term trends. Second, while the overall approach to measurement used by PISA is consistent across cycles, small refinements continue to be made, and so it would not be prudent to read too much into small changes in results at this stage. Furthermore, errors from sampling as well as measurement error, that are inevitably introduced when assessments are linked through a limited number of common items over time, limit the reliability of comparisons of results. To account for the latter, the confidence band for comparisons over time has been broadened correspondingly.[3]

With these caveats in mind, it is possible to make some comparisons.[4] On average across OECD countries, performance on the mathematics *space and shape* scale remained broadly similar among the 25 countries for which data can be compared (in 2000, the OECD average was 494 score points whereas in 2003 it was 496 score points). However the pattern was uneven across countries: in Belgium, Poland, the Czech Republic and Italy as well as the partner countries Brazil, Indonesia, Latvia, and Thailand, there have been significant performance increases, while performance in Iceland and Mexico has declined. For Australia, as for most countries, and for the OECD as a whole, there was no statistical difference in the performance of students in PISA 2003 and PISA 2000 on items in this subscale.

Some of the observed changes have not resulted from an even rise or fall in performance across the ability range: in some countries the range in performance has widened or narrowed over the three-year period. This is true not only in countries where a rise or fall in overall performance is concentrated in one part of the ability range, but also in some cases where average performance has remained the same, but there have been rises in some parts of the distribution and falls in others. This was not the case in Australia, where scores were similar on each percentile for 2000 and 2003.

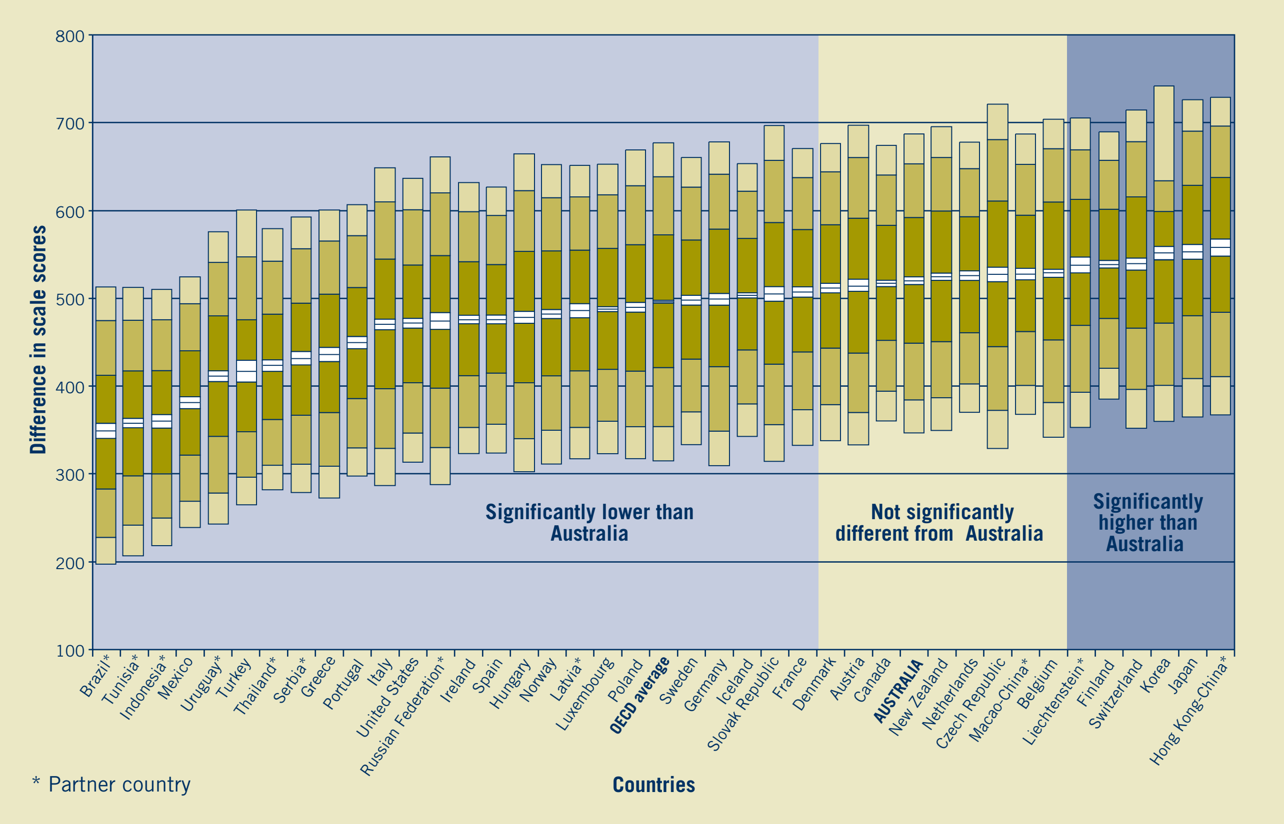


Figure 2.6 Performance on the *Space and Shape* Subscale for all Countries

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[3] See Annex A8 of the PISA International report (OECD, 2004a) for an explanation of the methods employed to establish the link between the PISA 2000 and 2003 assessments

[4] The data for these comparisons can be found in the PISA International Report (OECD, 2004a)

In Belgium, for example, the 28 point rise in average performance on the *space and shape* subscale has mainly been driven by improved performance in the top part of the distribution, with increases in scores at the 75th, 90th and 95th percentiles, while little has changed at the lower end of the distribution. A similar picture, though less pronounced, emerges for Italy. As a result, overall performance in these two countries increased, but the gap between the better and poorer performers widened.

In contrast, for Poland, the rise in average performance on the *space and shape* subscale is mainly attributable to an increase in performance at the lower end of the performance distribution (i.e., 5th, 10th and 25th percentiles). As a result, Poland succeeded in raising average performance of 15-year-olds on the *space and shape* subscale while narrowing the overall performance gap between the lower and higher achievers. To a lesser extent, this also holds for the Czech Republic, the remaining country with a substantial increase in average performance.

Gender differences on the space and shape subscale

Figure 2.7 shows gender differences for all countries on the *space and shape* subscale. It is clear from this figure that gender differences are far more evident on this subscale than in the area of *quantity*, with quite strong gender differences, primarily in favour of males, in all but seven countries (Japan, Netherlands, Norway, Thailand, Hong Kong–China, Serbia, and Finland). Again Iceland had strong gender differences (15 score points) in favour of females.

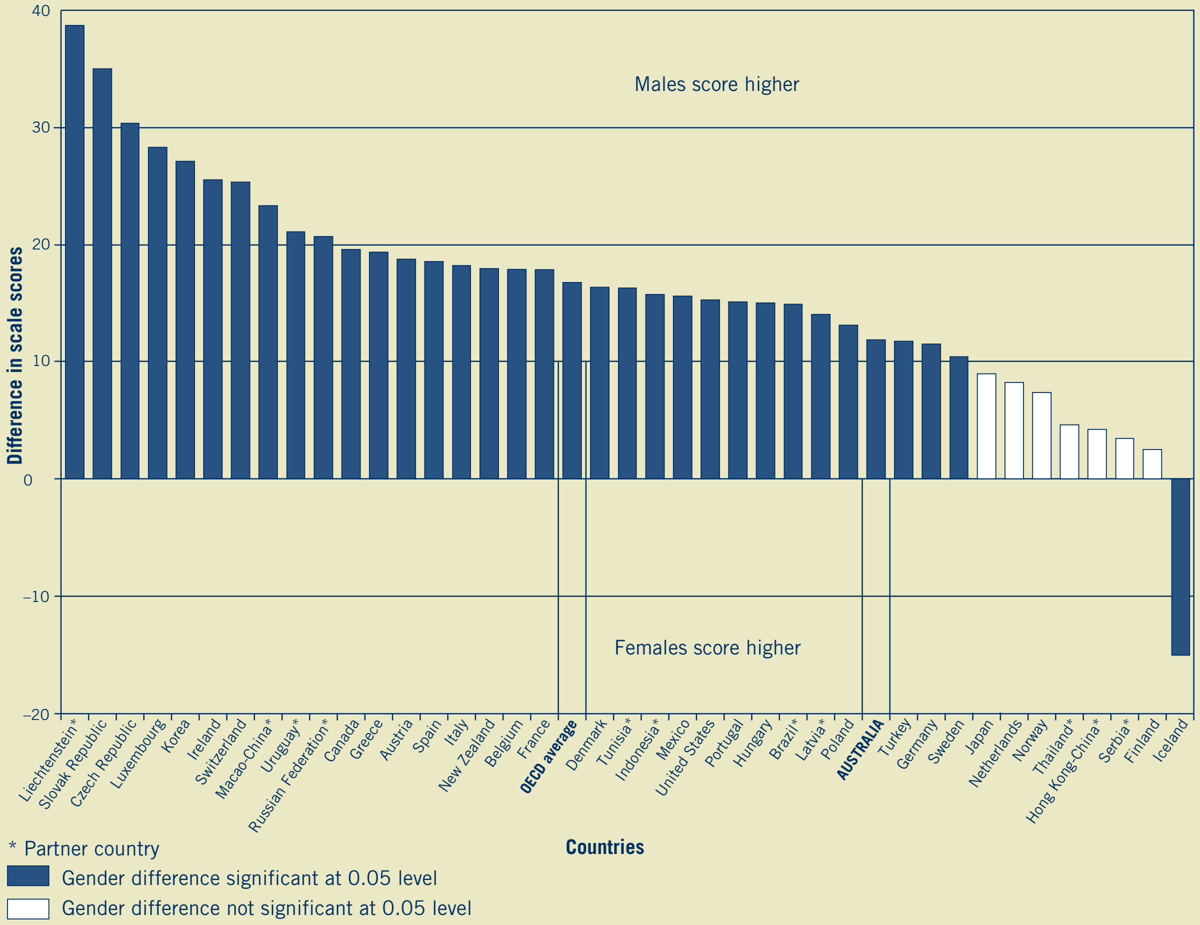

Figure 2.7 Gender Differences on the *Space and Shape* Subscale

Gender differences in favour of males ranged from 39 score points in Liechtenstein and 35 score points in the Slovak Republic, through to 11 score points in Germany and 10 score points in Sweden. The OECD average was 17 score points. The gender differences of 12 score points in Australia, although significantly in favour of males, was one of the lowest significant differences.

Change and relationships

A further quarter of the mathematical tasks given to students in PISA are related to mathematical manifestations of change, functional relationships and dependency among variables. The performance of PISA students in all countries can be seen in Figure 2.8.

Differences among countries on the change and relationships subscale

Among the various mathematics scales, the *change and relationships* subscale shows the largest gap in performance between high and low performing countries – 218 score points separate the Netherlands at half a student standard deviation above the OECD average from Indonesia and Brazil at more than one and a half student standard deviations below the OECD average. Within Australia, the difference between the 5th and 95th percentiles was 321 score points.

Australia's mean score on this subscale (525) was again significantly higher than the OECD average. It was surpassed by the Netherlands, Korea, Finland, Liechtenstein and Canada. Australia's mean score was statistically similar to those of Hong Kong-China, Japan, Belgium, New Zealand, Switzerland, France, Macau-China and the Czech Republic.

As for the *space and shape* subscale, it is also possible to estimate how much performance has changed since PISA 2000. However, as explained in that section, these differences need to be interpreted with caution since only data from two points are available and since the observed differences are not only influenced by sampling error but also by the uncertainty associated with the linking of the two assessments.

On average across OECD countries, performance among the 25 countries for which data can be compared has increased from 489 score points in 2000 to 499 score points in 2003. Again, changes have been very uneven: the Czech Republic and Poland have seen increases of around 30 score points while Belgium, Canada, Germany, Finland, Hungary, Korea, Portugal and Spain the increases of between 13 and 22 score points were still significant. For the remaining countries, the differences cannot be considered statistically significant when both measurement and link errors are taken into account.[5]

As for the *space and shape* subscale, some of the observed changes have not necessarily involved an even rise or fall of performance across the ability range. The large improvements in Poland have been driven by the increase in performance at the lower end of the performance distribution (i.e., 5th, 10th and 25th percentiles). As a result, Poland succeeded in significantly raising average performance of 15-year-olds in the *change and relationships* subscale and narrowing the overall performance

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[5] Luxembourg also shows a large performance difference between the 2000 and 2003 results but this may be due to the modified assessment conditions that allowed students to choose their preferred language among the two official languages of instruction.

gap between the lower and higher achievers over this period. A similar picture, though less pronounced, is also visible in the Czech Republic, Hungary, Latvia and Liechtenstein. Greece, Switzerland, and the Russian Federation have seen apparent improvements at the lower end of the distribution, but they were not sufficient to lead to statistically significant improvement in mean performance.

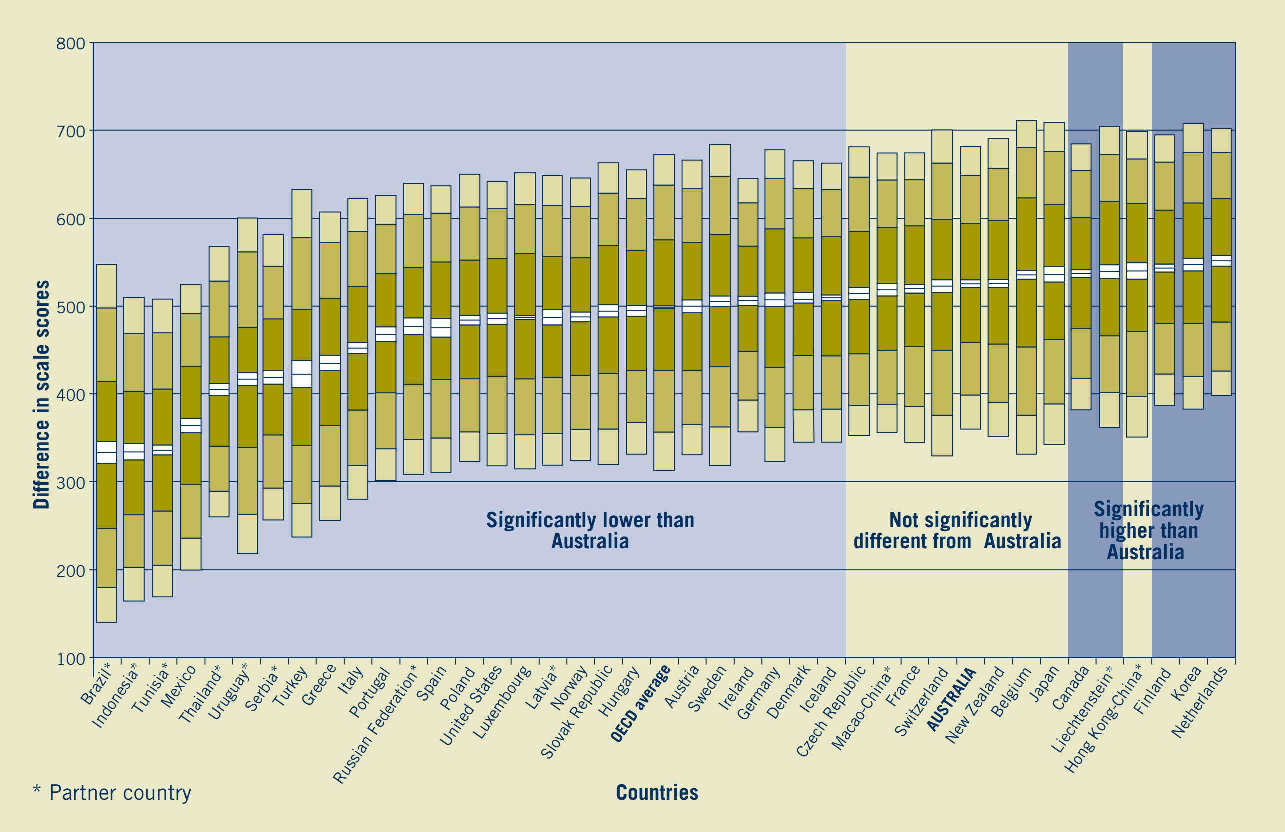


Figure 2.8 Performance on the *Change and Relationships* Subscale for all Countries

In contrast, in Canada, Finland, Germany, Italy, Korea, Portugal and Sweden, improvements in performance have mainly been driven by improved performance in the top part of the performance distribution, as visible in the increase in scores at the 75th, 90th and 95th percentiles, while less has changed at the lower end of the distribution. In some of these countries, disparities among students have grown. In the 2000 assessment, for example, Korea showed the smallest variation in student performance in mathematics whereas in the 2003 assessment variation is now at the OECD average level.

Australia's 2003 results are almost identical to those in 2000: there was a very slight increase in scores at the 75th, 90th and 95th percentiles but given the caveats already expressed these are not significant.

Gender differences in change and relationships subscale

Figure 2.9 shows the gender differences internationally on the *change and relationships* subscale. Males outperformed females in 17 OECD countries and four partner countries, but generally only by small amounts. The average performance difference between males and females is only 10 score points, i.e. somewhat smaller gap than the difference found for the *space and shape* subscale. Only in Iceland did females perform significantly better than males.

The largest significant differences in favour of males were found in Liechtenstein, where there were 26 scale points' difference between males' and females' mean scores, and Korea, with 25 scale points' difference. Australia was one of 18 countries with no gender differences on this subscale.

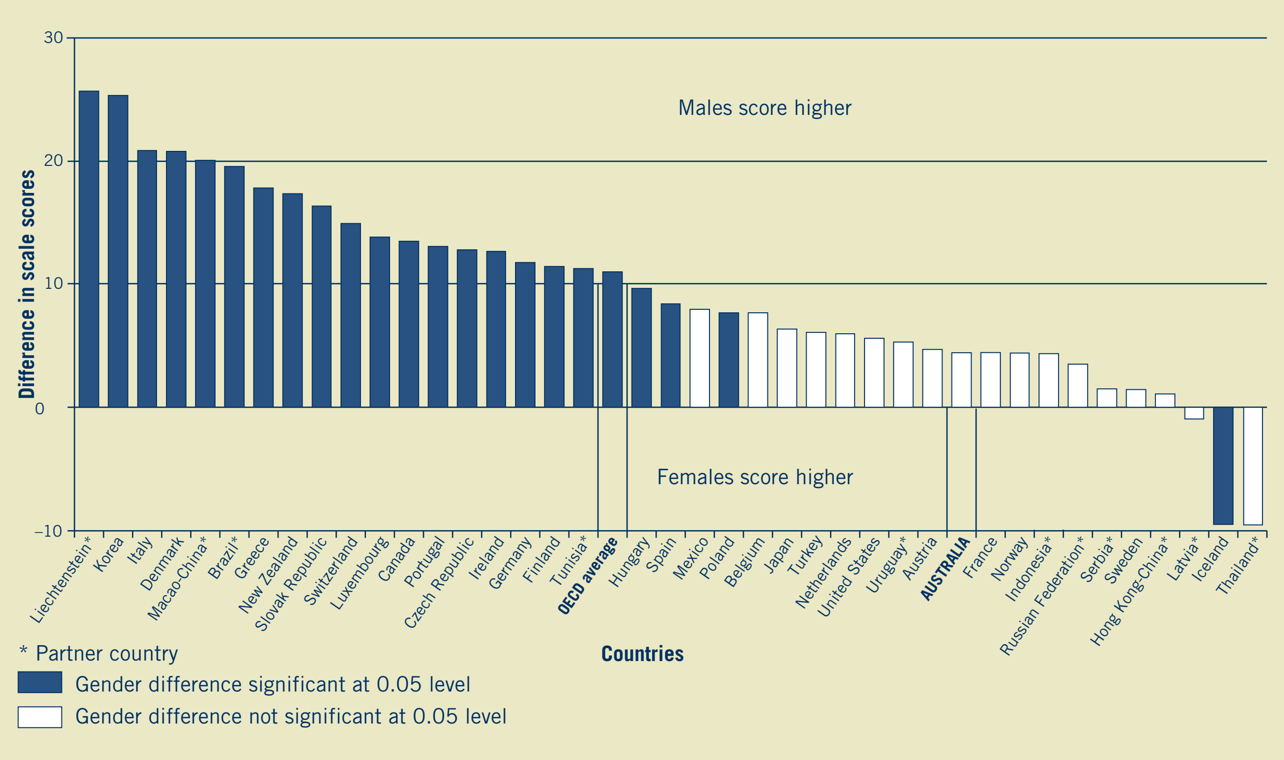


Figure 2.9 Gender Differences on the *Change and Relationships* Subscale

Uncertainty

One-quarter of the mathematical tasks assigned to students in PISA related to probabilistic and statistical phenomena and relationships. The performance of PISA students from all countries can be seen in Figure 2.10.

Differences among countries on the uncertainty scale

Australia's mean (531) on the *uncertainty* subscale was again significantly higher than the OECD average. Hong Kong-China, the Netherlands, Finland and Canada all achieved at a significantly higher level than Australia, while Korea, New Zealand, Macao-China, Japan, Iceland, Belgium and Liechtenstein were all statistically similar to Australia. The highest scoring country was Hong Kong-China (558), and the lowest scoring countries were Brazil (377) and Tunisia (363). The range of mean scores was a little less than two standard deviations of student scores. Within Australia, the difference between the 5th and 95th percentiles was 319 score points.

No comparison over time is possible given that this subscale was not included in the 2000 PISA assessment.

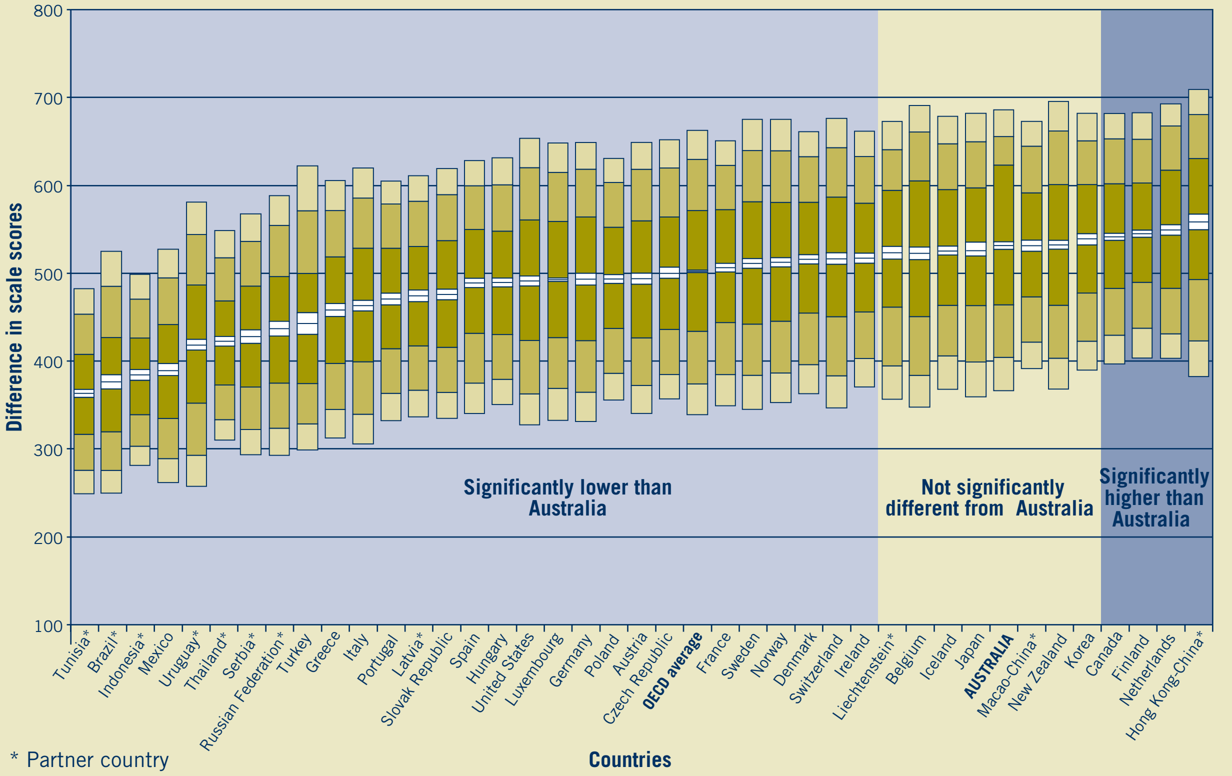


Figure 2.10 Performance on the *Uncertainty* Subscale for all Countries

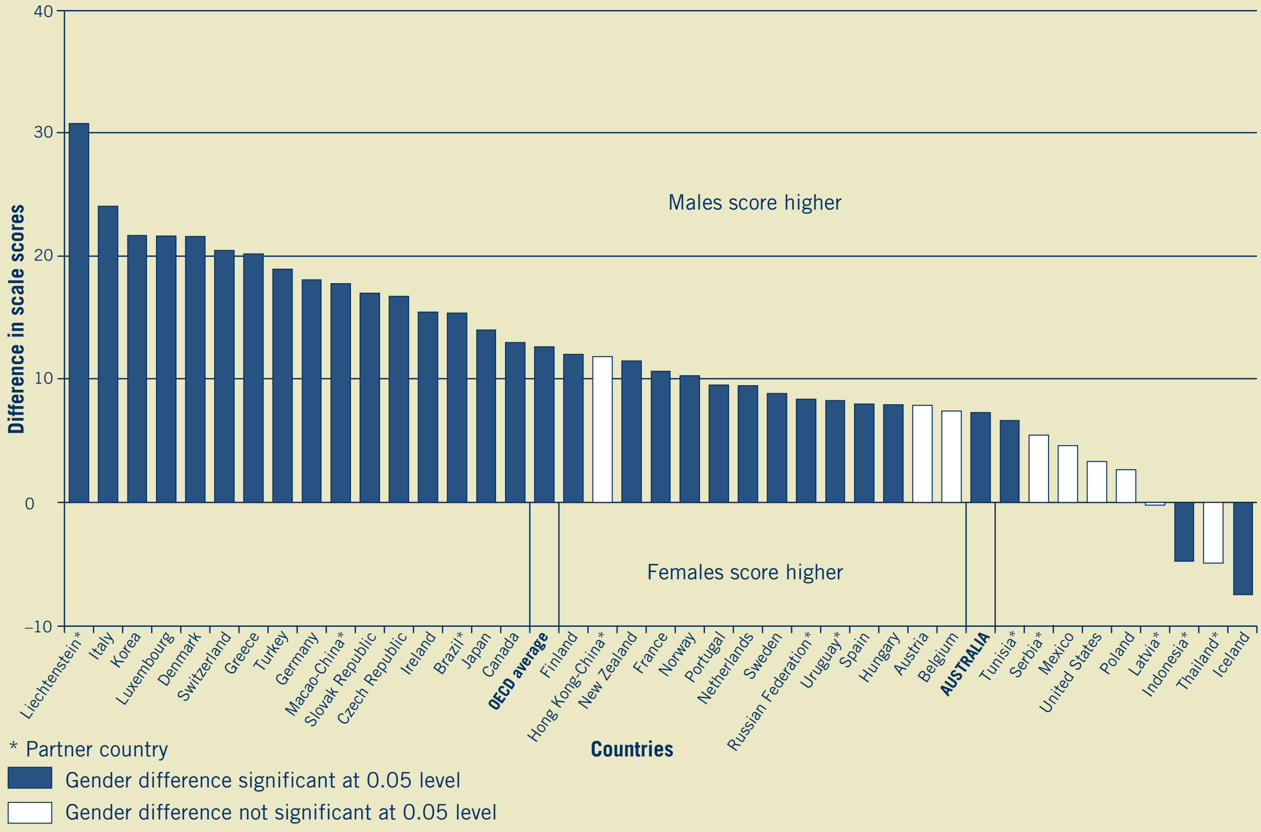


Figure 2.11 Gender Differences on the *Uncertainty* Subscale

Gender differences on the uncertainty sub-scale

Consistent with what was found in the other scales, males show an advantage also in the *uncertainty* scale (Figure 2.11). Males outperformed females in 23 OECD countries and six partner countries but differences tended to be small, with an advantage for males of just 11 score points on average for the combined OECD countries. Liechtenstein still showed the largest gender differences in favour of males, with males scoring on average 538 scale points and females 508 points. Italy, Luxembourg, Korea, Denmark, Switzerland and Greece all had at least a 20 score point gap in performance in favour of males. In Latvia, average scores for males and females were exactly the same, while in Iceland and Indonesia, females performed significantly better than males. There were five OECD countries in which no significant gender differences were apparent – Austria, Belgium, Mexico, the United States and Poland, and three partner countries – Serbia, Latvia and Thailand.

There was a significant gender difference for Australia on the *uncertainty* subscale, in favour of males, although the actual size of the difference was one of the smallest that was significant. The mean score on this subscale in Australia was 535 for males and 527 for females.

>> *Levels of mathematical literacy*

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' mathematical performance using proficiency levels as was done for *reading literacy* in PISA 2000. In that case, five 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, in particular among the students from different participating countries. A similar approach has been used here to analyse and report PISA 2003 outcomes for mathematics.

For PISA 2003 mathematics, six levels of proficiency have been defined and described. The continuum of increasing *mathematical literacy* that is represented in Figure 2.12 has been divided into five bands, each of equal width, and two unbounded regions, one at each end of the continuum. The band definitions on the PISA scale are also given in Figure 2.12.

The information about the items in each band has been used to develop summary descriptions of the kinds of mathematical competencies associated with different levels of proficiency. These summary descriptions can then be used to encapsulate typical mathematical proficiency of students associated with each level. As a set, the descriptions encapsulate a representation of growth in *mathematical literacy*. Figure 2.12 describes the levels of proficiency in detail.

Proficiency descriptions for each of the six levels have also been developed for each of the four *overarching ideas* of the mathematics framework. A summary of each of these is included in Appendix 3.

Score	Level	Description of mathematical literacy
669 Points	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.
607 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 insight pertaining to these situations. They can reflect on their actions and formulate and communicate their interpretations and reasoning.
545 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.
482 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.
420 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.
358 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.

Figure 2.12 Summary Descriptions for Six Levels of Overall *Mathematical Literacy*

Interpreting the *mathematical 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 *mathematical literacy*' is a continuous scale. The use of performance bands, or levels of proficiency, involves an essentially arbitrary 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 mathematics, 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 2003 results. Such an approach makes it possible to summarise aspects of student proficiency by describing the things related to PISA *mathematical literacy* that students can be expected to do at different locations on the scale.

Proficiency not yet at Level 1

Mathematics tasks any easier than the Level 1 tasks in PISA do not fit the PISA concept of *mathematical literacy* as skills that will enable young adults to participate fully in society beyond school. Students performing below the lower boundary of Level 1 were not necessarily incapable of performing any mathematical operation, but were unable to utilise mathematical skills in a given situation, as required by the easiest PISA tasks. On average, eight per cent of students in OECD countries and four per cent of students in Australia were unable to demonstrate Level 1 mathematics skills in PISA.

Overall proficiency levels

The proficiency levels for the overall *mathematical literacy* scale for all PISA countries are shown in Figure 2.13. This figure is made up of a series of stacked bars, each of which shows the percentage of students whose performance placed them at each of the six levels. The percentages in each of the stacked bars add to 100 per cent for each country. Countries are ranked in descending order of average achievement on the overall *mathematical literacy* scale.

Another way of looking at the results in relation to proficiency levels is to consider cumulative percentages of students, according to the highest proficiency level reached. It is assumed that students at a particular level are also able to deal with tasks at lower levels of proficiency. The stacked bars in the figures presented in this section can be used in this way, so that the bars can be followed down by eye to gain an impression of countries' relative success in getting their students to at least Level 4, for example.

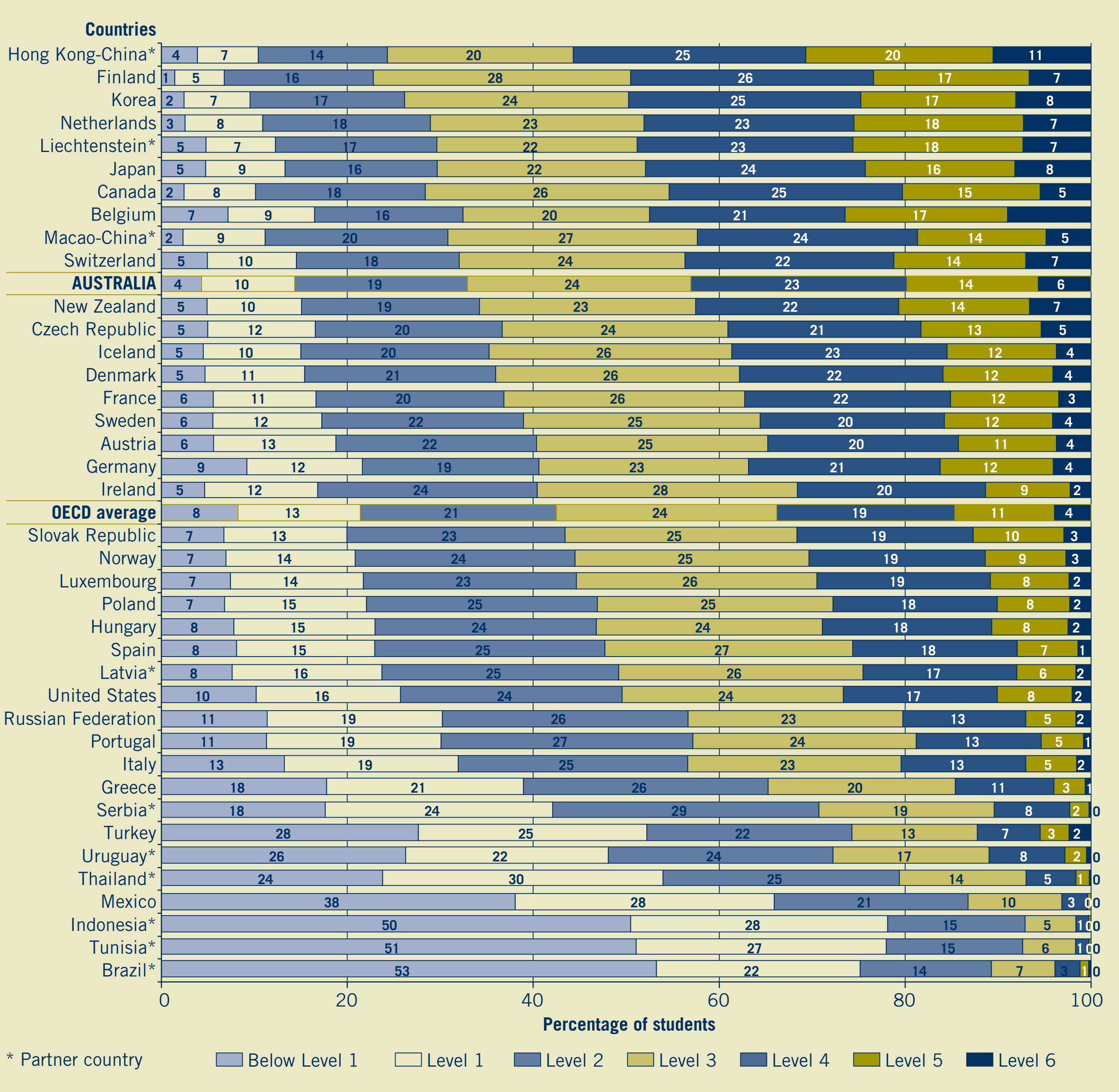


Figure 2.13 Proficiency Levels on the Overall *Mathematical Literacy* Scale for all Countries

While about one-third of students in OECD countries perform at the top three levels of the mathematics scale, this varies widely in both OECD and partner countries: half or more of 15-year-olds perform at Level 4 or above in the three highest-scoring countries, Hong Kong-China, Finland and Korea, and 43 per cent do so in Australia, but only three per cent do so in Mexico and even fewer in Indonesia and Tunisia. In most OECD countries, at least three quarters of students perform at Level 2 or above (86 per cent of Australian students), but in Italy, Portugal and the United States more than one-quarter of students, in Greece more than one-third of students and in Mexico and Turkey the majority of students are unable to complete tasks at Level 2.

The OECD has chosen Level 2 as the lower level with which to compare country performance as it represents a baseline level of mathematics proficiency on the PISA scale at which students begin to demonstrate the kind of skills that enable them to actively use mathematics as stipulated by the PISA definition. At Level 2, students demonstrate the use of direct inference to recognise the mathematical elements of a situation, are able to use a single representation to help explore and understand a situation, can use basic algorithms, formulae and procedures, and make literal interpretations and apply direct reasoning.

The distributions of proficiency levels are, of course, influenced by the countries' mean performance in each of the mathematical processes and also by how much variation there is within countries between the lowest and highest performers. Usually, if a country had a relatively high proportion of students achieving Level 6, it tended to have a relatively low proportion at or below Level 1. For example in Finland, one of the top performing countries, seven per cent of students achieved Level 6, while only six per cent (compared to an OECD average of 21 per cent) could not demonstrate skills at least at Level 2. In Australia, 14 per cent of students are unable to complete tasks at Level 2.

Six per cent of Australian students achieve at Level 6, which although below the percentage of students in Hong Kong-China achieving this level (11 per cent), is above the OECD average of four per cent and three times the percentage of students in the Unites States achieving at this level. Similarly, only four per cent of Australian students were below proficiency Level 1, which is half of the OECD average, the same as that of Hong Kong-China and less than one-half that of the United States.

Proficiency levels by subscale

The percentages of students at each proficiency level for the overall *mathematical literacy* scale and for each of the individual mathematical subscales for Australia are shown in Figure 2.14. This figure shows that there is really very little difference between subscales in the Australian students' performance at each proficiency level. While between 13 and 17 per cent of students were not able to consistently complete tasks beyond Level 1, around 40 per cent of students were achieving Level 4 or higher.

Levels in Space and Shape

In PISA 2003, only a small proportion of 15-year-olds – 6 per cent overall of the combined OECD countries – were able to perform the highly complex tasks required

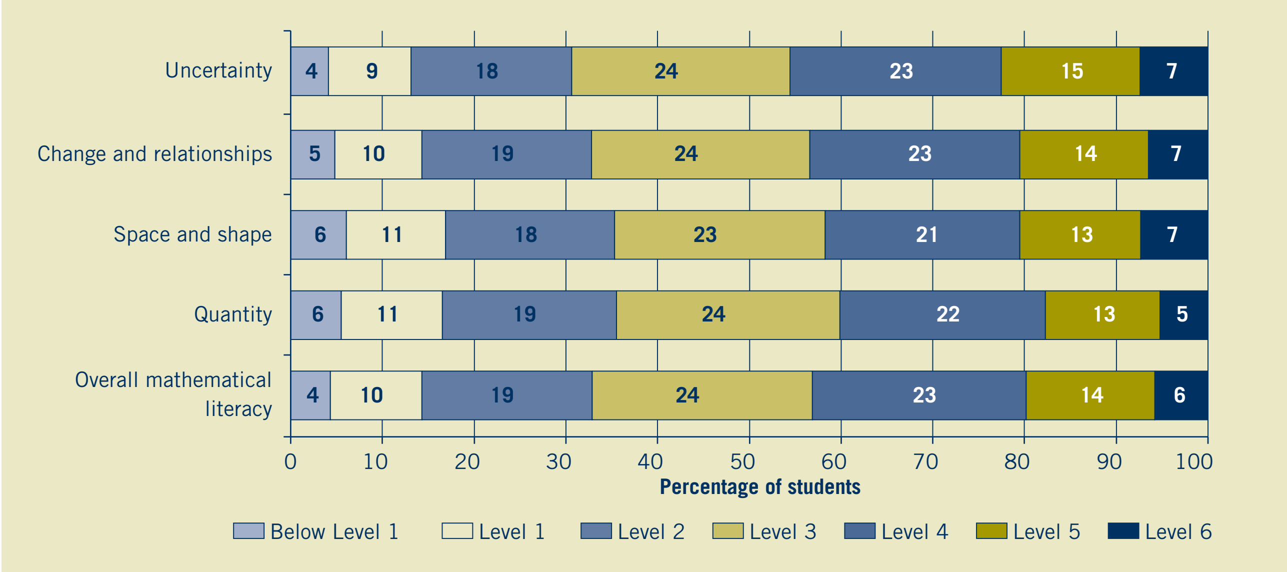


Figure 2.14 Proficiency Levels for Overall *Mathematical Literacy* and the Four Mathematics Subscales, for Australia

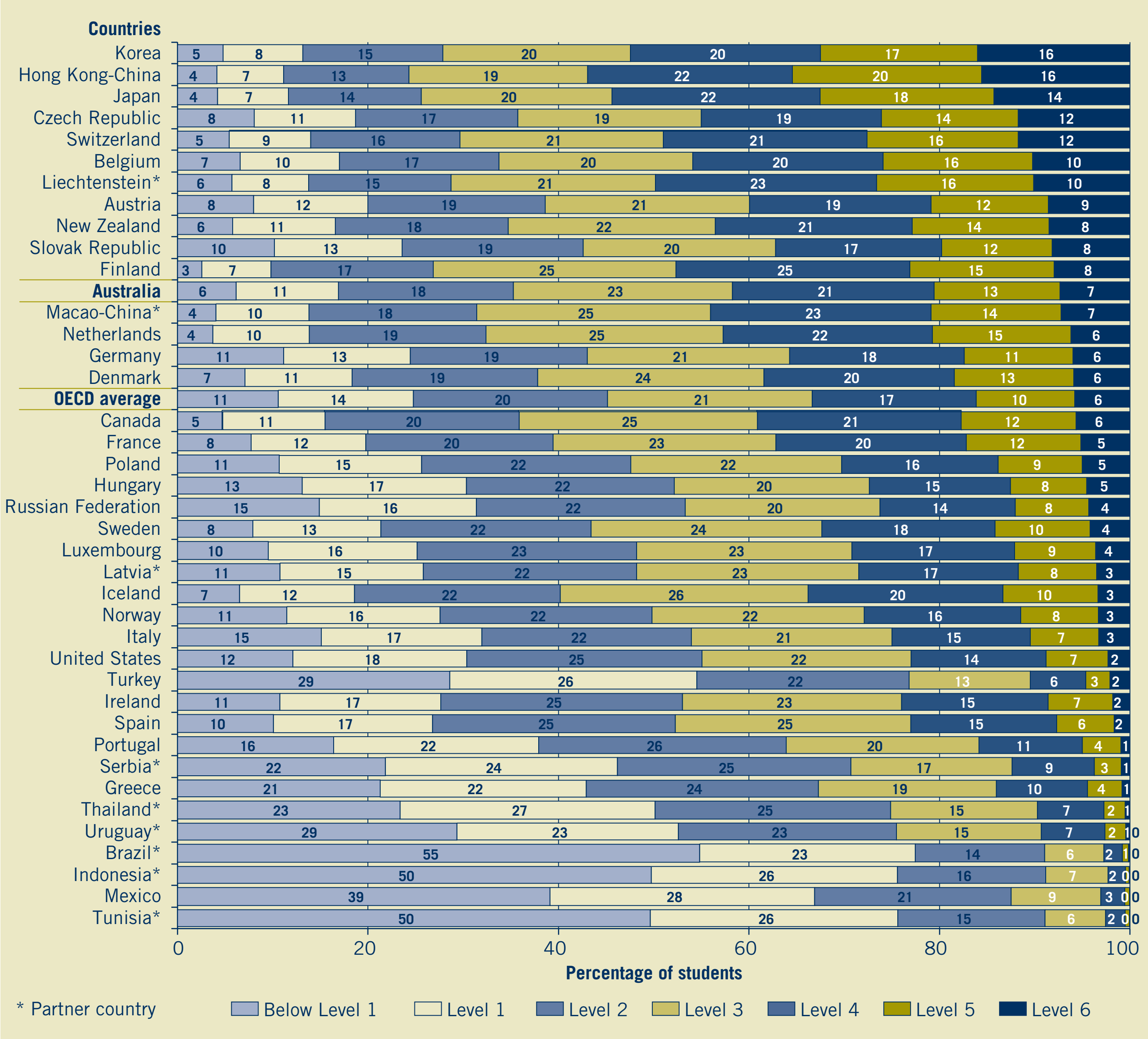


Figure 2.15 Proficiency Levels on the *Space and Shape* Subscale

to reach Level 6 in *space and shape* (Figure 2.15). However, more than 15 per cent of the students in Korea and Hong Kong-China, and more than 10 per cent of the students in Japan, the Czech Republic, Switzerland, Belgium, and Liechtenstein perform at Level 6. In contrast, in Greece, Mexico, Portugal, Brazil, Indonesia, Serbia, Thailand, Tunisia and Uruguay, fewer than one per cent reached Level 6. In Australia, about seven per cent of students reached this level.

A quarter or more of students in Greece, Hungary, Ireland, Italy, Luxembourg, Mexico, Norway, Poland, Portugal, Spain, Turkey and the United States as well as in the partner countries Brazil, Indonesia, Latvia, Tunisia, the Russian Federation, Serbia, Thailand, and Uruguay, were not able to complete tasks at Level 2 in *space and shape*. In Australia, 17 per cent of students were unable to reach Level 2 proficiency on this subscale.

Levels in change and relationships

Five per cent of students in the OECD, and seven per cent of Australian students, were able to perform Level 6 tasks in *change and relationships* (Figure 2.16). Twelve

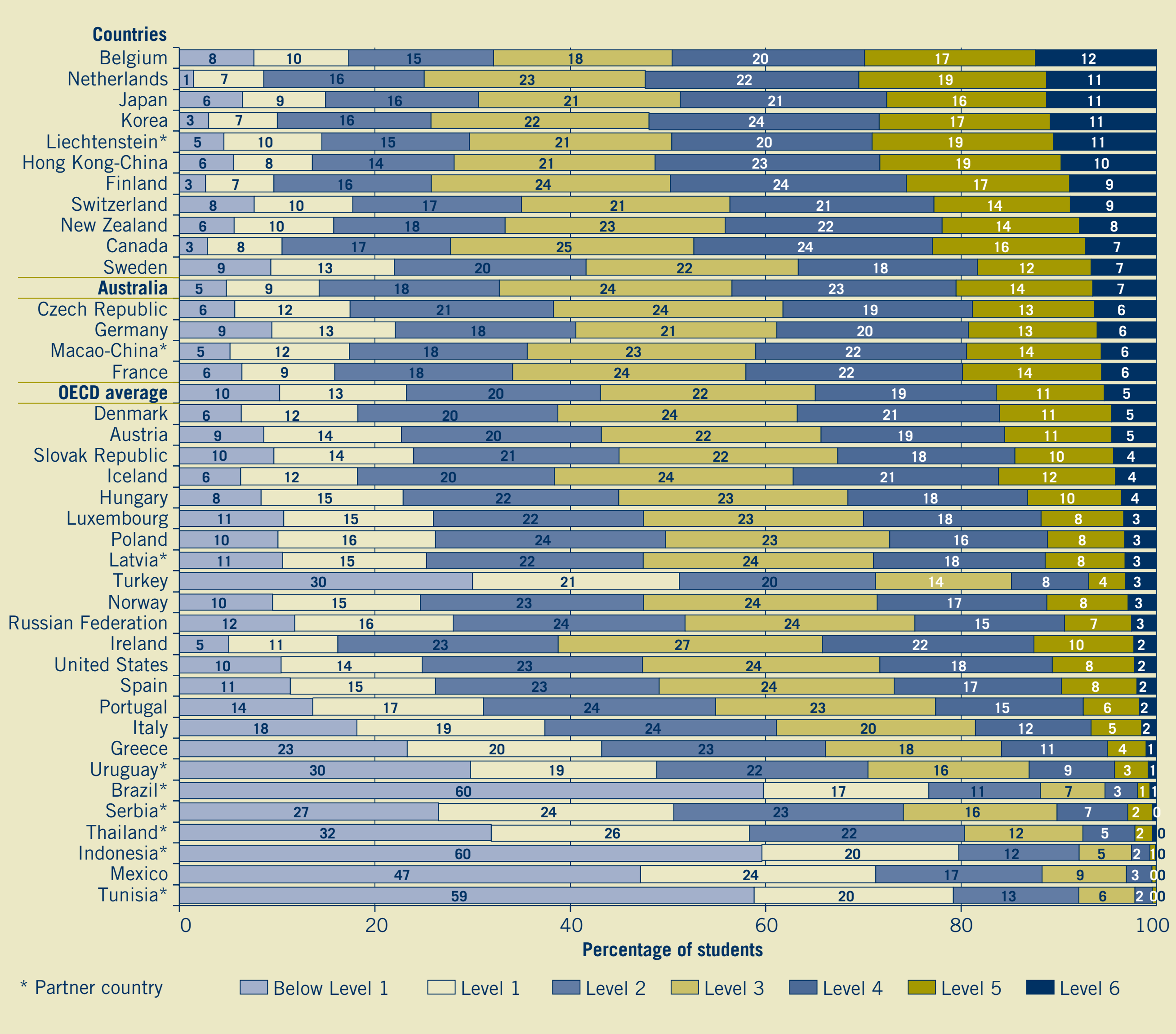


Figure 2.16 Proficiency Levels on the *Change and Relationships* Subscale

per cent of students in Belgium, and 11 per cent of students in the Netherlands Japan, Korea, and Liechtenstein were also achieving at this high level. Thirty-two per cent of students in the OECD, half of the students in Korea, the Netherlands, and Hong Kong-China, and just under half of the students in Belgium and Finland reached at least Level 4. Forty-four per cent of Australian students reached this level.

An average of 77 per cent of students internationally, and 86 per cent of students in Australia, performed at least at Level 2. However in Greece, Italy, Luxembourg, Mexico, Norway, Poland, Portugal, Spain, Turkey and the United States as well as in the partner countries Brazil, Indonesia, Latvia, the Russian Federation, Serbia, Thailand, Tunisia and Uruguay, a quarter or more of students failed to reach this threshold.

Levels in quantity

Slightly fewer students than for the previous two subscales – four per cent in the combined OECD, and five per cent for Australia (this was the subscale on which performances were slightly weaker for Australian students) – were able to perform at Level 6 in *quantity* (Figure 2.17). An average of 74 per cent for the combined

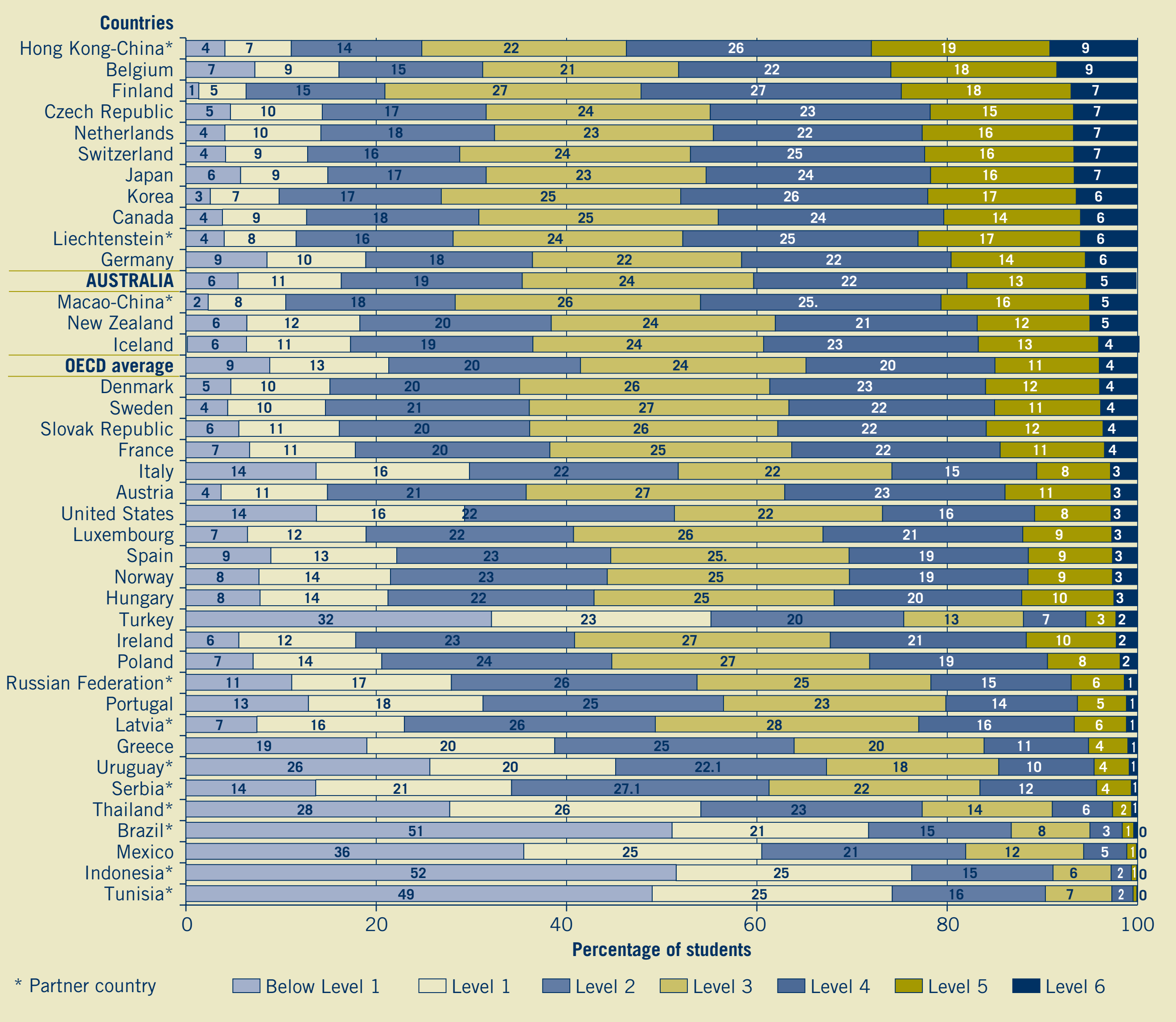


Figure 2.17 Proficiency Levels on the *Quantity* Subscale

OECD countries and 84 per cent of Australian students were able to perform at least at Level 2. However in Brazil, Greece, Italy, Indonesia, Mexico, Portugal, the Russian Federation, Serbia, Thailand, Tunisia, Turkey, the United States, and Uruguay, a quarter or more students failed to reach this threshold.

Levels in uncertainty

Fewer than four per cent of students in the combined OECD, and around 13 per cent in Hong Kong-China – were able to perform Level 6 tasks on the *uncertainty* subscale (Figure 2.18). However this subscale was one on which Australian students performed particularly well, and seven percent were able to achieve at Level 6. Thirty-one per cent of the combined student population in the OECD performed at least at Level 4, but more than half the students in Finland, the Netherlands and Hong Kong-China and 45 per cent of the students in Australia were able to perform at least at this level.

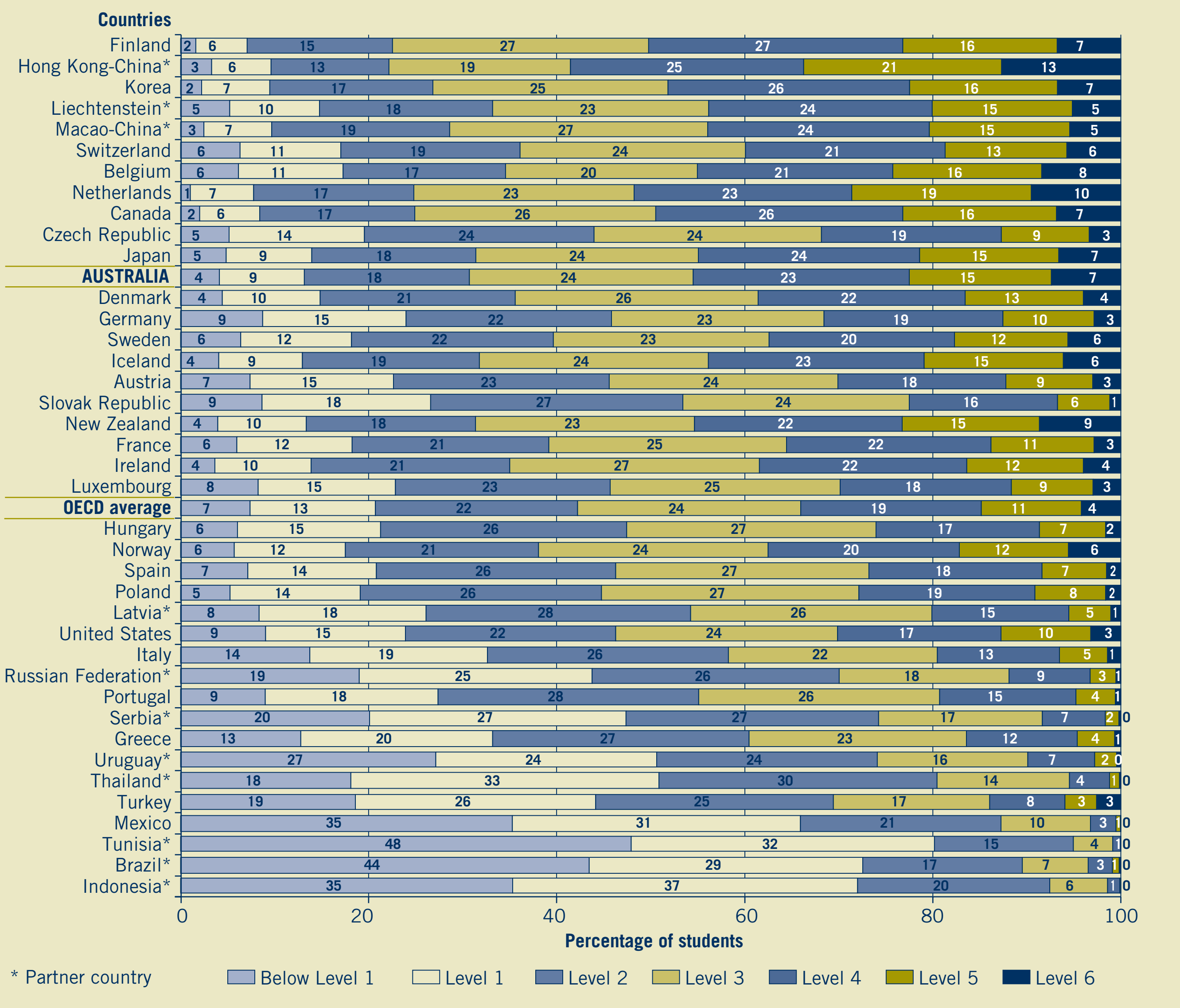


Figure 2.18 Proficiency Levels on the *Uncertainty* Subscale

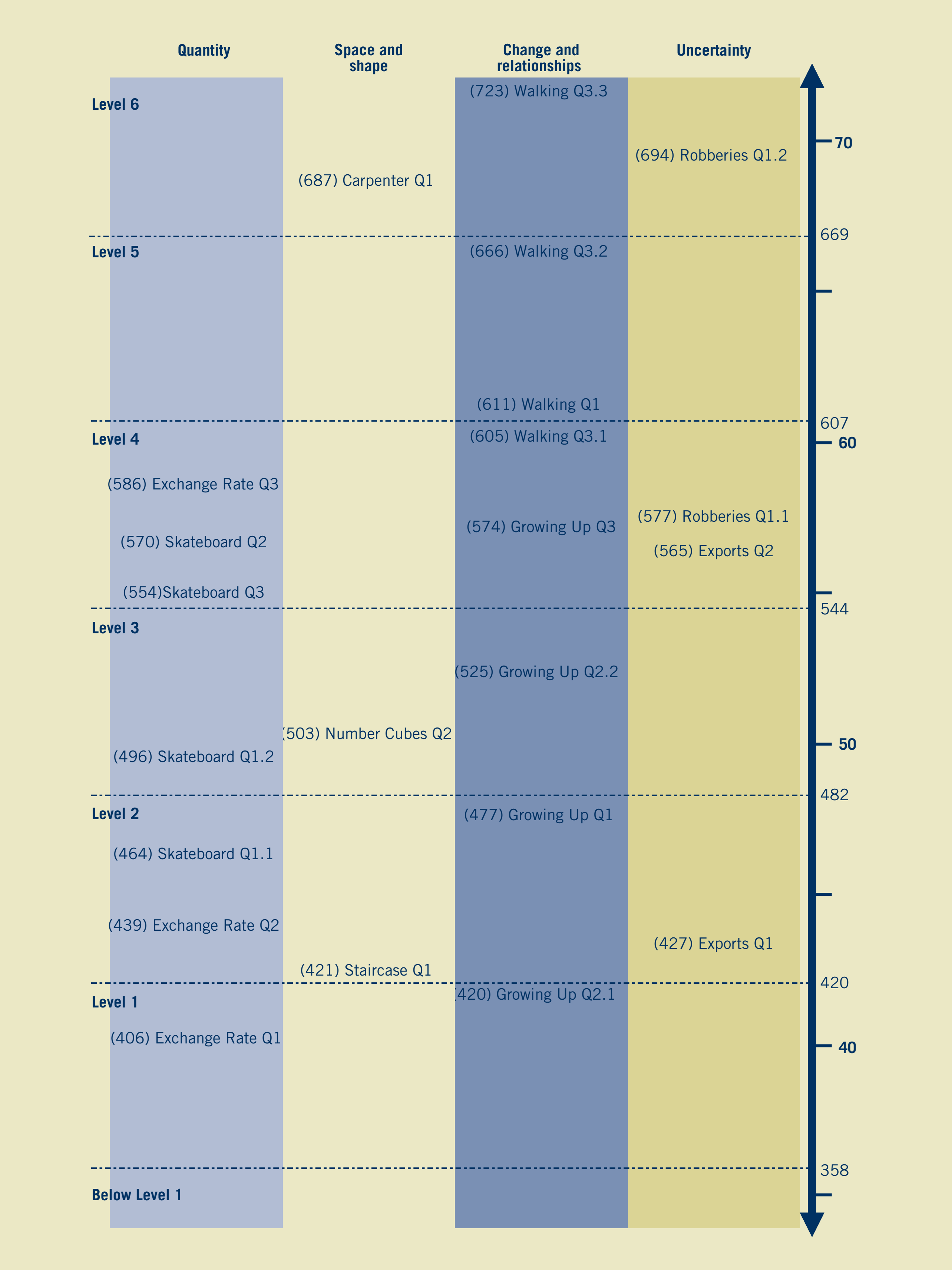


Figure 2.19 Cutpoints and Illustrative Items for PISA *Mathematical Literacy*

Seventy-five per cent of OECD students and 87 per cent of Australian students could at least function at the baseline Level 2. However in Brazil, Greece, Indonesia, Italy, Latvia, Mexico, Portugal, the Russian Federation, Serbia, the Slovak Republic, Turkey, Thailand, Tunisia and Uruguay a quarter or more of students failed to reach this threshold.

>> Sample and illustrative tasks

Figure 2.19 gives a visual representation of the PISA mathematics proficiency scale and the location of the defined levels, and shows the location of a number of test items from the PISA 2003 assessment that further illustrate the meaning of the levels of performance. In the final section of the chapter, those illustrative items are presented and discussed.

Sample Mathematics Items and Responses

Students were presented with mathematical 'units' which usually consisted of two or more items related to a piece of text or a diagram accompanied by text. A total of 85 mathematics tasks were used in PISA 2003 covering the four overarching ideas of *quantity*, *space and shape*, *change and relationships* and *uncertainty* and underpin mathematical curriculum in educational systems throughout the world.

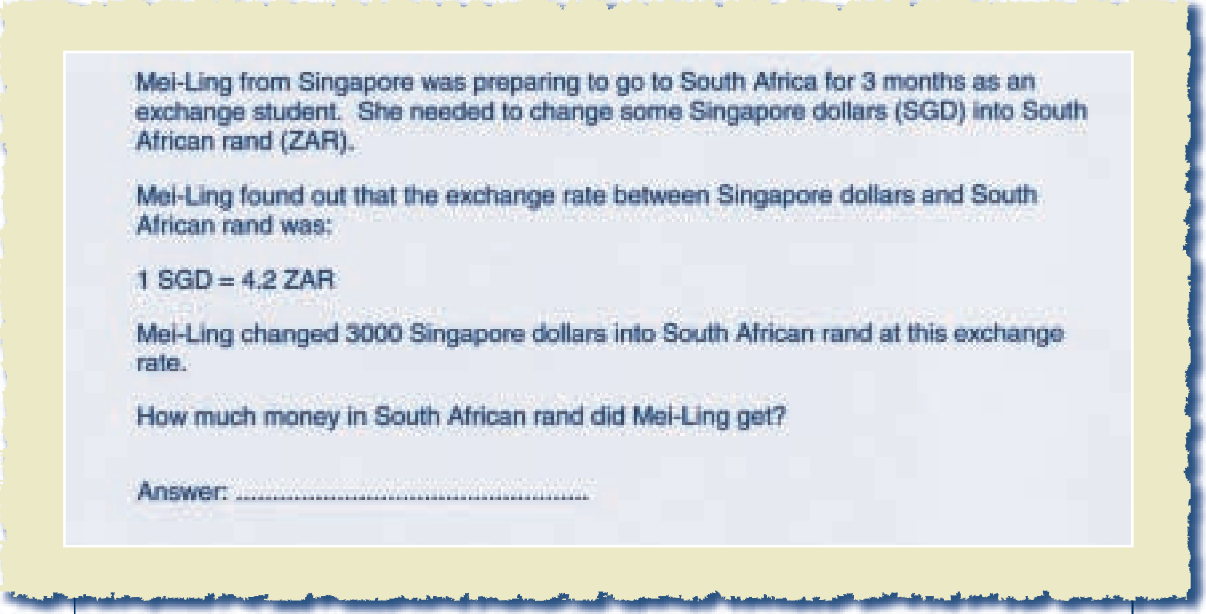
These sample items have been selected to illustrate various aspects of the PISA framework, different item types, and the wide range of complexity involved in such tasks. Tasks situated at the higher end of the *mathematical literacy* scale require considerably more processing, more connections to be made between different elements, more manipulation of abstract terms and more understanding in order to be able to explain solutions obtained.

The following two items can be placed in the overarching *Quantity* area.

EXCHANGE RATE

The unit Exchange Rate is situated in the *quantity* area and is a routine procedure. The concept of foreign exchange rates, and the possibility of both increasing and decreasing movements form the basis of this constructed response item, comprising three questions, that is situated in a public context. 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.

In question 1, a short constructed response item, students are required to interpret a simple, explicit mathematical relationship (the exchange rate for 1 Singapore Dollar/1 South African Rand), and a small reasoning step to apply the relationship directly to 3000 Singapore Dollars, using the calculation (3000 x 4.2). The straightforward multiplication exercise places the item in the *quantity* area, and also classifies it as belonging to the reproduction competency cluster.



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).

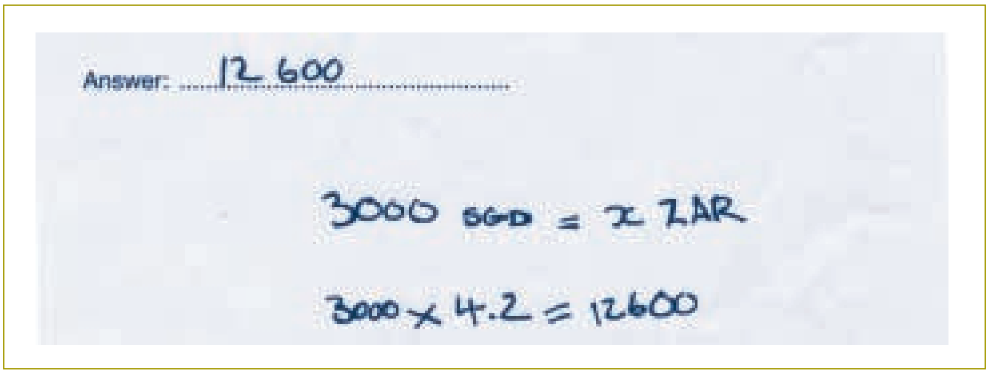
Mei-Ling found out that the exchange rate between Singapore dollars and South African rand was:

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: ………………………………………



Answer: 12 600

3000 SGD = x ZAR

3000 x 4.2 = 12600

Full credit was awarded to students who provided the correct result. The combination of familiar context, clearly defined question, and routine procedure fits comfortably in proficiency Level 1 with a difficulty of 406 PISA units.

In question 2, a short constructed response item, a limited form of mathematisation is needed: understanding a simple text, but also deciding that division is the correct procedure, making it less trivial than question 1. The straightforward division exercise places the item in the *quantity* area, and also classifies it as belonging to the reproduction competency cluster.

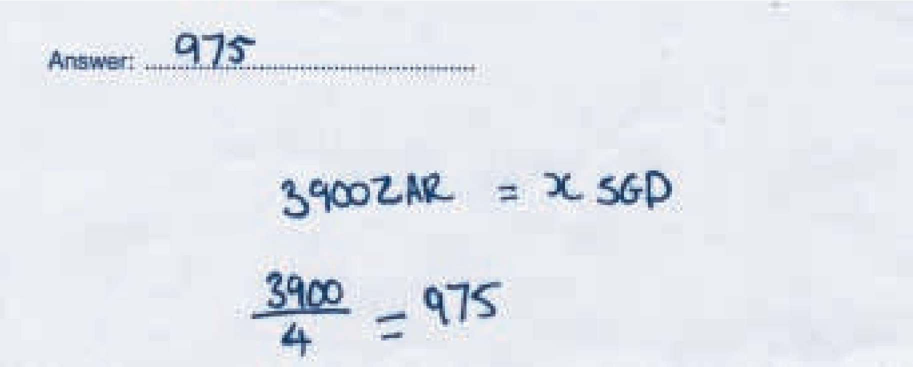
On returning to Singapore after 3 months, Mei-Ling had 3 900 ZAR left. She changed this back to Singapore dollars, noting that the exchange rate had changed to:

1 SGD = 4.0 ZAR

How much money in Singapore dollars did Mei-Ling get?

Answer: ………………………………………

Students are required to interpret a simple, explicit mathematical relationship and only a small reasoning step is required to apply the relationship directly to 3900 South African Rand using a calculation (3900/4.0). This item represents proficiency Level 2 with a difficulty of 439 PISA units.

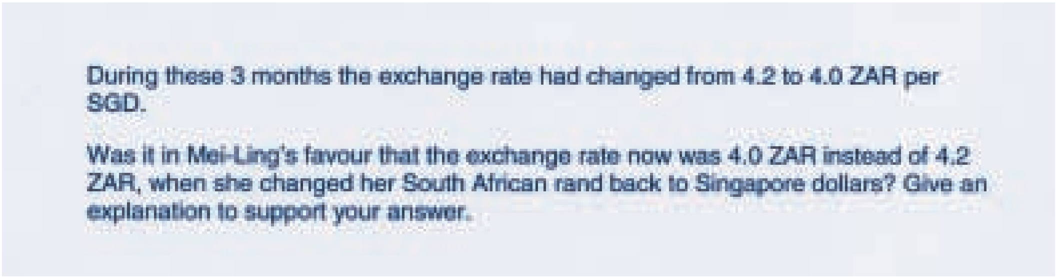


Answer: 975

3900ZAR = x SGD

$\frac{3900}{4} = 975$

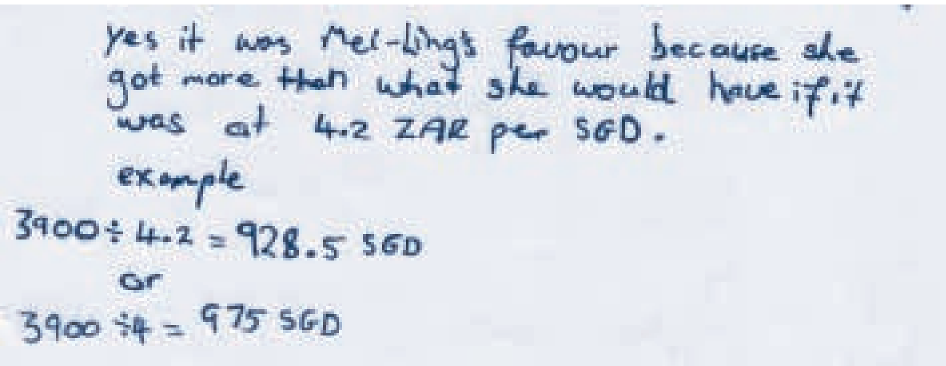
In question 3, an open constructed response item, the mathematics required to solve the problem is more demanding, as students need to reflect on the concept of exchange rate movements, and the subsequent consequences. The required procedural knowledge is more complex, and involves students applying 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.

Full credit was awarded to students who interpreted the specified change in the exchange rate, reasoned on the impact, and applied basic computational skills or quantitative comparison skills to solve the problem. Students also needed to provide an explanation of their conclusion. The item is classified as belonging to the reflection cluster and represents proficiency Level 4 with a difficulty of 586 PISA units.



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

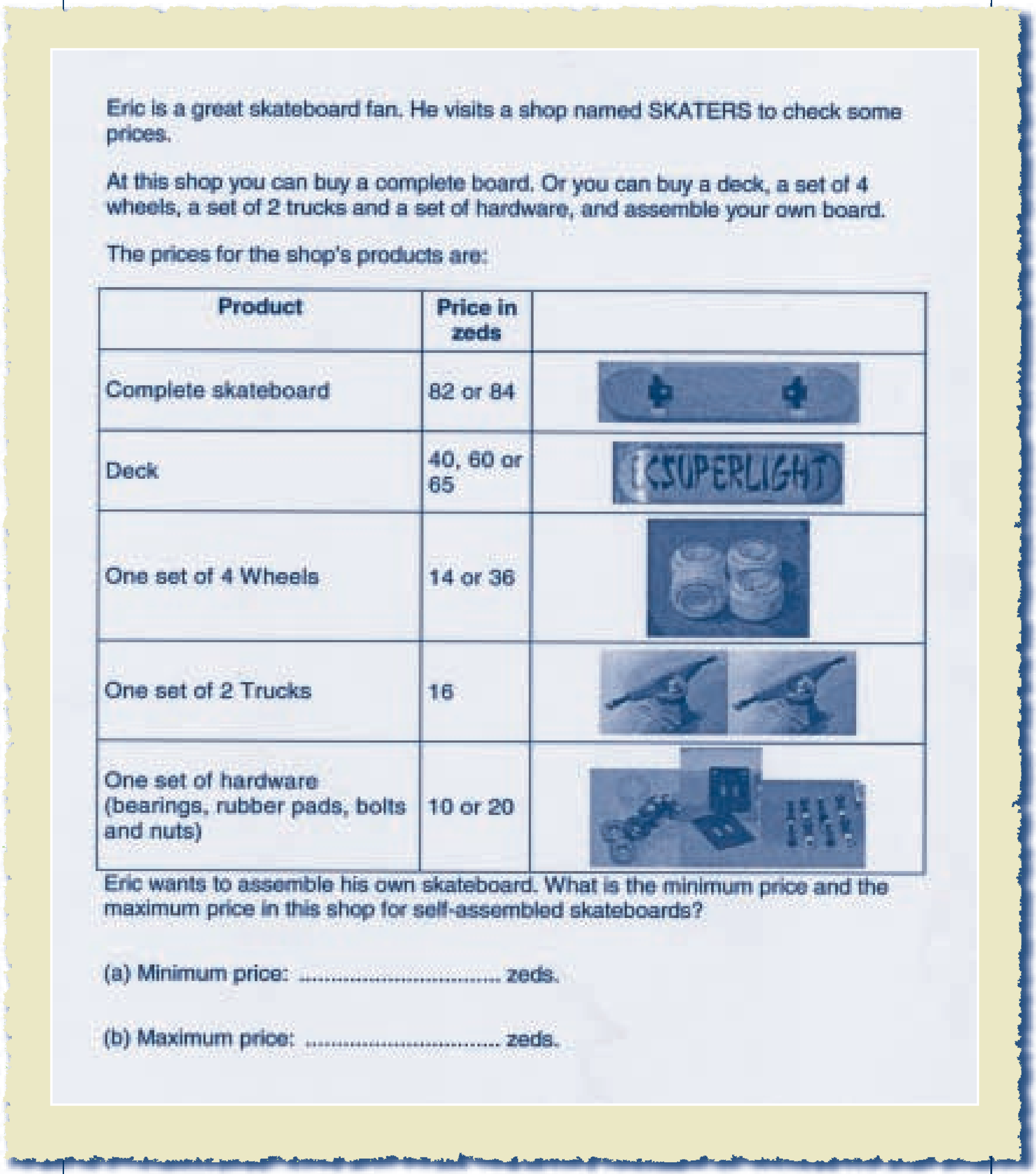
or

3900 ÷ 4 = 975 SGD

SKATEBOARD

Skateboards are part of the youth culture. Many students either actively participate and/or spectate. This short constructed response item is situated in a personal context.

In question 1, students are required to identify a minimum and maximum price for the construction of a skateboard under given numerical conditions. To solve the problem a simple strategy is required involving a routine addition procedure, that places the item in the reproduction competency cluster with the *quantity* overarching idea.



Eric is a great skateboard fan. He visits a shop named SKATERS to check some prices.

At this shop you can buy a complete board. Or you can buy a deck, a set of 4 wheels, a set of 2 trucks and a set of hardware, and assemble your own board.

The prices for the shop's products are:

Product	**Price in zeds**	
Complete skateboard	82 or 84	
Deck	40, 60 or 65	
One set of 4 Wheels	14 or 36	
One set of 2 Trucks	16	
One set of hardware (bearings, rubber pads, bolts and nuts)	10 or 20	

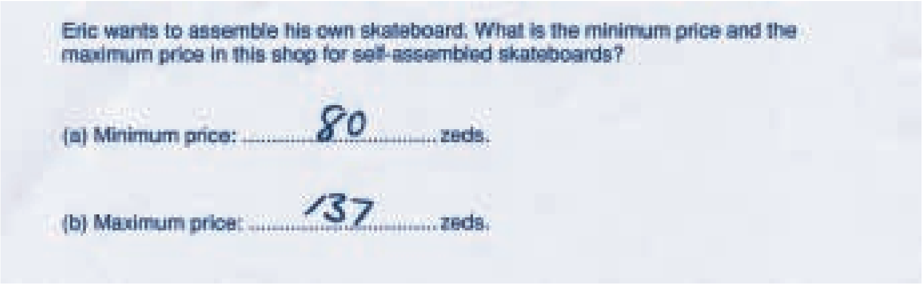
Eric wants to assemble his own skateboard. What is the minimum price and the maximum price in this shop for self-assembled skateboards?

(a) Minimum price: .... zeds.

(b) Maximum price: .... zeds.

Full credit is given for a response detailing both the minimum and maximum, which illustrates proficiency Level 3 with a difficulty of 496 PISA units. Students must recognise that two answers are required (80; 137).

Students providing only one answer illustrate proficiency Level 2 for a partial credit, with a difficulty of 464 PISA units.



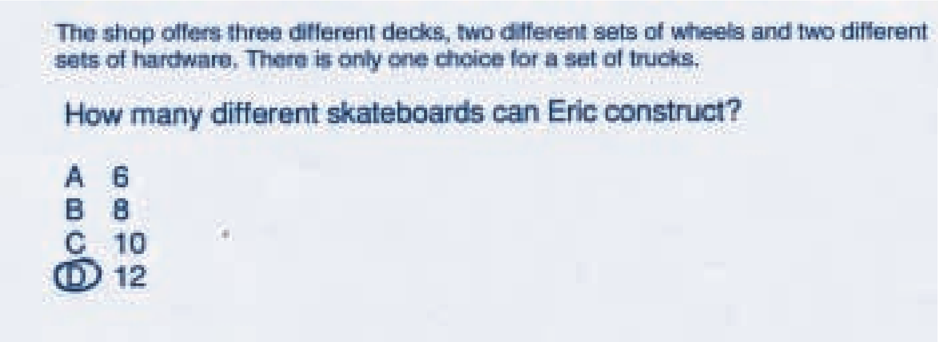
Eric wants to assemble his own skateboard. What is the minimum price and the maximum price in this shop for self-assembled skateboards?

(a) Minimum price: ....80.......... zeds.

(b) Maximum price: ....137.......... zeds.

Question 2, a multiple choice item, is situated in the same *personal* context as Question 1 and requires students to perform mathematical components involving *understanding and applying strategy*. The item belongs to the reproduction competency cluster and the content fits in the quantity area.

Credit is awarded to students correctly identifying the basic computation involved (3x2x2x1=12). The item illustrates proficiency Level 4, as the item score is 570 PISA units.

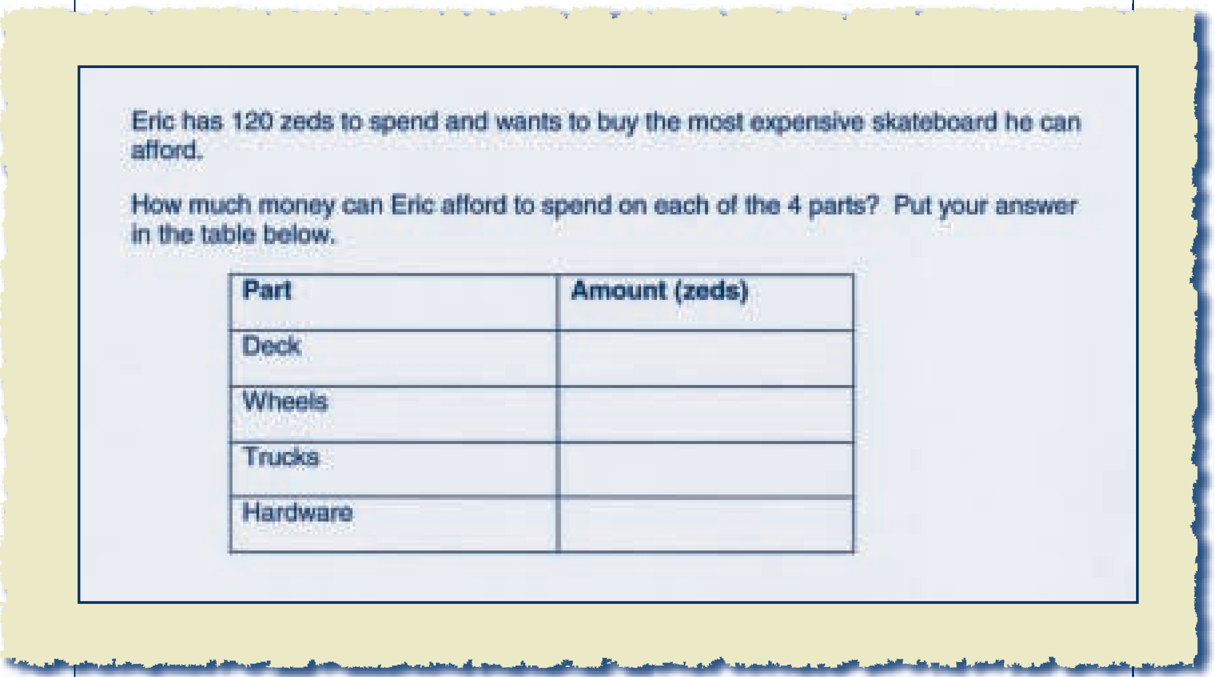


The shop offers three different decks, two different sets of wheels and two different sets of hardware. There is only one choice for a set of trucks.

How many different skateboards can Eric construct?

A 6
B 8
C 10
[✓ D] 12

Question 3, a short constructed response item within the *personal* context, is in the quantity area as students are required to compute 'what kind of skateboard can be purchased for 120 zeds'. The task is not straightforward and allows students to use a range of strategies to calculate the solution, including a degree of trial and error.

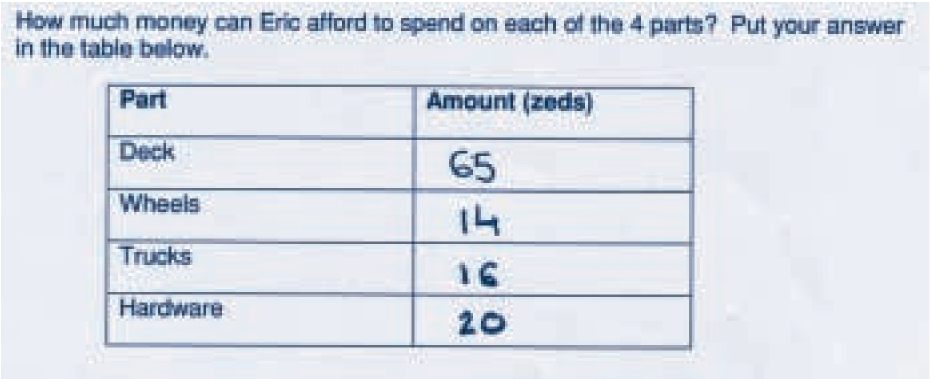


Eric has 120 zeds to spend and wants to buy the most expensive skateboard he can afford.

How much money can Eric afford to spend on each of the 4 parts? Put your answer in the table below.

Part	Amount (zeds)
Deck	
Wheels	
Trucks	
Hardware	

Credit is given to students able to relate text based information to a table representation, apply a non standard strategy, and carry out routine calculations. This item illustrates the lower part of proficiency Level 4, as the item has a difficulty of 554 PISA units.



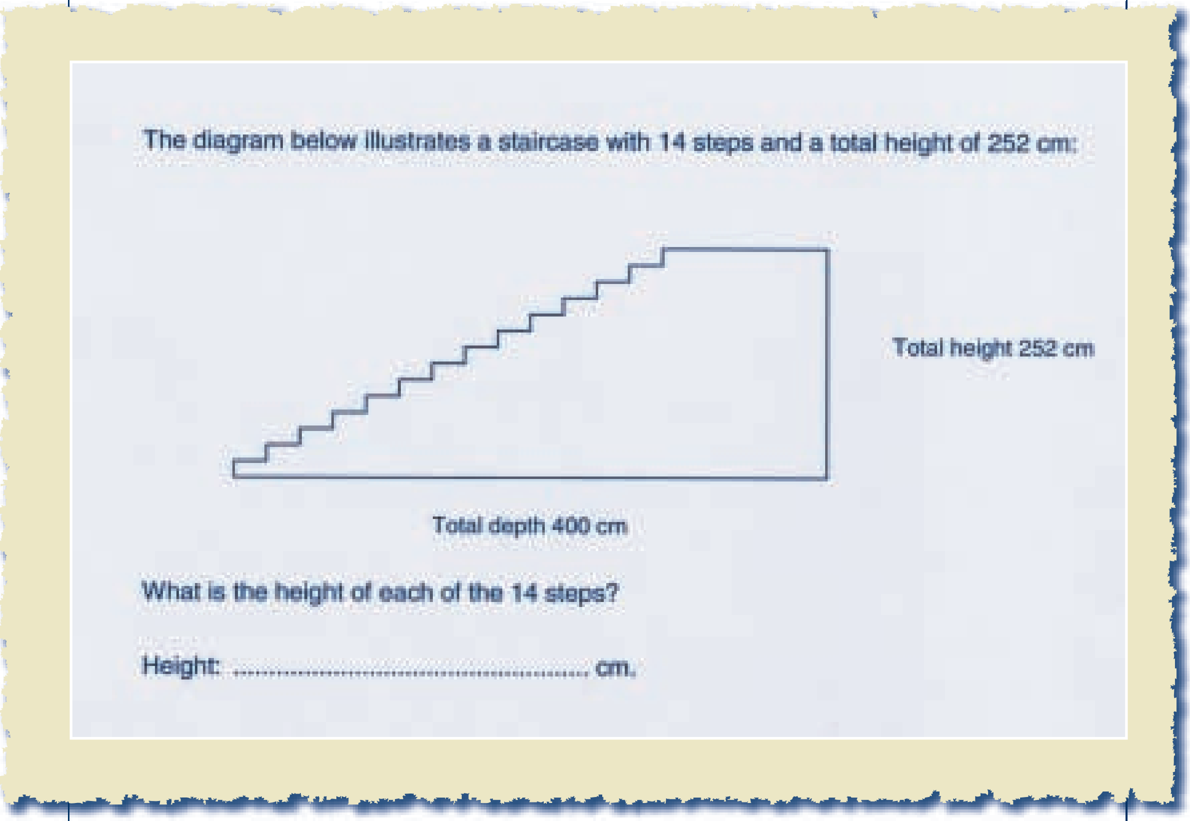
How much money can Eric afford to spend on each of the 4 parts? Put your answer in the table below.

Part	Amount (zeds)
Deck	65
Wheels	14
Trucks	16
Hardware	20

The following three items can be placed in the *Space and Shape* overarching area.

STAIRCASE

This short open constructed response item is situated in an *occupational* context. Students should be able to interpret and solve a problem like this that uses two different representation modes: language, including numbers, and a graphical representation.

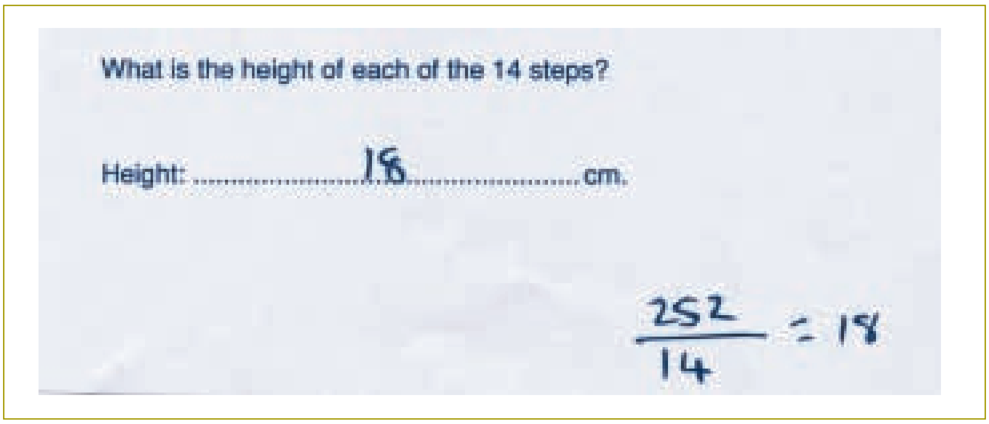


The diagram below illustrates a staircase with 14 steps and a total height of 252 cm:

What is the height of each of the 14 steps?

Height: .... cm.

This item is noteworthy because it has redundant information (depth of 400cm), which is sometimes considered by students to be confusing. In essence the problem required students to perform a simple division calculation (252 cm / 14). A routine procedure, this item belongs to the reproduction competency cluster, and illustrates a low proficiency Level of 2 with 421 PISA units, just beyond the boundary of Level 1.



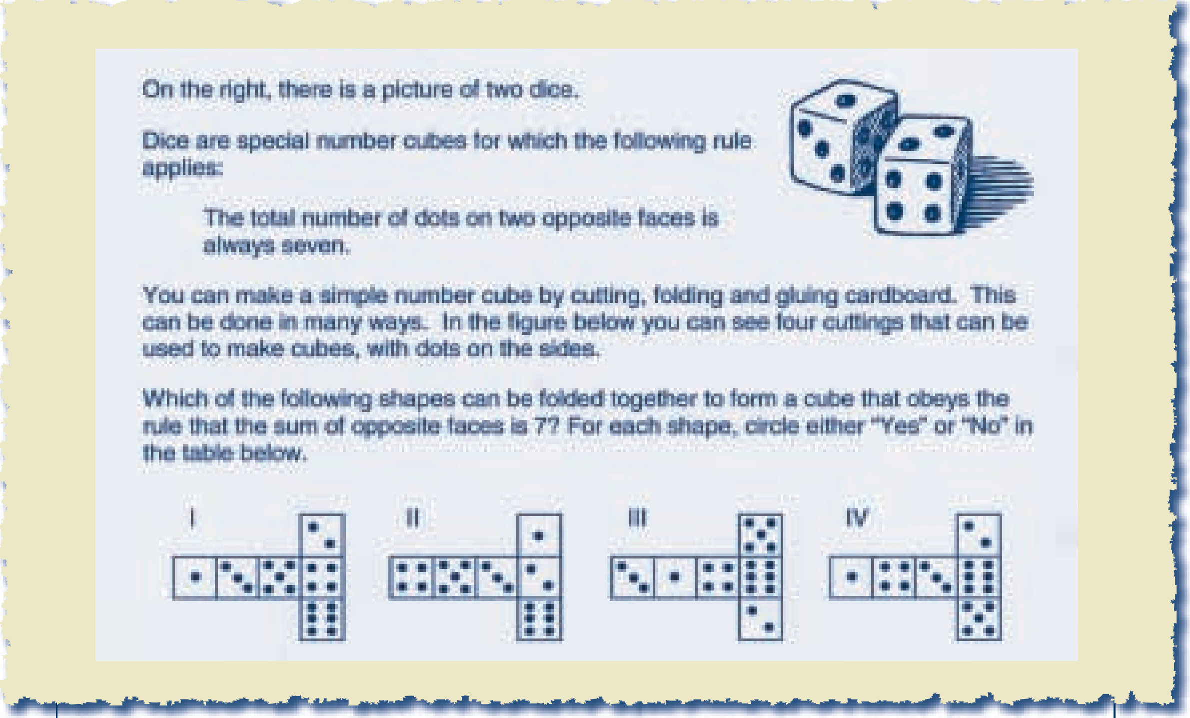
What is the height of each of the 14 steps?

Height: ....18............................cm.

$\frac{252}{14} = 18$

NUMBER CUBES

During their education students would have encountered many games and activities, whether formal or informal, which use number cubes/dice. Somewhat more challenging is the problem posed here, which requires spatial insight or mental visualization technique, as students need to imagine how the four planes of number cubes, if reconstructed into a three-dimensional number cube, obeys the numerical construction rule given in the information. (i.e two opposite sides have a total of seven dots)



On the right, there is a picture of two dice.

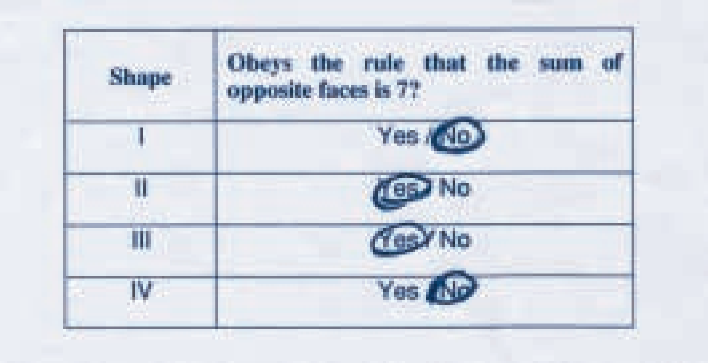
Dice are special number cubes for which the following rule applies:

> 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 and illustrates proficiency Level 3, with a difficulty of 503 PISA units. The problem requires 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 a classification in the connections competency cluster, an essential part of mathematical literacy, as students live in three-dimensional space and are often confronted with two-dimensional representations.

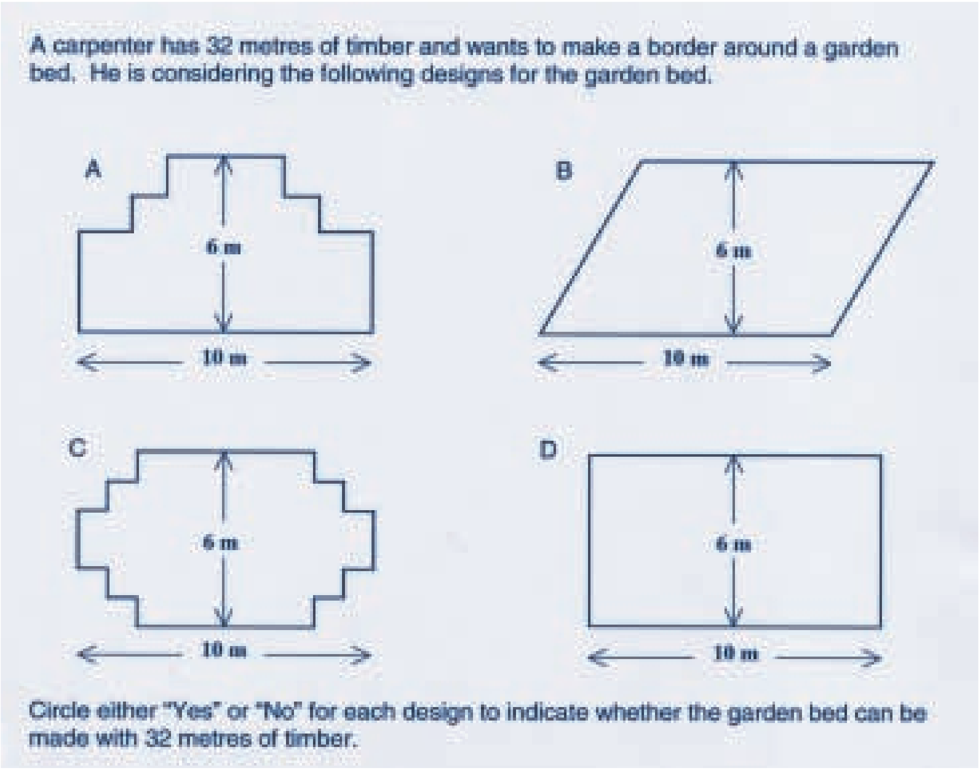


Shape	Obeys the rule that the sum of opposite faces is 7?
I	Yes / [✓ No]
II	[✓ Yes] / No
III	[✓ Yes] / No
IV	Yes / [✓ No]

CARPENTER

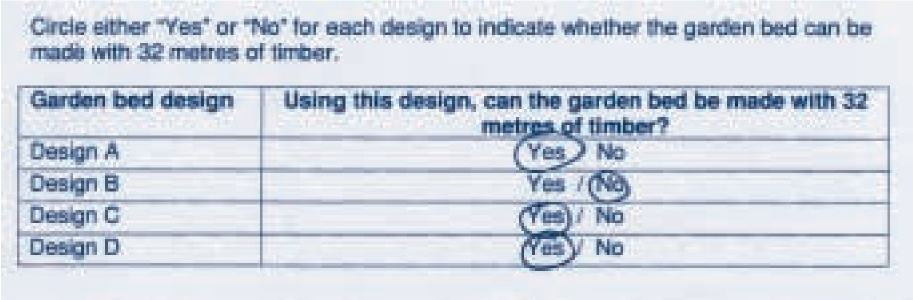
The following question, a complex multiple-choice item, fits into the *educational* context and belongs to the *space and shape* subscale.

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. To obtain full credit students had to correctly identify which of the given garden beds could be constructed.



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.

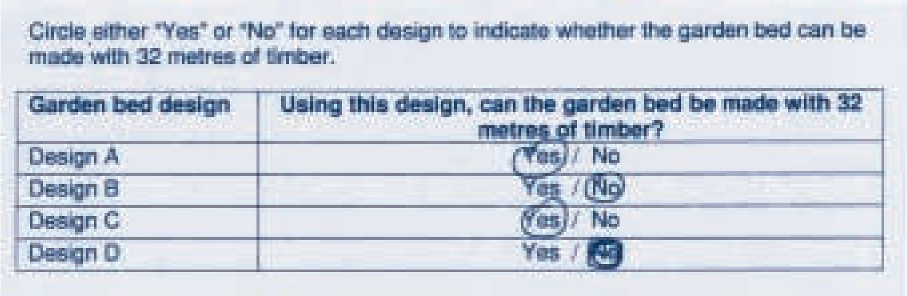
Circle either "Yes" or "No" for each design to indicate whether the garden bed can be made with 32 metres of timber.



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

Partial credit was given when students correctly identified 3 of the 4 multiple-choice answers.



Circle either "Yes" or "No" for each design to indicate whether the garden bed can be made with 32 metres of timber.

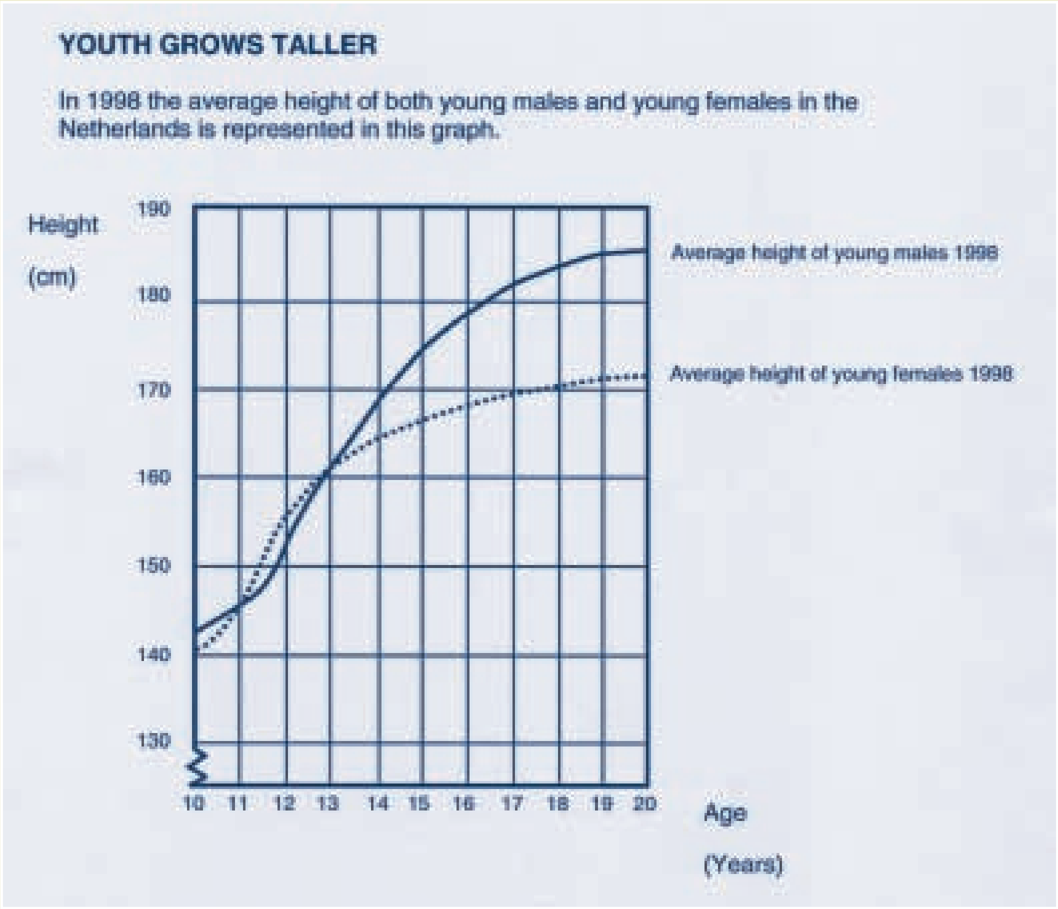
Garden bed design	Using this design, can the garden bed be made with 32 metres of timber?
Design A	[✓ Yes] / No
Design B	Yes / [✓ No]
Design C	[✓ Yes] / No
Design D	Yes / [✓ No]

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 item illustrates proficiency Level of 6 with a difficulty of 687 PISA units. Only a third of Australian students were able to correctly identify the required answers.

The following two items can be placed in the *Change and Relationships* overarching area.

GROWING UP

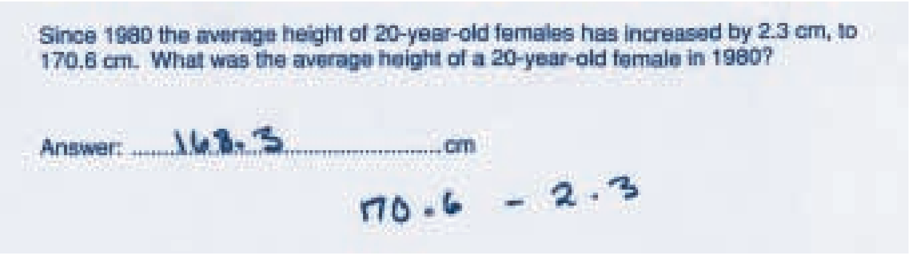
The focus on the relationship between age and height provides the basis for this item being included in the *change and relationships* subscale. This unit is situated in the *scientific* context because it illustrates a typical example that students are frequently confronted with in a mathematics classroom.



YOUTH GROWS TALLER

In 1998 the average height of both young males and young females in the Netherlands is represented in this graph.

Students were asked in question 1 to calculate an answer using a closed constructive response format.



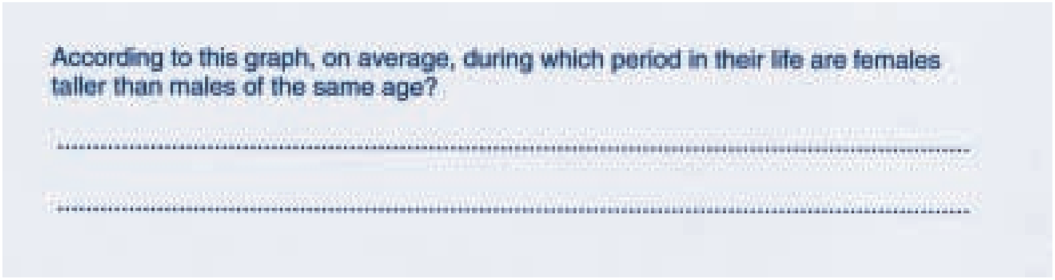
Since 1980 the average height of 20-year-old females has increased by 2.3 cm, to 170.6 cm. What was the average height of a 20-year-old female in 1980?

Answer: ......168.3........................cm

170.6 - 2.3

The question graph was not required as the answer could be found by extracting the relevant information in the stem of the question and using a basic subtraction algorithm (170.6 – 2.3 = 168.3). This item illustrates a proficiency Level of 2 with a difficulty of 477 PISA units.

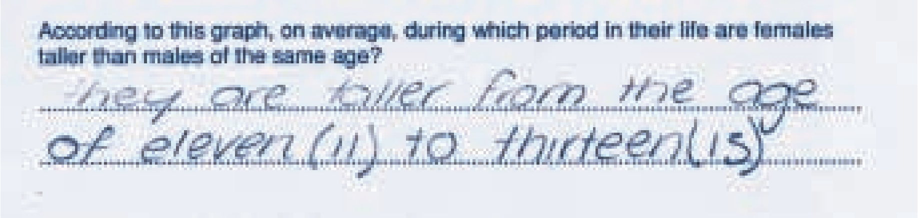
The second question, an open constructed response item, illustrated an item difficulty of 420 PISA units and was placed on the border of proficiency Level 1 and 2 for a partial credit response.


According to this graph, on average, during which period in their life are females taller than males of the same age?

……………………………………………………………………………………………

……………………………………………………………………………………………

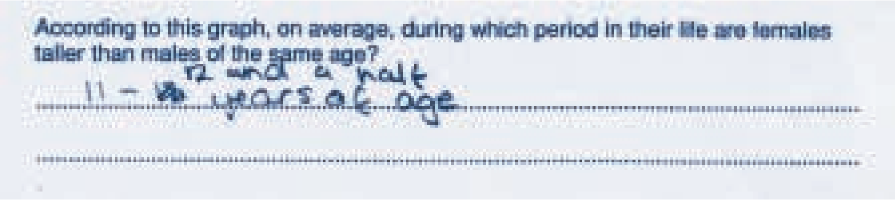
The full credit response, an example of which illustrated proficiency Level 3 with a difficulty of 525 PISA units. Students were awarded full credit when displaying clear understanding, interpretation and use of the graphical information.


According to this graph, on average, during which period in their life are females taller than males of the same age?

they are taller from the age

of eleven (11) to thirteen (13)

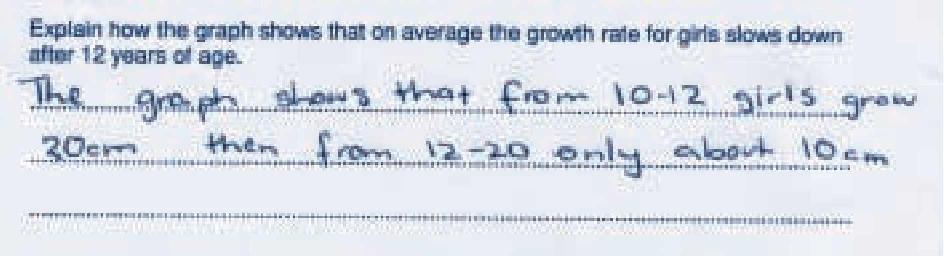
Although able to compare two graphs, students who failed to identify the continuum from 11 to 13 years, not realising the answer should be an interval, only received a partial credit.


According to this graph, on average, during which period in their life are females taller than males of the same age?

11 – 12 and a half years of age

……………………………………………………………………………………………

The third question, an open constructed response item, requires analysis of the different growth curves to successfully solve the problem. A very complex concept - “decreasing growth” needs to be understood and asks of the student intelligent linking of different ideas and information. The graphs indicate diminished growth occurs at approximately 12 years. Students gave answers ranging from daily life language to more mathematical language.



Explain how the graph shows that on average the growth rate for girls slows down after 12 years of age.

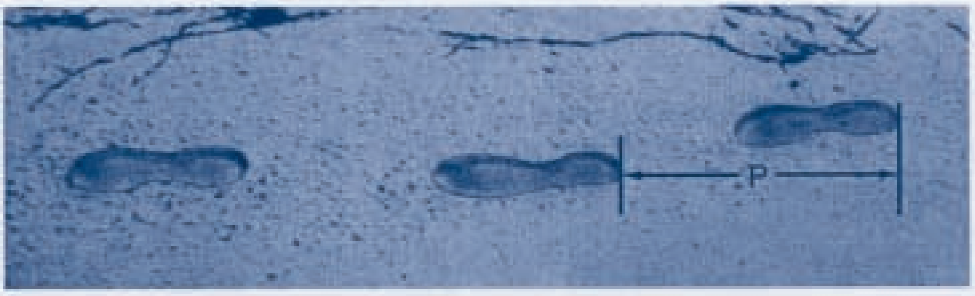
The graph shows that from 10-12 girls grow 30cm then from 12-20 only about 10cm

This question illustrates proficiency Level 4 with a difficulty of 574 PISA units.

WALKING

Reflecting on embedded mathematics from daily life is part of acquiring *mathematical literacy* and the two items following are examples of these phenomena. 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”.

Both questions are open constructed-response items situated in a *personal* context. The first question requires 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 needed to carry out the actual calculation.



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.

This type of item fits the *change and relationships* content area and belongs to the reproduction competency cluster, illustrating a lower Level 5 proficiency with a difficulty of 611 PISA units (just 4 points beyond the boundary with Level 4).

The following example gained credit for showing correct substitution of numbers in the formula with the correct answer.

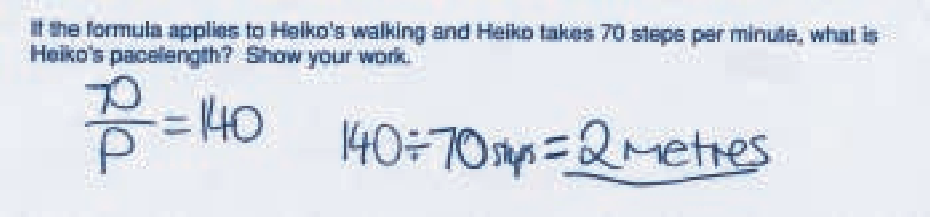
If the formula applies to Heiko's walking and Heiko takes 70 steps per minute, what is Heiko's pacelength? Show your work.

$$\frac{70}{p} \cdot p = 140 \cdot p$$

$$\frac{70}{140} = \frac{140p}{140}$$

$p = 0{\cdot}5$ metres

No credit could be given in the following example although it showed correct substitution in the formula, as the calculations were incorrect.

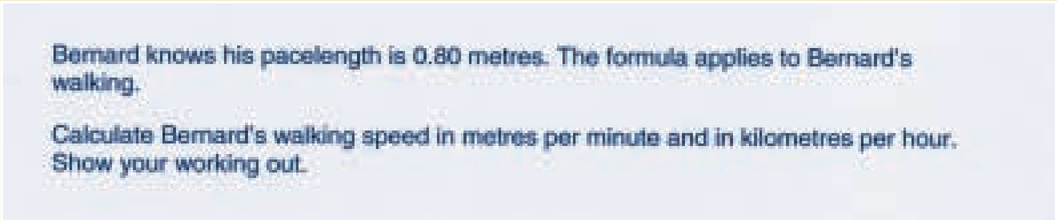


If the formula applies to Heiko's walking and Heiko takes 70 steps per minute, what is Heiko's pacelength? Show your work.

$\frac{70}{p} = 140$ 140 ÷ 70 stps = 2 metres

Table 2.4 shows that only a third of Australian students gained credit for this item, indicating a lower level of understanding of how to analyse and apply a given formula in a real life situation.

The second item 'Walking' also involves 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).

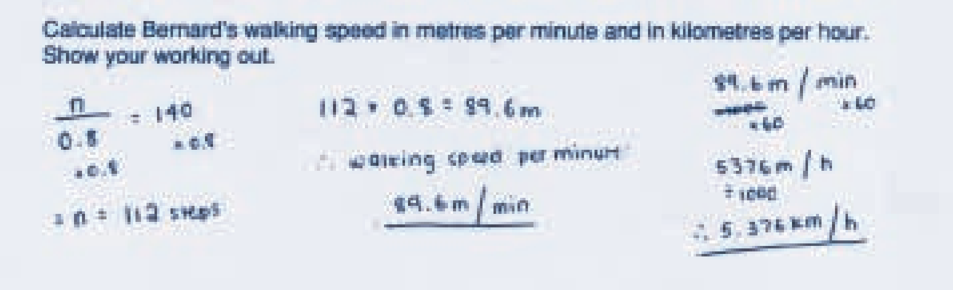


Bernard knows his pacelength is 0.80 metres. The formula applies to Bernard's walking.

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

More than routine operations are required here, with firstly substitution in an algebraic expression being used, followed by manipulating the resulting formula, in order to be able to carry out the required calculation.

The next step requires going beyond the observation that the number of steps is 112, as the question also asks for the speed per minute – he walks 1.2 x0.80 = 89.6 metres, so his speed is 89.6 m. The final step is to transform this speed in m/minute into km/h – a more common unit of speed. Full credit for this item illustrates the high part of proficiency Level 6 with a difficulty of 723 PISA units, and this problem fits the *change and relationships* overarching idea.



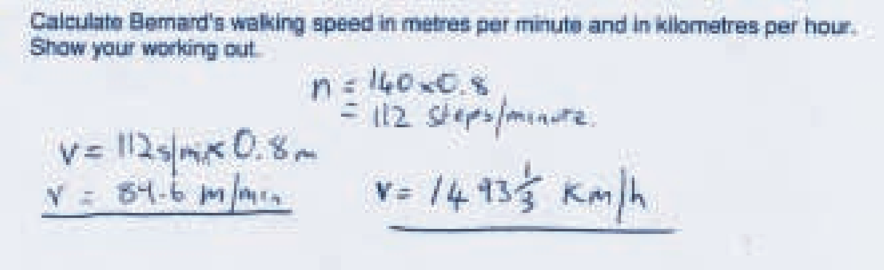
Calculate Bernard's walking speed in metres per minute and in kilometres per hour.
Show your working out.

$\frac{n}{0.8} = 140$
×0.8 ×0.8
∴ n = 112 steps

112 × 0.8 = 89.6m
∴ walking speed per minute
89.6m / min

89.6m / min
×60 ×60
5376m / h
÷1000
∴ 5.376km / h

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 of the requested units. This problem is rather complex and 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.



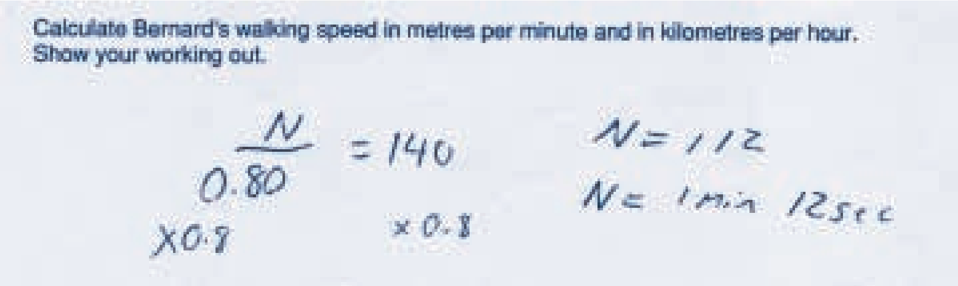
Calculate Bernard's walking speed in metres per minute and in kilometres per hour.
Show your working out.

n = 140×0.8
= 112 steps/minute.

v = 112s/min × 0.8m
v = 89.6 m/min

v = 14 93$\frac{1}{3}$ Km/h

Students who scored the higher level of partial credit for this item illustrate the higher part of proficiency Level 5 with a difficulty of 666 PISA units, only 3 points below Level 6. Although students were able to go further than finding the number of steps per minute, and made some progress towards the conversions, their final responses were not entirely correct or remained incomplete.



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

$\frac{N}{0.80} = 140$
X0.8 ×0.8

N = 112
N = 1min 12sec

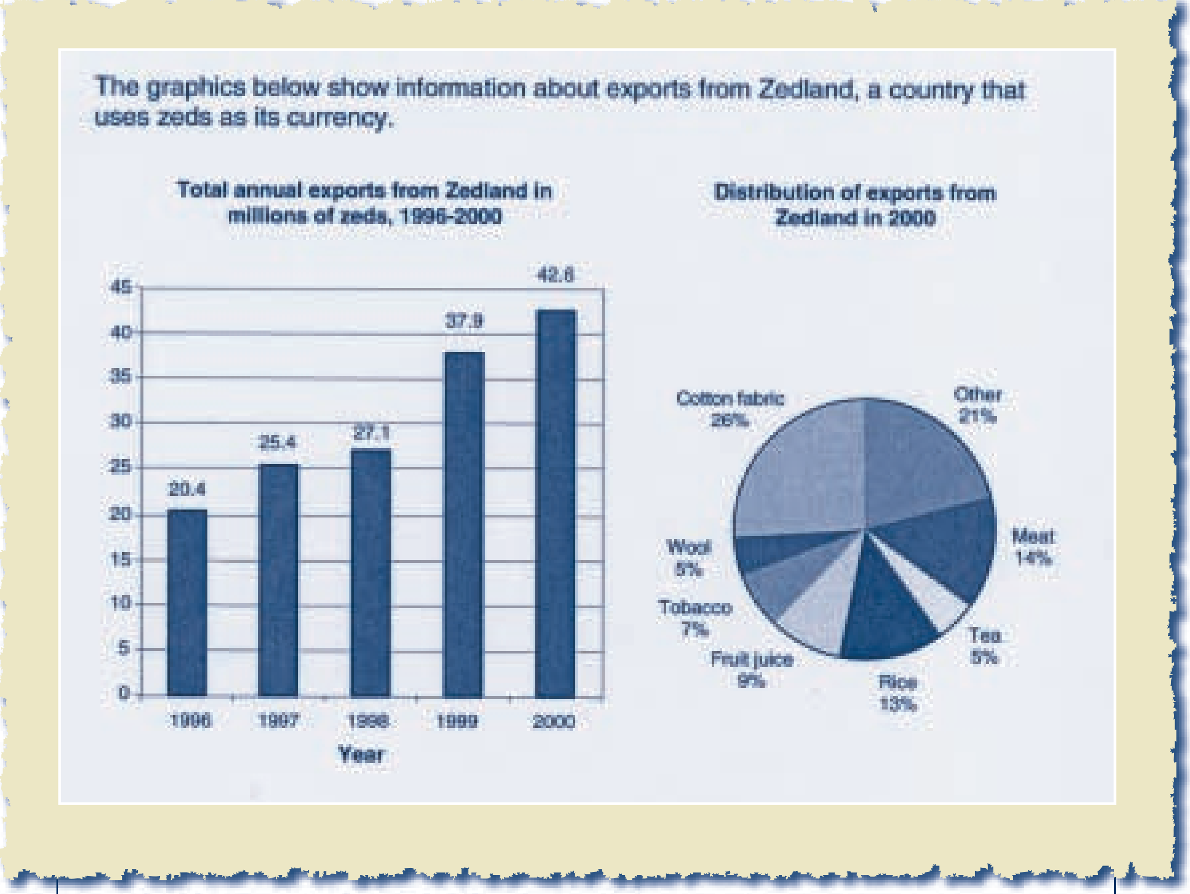
A lower level of partial credit was given when students showed they had understood the formula and correctly substituted the appropriate values, finding the number of steps per minute. The above example illustrates the top part of proficiency Level 4 with a difficulty of 605 PISA units – just 2 points below the boundary of Level 5.

The following two items can be placed in the *Uncertainty* overarching area.

EXPORTS

The information society in which we live relies heavily on data that is often represented in graphical format. For example, the media often use graphics to illustrate information within articles and to make a point more convincing and/or apparent. Ability to understand this type of information is therefore an essential component of *mathematical literacy*.

The unit *Export* uses two different graphs to present information about the exports and the currency from a fictitious country, Zedland. In today's media, graphs of these types are a common way of presenting information, to which students are frequently exposed. This unit was situated in the *public* context and is included in the *uncertainty* subscale because it involves data interpretation.



The graphics below show information about exports from Zedland, a country that uses zeds as its currency.

The first item in the unit was a closed constructed response involving the use of routine procedures. Students had to interpret, recognise and locate the relevant information in the graph.

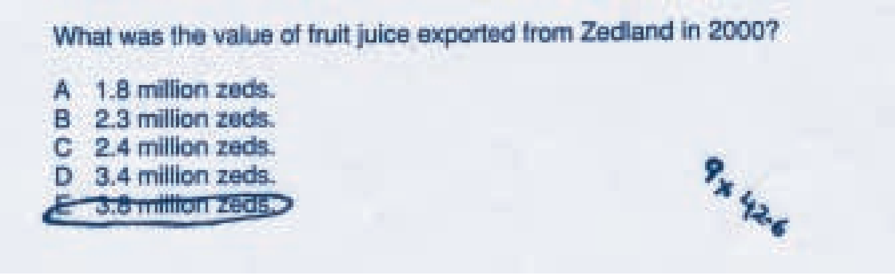
What was the total value (in millions of zeds) of exports from Zedland in 1998?

Answer: ......27.1 million..............

The next question belongs to the reproduction competency cluster and is an example of a proficiency Level 2 item, with a difficulty of 427 PISA units.

This question required students to indicate the correct response, in this case the value of the fruit juice exported from Zedland in 2000, using the multiple choice format.

In solving this problem, students had to understand that more than one step was involved. Firstly, they had to recognise both graphs were required to select the relevant data – the total annual export in 2000 (42.6) and the percentage of exports from Zedland in 2000 (9 %). Secondly, students had to combine this information, using a basic calculation (9% of 42.6) to obtain the answer of 3.8 million zeds.



What was the value of fruit juice exported from Zedland in 2000?

A 1.8 million zeds.
B 2.3 million zeds.
C 2.4 million zeds.
D 3.4 million zeds.
[✓ E 3.8 million zeds.]

9x 42.6

The use of interpreting familiar graphical charts combined with numerical reasoning placed this question in the connections competency cluster. This item was placed at proficiency Level 4 as it has a difficulty of 565 PISA units.

With regard to coding of items, a number of open-ended items have two-digit codes. The first digit is the score. The second digit is used to code different kinds of responses. There are two main advantages for using double digit-codes. Firstly, more information can be collected about students' misconceptions, common errors, and different approaches to solving problems. Secondly, double-digit coding allows a more structured way of presenting the codes, clearly indicating the hierarchical levels of groups of codes.

ROBBERIES

The unit *Robberies*, situated in the *public* context, provides 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 involves data interpretation, placing it in the *uncertainty* subscale and in the connections competency cluster, as students need 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 fits the data.

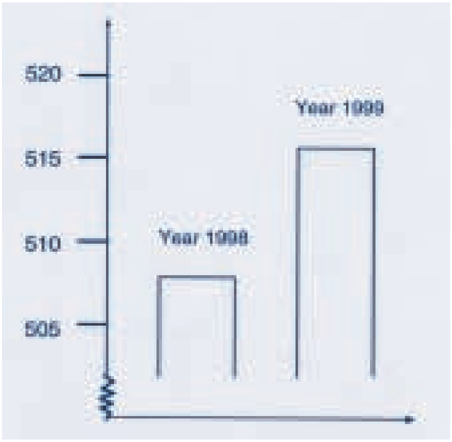
The marking guide for this question is included here to illustrate the nature of the PISA marking criteria. It also illustrates the way that items in PISA were marked with double-digit codes.

ROBBERIES

M179Q01- 01 02 03 04 11 12 21 22 23 99

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.

ROBBERIES SCORING 1

[Note: The use of NO in these codes includes all statements indicating that the interpretation of the graph is NOT reasonable. YES includes all statements indicating that the interpretation is reasonable. Please assess whether the student's response indicates that the interpretation of the graph is reasonable or not reasonable, and do not simply take the words "YES" or "NO" as criteria for codes.]

Full Credit

Code 21: No, not reasonable. Focuses on the fact that only a small part of the graph is shown.

- Not reasonable. The entire graph should be displayed.
- I don't think it is a reasonable interpretation of the graph because if they were to show the whole graph you would see that there is only a slight increase in robberies.
- No, because he has used the top bit of the graph and if you looked at the whole graph from 0 – 520, it wouldn't have risen so much.
- No, because the graph makes it look like there's been a big increase but you look at the numbers and there's not much of an increase.

Code 22: No, not reasonable. Contains correct arguments in terms of ratio or percentage increase.

- No, not reasonable. 10 is not a huge increase compared to a total of 500.
- No, not reasonable. According to the percentage, the increase is only about 2%.
- No. 8 more robberies is 1.5% increase. Not much in my opinion!
- No, only 8 or 9 more for this year. Compared to 507, it is not a large number.

Code 23: Trend data is required before a judgement can be made.

- We can't tell whether the increase is huge or not. If in 1997, the number of robberies is the same as in 1998, then we could say there is a huge increase in 1999.
- There is no way of knowing what "huge" is because you need at least two changes to think one huge and one small.

Partial Credit

Code 11: No, not reasonable, but explanation lacks detail.

- Focuses ONLY on an increase given by the exact number of robberies, but does not compare with the total.
- Not reasonable. It increased by about 10 robberies. The word "huge" does not explain the reality of the increased number of robberies. The increase was only about 10 and I wouldn't call that "huge".
- From 508 to 515 is not a large increase.
- No, because 8 or 9 is not a large amount.
- Sort of. From 507 to 515 is an increase, but not huge.

[Note that as the scale on the graph is not that clear, accept between 5 and

15 for the increase of the exact number of robberies.]

Code 12: No, not reasonable, with correct method but with minor computational errors.
- Correct method and conclusion but the percentage calculated is 0.03%.

No Credit

Code 01: No, with no, insufficient or incorrect explanation.
- No, I don't agree.
- The reporter should not have used the word "huge".
- No, it's not reasonable. Reporters always like to exaggerate.

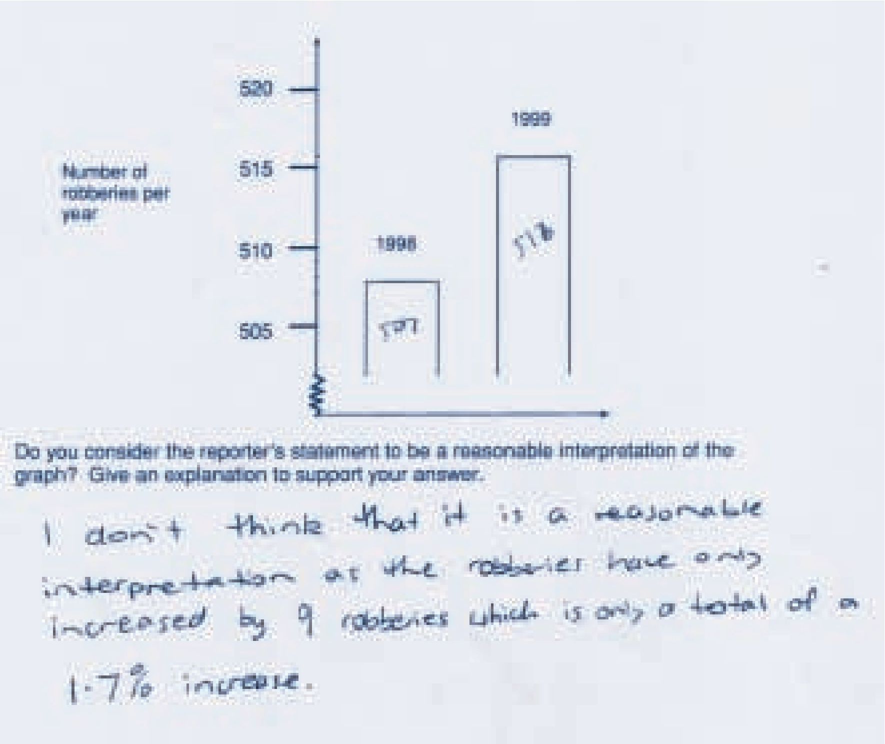
Code 02: Yes, focuses on the appearance of the graph and mentions that the number of robberies doubled.
- Yes, the graph doubles its height.
- Yes, the number of robberies has almost doubled.

Code 03: Yes, with no explanation, or explanations other than Code 02.

Code 04: Other responses.

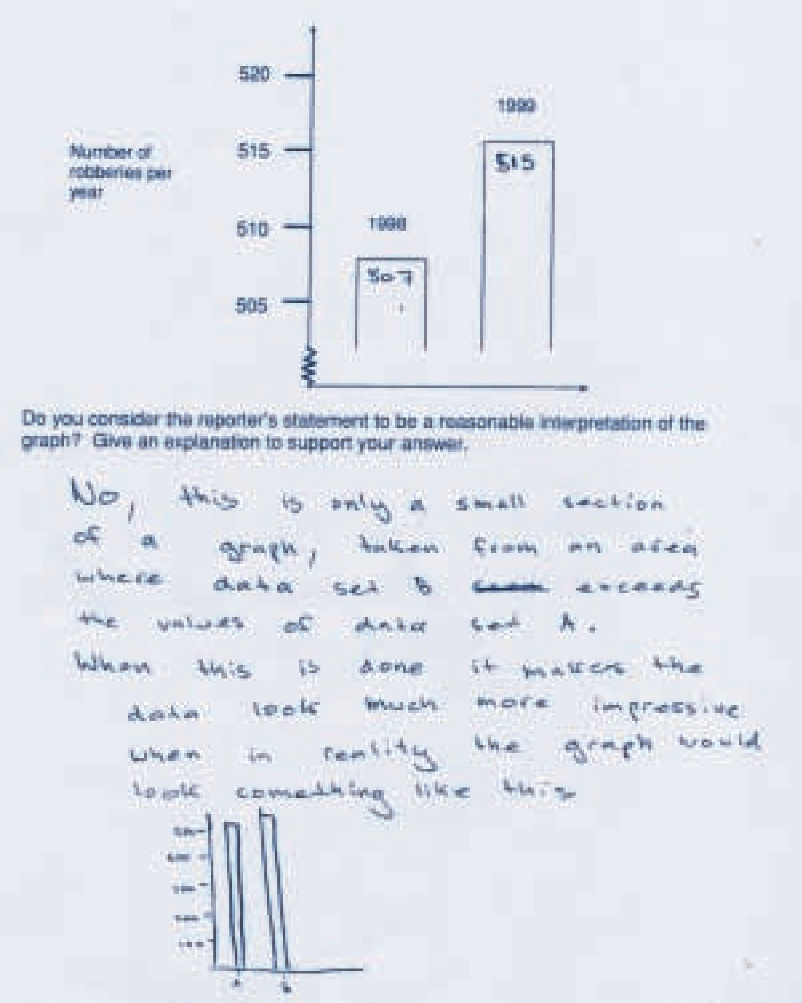
Code 99: Missing.

The full credit response illustrated a proficiency Level 6 (with a difficulty of 694 PISA units) as it required students to be able to communicate an argument based on interpretation of data, using some proportional reasoning in a statistical context, and in a not-too-familiar situation.



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.

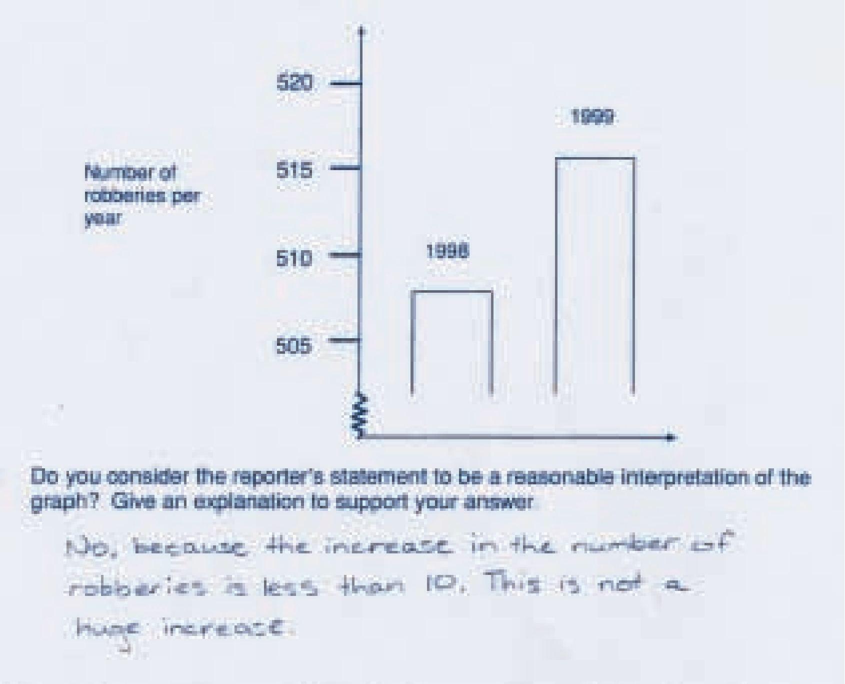


Do you consider the reporter's statement to be a reasonable interpretation of the graph? Give an explanation to support your answer.

No, this is only a small section of a graph, taken from an area where data set B exceeds the values of data set A. When this is done it makes the data look much more impressive when in reality the graph would look something like this

To obtain full credit, students had to indicate the statement was not reasonable and had to 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. Forty per cent of Australian students obtained full credit on this item.

To gain a partial credit (one point), students indicated that the statement was not reasonable, but failed to explain their judgment in appropriate detail. Students typically provided reasoning that only focused on an increase given by an exact number of robberies in absolute terms, but not in relative terms, as shown in the following example.

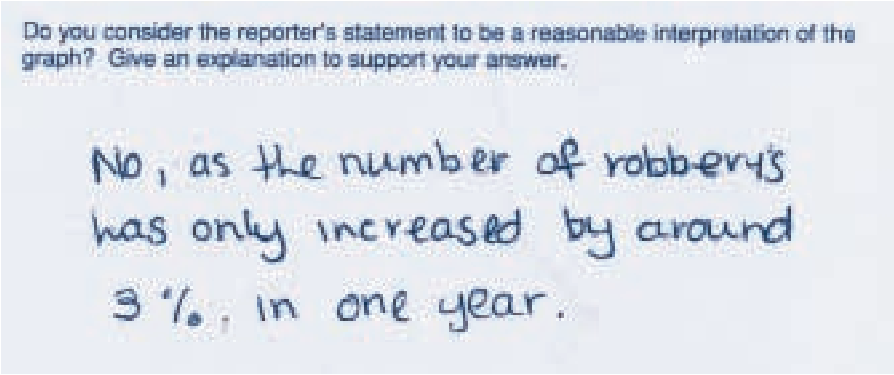


Do you consider the reporter's statement to be a reasonable interpretation of the graph? Give an explanation to support your answer

No, because the increase in the number of robberies is less than 10. This is not a huge increase.

This item shows the different degrees of difficulty in answering the question. Students who obtained a partial credit illustrated a proficiency Level 4 with a difficulty score of 577 PISA units.

The second example also shows a partial credit response, however in this case the student has incorrectly calculated the percentage of robberies.



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Give an explanation to support your answer.

No, as the number of robberys has only increased by around 3%, in one year.

In these types of responses, students use and communicate argumentation based on interpretation of data, therefore illustrating proficiency Level 4.

The Australian students' results on the items illustrated in this chapter are shown in Table 2.5, together with the results of the highest achieving country and the lowest achieving OECD country on each item.

Table 2.5 Selected Results (Percentages Correct) on Illustrated *Mathematical Literacy* Items

	Average for OECD and individual countries			Averages for Australia		
	All	Highest country	Lowest country	All	Females	Males
Exchange Rate						
Question 1	80	95 (Liechtenstein)	37 (Brazil)	81	80	83
Question 2	74	93 (Liechtenstein)	25 (Brazil)	75	74	76
Question 3	40	64 (Liechtenstein)	13 (Mexico)	46	47	45
Skateboard						
Question 1	72	85 (Finland)	22 (Indonesia)	79	78	80
Question 2	46	67 (Japan)	11 (Indonesia)	54	51	57
Question 3	50	65 (Macao-China)	11 (Indonesia)	57	55	59
Staircase						
Question 1	78	89 (Macao-China)	44 (Brazil)	78	78	79
Number Cubes						
Question 1	63	81 (Korea)	29 (Mexico)	69	66	71
Carpenter						
Question 1	20	40 (Hong Kong-China)	5 (Tunisia)	24	21	26
Growing Up						
Question 1	67	80 (France)	19 (Indonesia)	70	70	71
Question 2	69	82 (Korea)	24 (Indonesia)	71	73	70
Question 3	45	78 (Netherlands)	7 (Mexico)	58	60	55
Walking						
Question 1	36	62 (Hong Kong-China)	14 (Brazil)	34	34	35
Question 2	21	45 (Hong Kong-China)	6 (Brazil)	22	21	22
Exports						
Question 1	79	92 (France)	41 (United States)	86	88	84
Question 2	48	69 (Hong Kong-China)	30 (Tunisia)	46	41	51
Robberies						
Question 1	30	46 (Finland)	2 (Indonesia)	40	40	40

>>

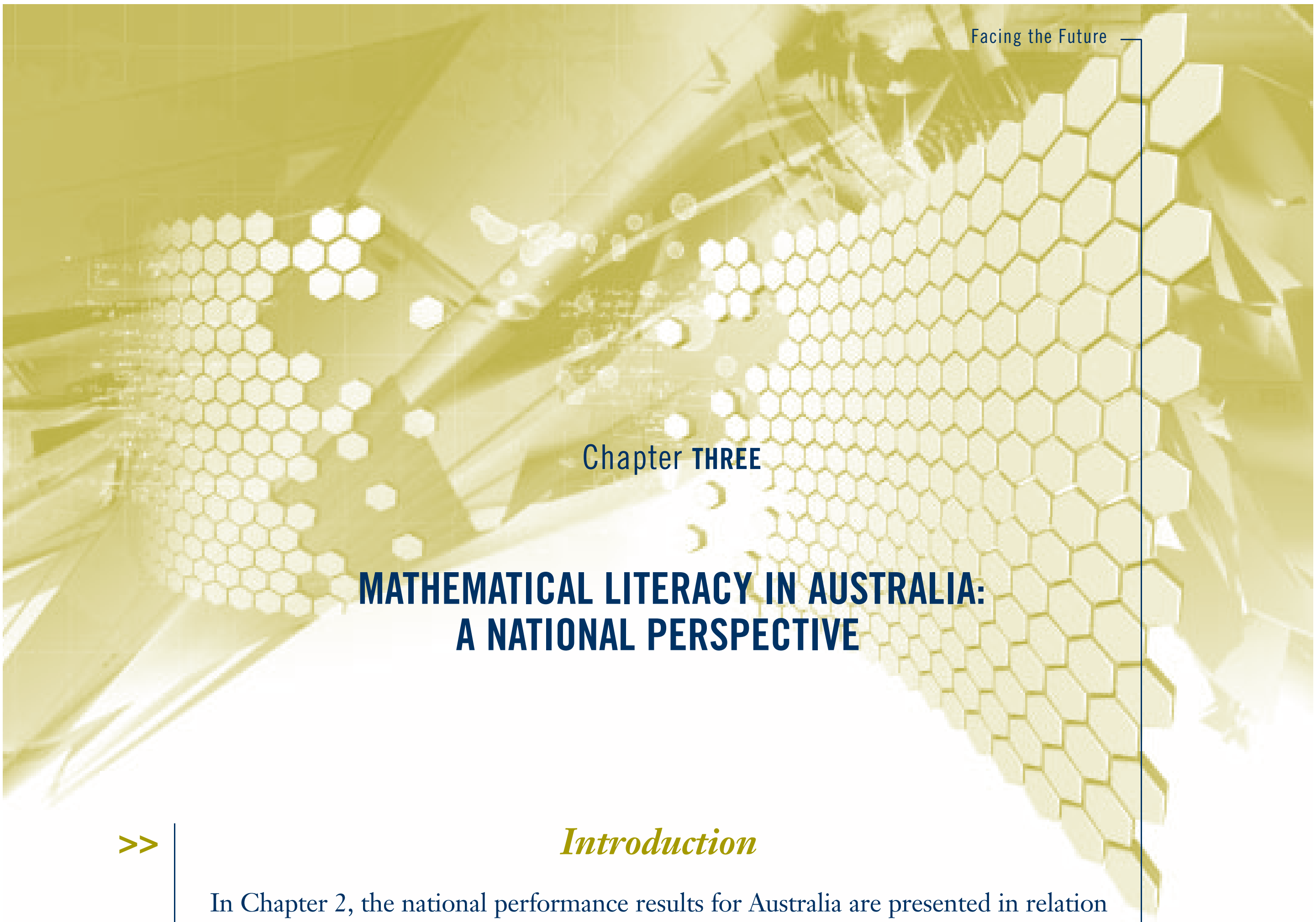
Summary

This chapter has examined differences in the means, dispersion of scores, and proficiency levels on the overall *mathematical literacy* scale and on the four subscales. On each of the subscales, the difference in mean scores between the highest and lowest country was found to be about two standard deviations of student scores, while within Australia, on each of the subscales, the difference between the 5th and 95th percentiles was in the order of three standard deviations. This illustrates that the variation within a country is usually larger than the variation between countries.

In the overall *mathematical literacy* scale for PISA 2003, Hong Kong-China, Finland, Korea and the Netherlands outperformed Australia. Australia's performance was equal to that of Japan, a country that outscored Australia in PISA 2000. It was significantly lower than that of Finland and Korea, countries that the Australian score was statistically similar to in PISA 2000. The Netherlands also outperformed Australia in PISA 2003, but was not part of the international data for PISA 2000. The gap between highest and lowest scores in Australia was 312 score points, less than the range of the international mean of 328 score points, and the 'tail' of the Australian distribution, 95 score points, was also lower than the international 'tail' mean of 101 score points.

Only Finland achieved higher performance scores than Australia in all four subscales. Hong Kong-China outperformed Australia in three – *quantity*, *space and shape*, *uncertainty*, Canada in three – *quantity*, *change and relationships*, and *uncertainty*, and Liechtenstein in three – *quantity*, *space and shape*, and *change and relationships*. Australia's performance scores were highest on the *uncertainty* subscale, and lowest on the *quantity* subscale, although any differences were only marginal.

Finally, this chapter presented some examples of *mathematical literacy* items that illustrate the PISA mathematics proficiency scale, the location of the defined levels, and that further elucidate the meaning of the levels of performance. In the next chapter, the Australian results in *mathematical literacy* are presented and discussed in a national context.



Chapter THREE

MATHEMATICAL LITERACY IN AUSTRALIA: A NATIONAL PERSPECTIVE

Introduction

In Chapter 2, the national performance results for Australia are presented in relation to the results for the OECD as a whole and for each country separately. This chapter presents results for the Australian states, for students in different geographic locations, and for population sub-groups such as Indigenous students and students with a language background other than English. Gender breakdowns of results for Australia are included in Chapter 2, but are included within this chapter for the states.

Year levels of the sampled Australian students

There are always difficulties in comparing aspects of education in the Australian states. There are both structural and curriculum differences in schooling from state to state, and many education policies are set at state level. Differences in school starting ages as set out in Table 3.1 create problems when interpreting the results of comparative studies, even at the basic level of age of the student, which can vary widely from state to state.

If a grade-based sample is used, as in TIMSS, the result is different age distributions of students by state, while if an age cohort is taken, as in PISA, students vary as to the grade they are in. Nationally, a little more than 70 per cent of the 2003 PISA sample was in Year 10, 19 per cent in Year 11 and eight per cent in Year 9. However it can also been seen from this table that in Western Australia 56 per cent and in Queensland 40 per cent of the sampled students are in Year 11. This is to be expected, given the different policy towards starting ages for these two states and given that the PISA students would have entered school directly into Year 1 when they started school. Table 3.1 provides a comparison of school starting ages and the year level at which children enter school for each of the states, approximately at the time the PISA students were starting school.

South Australia and the Northern Territory also have proportionally more Year 11 students, while Victoria with 16 per cent, and Tasmania with 30 per cent, have proportionally more students in Year 9 than the other states. The main conclusion from this table is that the majority of students in Queensland and Western Australia may have had up to a year's less schooling than their counterparts in other states. While the influence on outcomes is not known exactly, it is likely that in the final years of secondary schooling, the differences would be relatively small compared with the differences in the first few years of schooling.

Table 3.1 School Starting Age Policy Differences in Australian Education Systems

	Expected age-range on entry to full-time school in late 1980s – early 1990s	First year of full time school
New South Wales	4y 6m to 5y 5m	Kindergarten
Victoria	4y 7m to 5y 6m	Preparatory
Queensland	5y 1m to 6y 0m	Year 1
South Australia	5y 0m (continuous enrolment)	Reception*
Western Australia	5y 1m to 6y 0m	Year 1
Tasmania	5y 7m to 5y 11m	Prep./Year 1#
Northern Territory	5y 0m (continuous enrolment)	Transition*
Australian Capital Territory	4y 10m to 5y 9m	Kindergarten

* Children can spend less than a year in these programs, depending on when they enrol and how well they progress.

\# Until 1994, children older than 5 years 6 months on entry to school were enrolled in Year 1.

>> *Gender differences within Australia*

In PISA 2000, there were no gender differences on the *mathematical literacy* scale. The previous chapter found that while there were no gender differences in Australia on the overall *mathematical literacy* scale, males performed significantly better than females on two of the four subscales, *space and shape* and *uncertainty*. This can be seen from the means and standard errors in Table 3.2.

Table 3.2 Means and Standard Errors for Overall *Mathematical Literacy* and Subscales in Australia by Gender

Mathematical literacy scale	Females		Males	
	Mean	Standard error	Mean	Standard error
Overall mathematical literacy	522	2.7	527	3.0
Quantity	516	2.7	518	2.9
Space and shape	515	2.9	526	3.2
Change and relationships	523	2.8	527	3.2
Uncertainty	527	2.7	535	3.0

While the means for overall *mathematical literacy* show no gender differences, the levels of proficiency attained by males and females in Australia bear closer inspection. Figure 3.1 shows the proficiency levels for males and females as well as the aggregated proficiency levels for overall *mathematical literacy*, and the proficiency levels for the OECD as a whole, for comparison. This figure shows that while there are few gender differences in achievement of proficiency levels generally, almost twice as many males as females achieve the highest PISA proficiency level.

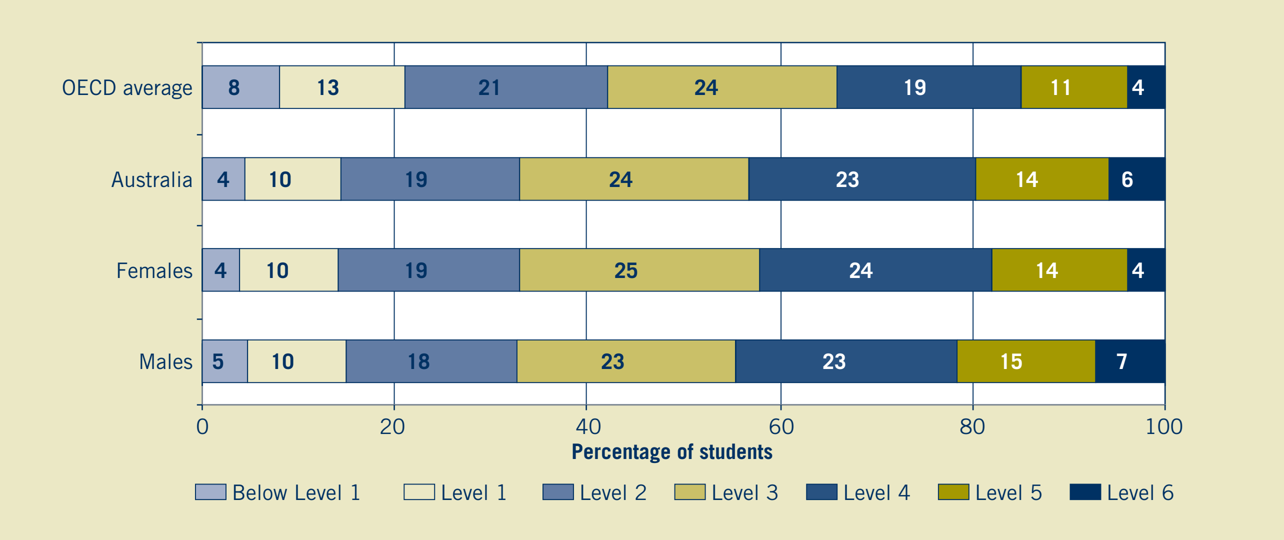


Figure 3.1 Proficiency Levels on the Overall *Mathematical Literacy* Scale by Gender

Performance of the Australian states and territories

Means and distributions of achievement by state

Figure 3.2 presents the distribution of performance for each of the Australian states in the same way as the international results were presented in Chapter 2. To place the state results in perspective, the means and distributions for the OECD, Australia and for the highest achieving country are also included in the figures. The states are ranked in each of the figures in order from lowest to highest mean scores.

For each state, the confidence interval, as shown by the white box in the middle of each bar, is either higher than, or overlaps the OECD average. This means that even in the lower achieving states, Australian students performed on average at least as well as the students on average across the OECD. Furthermore, students in Western Australia, the Australian Capital Territory and South Australia performed as well as students in Hong Kong-China, the highest performing country in *mathematical literacy*. What is also apparent from Figure 3.2 is the similarities in the Australian states' results. The significance of any differences is examined in the next section of this chapter.

Dispersion of performance

The Northern Territory had the widest range of performance scores on the PISA *mathematical literacy* assessment. The range from the 5th to 95th percentile for the Northern Territory was 344 score points, whilst the ranges for two of the higher performing states, South Australia and Western Australia, were 293 and 295 score points respectively. As a comparison, the range between the 5th and 95th percentile for Australia as a whole was 312 score points, for the OECD 328 score points and for Hong Kong-China 326 score points.

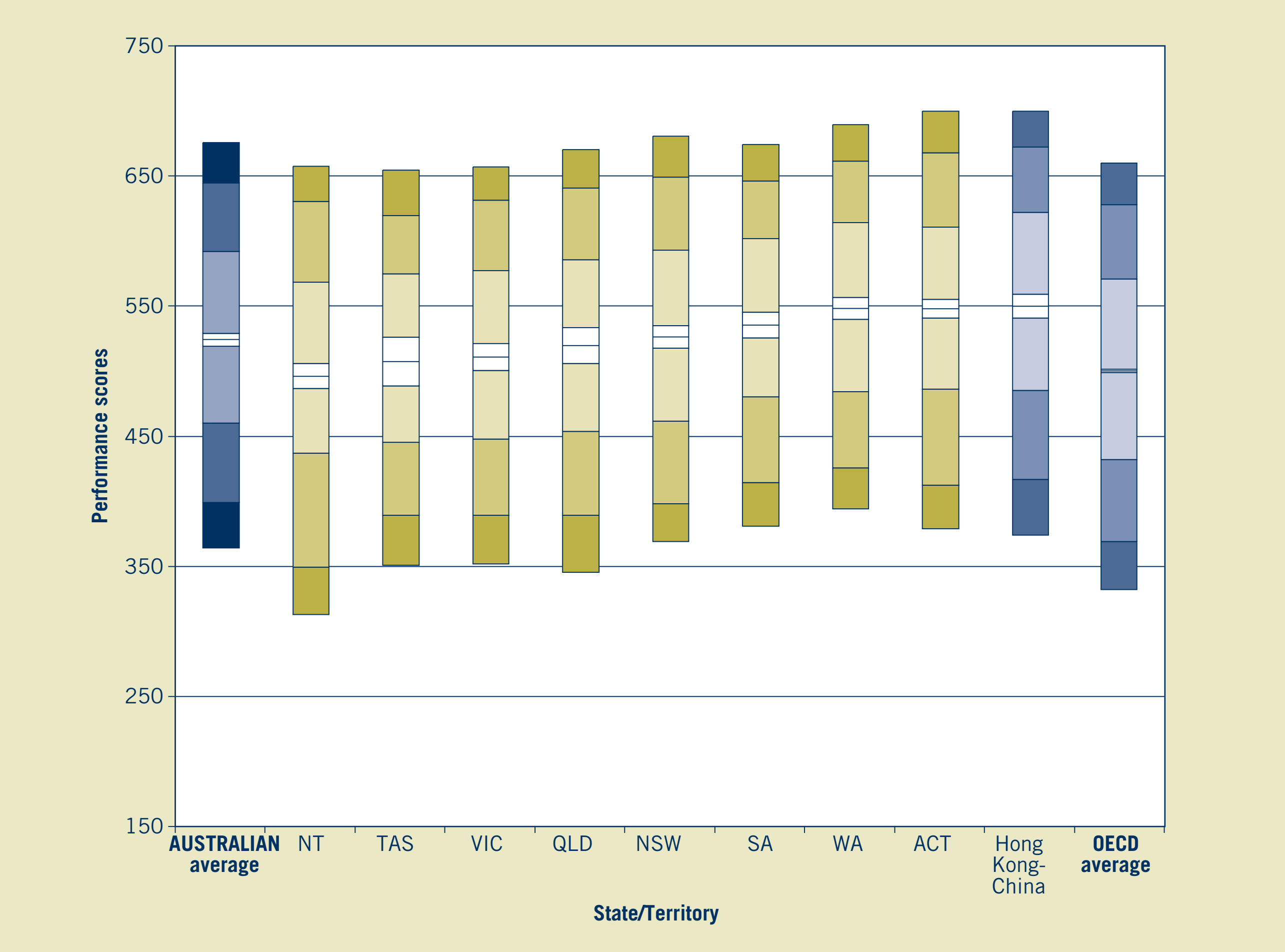


Figure 3.2 Comparative Performance in Overall *Mathematical Literacy* in the Australian States

The Northern Territory also has the longest 'tail', i.e. the range between the 5th and 25th percentile (124 score points), and the 'tails' for Queensland and the Australian Capital Territory are also relatively large, at 109 score points and 107 score points respectively. In comparison, the 'tail' for the OECD was 100 score points, for Australia 96 score points and for Hong Kong-China 111 score points. Western Australia, Tasmania and New South Wales all had 'tails' of less than the OECD and Australian averages, while the 'tails' for South Australia and Victoria were higher than the Australian average but lower than the OECD average.

Multiple comparisons of performance in mathematical literacy

The means and standard errors for *mathematical literacy* are shown for each state in Table 3.3. The statistical technique used to prepare this table is that commonly used both in PISA and in TIMSS, and compares results of several groups simultaneously in what are referred to as 'multiple comparisons'. Tests of significance were adjusted for the number of multiple comparisons being made, so that the probability level remained at 0.05. The results of the multiple comparison tests of significance are also shown in Table 3.3.

This table highlights many equivalent results when the analysis is done simultaneously. The average performance of students in the Australian Capital Territory was significantly higher than the average achieved by students in New South

Wales, Queensland, Victoria, Tasmania and the Northern Territory, and students from the Australian Capital Territory, Western Australia, South Australia, New South Wales and Queensland attained a higher average score than students in the Northern Territory. However, the performance of students in Victoria and Tasmania was not significantly different from the performance of students in the Northern Territory.

Table 3.3 Multiple Comparisons for Overall *Mathematical Literacy*

			ACT	WA	SA	NSW	QLD	VIC	TAS	NT
		Mean	548	548	535	526	520	511	507	496
	Mean	SE	3.5	4.1	4.9	4.3	6.9	5.1	9.4	4.9
ACT	548	3.5		●	●	▲	▲	▲	▲	▲
WA	548	4.1	●		●	▲	▲	▲	▲	▲
SA	535	4.9	●	●		●	●	▲	●	▲
NSW	526	4.3	▼	▼	●		●	●	●	▲
QLD	520	6.9	▼	▼	●	●		●	●	▲
VIC	511	5.1	▼	▼	▼	●	●		●	●
TAS	507	9.4	▼	●	●	●	●	●		●
NT	496	4.9	▼	▼	▼	▼	▼	●	●	

Note: Read across the row to compare a state's performance with the performance of each state listed as the column headings.
▲ 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

Investigating changes in mathematical literacy over time

A more detailed picture of *mathematical literacy* is portrayed by a comparison of the PISA 2003 results with the PISA 2000 results. In PISA 2000 *mathematical literacy* was a minor domain, and was restricted to assessment in *change and growth* and *space and shape* only. The multiple comparisons derived for that assessment found very few significant differences between the states; students in the Northern Territory had significantly poorer performance levels than students in the Australian Capital Territory and New South Wales, and students in the Australian Capital Territory outperformed students in Tasmania but no other differences were significant.

In PISA 2003, *mathematical literacy* was the major domain and the four *overarching ideas* were assessed. Therefore, while a comparison across all the countries can be made between the two *overarching ideas* common to both cycles, it is not possible to do so for the other two ideas. The results for the two subscales are shown in Table 3.4. These results indicate that while there has been a slight variation in scores from the first to the second cycle of PISA in these subscales, the differences are not significant.

Table 3.4 Means and Standard Errors for PISA *Mathematical Literacy* Subscales in Australia, 2000 and 2003

Mathematical literacy subscale	PISA 2000		PISA 2003	
	Mean	Standard error	Mean	Standard error
Space and shape	521	2.3	522	3.1
Change and relationships	525	2.3	520	2.9

Distribution of proficiency levels by state

As has been previously described, PISA adds to the means and standard errors by also describing performance in terms of proficiency levels. In Figure 3.3 the percentages of students at each proficiency level are shown for the Australian states, for the highest achieving country (Hong Kong-China), for Australia as a whole and for the OECD countries as a whole.

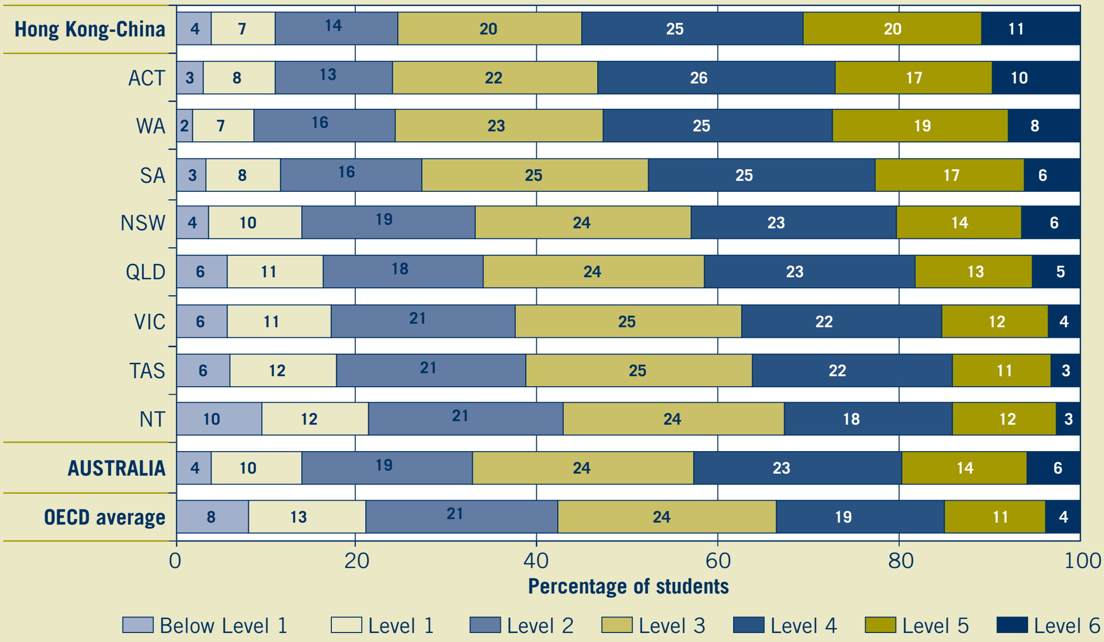


Figure 3.3 Proficiency Levels on the Overall *Mathematical Literacy* Scale for Australian States

From this figure, it can be seen that the percentage of students at the highest proficiency level from the Australian Capital Territory is almost as high as that of Hong Kong-China, and only in Tasmania and the Northern Territory is the proportion of students in this highest proficiency level lower than the OECD average, and in both cases this is only marginal.

The Australian Capital Territory and Western Australia both do very well in getting students to the highest proficiency level, and also in getting students past the minimal proficiency levels. In both of these states, more than half of the students achieve at proficiency Level 4 or higher, whilst only around one in ten are unable to complete tasks at Level 2. At the other end of the performance scale, one-third of the students in the Northern Territory were performing at proficiency Level 4 or higher, however one in five were unable to complete tasks above proficiency Level 2. Although this is almost exactly the same as for the OECD overall, it is a much poorer outcome than for the other states of Australia. A summary of the proportions of students in each state who have not achieved proficiency Level 2, and the proportion of students who have achieved at least Level 4, is shown in Table 3.5.

Table 3.5 Percentages of Students at Low and High Proficiency Level

State	At Level 2 or lower	At Level 4 or higher
ACT	11	53
WA	9	52
SA	11	48
NSW	14	43
QLD	17	41
VIC	17	38
TAS	18	36
NT	22	33
Australian average	**14**	**43**
OECD average	21	34

Gender differences within states

This section examines gender differences within each state, to see whether gender differences or lack thereof were uniform across the country. Table 3.6 provides the means and standard errors on overall *mathematical literacy* for each of the Australian states.

Table 3.6 Means and Standard Errors for Overall *Mathematical Literacy* by Gender within State

	Females		Males	
	Mean	Standard error	Mean	Standard error
WA	546	4.3	551	5.7
ACT	548	12.2	548	10.2
SA	530	7.1	540	7.0
NSW	524	3.9	529	6.9
QLD	521	8.6	518	7.7
VIC	503	6.2	518	6.6
TAS	508	9.9	507	10.7
NT	501	7.7	491	6.2
Australia	522	2.7	527	3.0

As with the PISA 2000 results, there are no significant gender differences on overall *mathematical literacy* by state. The results for male and female students in the Australian Capital Territory, New South Wales, Queensland, Western Australia, and Tasmania are virtually identical. Apparent differences in the other states, 10 points in the Northern Territory (where females' scores were numerically higher than males') and South Australia (where males' scores were numerically higher than females') and 15 points in Victoria (where males' scores were numerically higher than females'). These differences were not large enough to be statistically significant.

>> *Results by state for each of the subscales*

The different states of Australia have different curricula for mathematics and place different emphasis on the various content areas. The results from PISA can be used to gauge the relative differences in results in the states. Table 3.7 shows the mean score for each of the four PISA *mathematical literacy* subscales for each of the states, as well as the OECD average performance score.

Table 3.7 Means and Standard Errors for *Mathematical Literacy* Subscales by State

	Space and shape		Change and relationships		Uncertainty		Quantity	
	mean	Standard error	mean	Standard error	mean	Standard error	mean	Standard error
WA	545	4.6	551	4.4	552	3.9	540	3.9
ACT	546	3.8	548	3.7	557	3.7	540	3.7
SA	535	6.7	536	5.1	542	4.7	529	4.2
NSW	522	4.4	528	4.5	535	4.4	518	3.9
QLD	516	6.5	522	7.6	525	7.1	512	6.5
VIC	506	5.6	510	5.3	517	5.1	505	4.8
TAS	504	10.4	505	9.6	515	9.7	505	9.1
NT	495	5.9	494	5.3	500	5.5	491	5.8
OECD average	496	0.6	499	0.7	502	0.6	501	0.6

On each subscale, all states performed at least as well as the OECD average. Scores for the Australian Capital Territory, Western Australia and South Australia were not statistically different on any of the subscales, and were significantly higher than those for the other states. Comparisons using the multiple comparisons adjustment showed virtually the same pattern for each subscale as was found for the overall *mathematical literacy* scale, multiple comparisons for which were provided in Table 3.3.

Figure 3.4 shows the proficiency levels by gender for each of the Australian states. For many of the states there are very few differences in the proportions of male and female students by proficiency level. In Western Australia, for example, one of the highest performing states, seven per cent of males and six per cent of females achieved the highest proficiency level, and 11 per cent of males and eight per cent of females did not achieve proficiency Level 2. In contrast, the Australian Capital Territory, also one of the highest achieving states, exhibited a very different pattern of results. Only two per cent of males in the Australian Capital Territory achieved in the highest proficiency level, compared with eight per cent of females. At the other end of the distribution, more than one in five Australian Capital Territory males was not achieving proficiency Level 2, compared with just fewer than one in ten females.

In South Australia, the third of the high achieving states, the proportion of students achieving at higher than proficiency Level 5 is about the same, however 17 per cent of males compared with 11 per cent of females did not achieve proficiency Level 2. There are also quite substantial differences in Tasmania, where ten per cent of males and just three per cent of females attained proficiency Level 6, 19 per cent of males compared to nine per cent of females attained Level 5, but nine per cent of males and 17 per cent of females did not attain proficiency Level 2. Male and female students in Victoria, New South Wales and the Northern Territory exhibited patterns of achievement which were much more similar to each other.

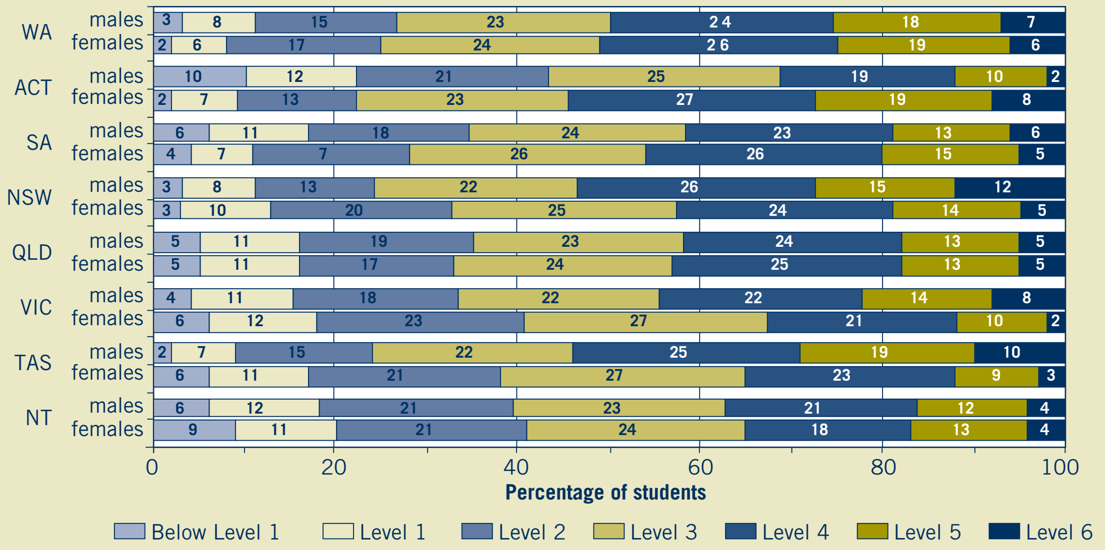


Figure 3.4 Proficiency Levels on the Overall *Mathematical Literacy* Scale by State and Gender

Mathematical literacy for Indigenous and non-Indigenous students

Four hundred and eighteen students identified themselves as Indigenous in the main PISA sample, and an additional 397 Indigenous 15-year-old students from the sampled PISA schools also participated in the assessment, as a special national option, providing a total sample of 815 Indigenous students, which is about 6 per cent of the PISA sample. The performance scores for *mathematical literacy* for Indigenous students are shown in Table 3.8, along with the results for non-Indigenous students.

It is evident from Table 3.8 that a very wide gap exists between the average achievement levels of Indigenous and non-Indigenous Australians. Non-Indigenous Australians on average scored about one-quarter of a standard deviation above the OECD mean, Indigenous Australians more than half a standard deviation below the OECD mean. Clearly these differences are significant both statistically and educationally. Nevertheless, the means do not show the whole picture, and Figure 3.5 adds to the picture of performance by showing the percentage of Indigenous and non-Indigenous students at each of the six PISA *mathematical literacy* proficiency levels, as well as the OECD average, for comparison.

Table 3.8 Means and Standard Errors for Overall *Mathematical Literacy* for Indigenous and Non-Indigenous Students

Student group	Mean	Standard error
Indigenous	440	5.4
Non-Indigenous	526	2.1

There is an over-representation of Indigenous students at the lower proficiency levels and an under-representation at higher proficiency levels. Forty-three per cent of Indigenous students were not able to achieve proficiency Level 2 and almost one in five Indigenous students were yet to consistently achieve proficiency Level 1. However 13 per cent were achieving at proficiency Level 4 or higher. In their further analysis of the PISA 2000 *mathematical literacy* results, De Bortoli and Cresswell (2004) found no significant gender differences for Indigenous students.

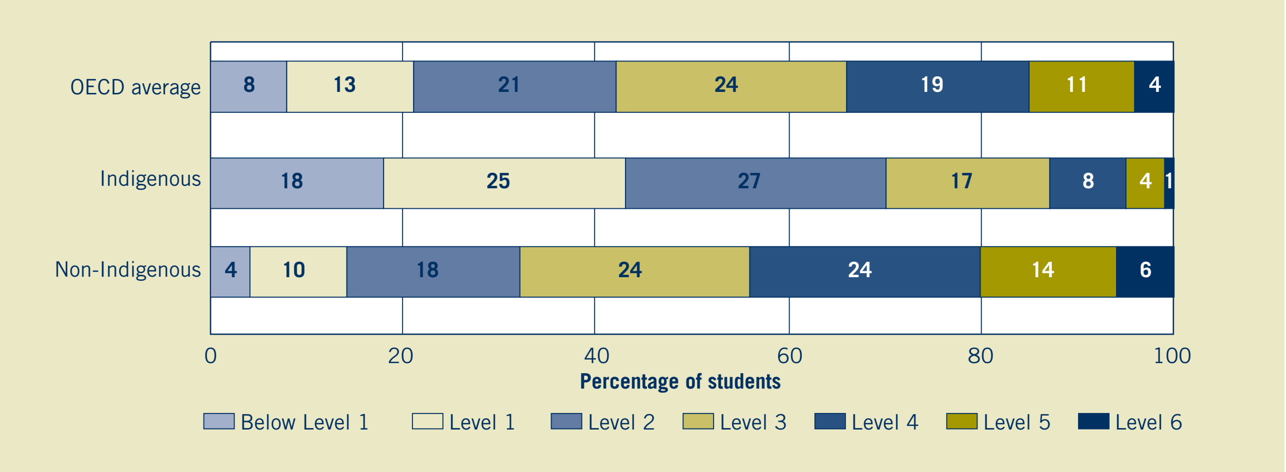


Figure 3.5 Proficiency Levels on the Overall *Mathematical Literacy* Scale for Indigenous and Non-Indigenous Students

Comparisons with PISA 2000

As has been previously discussed, it is difficult to make comparisons on the *mathematical literacy* scale between PISA 2000 and PISA 2003, as only two subscales were assessed in 2000. Given the caveats outlined in Chapter 2, it is possible to make some limited comparisons between performance for Indigenous and non-Indigenous groups. The scores on *mathematical literacy* for 2000 for the combined subscales *space and shape* and *change and relationships*, and on each of the subscales individually for 2003, are shown in Table 3.9.

This table shows that there is no real change in the difference between Indigenous and non-Indigenous students over the three years. In PISA 2000, the difference between the scores of the two groups of students was 0.86 of a standard deviation – in PISA 2003 the difference for *change and relationships* was exactly the same and for *space and shape* was 0.83 of a standard deviation.

Table 3.9 Comparison of *Mathematical Literacy* between PISA 2000 and PISA 2003 for Indigenous and Non-Indigenous Students

	2000	2003	
	Mathematical literacy Mean (SE)	Space and shape Mean (SE)	Change and relationships Mean (SE)
Indigenous	449 (89)	439 (7)	441 (7)
Non-Indigenous	535 (88)	522 (2)	527 (2)
Difference	86	83	86

>> *Mathematical literacy of immigrant students and those whose language background is not English*

The mathematics presented in PISA was presented in contexts that required students to read passages of text, and so unfamiliarity with the language of testing could possibly be a factor in student performance in *mathematical literacy*, although to a lesser extent than for *reading literacy*.

To examine the effect of immigrant status on *mathematical literacy* two indicators were used: immigrant status and language background.

The OECD defined three categories of student immigrant status: native, first-generation, non-native. For the Australian report, the first category has been labelled as 'Australian-born' and the third category as 'foreign-born', and they are defined in the following way.

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

The performance scores for each of these groups of students in *mathematical literacy* is presented in Table 3.10.

Table 3.10 Means and Standard Errors for *Mathematical Literacy* by Immigrant Status

Student group	Mean	Standard error
Australian-born students	527	2.1
First-generation students	522	4.7
Foreign-born students	525	4.9

It appears from these data that there were no significant differences in *mathematical literacy* by immigrant status. Figure 3.6 shows the PISA proficiency levels for each category of student as well, and this shows that the distributions are quite similar for each of these groups of students.

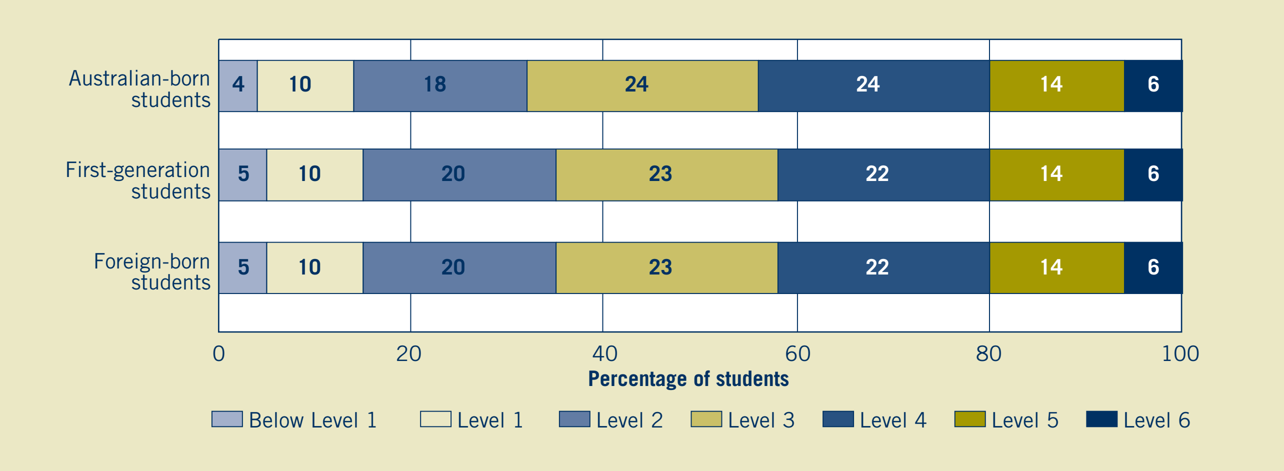


Figure 3.6 Proficiency Levels on the Overall *Mathematical Literacy* Scale by Immigrant Status

Table 3.11 shows the means for the students whose language background is English, and for the students for whom this is not the case. In this instance, the difference between the means is quite clearly statistically significant. Students whose language background is English performed at about one-quarter of a standard deviation above the OECD average, while those with a language background other than English performed at around the OECD average.

Table 3.11 Means and Standard Errors for Overall *Mathematical Literacy* Results by Main Language Spoken at Home

Student group	Mean	SE
English spoken at home	529	2.0
Language other than English spoken at home	505	6.1

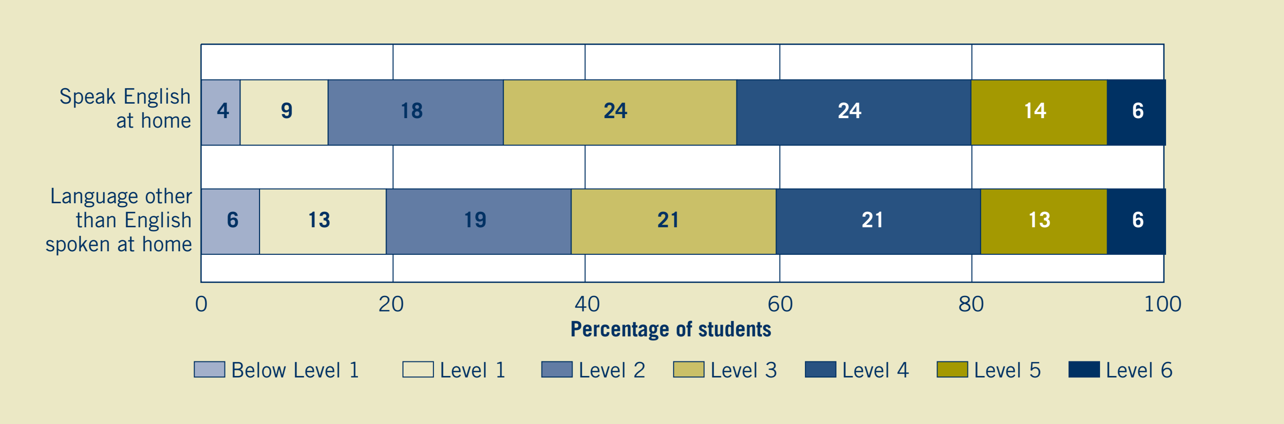


Figure 3.7 Proficiency Levels on the Overall *Mathematical Literacy* Scale by Main Language Spoken at Home

The proficiency levels for the two groups of students show that there is not a great deal of difference between the two groups at the upper end of the proficiency levels, with 44 per cent of students with an English-speaking background and 40 per cent of those with a language background other than English achieving at least proficiency Level 4. However while 13 per cent of students with an English-speaking background achieved below Level 2 as many as 19 per cent of students with a language background other than English achieved below this level.

As there were significant differences on the overall *mathematical literacy* scale, further analysis was conducted to examine differences between language groups on the subscales. Table 3.12 provides the means and standard errors for each of the *mathematical literacy* subscales, for students from the two language groups.

The only subscale for which the differences between the language groups was not significant was change and relationships. The differences between the language groups was between 11 and 12 score points on space and shape and quantity, and was 23 score points on uncertainty. In all cases students with an English-speaking background scored higher than those with a language background other than English.

Table 3.12 Means and Standard Errors for *Mathematical Literacy* Subscales by Main Language Spoken at Home

	Space & Shape		Change & Relationships		Uncertainty		Quantity	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
English spoken at home	523	2.2	528	2.2	535	2.1	520	2.0
Language other than English spoken at home	511*	6.4	523	6.3	512*	6.1	509*	5.6

* Differences significant at p < .05

>> *Results based on location of school*

This section of the report examines the relationship between mathematical literacy and geographic location. Schools' location was coded with respect to the recently developed MCEETYA Schools Geographic Location Classification. For the analysis in this report, only the broadest categories are used: Metropolitan, Provincial and Remote Classification, as described in Chapter 1.

Table 3.13 provides the means and standard errors for overall *mathematical literacy* for each of the three major locations. Performance was highest amongst students in metropolitan schools; followed by that of students in provincial areas, and performance by students in remote areas was lower than in other geographic locations. All of the differences between regions were statistically significant. Performance of students in metropolitan locations was, on average, about one-quarter of a standard deviation higher than the OECD average, while performance of those in remote area was slightly below the OECD average.

These findings are similar to those for *reading literacy* described in the secondary analysis of PISA 2000 based on geographic location (Cresswell & Underwood, 2004), and warrants some examination at a later date.

Table 3.13 Means and Standard Errors for Overall *Mathematical Literacy* by Geographic Location of School

School location	Mean	Standard error
Metropolitan	528	2.5
Provincial	515	4.4
Remote	493	9.6

>> *Summary*

This chapter has examined facets of *mathematical literacy* within Australia, and has presented results based on gender, state, Indigenous status, immigrant status, language background and geographic location.

There were no gender differences in overall *mathematical literacy*, however males performed significantly better than females on two of the subscales: *space and shape* and *uncertainty*, and twice as many males as females achieved at the highest PISA proficiency level (7 per cent and 4 per cent respectively).

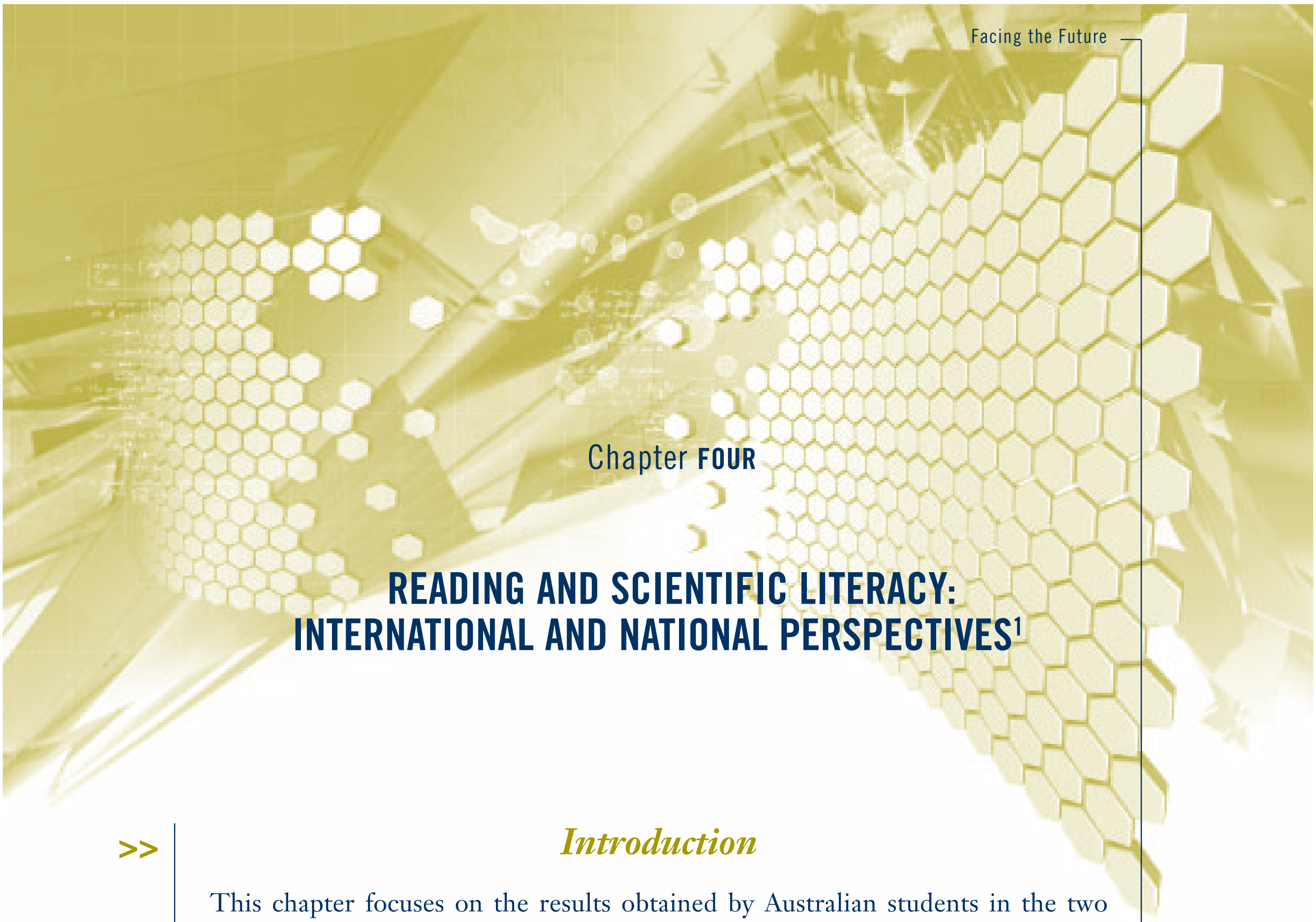
There were differences found in performance scores amongst the Australian states, but even in the lower achieving states, Australian students performed on average at least as well as students on average across the OECD. Students in Western Australia, the Australian Capital Territory and South Australia performed as well as students in the highest performing country in *mathematical literacy* (Hong Kong-China). However most apparent in the analyses conducted were the similarities in the Australian states' results.

Indigenous students were not found to have performed well in PISA. In general they were over represented at the lower levels of performance and under-represented at the higher levels of performance, although about 13 per cent were achieving at proficiency Level 4 or higher.

No differences were found in the performance of students based on whether they were born in Australia or had migrated to Australia, but students with an English language background were found to perform at a significantly higher level than those with a language background other than English. This was particularly evident on the *uncertainty* subscale.

Finally the discussion examined performance related to geographic location of the school, and found that students in cities performed at a higher level than those in country cities and large towns, while those students in regional areas performed better than students in remote and very remote areas.

In the next chapter, Australia's performances in *reading* and *scientific literacy* are examined.



Chapter FOUR

READING AND SCIENTIFIC LITERACY: INTERNATIONAL AND NATIONAL PERSPECTIVES[1]

Introduction

This chapter focuses on the results obtained by Australian students in the two minor domains in PISA 2003: *reading literacy* and *scientific literacy*. A description of the domain and the assessment framework is provided for each of *reading literacy* and *scientific literacy*. As minor domains, *reading* and *scientific literacy* were given shorter assessment time in PISA 2003 than the mathematics component which was the focus of the 2003 assessment, and so results for each of *reading* and *scientific literacy* are reported for PISA 2003 on single overall scales only (results on sub-scales are not reported).

Five levels of proficiency were defined and established in PISA 2000 for *reading literacy* when it was the major domain. In addition to reporting the results in terms of means and distributions, the *reading literacy* results in 2003 are also discussed in terms of percentages of students at each of these five established reading proficiency levels. The proficiency scale for *scientific literacy* will be developed and defined in 2006 when science will be the major domain for the first time. Results for *scientific literacy* are reported in this chapter based on means and distributions only.

Results for *reading literacy* are reported first followed by results for *scientific literacy*. In each section, Australia's results are reported for the country as a whole and comparisons are made both with the countries that participated in PISA 2003 and with the results of PISA 2000. Gender differences within Australia and in the other participating countries are discussed. The results of the Australian states and gender differences by state are then examined.

Lastly, results in both *reading* and *scientific literacy* for selected student sub-groups in Australia are reported. These sub-groups include Indigenous students, students of different immigrant status, students from a language background other than English and also students classified by geographic location of school.

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[1] Parts of this chapter were contributed by Siek Toon Khoo, and her assistance and expertise are gratefully acknowledged

Reading Literacy in PISA

Reading literacy was the major domain of testing in PISA 2000 and a minor domain in PISA 2003. In 2003, the shorter assessment in *reading literacy* allowed an update on overall performance rather than analysis of skills in depth. The same framework for assessment as in PISA 2000 was used. Results for *reading literacy* in PISA 2003 are reported on an overall *reading literacy* scale based on all the items assessed and not on the subscales reported in PISA 2000.

The PISA concept of *reading literacy* emphasises skills in using written information in situations which students may encounter in their life both at and beyond school. The PISA framework 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. 108, OECD, 2003)

This definition goes beyond the traditional notion of decoding information and literal interpretation of what is written towards more applied tasks. It implies that *reading literacy* involves understanding, using and reflecting on written information in a range of situations.

Processes involved in reading

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;

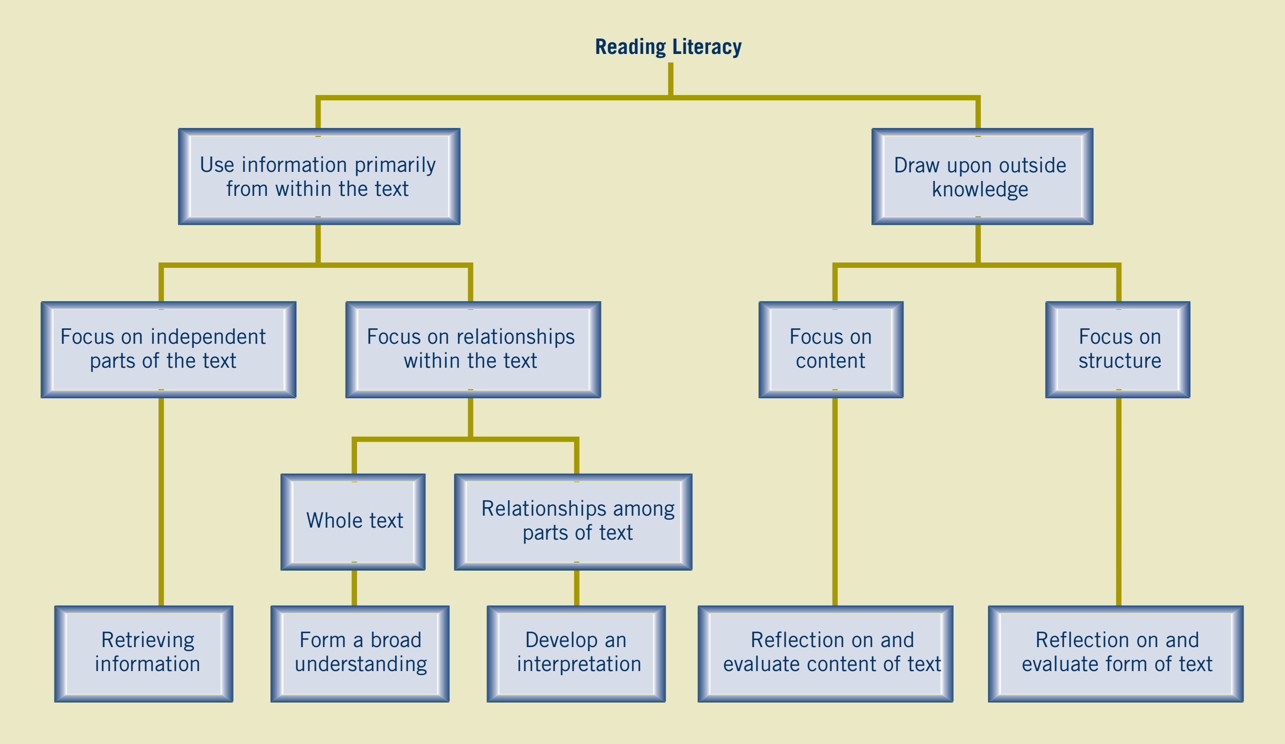


Figure 4.1 Characteristics Distinguishing the Five Processes of *Reading Literacy* (OECD, 2003)

- reflecting on and evaluating the content of a text; and
- reflecting on and evaluating the form of a text.

The full understanding of a text involves all of these processes. Figure 4.1 shows the details of the relationship between the reading processes. These five processes of reading are represented in the last line of the figure at the ends of the various branches. By starting at the top of the figure and following each branch one can see which characteristics are associated with each process.

For reporting purposes, the five processes were regrouped into three larger categories: retrieving information, interpreting texts (combining the two processes that require students to focus on relationships within a text) and reflection and evaluation (combining the two processes that require students to reflect on and evaluate content or form of text). Table 4.1 shows a distribution of *reading literacy* tasks by reading process and item type for PISA 2000 and PISA 2003. The total number of reading items in PISA 2003 was one fifth of the total number in PISA 2000.

Table 4.1 Distribution of *Reading Literacy* Tasks by Reading Process (Aspect) and Item Type

	Number of items											
Process (aspect)	Multiple-choice items		Complex multiple-choice items		Closed-constructed response items		Open-constructed response items		Short response items		Total	
	PISA 2000	PISA 2003	PISA 2000	PISA 2003	PISA 2000	PISA 2003	PISA 2000	PISA 2003	PISA 2000	PISA 2003	PISA 2000	PISA 2003
Interpreting texts	43	9	3	0	5	1	14	3	5	1	70	14
Reflection and evaluation	3	0	2	0	0	0	23	7	1	0	29	7
Retrieving information	10	0	2	1	10	3	6	0	14	3	42	7
Total	56	9	7	1	15	4	43	10	20	4	141	28

Reporting reading literacy performance

For PISA 2000, proficiency levels were developed and defined for the overall *reading literacy* scale and for the three subscales of retrieving information, interpreting texts, and reflection and evaluation. As has been described in Chapter 2 with regard to *mathematical literacy* (where there were six levels), there were five reading proficiency levels defined for each subscale. The levels are a useful way to explore the progression of the demands within each of the subscales. As well, when performance is reported on an overall combined scale, it is assumed that a student performing at a certain level has the skills described in the subscales at that level and the levels below it. For example, at the highest level — Level 5— students are able to carry out sophisticated tasks that might include locating information deeply embedded in a body of text, demonstrating a full understanding of a text, or critically evaluating a claim using specialised knowledge. Descriptions of the knowledge and skills required of students at each reading proficiency level are displayed in Figure 4.2.

At Level 1, students are able to retrieve a simple piece of explicitly stated information, with little or no competing information, able to recognise the main theme of an author's writing in a familiar topic, or make a simple connection

Score	Level	Retrieving Information	Interpreting	Reflecting
> 625	5	Locate and possibly sequence or combine multiple pieces of deeply embedded information, some of which may be outside the main body of the text. Infer which information in the text is relevant to the task. Deal with highly plausible and/or extensive competing information.	Either construe the meaning of nuanced language or demonstrate a full and detailed understanding of a text.	Critically evaluate or hypothesise, drawing on specialised knowledge. Deal with concepts that are contrary to expectations and draw on a deep understanding of long or complex texts.
553-625	4	Locate and possibly sequence or combine multiple pieces of embedded information, each of which may need to meet multiple criteria, in a text with familiar context or form. Infer which information in the text is relevant to the task.	Use a high level of text-based inference to understand and apply categories in an unfamiliar context, and to construe the meaning of a section of text by taking into account the text as a whole. Deal with ambiguities, ideas that are contrary to expectation and ideas that are negatively worded.	Use formal or public knowledge to hypothesise about or critically evaluate a text. Show accurate understanding of long or complex texts.
481-552	3	Locate, and in some cases recognise the relationship between pieces of information, each of which may need to meet multiple criteria. Deal with prominent competing information.	Integrate several parts of a text in order to identify a main idea, understand a relationship or construe the meaning of a word or phrase. Compare, contrast or categorise taking many criteria into account. Deal with competing information.	Make connections or comparisons, give explanations, or evaluate a feature of text. Demonstrate a detailed understanding of the text in relation to familiar, everyday knowledge, or draw on less common knowledge.
408-480	2	Locate one or more pieces of information, each of which may be required to meet multiple criteria. Deal with competing information.	Identify the main idea in a text, understand relationships, form or apply simple categories, or construe meaning within a limited part of the text when the information is not prominent and low-level inferences are required.	Make a comparison or connections between the text and outside knowledge, or explain a feature of the text by drawing on personal experience and attitudes.
335-407	1	Locate one or more independent pieces of explicitly stated information, typically meeting a single criterion, with little or no competing information in the text.	Recognise the main theme or author's purpose in a text about a familiar topic, when the required information in the text is not prominent.	Make a simple connection between information in the text and common, everyday knowledge.

Figure 4.2 Summary Descriptions for the Five Levels of *Reading literacy* across Subscales

between information in the text and common, everyday knowledge. There may be some students who are unable to complete tasks at Level 1. The interpretation of this is not that these students have no literacy skills at all, but that the skills lower than this level do not fit the PISA concept of *reading literacy* as skills that enable young adults to participate fully in society beyond school. Students at this level were unable to utilise *reading literacy* skills as required by the easiest PISA tasks.

>> *Sample reading items and responses*

Following PISA 2000, a number of *reading literacy* items were released. Releasing items provides examples of the type of questions that students face when they participate in the PISA assessment. The released items are described in *Sample tasks from the PISA 2000 assessment: reading, mathematical and scientific literacy* (OECD, 2002), while examples of Australian students' responses is provided in the first Australian PISA national report (Lokan, Greenwood, & Cresswell, 2001). As there was a sufficiently large number of *reading literacy* items from PISA 2000, no new items needed to be created for the PISA 2003 assessment, which is basically a subset of the PISA 2000 *reading literacy* items. This means that the linking of the results from the two cycles can be carried out effectively making it possible to report PISA 2003 *reading literacy* scores on the same scale established in PISA 2000 for direct comparisons of *reading literacy* scores across the two cycles.

There were no additional *reading literacy* items released after PISA 2003. Three of the items shown in the first Australian PISA national report (Lokan, Greenwood, & Cresswell, 2001) are therefore included in the following section to illustrate item types and to showcase the different skills needed to complete tasks at the different proficiency levels.

Items relating to the following text were among the easiest overall in the test. ‘Runners’, in the international title, was changed to ‘Running Shoes’ in Australia.

FEEL GOOD IN YOUR RUNNING SHOES

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.

All of the questions relating to 'Running Shoes' are at Level 1. The first, shown below, requires interpretation, but is easy because the point is made prominently near the beginning of the text.

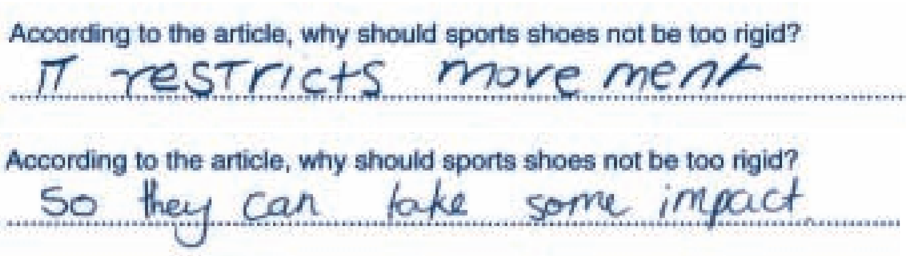
Running Shoes Question 1

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.

The second question asks for a single piece of information directly stated in the text to be located and written out. A further factor making the item relatively easy is that the information is at the beginning of a new section of text, though other information, which the second response shown below has been attracted to, is present in the rest of the section. Only the first answer shown here is correct.

Running Shoes Question 2



According to the article, why should sports shoes not be too rigid?

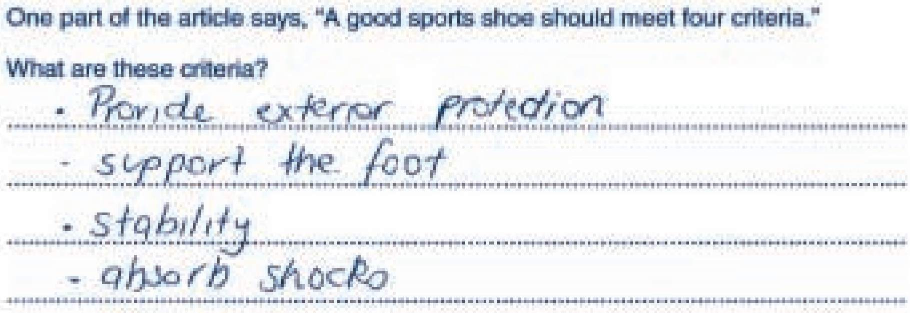
IT restricts move ment

According to the article, why should sports shoes not be too rigid?

So they can take some impact

The next item also asks for information to be located and written out. The item is a little more difficult because four pieces of information have to be correctly stated to gain a correct score. The students also have to filter out competing information. The marking criteria for this item are included here following the sample responses to illustrate the nature of the Marking Guide. Again, the first answer shown below is correct and the second one incorrect.

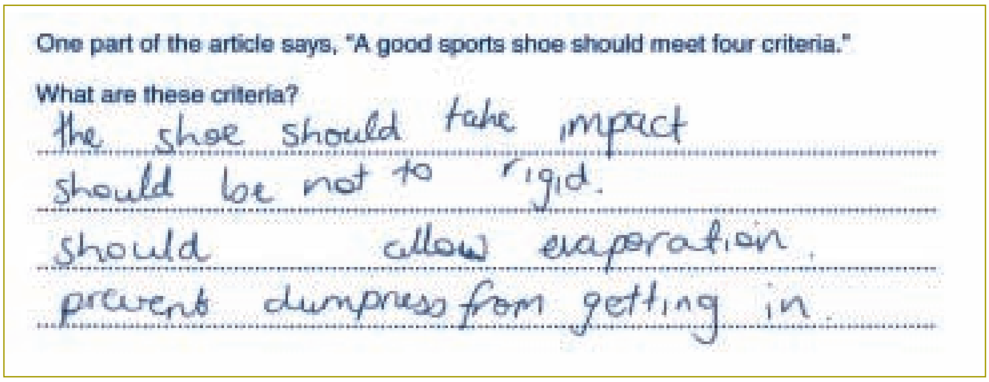
Running Shoes Question 3



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


One part of the article says, "A good sports shoe should meet four criteria."

What are these criteria?

the shoe should take impact

should be not to rigid.

should allow evaporation

prevent dumpness from getting in.

Extract from Marking Guide:

FULL CREDIT

Score 1: Responses which refer to the four criteria in italics in the text. Each reference may be a direct quotation, a paraphrase or an elaboration of the criterion. Criteria may be given in any order. The four criteria are:

(1) To provide exterior protection
(2) To support the foot
(3) To provide good stability
(4) To absorb shocks.

For example:

- **1** Exterior protection
  2 Support of the foot
  3 Good stability
  4 Shock absorption
- It must provide exterior protection, support the foot, provide the player with good stability and must absorb shocks.
- **1** They have to keep you from skidding and slipping. *[stability]*
  2 They have to protect your foot from shock (*e.g.* jumping). *[absorb shocks]*
  3 They have to protect you from bumpy ground and from the cold. *[exterior protection]*
  4 They have to support your foot and ankle. *[support foot]*
- Protect, support, stabilise, absorb *[Quotes sub-heading of this section of text.]*

NO CREDIT

Score 0: Other responses. For example:

1. Protect against knocks from the ball or feet.
2. Cope with unevenness in the ground.
3. Keep the foot warm and dry.
4. Support the foot.

Note that in the second response to Question 3 the student picked up some of the incorrect information flagged in the Marking Guide. This error was not uncommon.

The final item about running shoes requires students to reflect on the logical connection between two parts of a sentence, which are clearly indicated in the test item.

Running Shoes Question 4

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.

LAKE CHAD

The stimulus for 'Lake Chad' was presented graphically, with a minimum of text. Students needed to have a basic understanding of how information is shown in this form, and to be able to read line graphs. Items in this unit are at levels ranging from 1 to 4, and involve 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.

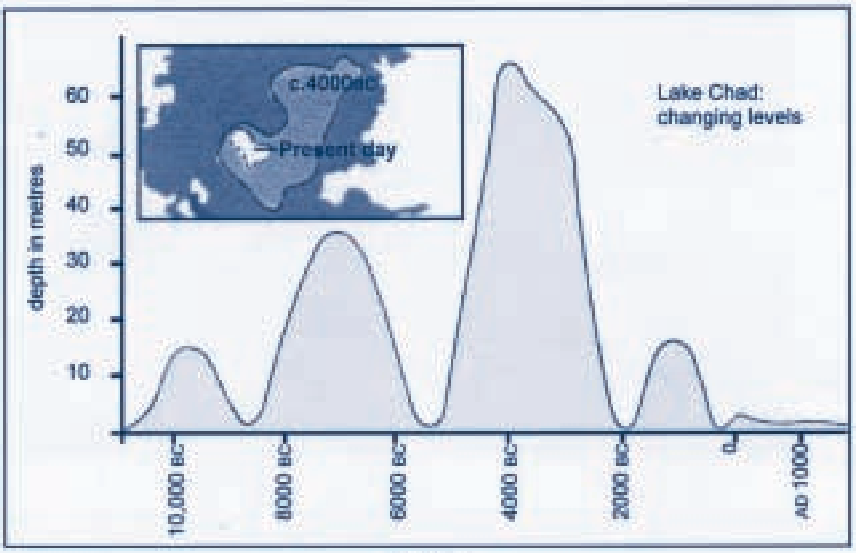


Figure 1

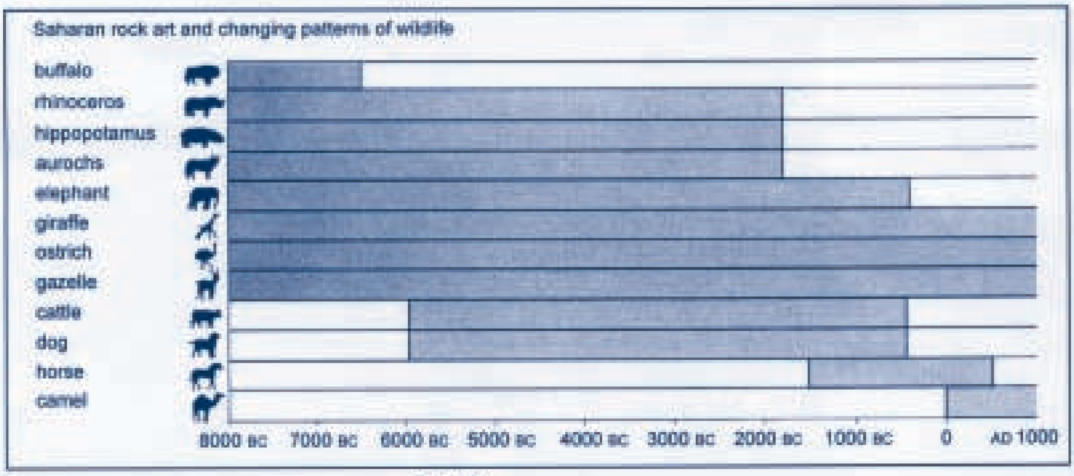


Figure 2

The first two items require retrieval of information, but are beyond Level 1 because of the added need to be able to locate information presented graphically. The first item, a multiple choice item (not shown) asks for the depth of Lake Chad today. That item is at Level 2. The second item also asks for some information from the graph, but is harder because some estimation is needed, the required value is not marked, and extra care is needed because the dates are in the negative direction for 'BC'. Many students wrote 10 000 as their answer, failing to extrapolate from the scale. The response below was assessed as correct – answers between 10 500 and 12 000 BC were accepted.

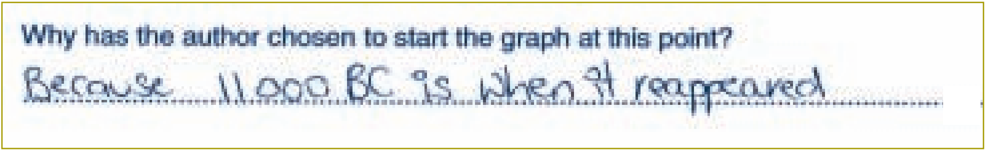
Lake Chad Question 2

In about which year does the graph in Figure 1 start?

11,000 BC

The next question is a 'short response' item, requiring students to evaluate what they have read and make an inference about the author's intention in preparing the graph. This is a Level 4 item. It is more difficult because of the level of reasoning that needs to be invoked. Students with the necessary skill could state the answer correctly and succinctly:

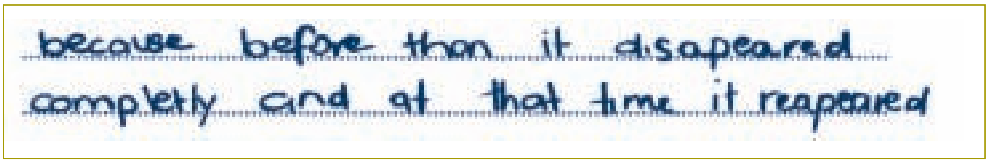
Lake Chad Question 3



Why has the author chosen to start the graph at this point?

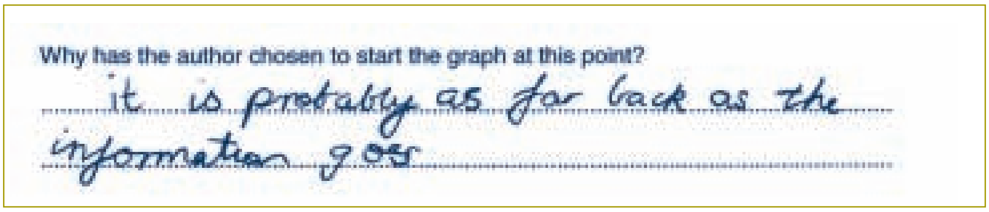
Because 11,000 BC is when it reappeared

but sometimes made spelling mistakes. Answers with mistakes in grammar and/or spelling were not penalised as long as the correct point was made. The following answer was marked correct:



because before than it disapeared
complety and at that time it reapeared

A common mistake was to ignore the information at the head of the stimulus when interpreting the graph:



Why has the author chosen to start the graph at this point?

it is probably as far back as the
information goes

The final two items in the Lake Chad unit are multiple choice, both requiring interpretation skills. One (not shown) is a Level 1 item asking for the reason these particular animals were chosen for illustration. The other is a Level 3 item, shown below. This item is harder because it requires consideration of both figures.

Lake Chad Question 5

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.

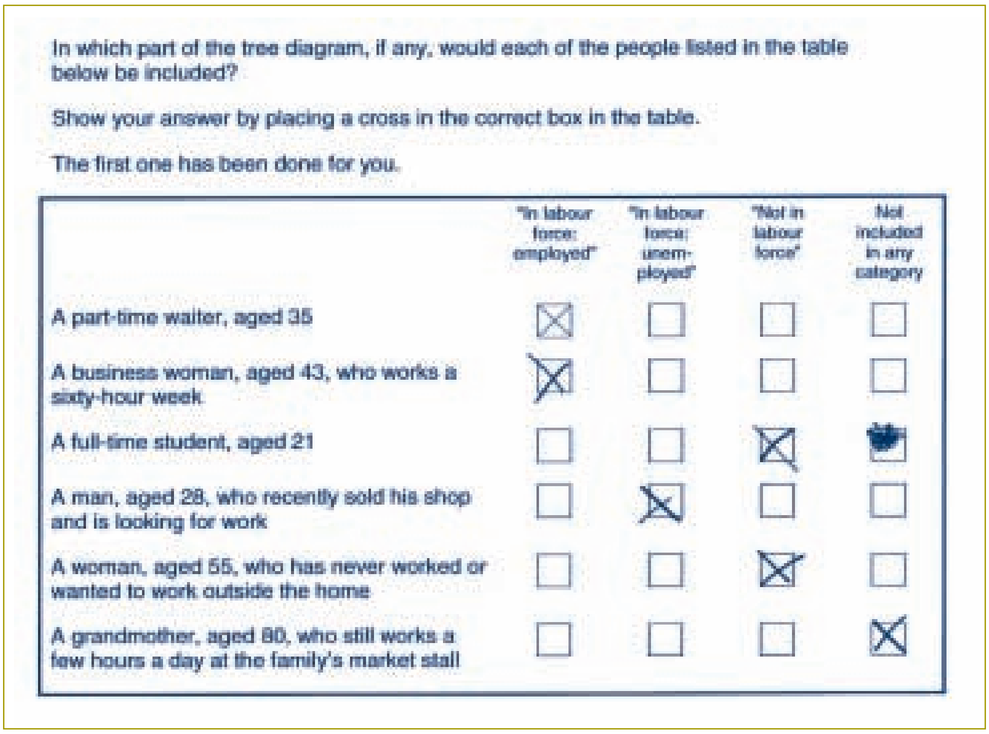
B in the middle of the period when Lake Chad was at its highest level.

[✓ **C**] after the level of Lake Chad had been falling for over a thousand years.

D at the beginning of an uninterrupted dry period.

Only a handful of items in the test were at Level 5, and most of these have not been released. A sample Level 5 item is included here. It comes from a unit about the structure of a country's labour market, in which the information is presented as a complex tree diagram with divisions such as 'in the labour force' and 'not in the labour force', with many divisions below these. For each branch of the tree, numbers in thousands, such as 318.1, and the percentages of the branch represented by the numbers, are given. Definitions of the 'working-age population' and 'not in the labour force' are provided.

Labour Question 3



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: unemployed"	"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	☐	☐	☐	☒

The item, which belongs to the 'interpreting texts' sub-scale, is an example of what is referred to as 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 or four were correct the answer was scored 1. This 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 give the correct answers.

Australia's results in overall reading literacy

Internationally, the overall *reading literacy* scale was constructed in PISA 2000 to have a mean of 500 points and a standard deviation of 100 points across the participating OECD countries. Using link items, the PISA 2003 *reading literacy* performance was scaled onto the same *reading literacy* reporting scale established in 2000. This linking of scales makes it possible to directly compare scores and monitor changes across time. For example, in 2003, the mean score for overall *reading literacy* across the participating OECD countries was 494 with a standard deviation of 100, a decline of 6 points from 2000. This decrease in the mean was statistically significant.

Australia's mean score in 2003 *reading literacy* was 525 score points, which is not significantly different from the score of 528 achieved in 2000.

A summary of performance in overall *reading literacy* by country for PISA 2003 is shown in Figure 4.3. Each vertical bar gives a summary of the performance of a country with coloured bands displaying the mean, the confidence limits around the mean, the 5th, 10th, 25th, 75th, 90th and 95th percentiles thereby showing the spread of the scores achieved by 90 per cent of the students in each country. A complete description of how to read these charts is provided in Chapter 2.

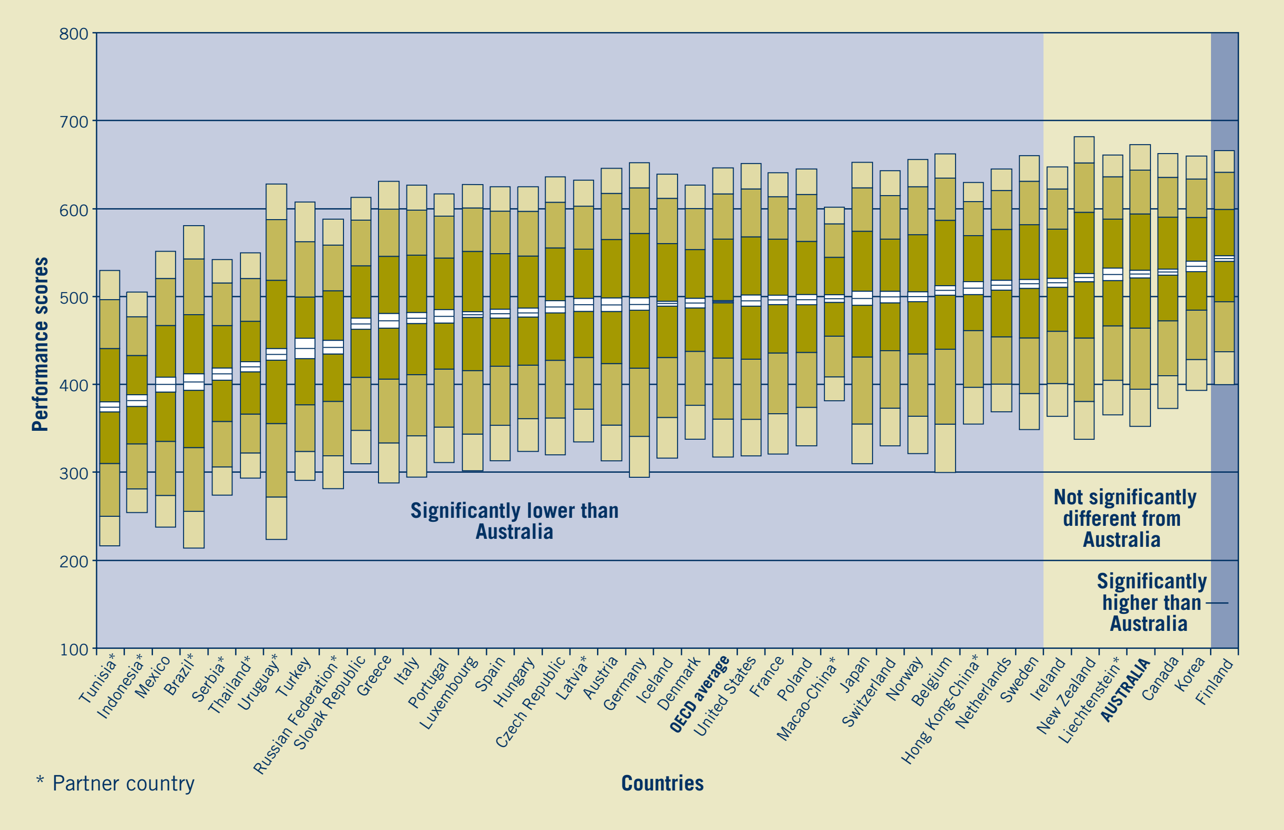


Figure 4.3 Student Performance in Overall *Reading Literacy* by Country

In Figure 4.3, the countries are ordered according to their overall *reading literacy* mean score in PISA 2003. For example, Finland, being the highest scoring country in *reading literacy*, is represented in the right-most bar. Australia was among the top scoring countries in *reading literacy* in PISA 2000, and is again one of the top scoring countries in PISA 2003. Australia's mean score of 525 in *reading literacy* was well above the OECD mean of 494, and Finland, the highest scoring country with a mean score of 543 was the only country which had a significantly higher score than Australia in *reading literacy*. Australia was in a group of six countries whose results were statistically similar – these were Korea, Canada, Australia, Liechtenstein, New Zealand, and Ireland. Finland was also the only country which scored higher than Australia in PISA 2000.

For Australia, the range between the 5th percentile and the 95th percentile was 321 score points. This range for Australia was not significantly different from the corresponding Australian range of 331 in 2000, but is slightly wider than for most of the other top-scoring countries. For example, Finland's range for the middle 90 per cent was 266 and Korea's 267. Australia's range was, however, slightly below that of the OECD average range of 329. Among the 10 countries with the highest mean scores, only New Zealand had a larger spread than Australia, with a range of 344 score points between the 5th percentile and the 95th percentile. Among all the 41 countries, Uruguay had the largest spread of 404 score points followed by Belgium (362), Germany (357), New Zealand (344) and Greece (343). Macao-China had the narrowest spread at 220.

Reading literacy results by gender

In PISA 2000 there were significant gender differences in the mean *reading literacy* scores in all countries, with females outperforming males in all cases. The gender difference in *reading literacy* in PISA 2000 was 34 points in Australia and the range for other countries varied from 14 points in Korea to 53 points in Latvia, with the OECD average difference being 34 points. Figure 4.4 shows the magnitude of the gender differences for all the participating countries in PISA 2003. Each bar in this figure shows the number of points that the females in the country scored higher than the males. (Countries are ordered by the magnitude of the gender difference, from left to right)

These gender differences were statistically significant for all countries except Liechtenstein. The difference was more than 40 points in seven of the participating countries. The largest differences were 58 points in Iceland, 49 points in Norway, 47 points in Austria and 44 points in Finland. Only two countries (Liechtenstein and Macao-China) had a gender difference less than 20 points.

In Australia, the gender difference remained relatively high in PISA 2003 at 39 points (female mean 545; male mean 506), which was larger than the OECD average. The corresponding gender difference in New Zealand was 28 points, which was narrower than the OECD average gap.

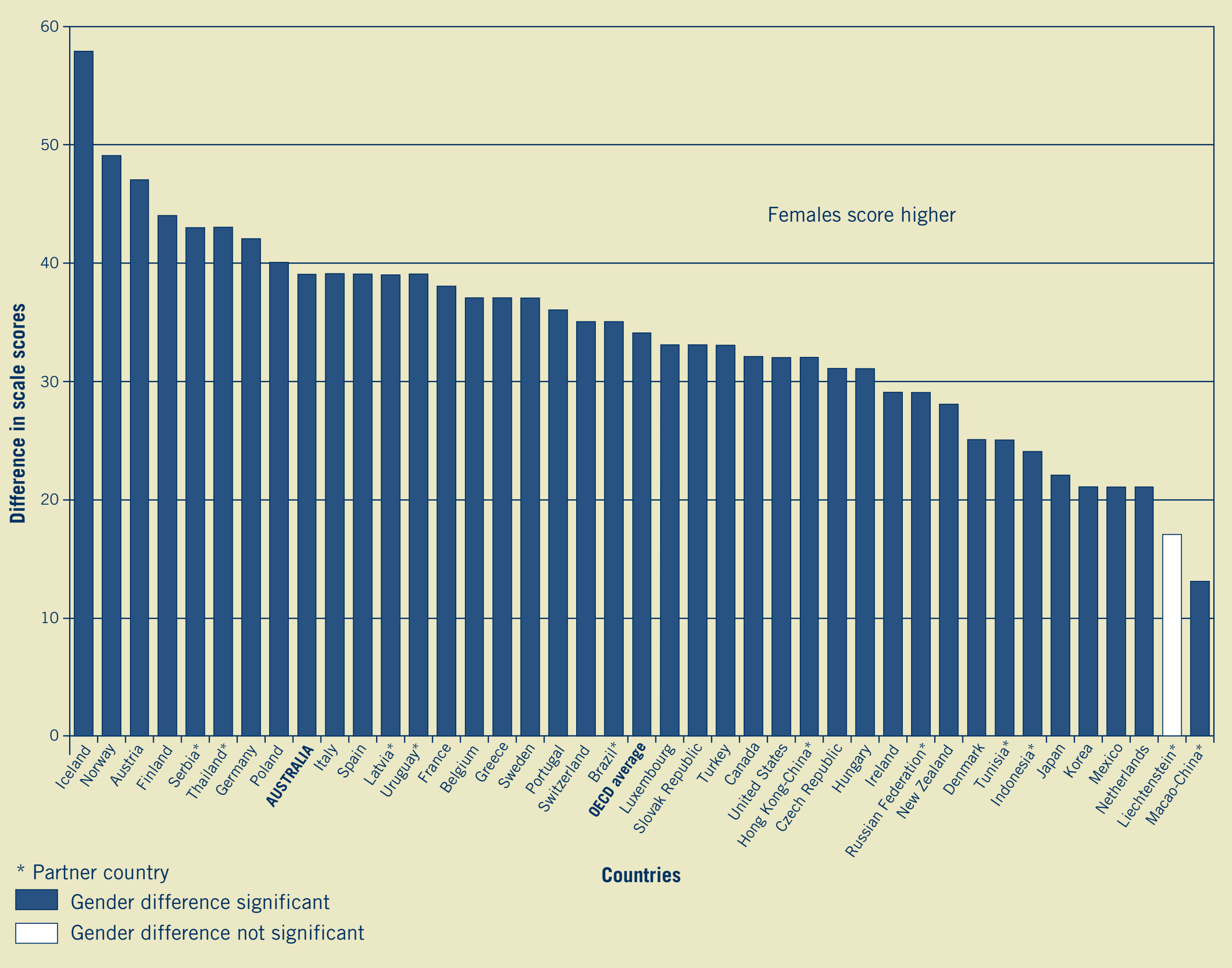


Figure 4.4 Student Performance in Overall *Reading literacy* by Country and Gender

The gender difference for *reading literacy* in Australia in PISA 2000 was about one-third of a standard deviation, as pointed out in the first Australian PISA national report (Lokan, Greenwood, & Cresswell, 2001). This was noted as being a cause for concern and signalled a need for enhanced effort to improve male students' literacy skills. The national gender difference in *reading literacy* as indicated in the PISA 2003 results is about 0.4 of a standard deviation.

Table 4.2 Means and Standard Errors for *Reading Literacy* by Gender within States

	2003		% females	Females		Males		Difference	
State/Terr.	Mean	SE	in sample	Mean	SE	Mean	SE	2003*	2000#
ACT	549	6.0	52	569	12.2	527	9.2	42	23
WA	546	4.3	51	565	4.8	526	5.7	40	34
SA	532	4.3	46	551	8.0	517	5.9	34	29
NSW	530	4.3	52	550	4.1	510	6.6	39	30
QLD	517	8.1	45	544	8.2	495	8.9	49	47
VIC	514	5.0	49	530	5.9	499	6.8	30	28
TAS	508	7.2	46	532	8.0	487	10.0	45	50
NT	496	6.1	53	523	9.0	465	7.3	58	30

* All differences are statistically significant with $p < 0.05$

All differences are statistically significant with $p < 0.05$ except for ACT

Reading literacy results by state

A summary of 2003 state performance in overall *reading literacy* is shown in Table 4.2 and Figure 4.5. Each vertical bar in Figure 4.5 displays the mean, the confidence limits around the mean, as well as the 5th, 10th, 25th, 75th, 90th and 95th percentiles for the states of Australia. In the figure, the states are ordered in ascending order of the state means from left to right. The summary results for Finland, the highest scoring country, and for the OECD average are also included in the figure for comparison. Students in the highest-achieving Australian states, the Australian Capital Territory (549) and Western Australia (546), performed on a par with students in the highest achieving country, Finland (543). On average, students in the lowest achieving Australian state, the Northern Territory (496), performed at the OECD average (494).

Table 4.3 Multiple Comparisons for Overall *Reading Literacy* Performance by State

	Mean	Mean SE	ACT	WA	SA	NSW	QLD	VIC	TAS	NT
			549	546	532	530	517	514	508	496
			6.0	4.3	4.3	4.3	8.1	5.0	7.2	6.1
ACT	549	6.0		●	●	●	▲	▲	▲	▲
WA	546	4.3	●		●	●	▲	▲	▲	▲
SA	532	4.3	●	●		●	●	▲	▲	▲
NSW	530	4.3	●	●	●		●	●	●	▲
QLD	517	8.1	▼	▼	●	●		●	●	●
VIC	514	5.0	▼	▼	▼	●	●		●	●
TAS	508	7.2	▼	▼	▼	●	●	●		●
NT	496	6.1	▼	▼	▼	▼	●	●	●	

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

Results of the multiple comparison tests of significance of the state differences in PISA 2003 overall *reading literacy* mean scores are presented in Table 4.3. The Australian Capital Territory, Western Australia, South Australia and New South Wales achieved means which were statistically similar when they were compared simultaneously while Queensland, Victoria, Tasmania and the Northern Territory also were statistically similar with each other in terms of their mean scores. Students in the Australian Capital Territory and Western Australia performed on average significantly better than students in Queensland, Victoria, Tasmania and the Northern Territory, while students in South Australia performed on average significantly better than students in the last three - named states. These results are very similar to those for PISA 2000, with the only change that the Northern Territory performed better in 2003 in relation to the other states. In PISA 2000, all states other than Tasmania performed significantly better than the Northern Territory.

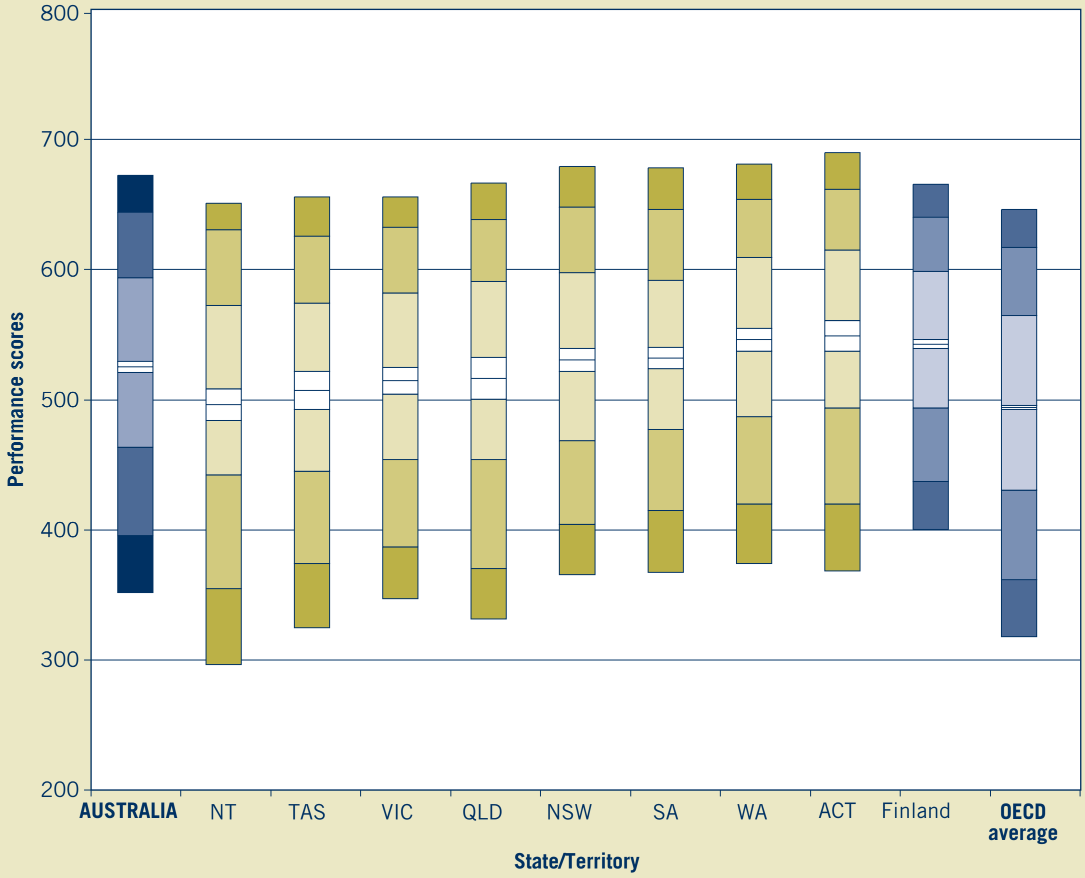


Figure 4.5 Comparative Performance in Overall *Reading Literacy* in the Australian States

Gender differences in reading literacy within Australia

Gender differences within the states of Australia in *reading literacy* 2003 are presented in Table 4.2. The table also provides information on state means, the percentage of the sample in each state that was female, and the state gender differences in PISA 2000. The states are ordered according to the 2003 state means. Females significantly outperformed males in every state in 2003 and in every state except for the Australian Capital Territory in 2000. The percentage of females in each state ranged from 46 to 53 per cent. The small deviations from 50 per cent were attributable to sampling and did not represent real differences. Comparing the gender differences across 2000 and 2003 shows that the gender gap appears to be broadening. The differences were larger in 2003 than in 2000 in all the states except for Tasmania, which had the largest gap in 2000 (a difference of 50 score points). The two states with the largest gender differences in 2003 were Queensland (49) and Northern Territory (58) with Tasmania (45) close behind. The gender differences in these three states were approximately half a standard deviation. This increasing gap across gender reinforces the message from PISA 2000 of a pressing need for examining the education of our male students in *reading literacy*.

Reading literacy performance by proficiency levels

The *reading literacy* results can also be presented in terms of the proficiency levels described in Figure 4.2. The cut-off scores for the proficiency levels on the PISA *reading literacy* scale were set in 2000 to define five levels. Students with scores higher than 625 are said to perform at Level 5, those with scores in the range of 553 to 625 are at Level 4, those in the range of 481 to 552 are at Level 3, scores between 408 and 480 are at Level 2 and those with scores between 335 and 407 are performing at Level 1. Students scoring below 335 are considered to have not reached Level 1. The percentages of students at each of the five *reading literacy* proficiency levels for PISA 2003 are shown in Figure 4.6 for each of the participating countries. The countries are ordered according to their overall *reading literacy* mean scores. The percentages are shown using stacked bars. There is also a bar for the percentage of students who have not reached Level 1.

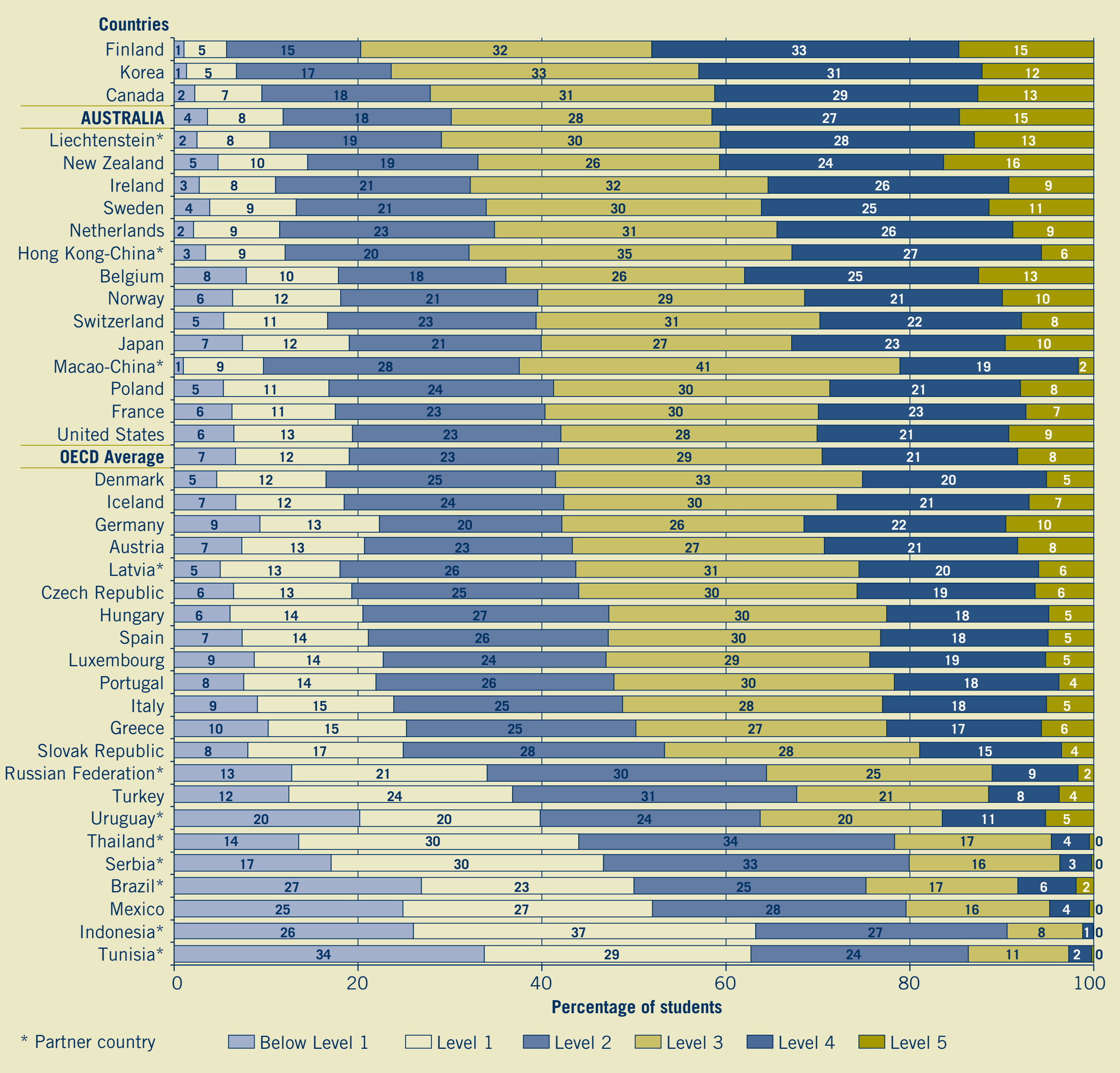


Figure 4.6 Proficiency Levels on the Overall *Reading Literacy* Scale by Country

For the top performing country Finland the numbers on the bar show that 15 per cent of its students performed at Level 5, 33 per cent at Level 4, 32 percent at Level 3, 15 per cent at Level 2, only five per cent at Level 1 and one per cent who had not reached Level 1. (Note that the percentages shown for each country may not add to 100 due to rounding.)

Countries which achieved a higher mean score tend to have higher percentages of students in Levels 4 and 5 than countries with a lower mean score, while the lower performing countries tend to have a higher percentage at students at Level 1 and below Level 1. The highest proportions of students achieving at Level 5 occurred in New Zealand (16 per cent), Finland (15 per cent) and Australia (15 per cent). Australia ranked third in terms of the percentage of students performing at least at Level 4 (42 per cent), behind Finland (48 per cent) and Korea (43 per cent). Australia had 15 per cent of students at Level 5, 27 per cent at Level 4, 28 per cent at Level 3, 18 per cent at Level 2, eight per cent at Level 1 while four per cent of students had not reached Level 1.

Approximately 70 per cent of students in Australia were performing at Level 3 or higher in 2003, comparing favourably to the OECD average of about 58 per cent. In the highest performing country, Finland, about 80 per cent of students achieved at least Level 3 proficiency. The corresponding percentages in 2000 were 69 per cent in Australia, 60 per cent for the OECD average and 79 per cent in Finland. Thus, these results were fairly steady across 2000 and 2003.

Adding percentages for below Level 1 and at Level 1, it can be seen that about 12 per cent of students in Australia were performing at Level 1 or below. The OECD average was about 19 per cent, while the best performing country, Finland, had about 6 per cent performing at Level 1 or below in 2003. The corresponding percentages in 2000 were about 12 per cent in Australia, 18 per cent for the OECD average and seven per cent in Finland. Again, the results were consistent across 2000 and 2003.

Gender differences within Australia by reading proficiency levels

The high overall performance in Australia was largely due to the very good performance on average of female students. Figure 4.7 shows that 19 per cent of the female students were performing at Level 5 while only 11 per cent of the male students were performing at that level. Seventy-nine per cent of the females were performing at Level 3 or higher while only 62 per cent of the male students were performing at these levels.

At the other end of the performance distribution, there were more males than females who were performing at Level 1 or below. Seven per cent of females compared with 17 per cent of males were at Level 1 or below. Nonetheless, the performance of male students in Australia was similar to the average performance across the OECD countries for all students. Female students in Australia performed as well as students in the highest-scoring country, Finland, where six per cent of students were not yet achieving Level 1, and 49 per cent of students were achieving at Level 4 or higher.

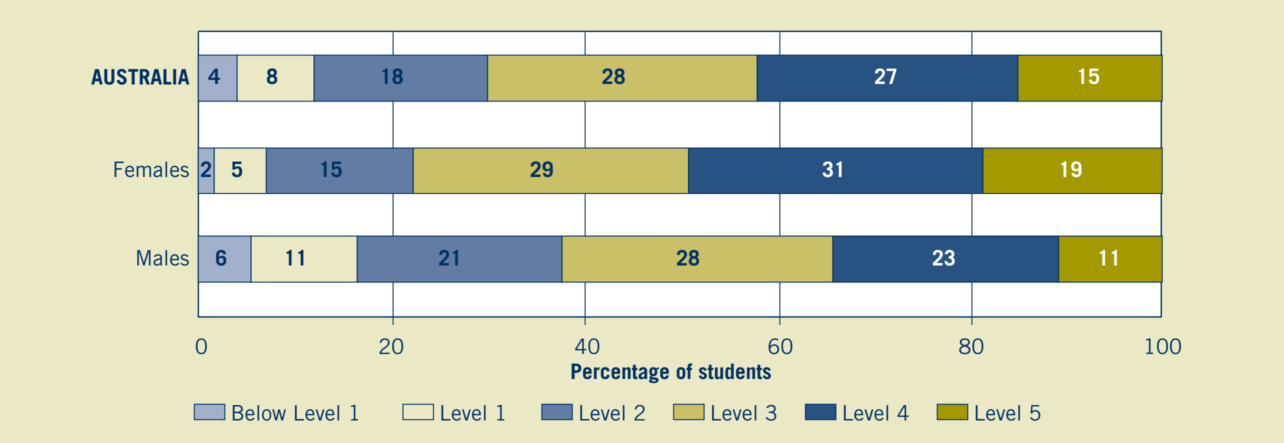


Figure 4.7 Proficiency Levels on the Overall *Reading Literacy* Scale in Australia by Gender

State differences in reading proficiency levels

Performance of the Australian states relating to the proficiency levels is displayed in Figure 4.8. The performance of the highest performing country, Finland, and the OECD average are also included in the figure for comparison. The distributions in the figure show that in the Australian Capital Territory and Western Australia, the percentages of students performing at proficiency Level 5 were higher than those achieved by Finland. In the Australian Capital Territory – 22 per cent, and in Western Australia 20 per cent of students achieved the highest of the PISA proficiency levels, compared to Finland's 15 per cent and the OECD average of eight per cent. The percentages of students performing at proficiency Level 5 were the same as Finland in New South Wales and South Australia, while each of the other four states performed as well as, or better than, the OECD average.

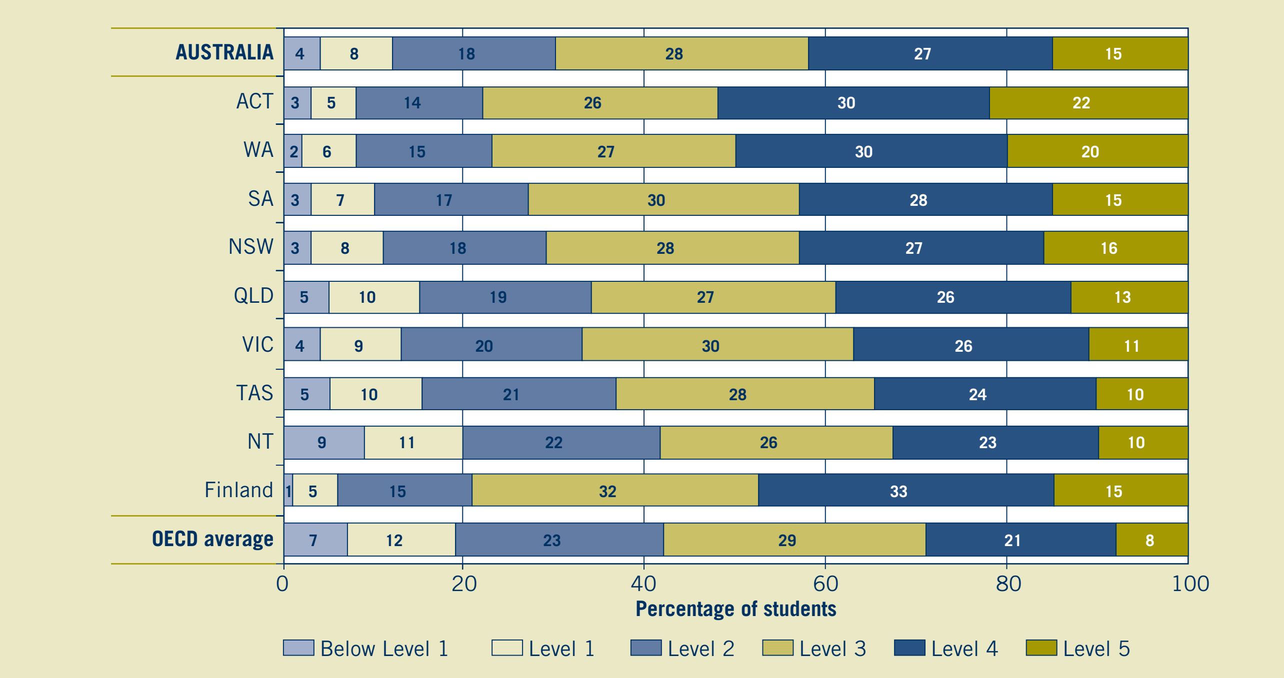


Figure 4.8 Proficiency Levels on the Overall *Reading Literacy* Scale by State

The percentages of students performing at Level 1 or below also vary across states, and in some cases may be a cause for concern. Thirteen per cent of Victorian students, 15 per cent of students in both Queensland and Tasmania and 20 per cent of students in the Northern Territory performed at Level 1 or below. The average across the OECD was 19 per cent, and so the performance of students in all states is still better than or equivalent to the OECD average.

Gender differences within states in reading proficiency levels

The gender difference within states in Australia illustrated in Table 4.1 are further reflected in Figure 4.9 in terms of the distribution of students across the reading proficiency levels. In the figure, the states are ordered according to the 2003 state means in overall *reading literacy*.

Figure 4.9 shows that the percentage of female students performing at the highest PISA proficiency level, Level 5, ranged from 13 per cent in Victoria and Tasmania through to 27 per cent in the Australian Capital Territory, while the percentage of male students performing at Level 5 ranged from four per cent in the Northern Territory through to 15 per cent in the Australian Capital Territory.

The percentage of females achieving Level 3 or higher ranged from 70 per cent in the Northern Territory to 82 per cent in South Australia and 84 per cent in the Australian Capital Territory and Western Australia, while the percentages of male students achieving this proficiency level ranged from 47 per cent in the Northern Territory to 71 per cent in the Australian Capital Territory. In this respect, state differences in the performance of *reading literacy* were greater for male students than for female students.

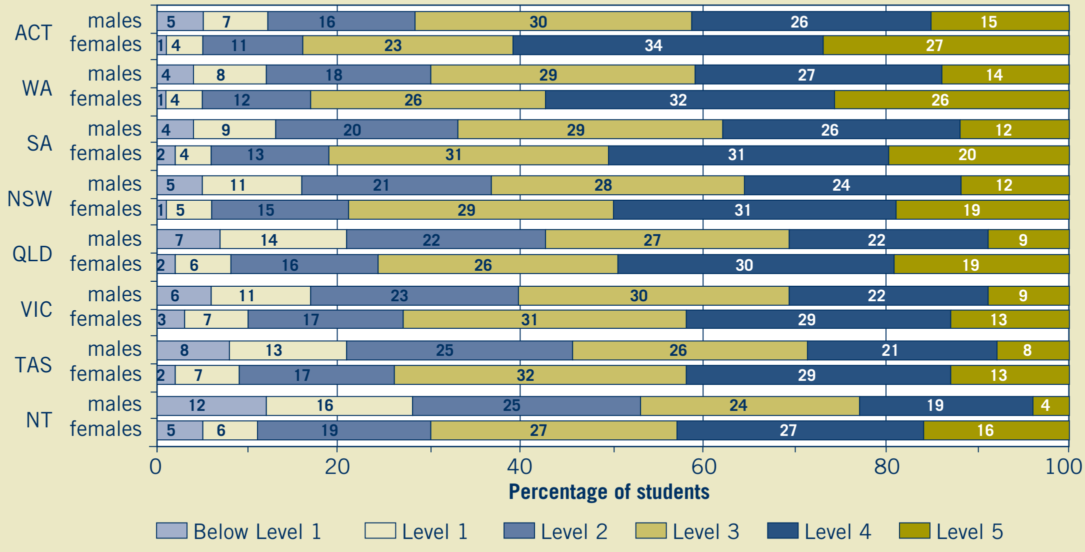


Figure 4.9 Proficiency Levels on the Overall *Reading Literacy* Scale by Gender within State

Furthermore, the percentages of female students performing at Level 1 or below ranged from five per cent in the Australian Capital Territory and Western Australia to 11 per cent in the Northern Territory. These percentages were on par with the top-scoring countries. For males, however, the percentages of students performing at Level 1 or below ranged from 12 per cent in the Australian Capital Territory and Western Australia to 28 per cent in the Northern Territory. In three of the Australian states (the Northern Territory, Tasmania and Queensland), more than one in five of the male 15-year-old students were performing at Level 1 or below in *reading literacy*, pointing to a serious problem that needs to be addressed as a matter of some urgency, given that these students are in their final year of compulsory secondary schooling.

>> Scientific literacy in PISA

According to the PISA assessment approach science has a particular role in helping young people to acquire skills in 'drawing appropriate and guarded conclusions from evidence and information given to them' (OECD, 2003). In addition, the desired outcomes of science education emphasise the general understanding of important concepts and explanatory frameworks of science, of the methods by which science gets its evidence and of the strengths and limitations of science.

Taking this into consideration, in PISA *scientific literacy* is defined as:

> *… the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.*
>
> (p. 133, OECD, 2003)

The assessment of *scientific literacy* remained a minor domain for 2003 as it was in 2000. It will be the major domain of testing in PISA 2006.

There are of three main aspects in the assessment of PISA *scientific literacy*: *scientific knowledge or concepts*, *scientific processes* which are used in relation to the subject matter of science and *situations or context* in which the knowledge and processes are assessed.

Scientific knowledge or concepts

As assessment time for science in PISA 2003 was limited, it was not possible to assess all areas of scientific knowledge, and so a sample of concepts was assessed. The selection of these concepts from the major scientific fields of physics, chemistry, biological science and Earth and space science was guided by a number of principles.

Firstly the knowledge assessed is useful and relevant in every-day life. Secondly, the knowledge should be likely to remain important and relevant to life throughout the next decade and beyond, and thirdly the knowledge can be combined with selected scientific processes in the assessment.

Scientific processes

In PISA there are three main scientific processes that students were required to demonstrate an understanding of:

- *describing, explaining and predicting scientific phenomena* – where students can demonstrate their understanding by applying appropriate scientific knowledge.
- *understanding scientific investigation* – where students recognise questions that can be investigated scientifically and knowing what is involved in such investigations. It can involve an understanding of the variables that may need to be included in an investigation or what additional information is necessary.

- *interpreting scientific evidence and conclusions*: where students are asked to make sense of scientific findings as evidence for claims or conclusions. This could involve giving reasons why a particular conclusion had been found or identifying assumptions made in reaching a conclusion.

Science situations or contexts

There are three contexts or situations in which these processes are assessed in PISA:

a) Science in life and health;
b) Science in Earth and the environment; and
c) Science in technology.

Sample science items and responses

Following PISA 2000, two science items were released. The released items are described in *Sample Tasks from the PISA 2000 Assessment: Reading, Mathematical and Scientific literacy* (OECD, 2002), and a description of Australian students' responses to these items was included in the first Australian PISA national report (Lokan, Greenwood, & Cresswell, 2001). The release of these items necessitated the creation of some replacement items for inclusion in the assessment. New items were trialled in 2002 and a number of those items were subsequently added to the 2003 assessment. Importantly, the items retained from PISA 2000 allowed links to be made between the two cycles of testing so that monitoring of trends could begin. Link items will be retained to be included in each cycle of PISA.

Two further *scientific literacy* items from the PISA 2003 assessment have been released to illustrate the operational meaning of the processes assessed. These are included as follows.

CLONING

Students were asked to read a newspaper article about the cloning process that produced the cloned sheep, Dolly. There were three questions in the unit.

A copying machine for living beings?

Without any doubt, if there had been elections for the animal of the year 1997, Dolly would have been the winner! Dolly is a Scottish sheep that you see in the photo. But Dolly is not just a simple sheep. She is a clone of another sheep. A clone means: a copy. Cloning means copying ‘from a single master copy’. Scientists succeeded in creating a sheep (Dolly) that is identical to a sheep that functioned as a ‘master copy’.

It was the Scottish scientist Ian Wilmut who designed the ‘copying machine’ for sheep. He took a very small piece from the udder of an adult sheep (sheep 1).

From that small piece he removed the nucleus, then he transferred the nucleus into the egg-cell of another (female) sheep (sheep 2). But first he removed from that egg-cell all the material that would have determined sheep 2 characteristics in a lamb produced from that egg-cell. Ian Wilmut implanted the manipulated egg-cell of sheep 2 into yet another (female) sheep (sheep 3). Sheep 3 became pregnant and had a lamb: Dolly.

Some scientists think that within a few years it will be possible to clone people as well. But many governments have already decided to forbid cloning of people by law.

Cloning Question 1

To gain credit for the first multiple choice question, students were required to evaluate the information given and to use relevant pieces of it.

Which sheep is Dolly identical to?

[✓ **A**] Sheep 1

B Sheep 2

C Sheep 3

D Dolly’s father

Cloning Question 2

In the second question, another multiple-choice item, students had to use their scientific knowledge to identify what was meant by 'a very small piece'.

In line 14 the part of the udder that was used is described as "a very small piece". From the article text you can work out what is meant by "a very small piece".

That "very small piece" is

[✓ **A** a cell.]

B a gene.

C a cell nucleus.

D a chromosome.

Cloning Question 3

The third question from the Cloning unit required students to understand the nature of questions that can be investigated with scientific methods, and is also an example of the complex multiple-choice format. Both parts of the question had to be answered correctly for the student to gain credit.

In the last sentence of the article it is stated that many governments have already decided to forbid cloning of people by law.

Two possible reasons for this decision are mentioned below.

Are these reasons scientific reasons?

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

Reason:	**Scientific?**
Cloned people could be more sensitive to certain diseases than normal people.	[✓ Yes] / No
People should not take over the role of a Creator.	Yes / [✓ No]

DAYLIGHT

This item raises the everyday experience of day and night and asks how 15 year olds could be expected to relate this to their scientific understanding of the movements of the earth and the sun. Information on the variation in the length of daylight between the Northern and Southern hemispheres was provide and students had to make use of their scientific knowledge and relate the earth's rotation on its axis to the variation of daylight and darkness.

DAYLIGHT ON 22 JUNE 2002

Today, as the Northern Hemisphere celebrates its longest day, Australians will experience their shortest.

In Melbourne*, Australia, the Sun will rise at 7:36 am and set at 5:08 pm, giving nine hours and 32 minutes of daylight.

Compare today to the year's longest day in the Southern Hemisphere, expected on 22 December, when the Sun will rise at 5:55 am and set at 8:42 pm, giving 14 hours and 47 minutes of daylight.

The President of the Astronomical Society, Mr Perry Vlahos, said the existence of changing seasons in the Northern and Southern Hemispheres was linked to the Earth's 23-degree tilt.

*Melbourne is a city in Australia at a latitude of about 38 degrees South of the equator.

Daylight Question 1

To gain credit for question 1, a multiple choice item with 4 scientifically correct alternatives, students needed to distinguish between the phenomena of the seasons, which results from the tilt of the earth's axis as it revolves around the sun.

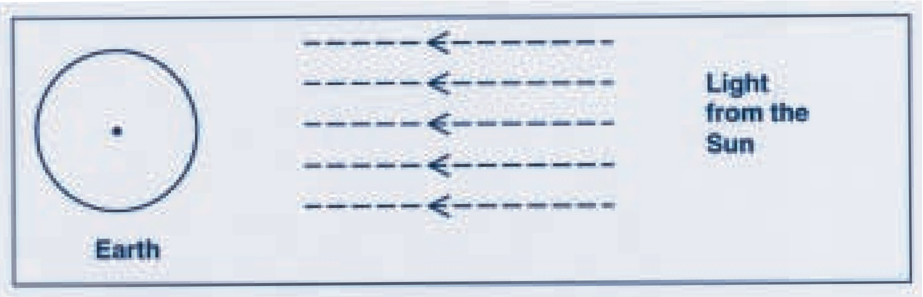
Which statement explains why daylight and darkness occur on Earth?

[✓ A] The Earth rotates on its axis.
B The Sun rotates on its axis.
C The Earth's axis is tilted.
D The Earth revolves around the Sun.

Daylight Question 2

The second daylight question is a short response item where students were required to create a conceptual model in the form of a diagrammatic representation of the relationship between the rotation of the tilted earth's hemispheres and their orientation to the sun, during the year revolving around the sun. Students also had to include the position of the equator at a 90 degree angle to the tilted axis to gain full credit.

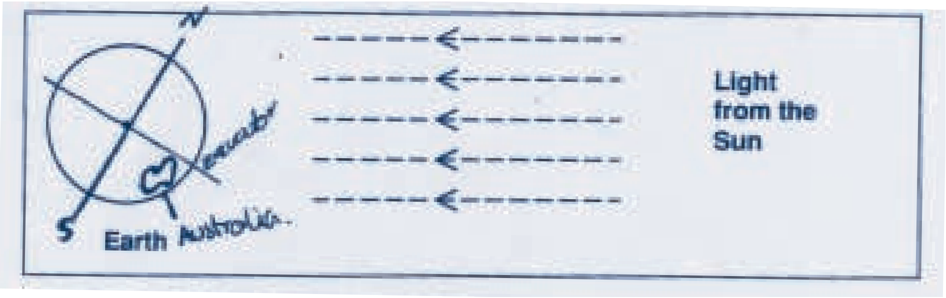
In the Figure light rays from the Sun are shown shining on the Earth.

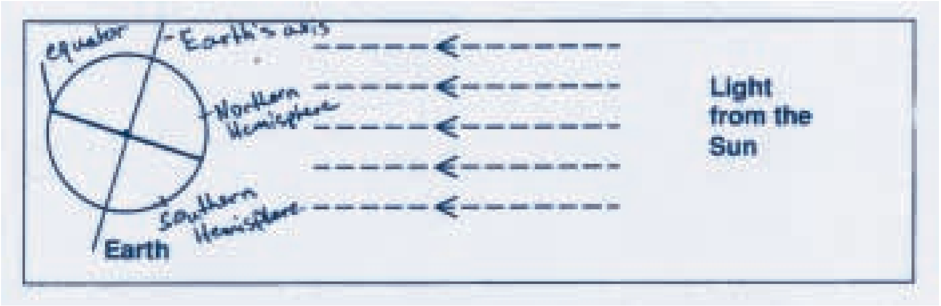


Suppose it is the shortest day in Melbourne.

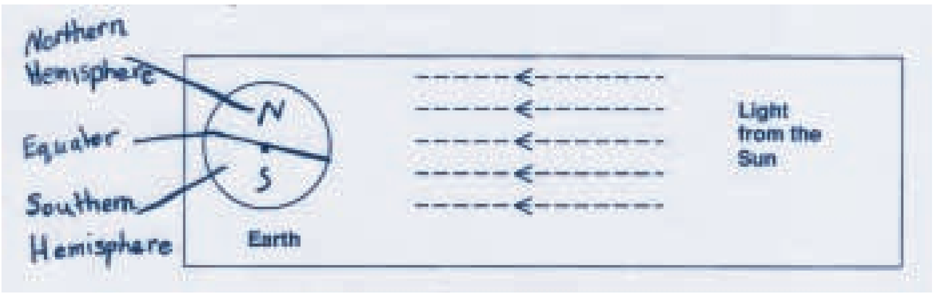
Show the Earth's axis, the Northern Hemisphere, the Southern Hemisphere and the Equator on the Figure. Label all parts of your answer.

The following samples illustrate a full credit response:





Partial credit was awarded for a correct diagram with respect to the orientation of the axis and the hemispheres whilst either omitting or incorrectly locating the equator.
In the following sample response, the student correctly placed the Equator between 10° and 45°, and labelled the Northern and Southern Hemispheres. However the student failed to show the Earth's axis and subsequently earned a partial credit.



The percentages correct for selected countries on the illustrated PISA science units are shown in Table 4.4 and illustrates students had more difficulty answering the Daylight question compared with the Cloning question .

Table 4.4 Selected Results (Percentages Correct) on Illustrated PISA Science Units

	International			Australia		
	OECD Average	Highest country	Lowest country	All	Females	Males
Cloning						
Question 1	65	75 (Finland)	26 (Indonesia)	67	68	66
Question 2	49	63 (Finland)	20 (Tunisia)	56	57	55
Question 3	62	75 (New Zealand)	21 (Indonesia)	73	79	66
Daylight						
Question 1	43	69 (Slovak Republic)	20 (Tunisia)	34	29	38
Question 2	19	38 (Japan)	3 (Indonesia)	25	22	29

Assessment structure

In keeping with the other PISA domains, questions in *scientific literacy* occur in units which have a main stimulus followed by a number of items. These items are a blend of multiple-choice and open response questions. In the great majority of the units, there are two types of items: those eliciting knowledge and understanding of the science involved, and those requiring use of one or more of the selected scientific processes. Table 4.5 shows the distribution of *scientific literacy* tasks by science process and item type for PISA 2003.

Table 4.5 Distribution of *Scientific Literacy* Tasks by Science Process and Item Type

	Number of items				
Process	Multiple-choice items	Complex multiple-choice items	Open-constructed response items	Short response items	Total
Describing, explaining and predicting scientific phenomena	7	3	6	1	17
Understanding scientific investigation	2	2	3	0	7
Interpreting scientific evidence and conclusion	4	2	5	0	11
Total	13	7	14	1	35

The PISA *scientific literacy* assessment requires the application of the processes in situations that go beyond the school laboratory or classroom. With respect to the balance in the contexts or situations, the three main groups, Science in life and health, Science in earth and the environment, and Science in technology are given equal weights.

>> Australia's results in overall scientific literacy

As in the other domains, the overall *scientific literacy* scale was constructed in PISA 2000 to have a mean of 500 points and a standard deviation of 100 points across the participating OECD countries. Using link items, the PISA 2003 *scientific literacy* performance was scaled onto the reporting scale established in 2000 so that direct comparisons of scores across cycles possible.

In 2003, the mean score for *scientific literacy* across the participating OECD countries was 500 with a standard deviation of 105, that is, the mean score in PISA 2003 remained 500 but with a wider spread. The Australian mean score in 2003 for *scientific literacy* was 525 score points with a standard deviation of 102 compared with a mean score in PISA 2000 of 528 score points with a standard deviation of 94. The 2003 *scientific literacy* mean score in Australia is not significantly different from the 2000 mean score but the spread is wider.

There were three countries that scored significantly higher than Australia: Finland (548), Japan (548), and Korea (538). Australia is in a group of nine countries which have results that are not significantly different from each other. The other countries in this group are Hong Kong-China, Liechtenstein, Macao-China, the Netherlands, the Czech Republic, New Zealand, Canada, and Switzerland. This is shown in Figure 4.11, where the countries are ordered according to their *scientific literacy* scores.

Scientific literacy was a minor domain both in PISA 2000 and 2003, and hence there has thus far been insufficient information to define proficiency levels in the same way as was done for *reading literacy* in 2000 and for *mathematical literacy* in 2003. Detailed proficiency levels will be established when *scientific literacy* is the major assessment domain in 2006.

Before the proficiency levels are established, however, it is possible to describe the criteria for harder and easier tasks in relation to items associated with different points on the *scientific literacy* scale. Three broad levels are described in Figure 4.10. The results in *scientific literacy* will not be examined in terms of percentages of students performing at these described levels. Rather, described levels are intended to provide an educational context to relate scores to what the students are expected to be able to do.

Highest described level (around 690 points)

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.

Middle described level (around 550 points)

Students are typically able to use scientific concepts 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.

Lowest described level (around 400 points)

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

Figure 4.10 Described Levels on the PISA *Scientific Literacy* Scale

A summary of the PISA 2003 performance by country is displayed in Figure 4.11. As with previous graphs of this type, each vertical bar gives the summary of performance of 90 per cent of students within a country, with coloured bands displaying the mean, the confidence limits around the mean, the 5th, 10th, 25th, 75th, 90th and 95th percentiles showing the spread of the scores.

Australia had a 5th percentile of 351 score points and a 95th percentile of 686 score points. This means that five per cent of students in Australia scored below 351 points and 5 per cent scored at least 686. The range of scores for the middle 90 per cent of the students in Australia is 335 points, slightly less than the average range of 344 points across the OECD countries. The range of scores for the middle 90 per cent of students was very similar among the top 10 countries except for Japan, which had a markedly wider range (358 score points) and Macao-China, which had a markedly narrower range (288 score points).

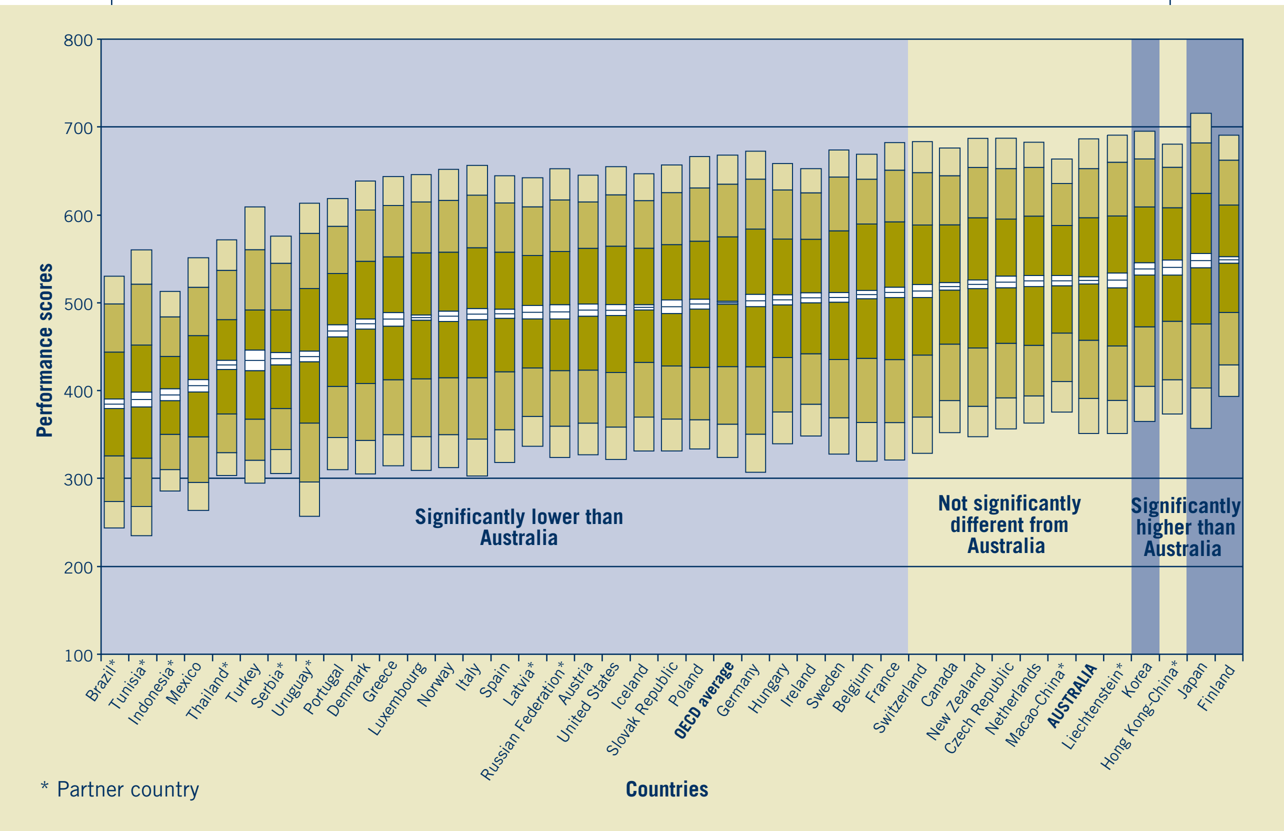


Figure 4.11 Student Performance in Overall *Scientific Literacy* by Country

Scientific literacy results by gender

As shown in Figure 4.12, there were gender differences in 2003 that were statistically significant in 16 countries. In 13 of these countries, males scored higher than females. Australia was among the 24 countries where the differences were not statistically significant, however the gender difference countries was statistically different in favour of males across the OECD. The three countries where females performed significantly better than males were Iceland, Tunisia and Finland. In Iceland, the female students performed on par with the OECD average but the male students performed below the OECD average. In Tunisia, both male and female students performed well below the OECD average whereas in Finland, both males and females performed well above the OECD average.

For countries where males scored significantly higher than females, the largest gender gap occurred in Liechtenstein where both males and females performed well above the OECD average. Interestingly, it was found in PISA 2000 that females outperformed males in New Zealand but the reverse occurred for PISA 2003. There was no evidence of a gender gap in *scientific literacy* for Australia in either PISA 2000 and 2003.

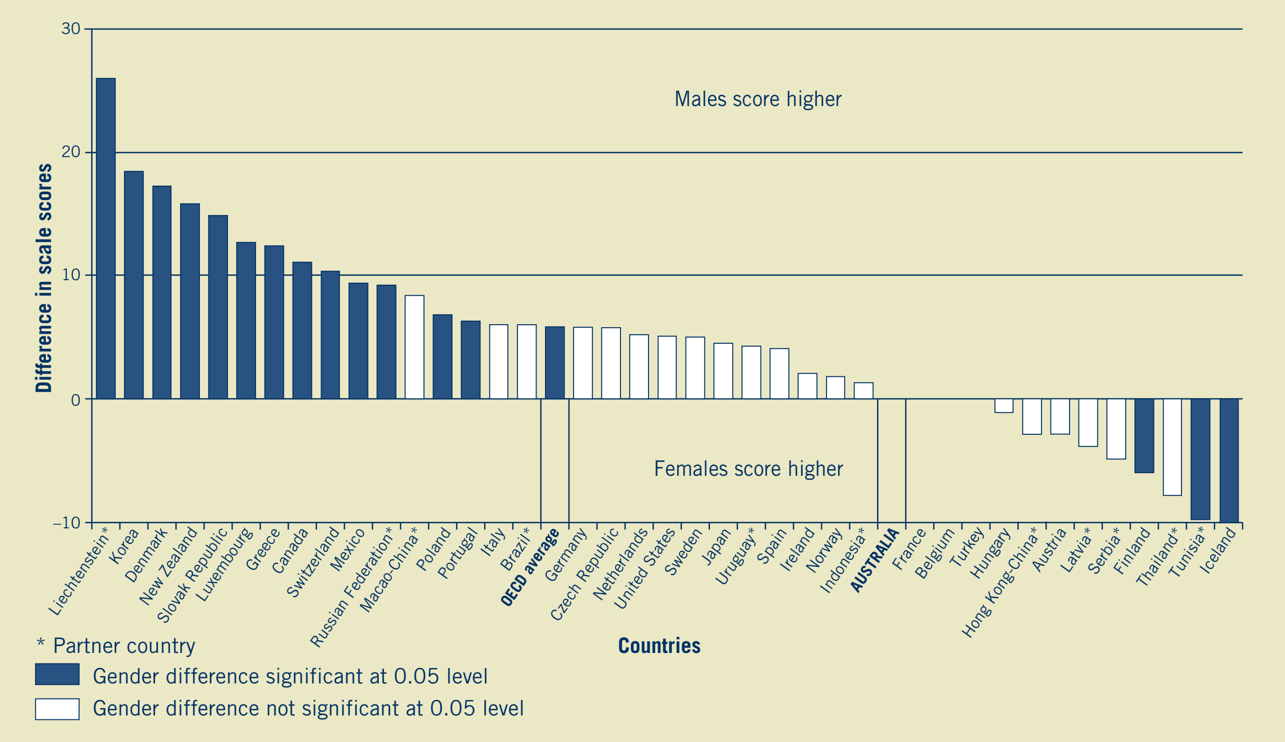


Figure 4.12 Student Performance Difference in Overall *Scientific Literacy* by Gender and Country

Scientific literacy results by state

A summary of 2003 state performance in overall *scientific literacy* is shown in Figure 4.13. Each vertical bar displays the mean, the confidence limits around the mean, the 5th, 10th, 25th, 75th, 90th and 95th percentiles. In the figure, the states are ordered by increasing state means from left to right. The summary results for Finland (the country with the highest mean score[1]) and for the OECD average are also included in the figure for comparisons.

Students in the highest achieving Australian states[2], the Australian Capital Territory (mean=553) and Western Australia (mean=546), performed on par with students in Finland (mean=548), but with a larger spread. The highest performing five per cent of students in the Australian Capital Territory and Western Australia achieved at least 707 and 703 points respectively in *scientific literacy*, compared with at least 691 points for Finland's highest performing five per cent. The lowest performing five per cent of students in the Australian Capital Territory and Western Australia achieved less than 360 and 376 points respectively, compared with lower than 393 points for Finland's lowest performing five per cent.

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[1] The mean for Finland is statistically the same as Japan and Korea.
[2] The means are shown in Table 4.6

Students in the lowest achieving Australian states, Northern Territory (mean=495) and Tasmania (mean= 509) performed on average as well as the OECD mean but also with a slightly larger spread. The highest performing five per cent of students in the Northern Territory and Tasmania achieved at least 660 and 674 points, respectively in *scientific literacy*, compared with at least 668 points on average across the OECD countries. The lowest performing five per cent of students in the Northern Territory and Tasmania achieved less than 293 and 319 points, respectively, compared with less than 324 points on average across the OECD countries.

Gender differences in *scientific literacy* were not statistically significant in any of the states within Australia. This is the same as in PISA 2000.

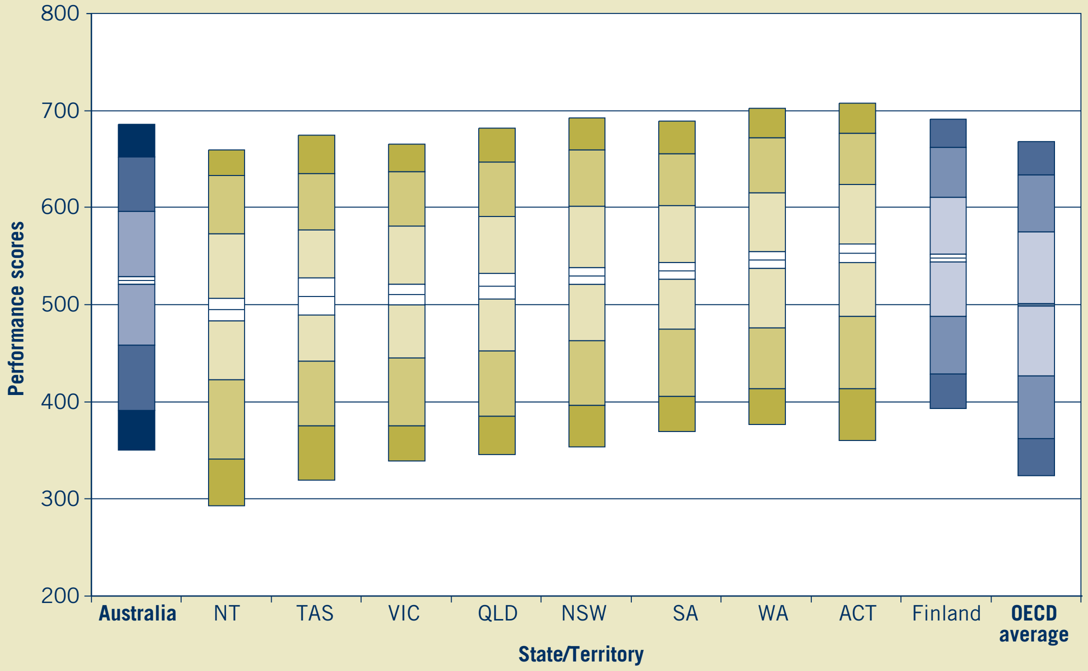

Figure 4.13 Overall *Scientific Literacy* Performance by State

Results of the multiple comparison tests of significance of the state differences in PISA 2003 *scientific literacy* mean scores are presented in Table 4.6. The results of the comparison show that the Australian Capital Territory and Western Australia achieved means that were statistically similar. While the Australian Capital Territory performed significantly better than the remaining states, Western Australia performed significantly better than Queensland, Victoria, Tasmania and the Northern Territory but not significantly better than South Australia or New South Wales. Victoria, Tasmania and Northern Territory also were statistically similar to each other in terms of their mean scores in *scientific literacy*.

Table 4.6 Multiple Comparisons of Overall *Scientific Literacy* Performance by State

			ACT	WA	SA	NSW	QLD	VIC	TAS	NT
		Mean	553	546	535	530	519	510	509	495
	Mean	SE	4.7	4.3	4.3	4.4	6.6	5.2	9.5	5.8
ACT	553	4.7		●	▲	▲	▲	▲	▲	▲
WA	546	4.3	●		●	●	▲	▲	▲	▲
SA	535	4.3	▼	●		●	●	▲	●	▲
NSW	530	4.4	▼	●	●		●	▲	●	▲
QLD	519	6.6	▼	▼	▼	●		●	●	▲
VIC	510	5.2	▼	▼	▼	▼	●		●	●
TAS	509	9.5	▼	▼	●	●	●	●		●
NT	495	5.8	▼	▼	▼	▼	▼	●	●	

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

>> *Reading and scientific literacy of Indigenous and non-Indigenous students*

The PISA 2003 results for *reading literacy* and *scientific literacy* for the 815 Indigenous students in the Australian PISA sample, together with the results for the non-Indigenous students are shown in Table 4.7.

Table 4.7 Means and Standard Errors for *Reading* and *Scientific Literacy* for Indigenous and Non-Indigenous Students

	Reading literacy		Scientific literacy	
Student group	Mean	Standard error	Mean	Standard error
Indigenous	444	8.6	434	7.7
Non-Indigenous	527	2.0	527	2.0
All Australian Students	525	2.1	525	2.8
All Australian Students	525	2.1	525	2.8

There were large differences between the mean performance of the Indigenous and non-Indigenous students both in PISA 2003 in both *reading literacy* and *scientific literacy*. These differences are, as was found for *mathematical literacy* in the previous chapter, significant both statistically and educationally. The mean for Indigenous students in *reading literacy* is more than half a standard deviation lower than the OECD mean, while the mean for *scientific literacy* is almost 0.7 of a standard deviation below the OECD mean.

Figure 4.14 shows the percentages of Indigenous and non-Indigenous students, and for comparison the OECD average, at each proficiency level on the overall *reading literacy* scale. Even though the mean score for Indigenous students (444) is very much lower that that of the non-Indigenous students, there were four per cent of Indigenous students who performed at the highest level of proficiency (requiring at least 625 score points) on the overall reading proficiency scale and an additional 11 per cent who performed at Level 4 (553 to 625 score points).

These results were very similar to the results in PISA 2000. An in-depth analysis of the Indigenous students' performance in PISA 2000 can be found in a separate monograph (De Bortoli & Cresswell, 2004). The report examines performance of Indigenous students in comparison with other Australian students relating to characteristics such as home background, home resources, socioeconomic status, learning environment and learning strategies.

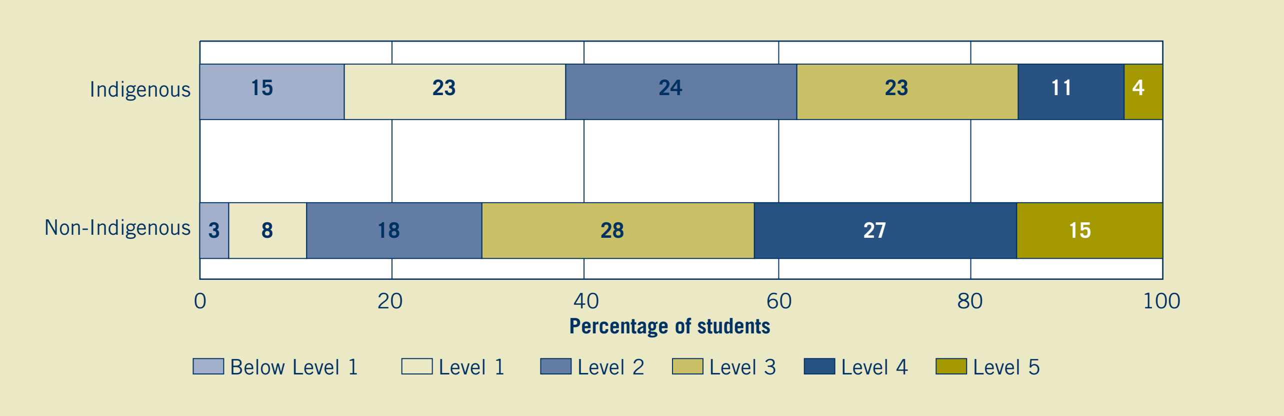

Figure 4.14 Proficiency Levels on the *Reading Literacy* Scale for Indigenous and Non-Indigenous Students

While it is heartening to see 15 per cent of Indigenous students achieving at the two highest proficiency levels, the reality remains that Indigenous students are, as with *mathematical literacy*, vastly over-represented at the lower achievement levels and under-represented at the higher achievement levels. Take, for example, the proportions of students not yet achieving proficiency Level 1, whom the OECD describes as likely to be seriously disadvantaged in their lives beyond school. On average across the OECD, fourteen per cent of students are not able to achieve proficiency Level 1. Within Australia, only three per cent of non-Indigenous students are unable to achieve this proficiency level, however for Indigenous students fifteen per cent are not able to achieve the same level.

>> *Reading and scientific literacy of immigrant students and those whose language background is not English*

This section examines overall *reading literacy* and *scientific literacy* for three categories of Australian students based on their immigrant status and for students whose language background is English compared with those for whom it is not. The results on *reading literacy* and *scientific literacy* are shown in Table 4.8 for the three subgroups described in Chapter 1:

- Australian-born students;
- students who were first-generation Australians; and
- foreign-born students.

Multiple comparisons of the differences show that none of the differences are statistically significant, for either *reading literacy* or *scientific literacy*.

Table 4.8 Means and Standard Errors for *Reading* and *Scientific Literacy* by Immigrant Status

Student group	Reading literacy Mean	Reading literacy Standard error	Scientific literacy Mean	Scientific literacy Standard error
Australian-born students	529	2.2	529	2.1
First-generation students	525	4.6	520	4.7
Foreign-born students	517	5.0	515	5.5
All Australian Students	525	2.1	525	2.8

Figure 4.15 shows the percentage of students at each proficiency level on the *reading literacy* scale by immigrant status. The percentages at each level of reading proficiency were very similar across the three groups. In summary, there is no evidence that immigrant status made a difference to either *reading* or *scientific literacy* performance.

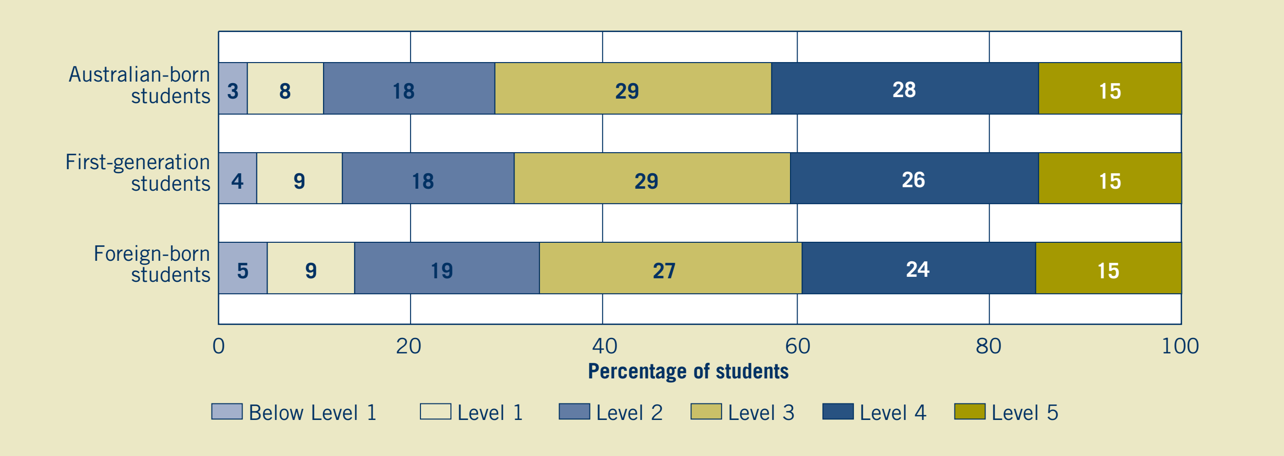

Figure 4.15 Proficiency Levels on the *Reading Literacy* Scale by Immigrant Status

In PISA 2003, students in Australia were asked about what language they spoke at home most of the time. Based on their answers, the students were classified into two groups: those whose main language at home was English and those whose main language at home was a language other than English. The results on *reading literacy* and *scientific literacy* for these two groups are shown on Table 4.9. The differences in the mean scores are statistically significant for both *reading literacy* and *scientific literacy*, with students whose home language is English achieving higher scores then those whose home language is not English.

Figure 4.16 shows the distribution of students across the proficiency levels on the *reading literacy* scale for students by the main language spoken at home (English/other than English). There were some differences apparent across the levels of reading proficiency by language group. For students whose main language spoken at home was English, 43 per cent performed at Level 4 or higher compared to 35 per cent of students who spoke a language other than English at home. Eleven per cent of students whose language background was English performed at Level 1 or below, compared to 16 per cent of those whose home language was not English.

Reporting by science proficiency levels is not possible for the reasons outlined in a previous section.

Table 4.9 Means and Standard Errors for *Reading* and *Scientific literacy* for Students by Main Language Spoken at Home

Student group	Reading literacy Mean	Reading literacy Standard error	Scientific literacy Mean	Scientific literacy Standard error
Home language English	529	2.1	529	2.0
Home language not English	509	5.1	505	6.1
Total	525	2.1	525	2.8

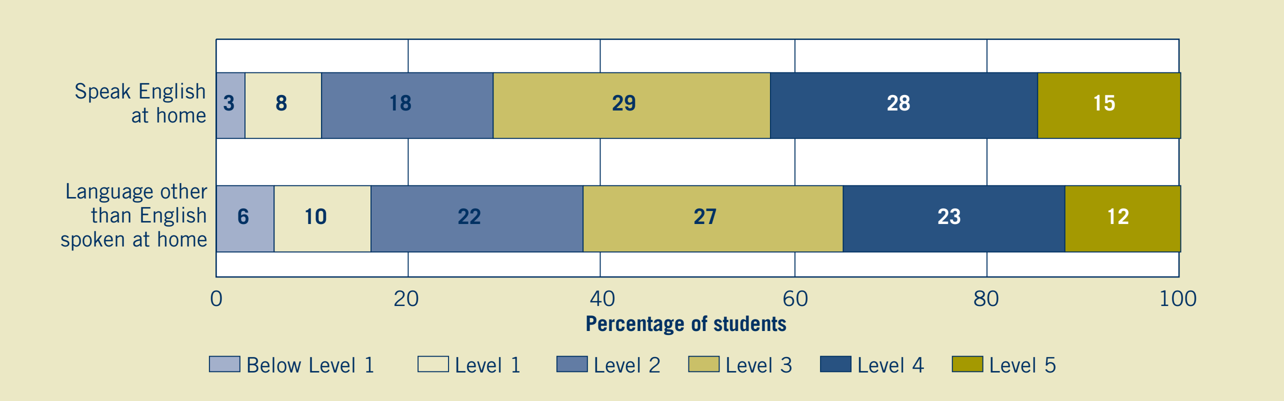

Figure 4.16 Proficiency Levels on the *Reading Literacy* Scale by Main Language Spoken at Home

>> *Reading and scientific literacy of students in different locations of schools*

The results for *reading literacy* and *scientific literacy*, using the broad categories of location from the MCEETYA Schools Geographic Location Classification[3], are shown in Table 4.10. The differences in the mean scores are statistically significant for both *reading literacy* and *scientific literacy*. Students who attended schools in metropolitan areas performed at a higher level than students from schools in provincial or remote areas, and students who attended schools in a provincial area performed at a higher level than students whose schools were located in a remote area.

Table 4.10 Means and Standard Errors for *Reading* and *Scientific Literacy* by Geographic Location of School[4]

Geographic Location	Reading Literacy Mean	Reading Literacy SE	Scientific literacy Mean	Scientific literacy SE
Metropolitan	530	2.6	529	2.6
Provincial	514	4.6	516	4.2
Remote	489	7.5	489	6.8

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[3] See chapter 1

The report which explored the differences in performance in PISA 2000 by school geographic locations (Cresswell & Underwood, 2004) found that in the opinion of principals, school factors such as the availability of resources have an impact on student performance, and that availability of resources declined depending on the distance from a major city.

Summary

This chapter examined Australia's results in *reading* and *scientific literacy*. Following a description of the assessment framework, Australia's results were discussed in relation to other countries' results, firstly in terms of means and distributions of performance and secondly in terms of proficiency levels.

Australia was again among the top scoring countries in *reading literacy*, with only one country, Finland, scoring significantly higher than Australia. Australia's performance in PISA 2003 was not significantly different from its performance in PISA 2000. Fifteen per cent of Australian students achieved Reading Proficiency Level 5; 27 per cent were at Level 4; 28 per cent at Level 3; 18 per cent at Level 2; and eight per cent at Level 1 while four per cent of students did not reach Level 1. For the OECD average, the comparable figures were: Level 5 – eight per cent, Level 4 – 21 per cent, Level 3 – 29 per cent, Level 2 – 23 per cent, Level 1 – 12 per cent, and seven per cent of students did not reach Level 1.

Significant gender differences in *reading literacy* in favour of females were found in all except one country (Liechtenstein). A difference of 39 score points was found between the results of Australian females and males, which was slightly larger than the OECD average of 34 score points. The gender differences in Australia were similar between PISA 2000 and PISA 2003.

Differences in *reading literacy* performance were found between the states, with students in the Australian Capital Territory and Western Australia performing on average significantly better than students in Queensland, Victoria, Tasmania and Northern Territory while students in South Australia performed on average significantly better than students in the three last-named states.

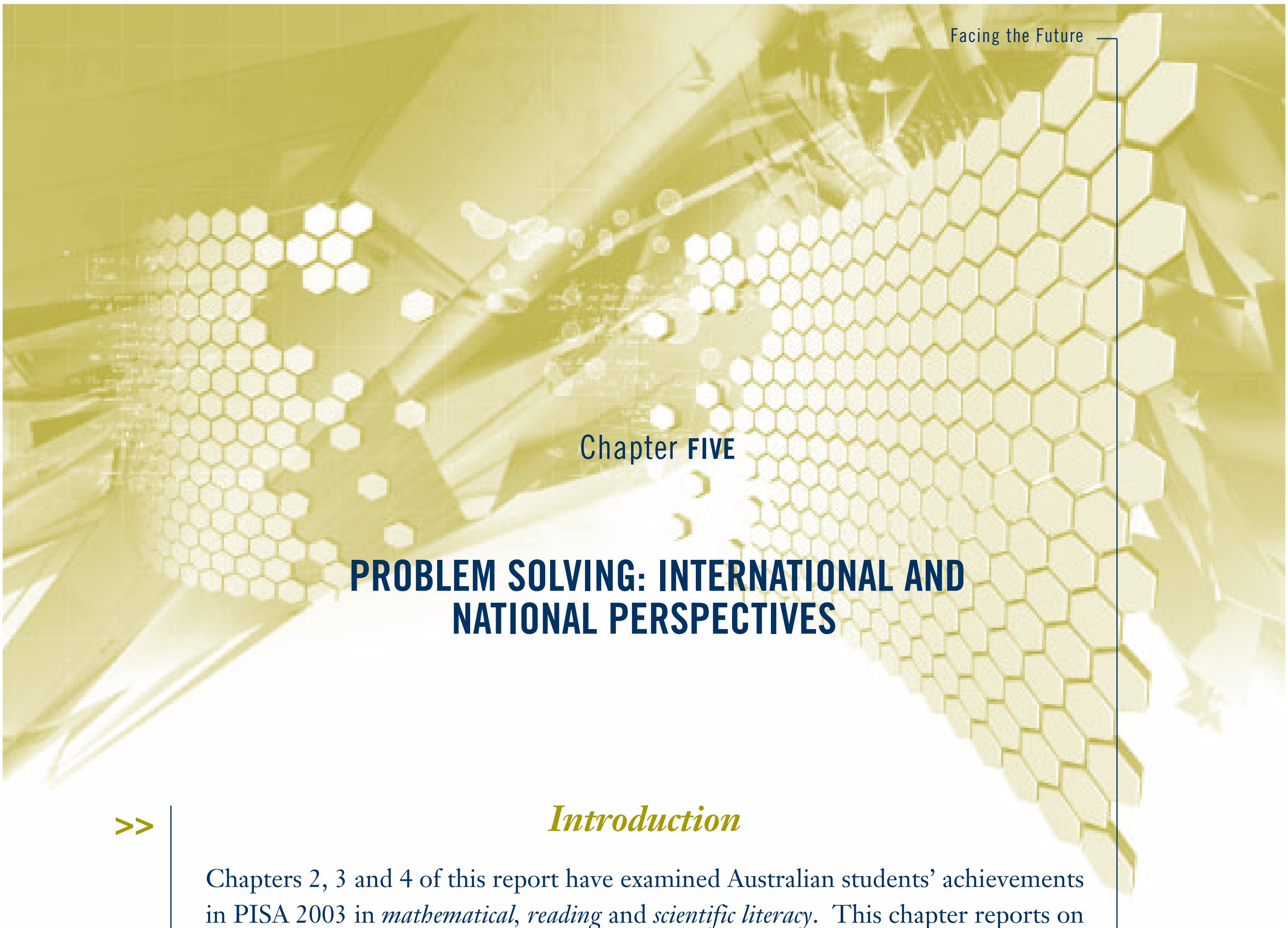
Australian students also performed at a high level in *scientific literacy*, with only three countries, Finland, Japan and Korea, scoring significantly higher than Australia. Australia's mean score in PISA 2003 was not significantly different from its mean score in PISA 2000.

Significant gender differences in *scientific literacy* were found in 16 countries, with males performing at a higher level than females in all except three countries. There was no gender difference in *scientific literacy* in Australia.

Comparisons between states showed that the Australian Capital Territory and Western Australia performed at the highest level with the Australian Capital Territory performing at a higher level than six other states and Western Australia's performance being higher than for four other states. All states performed at least as well as students on average across all OECD countries.

This chapter includes results achieved by Indigenous status, by immigrant status, by language background and by geographic location. Large differences were found in *reading literacy* and *scientific literacy* performance between Indigenous and non-Indigenous students. Although no differences in *reading literacy* or *scientific literacy* performance were found students who spoke English as their main language in the home performed at a higher level in *reading literacy* and *scientific literacy* than those students who spoke a language other than English.

In the next chapter, the PISA approach to problem solving is defined and described with particular reference to the Australian students.



Chapter FIVE

PROBLEM SOLVING: INTERNATIONAL AND NATIONAL PERSPECTIVES

>> *Introduction*

Chapters 2, 3 and 4 of this report have examined Australian students' achievements in PISA 2003 in *mathematical*, *reading* and *scientific literacy*. This chapter reports on a new aspect of assessment within the PISA framework – problem solving. The collection of information regarding students' problem-solving skills as part of PISA 2003 resulted from concern in OECD countries that students' capabilities in reading, mathematics and science might not always be matched by their overall capacity to solve problems in real-life situations beyond the specific context of these curriculum domains. In many countries, various curricula ask students to confront problem situations by understanding the information given, identifying critical features and any relationships in a situation, constructing or applying one or more external representations, resolving any ensuing questions and finally, evaluating, justifying and communicating any results as a means of further understanding the situation. To address these issues, a problem-solving component was added to the PISA 2003 assessment.

This chapter focuses on the results obtained by Australian students on the problem-solving component of the assessment within the context of an international study, and also examines the relationship between performance in problem solving and performance in the other three assessment domains.

>> *Problem solving in PISA 2003*

The PISA framework (OECD, 2003) defines problem solving literacy as:

> *… an individual's ability to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricular areas that might be applicable are not within a single domain of mathematics, science or reading (p. 156)*

The problem-solving component within the PISA 2003 assessment examines how well prepared young adults are to solve the problems that they will encounter in life beyond school, in order to fulfil their goals in work, as citizens and in further learning. For some of life's challenges, students will need to draw on knowledge and skills learned in particular parts of the school curriculum: for example, to recognise and deal with a mathematical problem. Other problems will be less obviously linked to school knowledge, and will often require students to think about how to resolve unfamiliar situations, by thinking flexibly and pragmatically. PISA is concerned with problem solving of the second, more general variety. This chapter presents a profile of 15-year-olds' competency as general problem solvers in Australia.

The assessment of problem-solving skills can be thought of within the general context of the PISA concern with knowledge and skills for life. PISA seeks to measure how well young adults, at 15 years of age and approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies, and focuses on young people's ability to use their knowledge and skills to meet real-life challenges, rather than on the extent to which they have mastered a specific school curriculum.

>> *The problem-solving framework*

There are four main components to the assessment of problem solving as defined in the Framework:

- **Problem types**. Although problem solving covers a wide spectrum of problem types, PISA 2003 focussed on three problem types: *decision making*, *system analysis and design*, and *trouble shooting*. These were chosen as they are widely applicable and occur in a variety of settings.
- **Problem context**. The problems used in the assessment were not set in the classroom or based on materials studied in the curriculum, but set in contexts that a student would find in his/her personal life, work and leisure, in the community and society.
- **Problem solving process**. The assessment was designed so that the results would describe the degree to which students are able to confront, structure, represent and solve problems effectively. In particular, students had to demonstrate that they could:
    - —*Understand the problem*: This includes understanding text, diagrams, formulas or tabular information and drawing inferences from them; relating information from various sources; demonstrating understanding of relevant concepts; and using information from students' background knowledge to understand the information given.
    - —*Characterise the problem*: This includes identifying the variables in the problem and noting their interrelationships; making decisions about which variables are relevant and irrelevant; constructing hypotheses; and retrieving, organising, considering and critically evaluating contextual information.
    - —*Represent the problem*: This includes constructing tabular, graphical, symbolic or verbal representations or applying a given external representation to the solution of the problem; and shifting between representational forms.

  - —*Solve the problem*: This includes making decisions (in the case of *decision making*); analysing a system or designing a system to meet certain goals (in the case of *system analysis and design*); or diagnosing and proposing a solution (in the case of *trouble shooting*).
  - —*Reflect on the solution*: This includes examining solutions and looking for additional information or clarification; evaluating solutions from different perspectives in an attempt to restructure the solutions and make them more socially or technically acceptable; and justifying solutions.
  - —*Communicate the problem solution*: This includes selecting appropriate media and representations to express and to communicate solutions to an outside audience.
- **Reasoning skills**. Beyond drawing on students' knowledge bases, good problem solvers also draw upon their reasoning skills. In understanding a problem situation, the problem solver may need to distinguish between facts and opinion. In formulating a solution, the problem solver may need to identify relationships between variables. In selecting a strategy, the problem solver may need to consider cause and effect. In solving a problem and communicating the results, the problem solver may need to organise information in a logical manner. These activities often require analytic reasoning, quantitative reasoning, analogical reasoning and combinatorial reasoning.

Thus, a student needs to combine a number of different cognitive processes to solve a problem. The PISA problem-solving assessment strives to identify the processes students use as well as to describe and quantify, where possible, the quality of the students' problem-solving work.

>> *The PISA problem-solving scale*

The PISA problem-solving scale results from an analysis of some theoretical constructs underlying problem solving and supported by an analysis of student work on solving these problems (OECD, 2003). The scale extends from the students with the weakest problem-solving skills to those with the strongest problem-solving skills, and has three distinct, described proficiency levels. As with the other PISA domains, these levels provide an analytical model for describing what individual students are capable of, as well as comparing and contrasting student proficiency across countries.

The proficiency levels can be described briefly as:

- **Level 3:** *Reflective, communicative problem solvers.* Students proficient at Level 3 analyse a situation and make decisions, and they also think about underlying relationships in a problem and relate these to a solution. Level 3 students have a systematic approach to problems, construct a variety of representations to aid in finding a solution to the problem and are effective communicators.
- **Level 2:** *Reasoning, decision-making problem solvers.* Students proficient at Level 2 use reasoning and analytic processes and solve problems requiring decision-making skills. They apply various types of reasoning to analyse situations and solve problems that require them to make a decision from well-defined alternatives.

- **Level 1:** *Basic problem solvers.* Students proficient at Level 1 solve problems where they have to deal with a single data source containing discrete, well-defined information. Level 1 students are generally not capable of dealing with multi-faceted problems involving more than one data source or requiring the student to reason with the information provided.

Students below Level 1 (405 score points) are only able to work in highly structured and straightforward settings, where they could deal with information available from direct observation or from very simple inferences. Below Level 1, students are characterised as *weak or emergent problem solvers.*

>> *Problem solving performance in PISA*

As has been discussed, problem-solving performance can be represented by overall scores or by proficiency levels. The mean across OECD countries was scaled to be 500 with a standard deviation of 100. Australia's average score (530) is significantly higher than the OECD mean, and statistically similar to that of New Zealand, Macao-China, Liechtenstein, Canada, Belgium, Switzerland, the Netherlands and France (Figure 5.1). Australia's score was significantly lower than that of the highest scoring four countries: Korea (550), Hong Kong-China (548), Finland (548) and Japan (547).

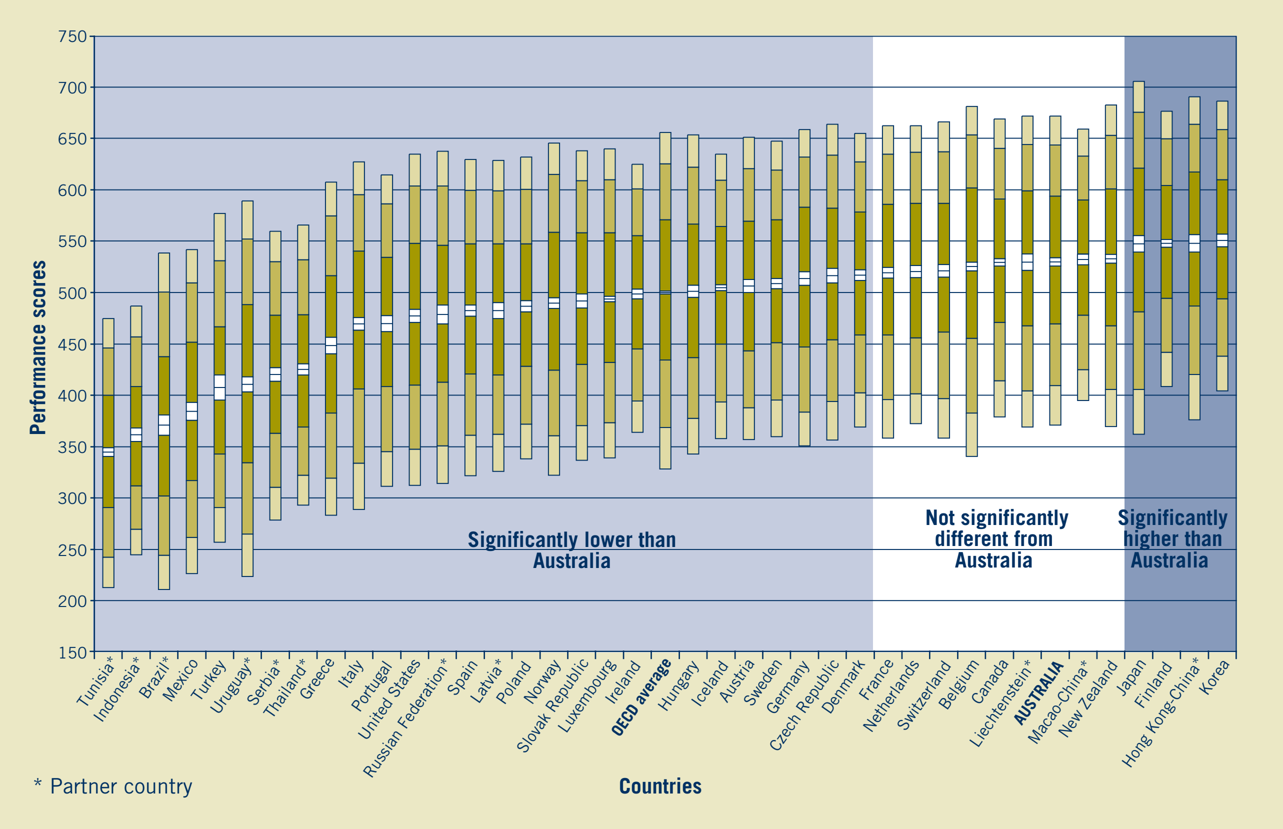


Figure 5.1 Performance in Problem Solving for All Countries

Figure 5.2 shows the proficiency levels for problem solving, ranked by ascending mean score on the problem solving scale. In five countries – Tunisia, Indonesia, Brazil, Mexico and Turkey, more than half of the students did not reach Level 1,

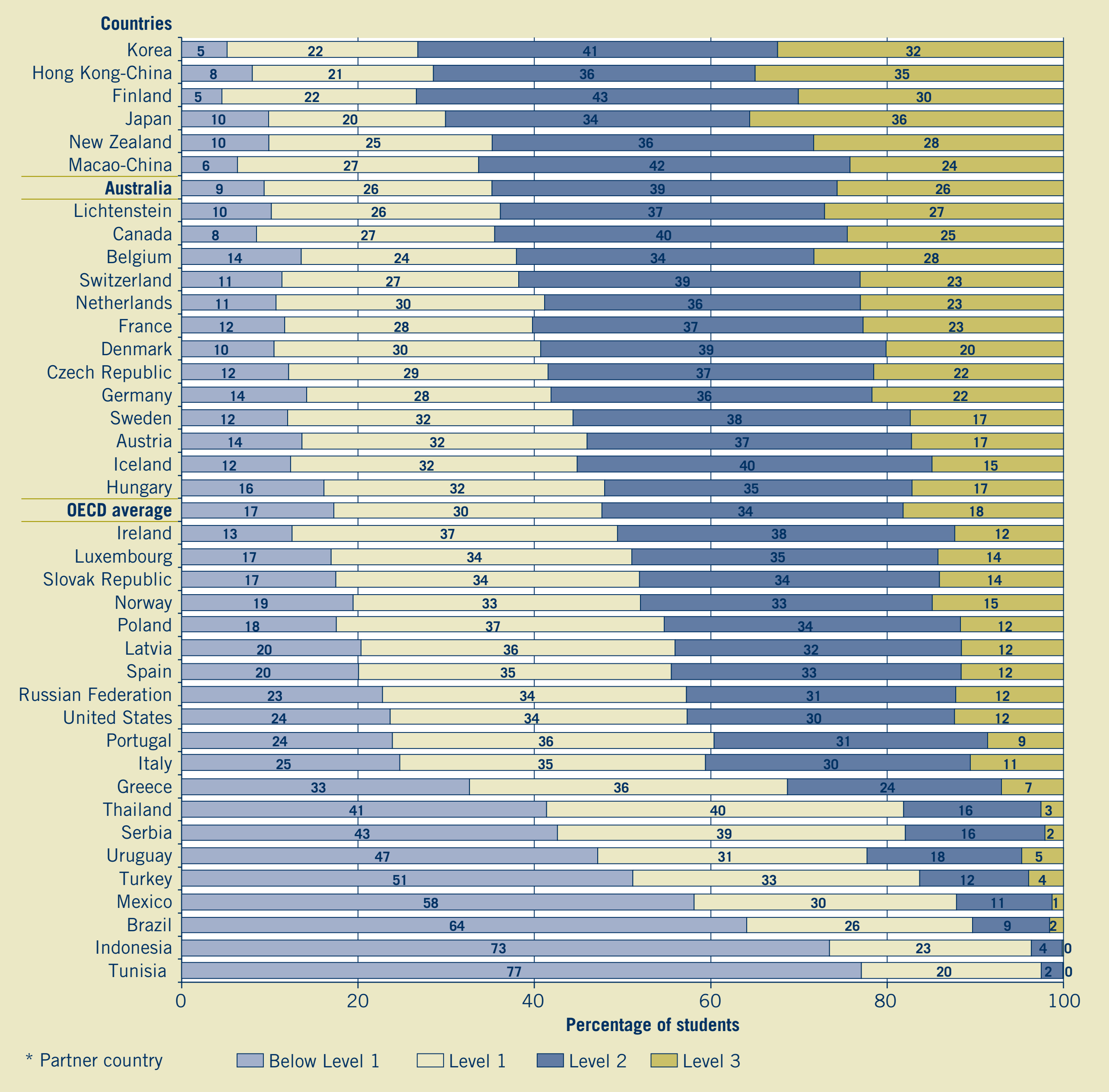


Figure 5.2 Proficiency Levels on the Problem-Solving Scale

while in the four highest performing countries, Korea, Hong Kong-China, Finland and Japan, between five and 10 per cent of students perform below Level 1. Australia has nine per cent of students below Level 1.

On average 30 per cent of students across the OECD are basic problem solvers. For the highest performing countries, this was as low as 20 per cent, and for Australia it was 26 per cent.

The distinction between students performing at Level 1 and those performing at Level 2 is an important demarcation in terms of problem solving capability. Students at Level 1 are in general limited to handling relatively straightforward problems, to make simple use of data or straightforward transformations of data (i.e. from a table or a graph into a numerical form). *Basic problem solvers* are generally not capable of drawing data from multiple sources, comparing and contrasting these data and integrating the data into the development of a solution to a multifaceted problem.

However these are the very skills that are targeted as necessary skills in emergent workforce demands. New employee qualifications are focussing on the ability to deal with complexity, on communication skills, and on increased problem solving capabilities (OECDb, 2004).

As 15-year-olds develop the problem solving-skills that are associated with Levels 2 and 3 of the PISA problem-solving scale, they have increased opportunities for employment and the ability to compete economically in a rapidly changing, technological society. These skills are marked by the problem solving actions and outcomes described in Levels 2 and 3 of the problem-solving framework.

Level 2 (499 – 592 score points) is associated with critical thinking skills. Students labelled as Level 2 problem solvers exhibit the capability to apply analytical reasoning skills to solve problems involving decision making that requires combinations of multiple alternatives. In doing so, these reasoning, decision-making problem solvers are able to handle a variety of representations of related information and use these to select the best of several alternatives in a variety of situations. On average amongst OECD countries, 34 per cent of students are *reasoning, decision-making problem solvers*, and in Australia, 39 per cent of students fall into this category.

Level 3 (more than 592 score points) is the highest identified level of problem solving. It includes student work that not only reflects the ability to confront and derive a solution to a problem, but also the capacity to reflect on and use their own representations of problems from pieces of information and then in systematic ways solve the problem and communicate the solution to others. *Reflective, communicative problem solvers* are capable of handling a greater number of variables, of handling time and sequential relationships, and a variety of other problem-specific constraints. While none of the participating countries have Level 3 as their mean, nine countries have 25 per cent or more of their students performing at this level: Australia, Belgium, Canada, Finland, Hong Kong-China, Japan, Korea, Liechenstein and

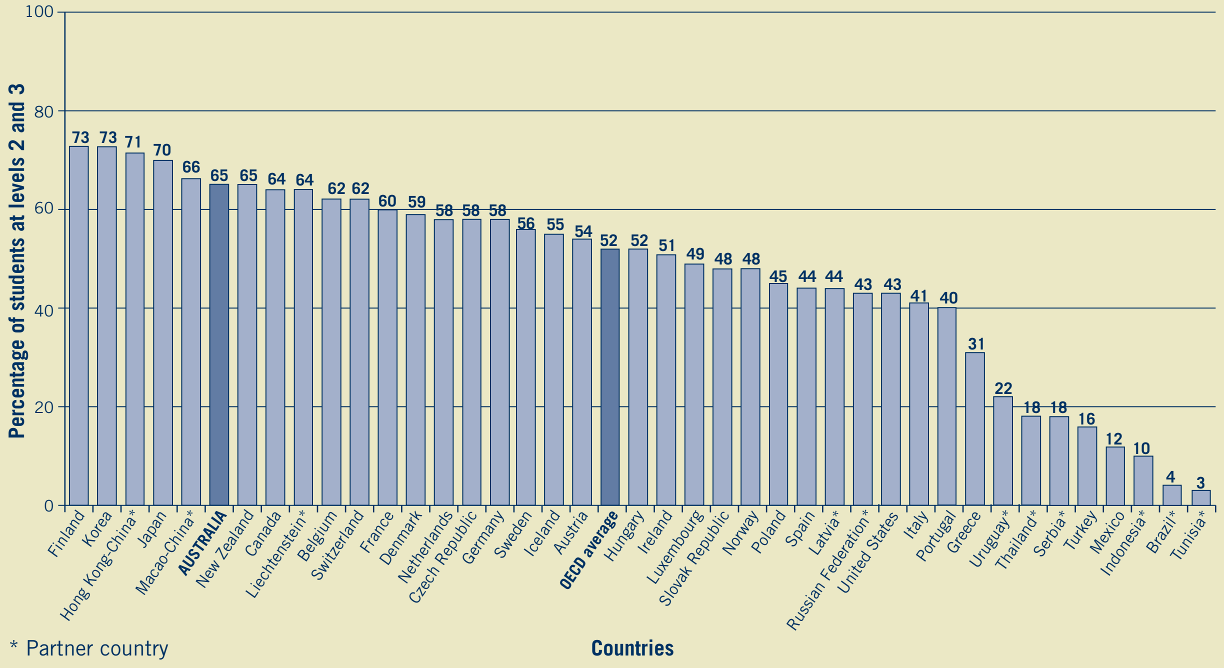


Figure 5.3 Percentage of Students Prepared for Productive 21st Century Employment

New Zealand. On average across the OECD 18 per cent of students are *reflective, communicative problem solvers*.

Differences among countries

If the percentage of students achieving a problem-solving performance at either Level 2 or Level 3 is taken as an indicator of how well prepared 15-year-olds are for productive participation in an emerging workforce, then the majority of students are adequately prepared in only 22 of the 40 countries. Figure 5.3 shows the percentage of students in this category for the PISA countries. In OECD countries, on average, only 52 per cent of students may be well prepared for future workforce requirements. In Australia, almost two-thirds of PISA students were achieving at Level 2 or Level 3.

Relations between problem solving and other domains

Problem solving differs from mathematics, reading and science in that it is not a subject domain in the curricula of most countries. In order to focus the assessment on problem-solving processes rather than knowledge content, the amount and difficulty of reading, mathematics and science was limited. While reading comprehension is, of course, a pre-requisite of problem-solving, written texts were kept to a minimum in the problem-solving units. Similarly, where mathematical manipulations are required, the tasks are limited to simple addition, and it was decided that no problem-solving item should require scientific content knowledge.

So what are the main skills tested in the problem-solving assessment, once content related items are removed? It is argued that the key skill needed to solve problems is analytical reasoning. It is further hypothesised that there would be a high correlation between mathematics performance and problem-solving performance, because mathematics also requires a high level of analytic reasoning skills (e.g. Carroll, 1996).

In order to further understand the cognitive demands of the problem-solving items, an exploratory factor analysis was carried out to identify patterns in student responses across PISA that might suggest which groups of tasks are being influenced by certain common factors. Two factors were chosen for the rotated solution, based on a hypothesis that mathematics items and reading items should load separately on these two factors, and it was of interest to see how problem solving loaded in these two dimensions. The results of the exploratory factor analysis suggest that different factors were influencing students' performance in reading and in mathematics, with problem-solving responses more closely associated with the mathematics factors.

Table 5.1 shows the latent correlations between the four PISA domains. Latent correlations are direct estimates of the correlations between the different traits of individuals. The estimates are high regardless of any measurement error, that is to say a student doing well in one domain is likely to do well in another. The relatively high correlations are as expected, and not surprisingly, the correlation between problem solving and mathematics is the highest. Next highest is the correlation for problem solving with reading and the correlation with science is somewhat lower.

Table 5.1 Latent Correlations between the Four PISA Domains

	Mathematics	Reading	Science
Reading	0.774		
Science	0.827	0.833	
Problem solving	0.892	0.820	0.796

To place the magnitude of these correlations in perspective, Table 5.2 shows the estimates of the latent correlations between student performances on the four mathematics subscales. The correlation between problem-solving and mathematics is of about the same order of magnitude as the correlations amongst the mathematics subscales. This is perhaps not surprising given that there is a focus on reasoning skills in the problem-solving assessment, and the *mathematical literacy* assessment items focus on the problem-solving aspects of applying mathematics in the real world. Nevertheless, the problem solving tasks do not contain mathematics content, providing some evidence of an underlying 'reasoning ability' trait.

Table 5.2 Latent Correlations between the *Mathematical Literacy* Subscales

	Space and shape	Change and relationships	Uncertainty
Change and relationships	0.888		
Uncertainty	0.875	0.924	
Quantity	0.893	0.919	0.899

The scores for problem solving were scaled with a mean of 500 and a standard deviation of 100 among OECD countries, as were the scores for mathematics. If a country has different mean scores for mathematics and problem solving, it shows a difference in terms of how that country performs relative to the OECD average, not that students in that country found either mathematics or problem solving easier or more difficult relative to each other.

If a country performs relatively higher in mathematics than problem solving, this may show that students in that country have a better understanding of mathematics content as compared to other countries after controlling for the level of problem-solving skills in students. This may indicate that mathematics instruction was particularly effective in that country. In contrast, if a country performs relatively better in problem solving, it could be hypothesised that students have the potential to do better in mathematics than currently, since their level of problem-solving skill is relatively higher.

These differences are shown in Figure 5.4. In the Netherlands, students scored on average 18 points more in mathematics than problem solving, and there was a difference of at least 10 points in this direction in Serbia, Turkey, Tunisia, Uruguay and Iceland. As discussed, this could mean that mathematics instruction is relatively effective in helping students reach their potential. In Japan, on the other hand, students score 13 points more on average in problem-solving than mathematics, and in Germany, Hungary and the Russian Federation they do so by more than 10 points. For these countries, students have generic problem-solving skills that the mathematics curriculum might make more use of. The difference for Australia is small, just six points, but it is significant and in the direction of students performing relatively less well in mathematics than in problem solving.

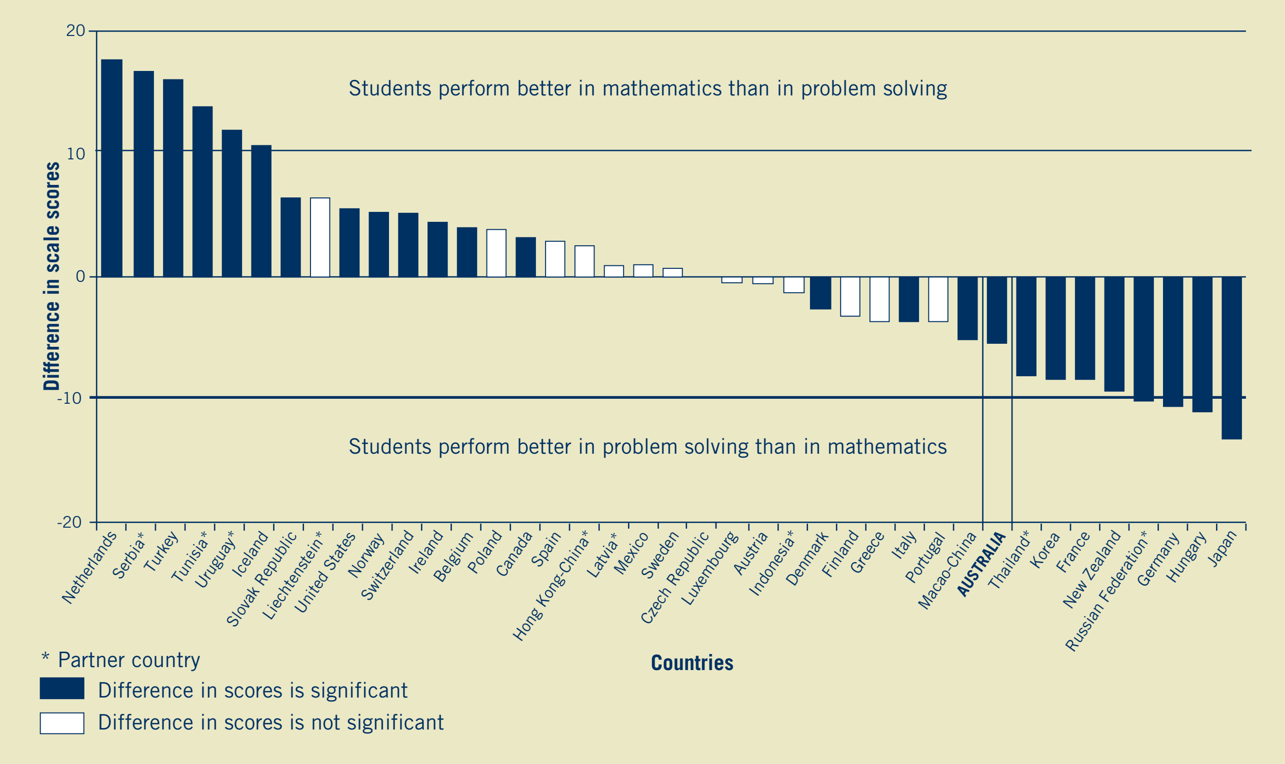


Figure 5.4 Difference between Student Performance in Problem Solving and *Mathematical Literacy*

It should be noted that the magnitude of the differences between mathematics and problem solving is not great: at the most just under a quarter of a proficiency level on the problem-solving scale and about one-third on the six-level mathematics scale.

>> *Performance in the Australian states*

Means and distributions of achievement by state

Figure 5.5 presents the distribution of performance for each of the Australian states in the same way as the international results were presented in Chapter 2. To place the state results in perspective, the means and distributions for the OECD, Australia and for the highest achieving country (Korea) are also included in the figures. The states are ranked in each of the figures in order from lowest to highest mean scores.

For each state, the confidence interval, as shown by the white box in the middle of each bar, is either higher than or overlaps the OECD average. This means that even in the lower achieving states, Australian students performed on average at least as well as the students on average across the OECD. Furthermore, students in Western Australia, the Australian Capital Territory and South Australia performed as well as students in the highest performing country in problem-solving literacy, Korea. What is also apparent from Figure 5.5 is the similarities in the Australian states' results.

The largest dispersion of scores could be seen in the Northern Territory, where the range from the 5th to 95th percentile was 324 score points. In the two highest scoring states, Western Australia and the Australian Capital Territory, the range from 5th to 95th percentile was 281 score points and 293 score points, respectively. The average range for the OECD was 327 score points.

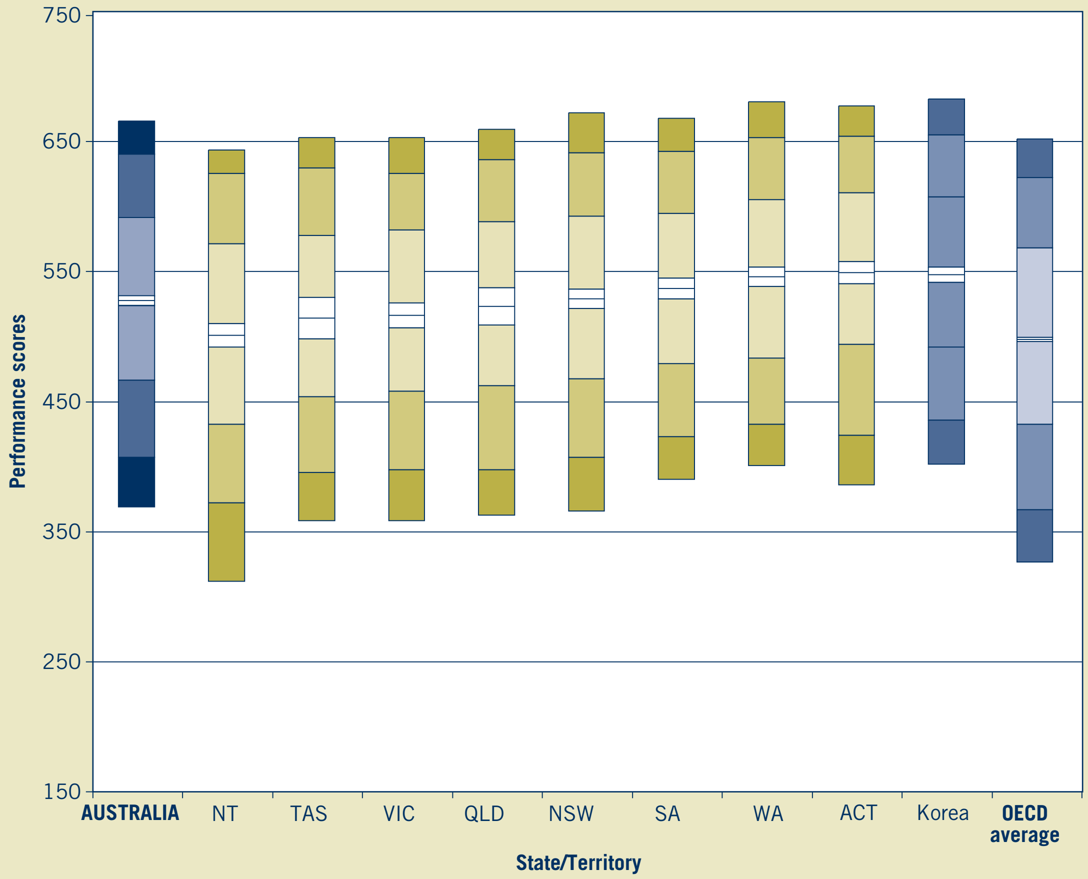


Figure 5.5 Comparative Performance in Problem Solving for the Australian States

Table 5.3 Multiple Comparisons for Problem Solving by State

			ACT	WA	SA	NSW	QLD	VIC	TAS	NT
		Mean	552	548	540	532	526	519	517	503
	Mean	SE	4.3	3.8	3.8	3.9	7.2	4.8	8.0	4.8
ACT	552	4.3		●	●	▲	▲	▲	▲	▲
WA	548	3.8	●		●	▲	▲	▲	▲	▲
SA	540	3.8	●	●		●	●	▲	●	▲
NSW	532	3.9	▼	▼	●		●	●	●	▲
QLD	526	7.2	▼	▼	●	●		●	●	●
VIC	519	4.8	▼	▼	▼	●	●		●	●
TAS	517	8.0	▼	▼	●	●	●	●		●
NT	503	4.8	▼	▼	▼	▼	●	●	●	

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

▲ 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 means and standard errors for problem solving are shown for each state in Table 5.3, which shows the results for the tests of multiple comparisons. This table highlights many equivalent results when the analysis is done simultaneously, and the results are not a great deal different to the analysis carried out for *mathematical literacy*. While there were many equivalent performances in problem solving, the average performance of students in the Australian Capital Territory and Western Australia was significantly higher than the average achieved by students in all other states with the exception of South Australia. Students from the Australian Capital Territory, Western Australia, South Australia and New South Wales attained a higher average score than students in the Northern Territory, however the performance of students in Victoria and Tasmania was not significantly different than the performance of students in the Northern Territory.

>> Differences associated with student characteristics

Gender

Figure 5.6 shows the observed differences between the mean performances of females and males on the PISA problem-solving assessment. The length of the bars shows the difference between genders on the scale, and countries are ranked in descending order of performance advantage for females.

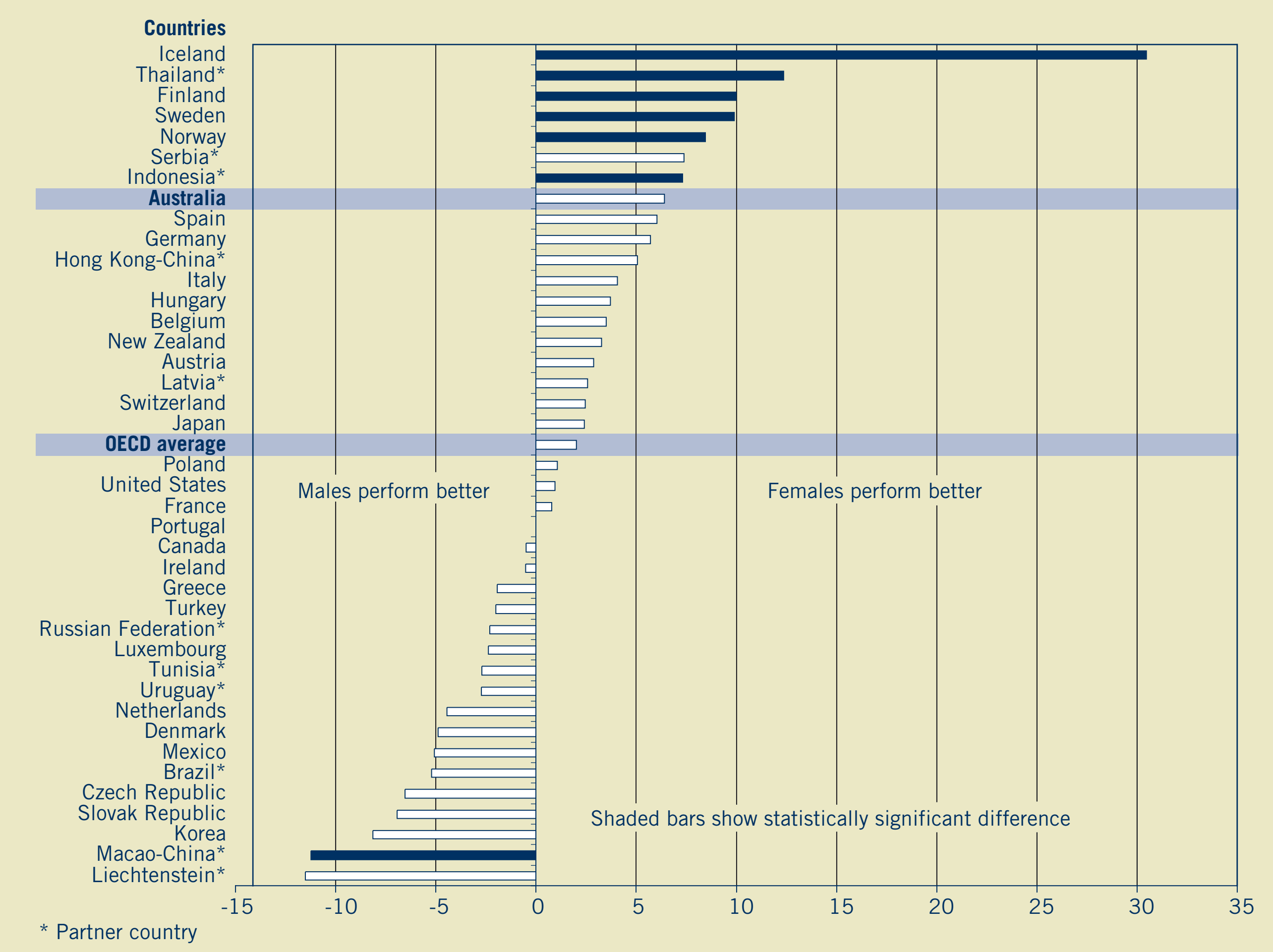


Figure 5.6 Gender Differences in Problem Solving Performance

Only a few countries show significant differences in problem solving. These countries were Iceland, Thailand, Finland, Sweden, Norway, Indonesia and Macao-China. The strongest gender differences are in Iceland, where females did better than males by some 30 score points, and this is similar to Iceland's result on *mathematical literacy*. The next largest gender differences were in Liechtenstein in favour of females and in Macao-China in favour of males, of 12 scale points. It is notable that there are more countries in which females are performing significantly better than males than the other way around. In Australia there was no gender difference.

Socioeconomic background

Parents' occupational status has a strong association with student performance in PISA's three core domains. Problem-solving performance in PISA reflects the student's capability to deal with cross-disciplinary tasks that approximate real-life situations. In general, countries are interested in addressing inequities in performance based on aspects of socioeconomic status, as it is important for future society that students from all walks of life are able to successfully manage future challenges. To illustrate the differences in problem-solving performance between students with parents in different occupations, the student population within each country is divided into quarters, ranked by their parents' occupational status (HISEI).[1] Figure 5.7 shows the mean problem-solving performance for students in each of these groups. Countries are ranked in descending order of the difference in performance between students in the top and bottom quarters of the individual socioeconomic index of occupational status, from right to left. The lengths of the lines represent the gap in problem-solving scores between students in the highest and lowest groups of parents' occupational status within each country.

Among OECD countries on average, students in the top national quartile on the international socioeconomic index of occupational status (HISEI) reach a mean score of 542 points on the problem solving scale, or 42 points above the OECD average. The average score in OECD countries for students in the lowest national quartile is 466 points. This means that students with parents in lower status occupations (such as small-scale farming, truck-driving, and serving in restaurants) perform on average at the level of *basic problem solvers* (Level 1), while students with parents in the highest status occupations (who have occupations such as medicine, university teaching and law) perform on average at the level of *reasoning, decision-making problem solvers* (Level 2).

The disadvantage associated with a low occupational status of students' parents is much more pronounced in some countries than in others. For instance the difference in the problem-solving performance between the top and bottom quartiles on the index of parental occupation is equivalent to at least one proficiency level in Liechtenstein (103 points), Hungary and Uruguay (101 points), Belgium (99 points) and Germany (94 points). In some countries the gap is less than one-half of a proficiency level (47 points in Korea and

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[1] This international socioeconomic index of occupational status is based on students' responses about their fathers' and mothers' occupations. The responses are coded in accordance with the International Standard Classification of Occupations (ISCO), for which values can range from 0 (representing low status occupations) to 90 (representing high status occupations). The higher of fathers' and mothers' occupation is used in to create the HISEI – the higher of mothers' and fathers' socioeconomic index, which is used in some of the calculations to represent socioeconomic status.

Hong Kong-China, 40 points in Iceland and 18 points in Macao-China), and in Australia it is 69 points, or about 0.7 of a proficiency level. Students in the bottom quartile, on average, are just achieving proficiency Level 2, while those in the highest quartile are in the top part of the same level.

While in some countries there are obvious inequities between students with parents in high and low status occupations, it is also clear that these inequities are not inevitable. In several countries, students from the lower quartiles in the socioeconomic index of occupational status perform on average above the OECD average (Canada, Finland, Hong Kong-China, Japan, Korea and Macao-China).

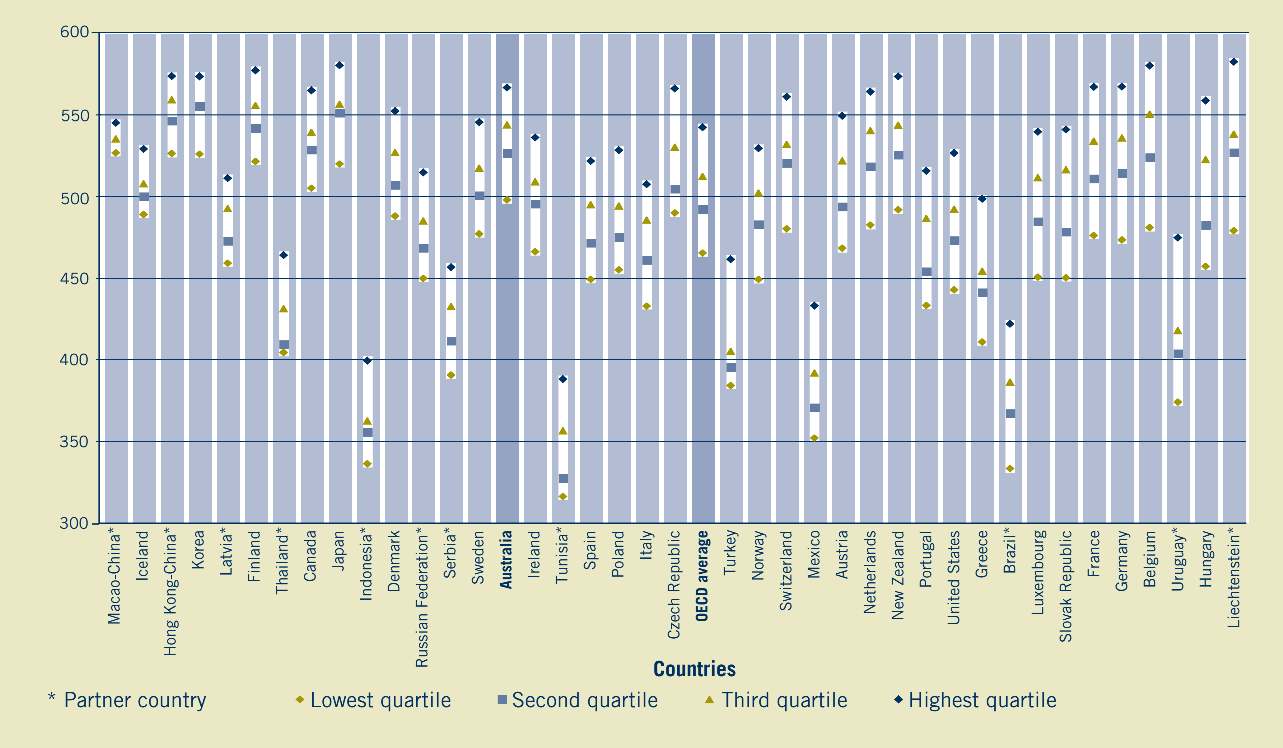

Figure 5.7 Quarters of the International Socioeconomic Index of Occupational Status (HISEI) and Student Performance in Problem Solving

Indigenous status

The gap in scores between Indigenous and non-Indigenous students is not as large for problem solving literacy as it is for *mathematical literacy*. However it is still in the region of 0.8 of a standard deviation (79 score points), which is statistically and educationally significant. The means and standard errors for Indigenous and non-Indigenous students are presented in Table 5.4.

Table 5.4 Mean Scores and Standard Errors for Problem Solving for Indigenous and Non-Indigenous Students

Student group	Mean	Standard Error
Indigenous	453	6.8
Non-Indigenous	532	1.9
Australian average	530	2.0

Proficiency levels in problem solving are shown in Figure 5.8. In terms of the proficiency levels, Indigenous students are, on average, performing at Level 1, while non-Indigenous students are performing at Level 2, which can be interpreted as, according to the OECD, Indigenous students are on average not well-prepared for participation in the emergent workforce. Almost one-third of Indigenous students are below Level 1, compared to nine per cent of non-Indigenous students. However it is encouraging to note that almost one-third of Indigenous students are performing at Level 2 or above.

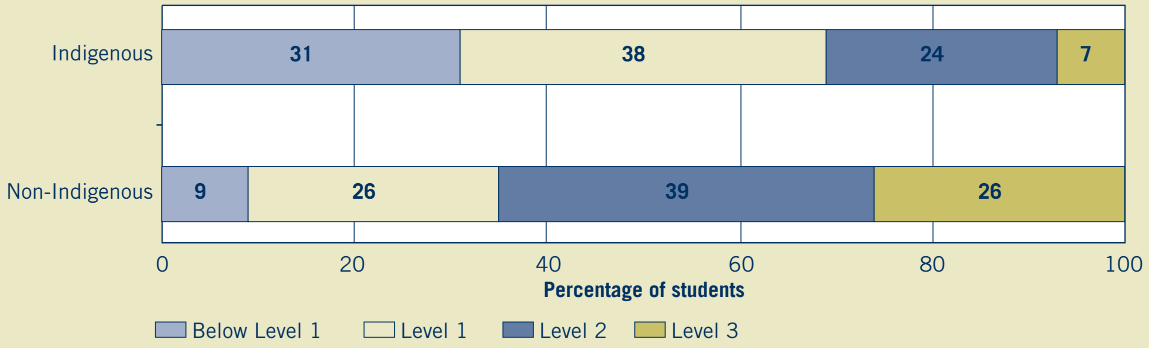

Figure 5.8 Proficiency Levels on the Problem Solving Scale by Indigenous Status

Immigrant status

Internationally, students classified as first-generation and 'non-native'[2] students are at a clear disadvantage in terms of problem solving. On average in OECD countries, first-generation students score 38 points lower than 'native' students, and 'non-native' students score 50 points lower than 'native' students. In Australia, about 23 per cent of all 15-year-olds are either foreign-born or first-generation Australians, however, as with *mathematical literacy*, there is little disadvantage in performance score for either of these groups compared to Australian-born students (see Table 5.5). Similar results were found in the United States and Canada, and to a slightly lesser extent, in New Zealand, all predominantly English-speaking countries with a relatively high proportion of immigrant students. In contrast, students from several European countries (Belgium, France, Germany and Switzerland), with between 12 and 20 per cent 'non-native' and first-generation students, perform distinctly less well than 'native' students.

Table 5.5 Means and Standard Errors for Problem Solving by Immigrant Status

Student group	Mean	Standard Error
Australian-born	534	2.1
First-generation	521	4.0
Foreign-born	523	4.8

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[2] The OECD use the terms 'native' to refer to students who were born in and have parents who were born in the country of assessment, and non-native' to refer to those students who were born in another country. For Australian students we have used the terms 'Australian-born' and 'Foreign-born' respectively.

Geographic location

Table 5.6 records the mean scores for problem solving by geographic location, based on the MCEETYA Schools Geographic Location Classification. These data show similar patterns to that found for *mathematical literacy*. That is, students in metropolitan schools performed significantly better than students in provincial areas (although this difference is not huge), who, in turn, performed significantly better than students at schoools in remote locations. This is an interesting finding since problem solving would not be expected to be as dependent on resources as *mathematical literacy* might be.

Table 5.6 Means and Standard Errors for Problem Solving by Geographic Location of School

Geographic Location	Mean	Standard Error
Metropolitan	533	2.2
Provincial	522	4.4
Remote	503	8.4

Sample and illustrative tasks

Problem solving is widely seen as providing an essential basis for future learning, for effectively participating in society, and for conducting personal activities. Thus problem solving is a central part of education across the curriculum, and to assess it in a cross-disciplinary context requires real-life problems with non-routine solutions involving a range of flexible thinking skills.

Problem solving covers a wide spectrum of problem types. PISA 2003 focused on three problem types: *decision making*, *system analysis and design*, and *trouble shooting*. Chosen because they are widely applicable and occur in a variety of settings, the problems used in the assessment were set in contexts that a student would find in their personal life, work and leisure, and in the community and society. Tasks included in the assessment were selected to collect evidence of students' knowledge and skills associated with problem solving processes.

Sample problem-solving items and responses

The following three items illustrate the nature of the various problem types, and of the processes required for students to succeed in problem-solving tasks at various levels of difficulty, within the nineteen items involved[1]. A student can score full, partial (not fully correct or less sophisticated answers), or no credit for a given item, as has been described in Chapter 2.

All items were assessed (coded) by experts, and to ensure consistency in the marking process many of the more complex items were marked independently by up to four individuals.

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[1] All of the items for Problem solving have been released, and can be found in Volume 2 of the PISA International Report (OECD, 2004b.)

DECISION MAKING unit example

HOLIDAY

The first item to be examined, which is associated with *decision making*, is characterised by presenting students with a situation requiring a decision and asking them to choose among alternatives under a set of conditions constraining the situation. Students have to understand the situation provided, identify the constraints, possibly translate the way in which the information is presented, make a decision based on the alternatives under the constraints, check and evaluate the decision, and then communicate the required answer.

This unit asked students two questions dealing with the planning of a route and places to stay overnight on a holiday trip.

In Question 1 students were provided with a map and chart showing distances between towns illustrated on the map, requiring limited reading of text.

Figure 1: Map of roads between towns.

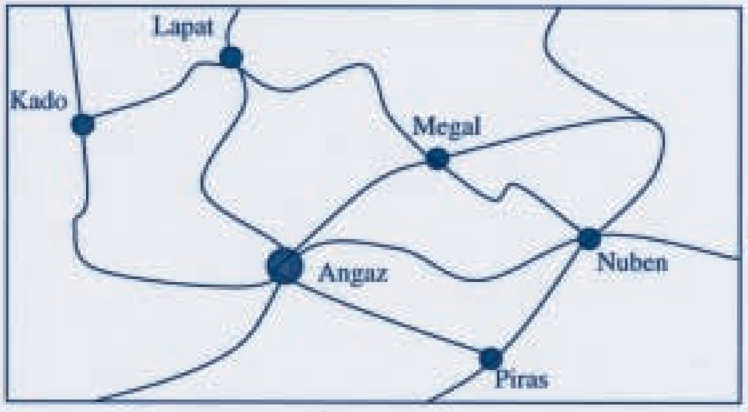
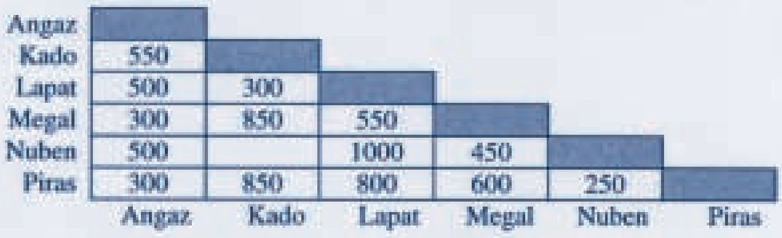


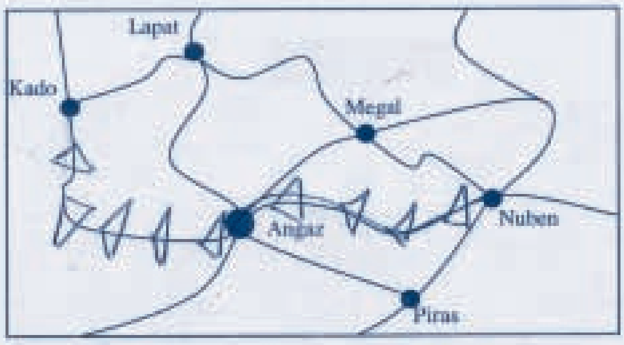
Figure 2: Shortest road distance of towns from each other in kilometres.

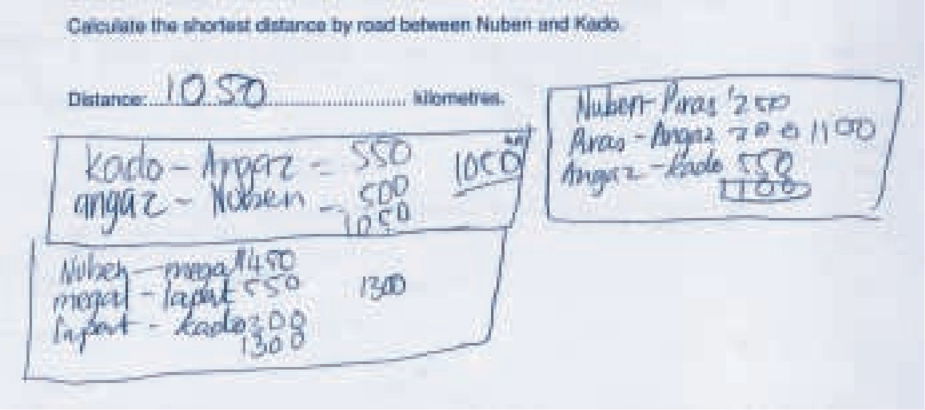


	Angaz	Kado	Lapat	Megal	Nuben	Piras
Angaz						
Kado	550					
Lapat	500	300				
Megal	300	850	550			
Nuben	500		1000	450		
Piras	300	850	800	600	250	

In this closed constructed response question students need to read and interpret information from a map and distance chart. The item represents proficiency Level 2 with a PISA scale score of 569.

Figure 1: Map of roads between towns.





Calculate the shortest distance by road between Nuben and Kado.

Distance: 1050 .... kilometres.

Kado – Angaz – 550
angaz – Nuben – 500
1050

1050

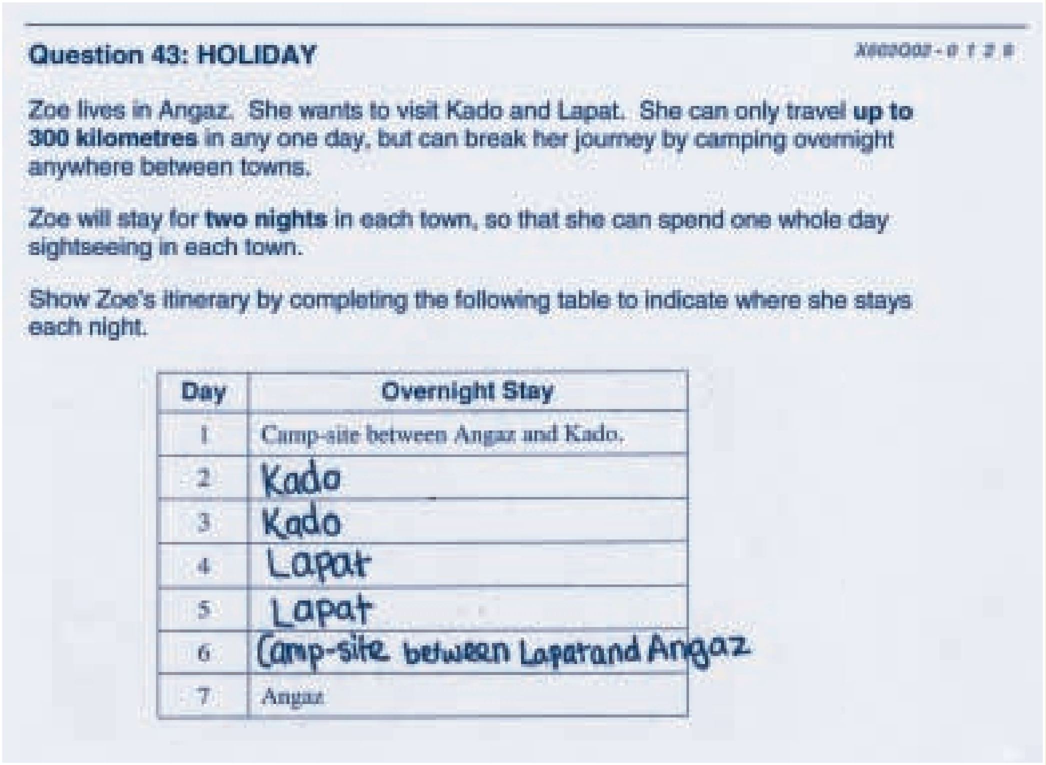
Nuben – megal 450
megal – lapat 550
lapat – kado 300
1300

1300

Nuben-Piras 250
Piras – Angaz 300 1100
Angaz – Kado 550
1100

The example shows the student was quite methodical as demonstrated by his or her detailed, systematic approach to arriving at his or her response.

Question 2 is associated with performances scoring higher on the PISA scale. This open constructed-response item asked students to make a decision about how to schedule travel among the towns, in terms of overnight stays.



Question 43: HOLIDAY X603Q02 - 0 1 2 9

Zoe lives in Angaz. She wants to visit Kado and Lapat. She can only travel **up to 300 kilometres** in any one day, but can break her journey by camping overnight anywhere between towns.

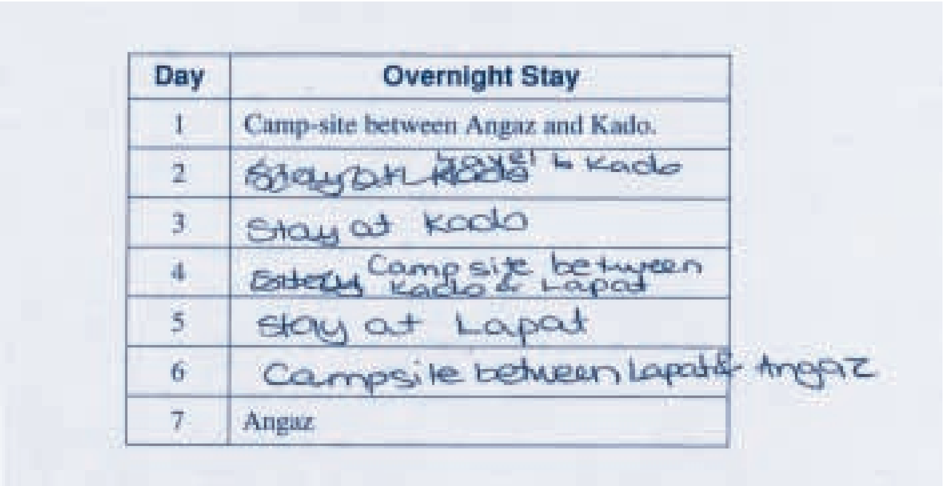
Zoe will stay for **two nights** in each town, so that she can spend one whole day sightseeing in each town.

Show Zoe's itinerary by completing the following table to indicate where she stays each night.

Day	Overnight Stay
1	Camp-site between Angaz and Kado.
2	Kado
3	Kado
4	Lapat
5	Lapat
6	Camp-site between Lapat and Angaz
7	Angaz

This question imposed a number of constraints that required students to consider all particulars simultaneously. While full credit, associated with Level 3, could only be awarded for a fully correct answer, representing a PISA scale score of 603, partial credit could be obtained with one incorrect component of the answer.

Partial credit answers represent the top of Level 2 (only eleven points below the base of Level 3) representing a PISA scale score of 592. A student who made one mistake in calculating the answer to this problem was still able to go through the main steps required to solve it, as shown in the next example.



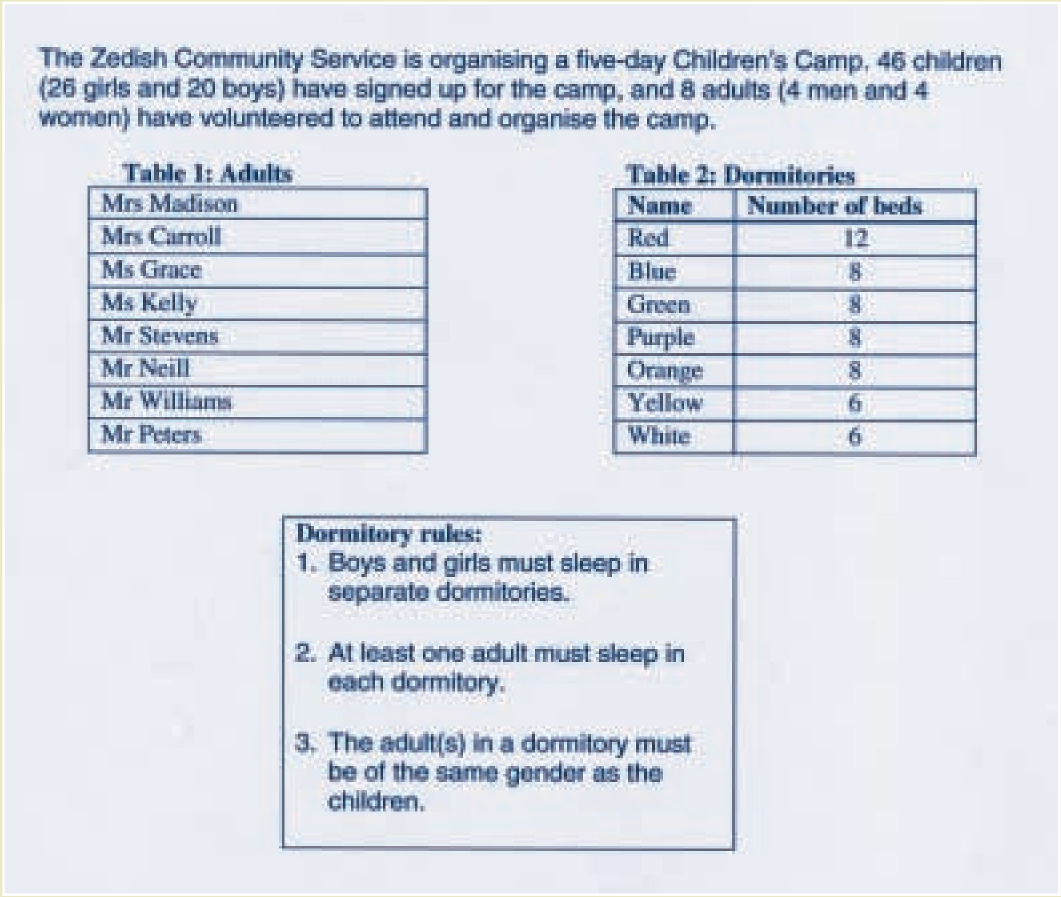
Day	Overnight Stay
1	Camp-site between Angaz and Kado.
2	~~Stay at Kado~~ travel to Kado
3	Stay at Kado
4	~~Stay~~ Campsite between Kado & Lapat
5	Stay at Lapat
6	Campsite between lapat & Angaz
7	Angaz

SYSTEM ANALYSIS AND DESIGN unit example

CHILDRENS CAMP

PISA included units assessing students' capabilities to solve problems involving *system analysis and design*. This type of problem differs from the *decision making* items as not all possible options are given nor are the constraints as apparent. Students have to develop an understanding of the problem, beginning with either the identification of relationships between parts of the system analysis, or to design a system with certain relationships among its main features. Students then have to develop a representation that brings the inherent relationships into a manipulative form, so that students can test the system or design by working with individual or sets of related features. The final step involves students justifying their analysis or design rationale.

This second item type example – *Children's Camp* contains a common system problem of the assignment of classes of people to positions, consistent with specified relationships between the classes, and people within the classes. These relationships concern adult - child, male – female, and the allocation within specified dormitory rules. This open constructed-response problem needs to be considered and manipulated by students to arrive at the expected answer, addressing the challenging nature of the available dormitory options, within the imposed constraints.



The Zedish Community Service is organising a five-day Children's Camp. 46 children (26 girls and 20 boys) have signed up for the camp, and 8 adults (4 men and 4 women) have volunteered to attend and organise the camp.

Table 1: Adults

Mrs Madison
Mrs Carroll
Ms Grace
Ms Kelly
Mr Stevens
Mr Neill
Mr Williams
Mr Peters

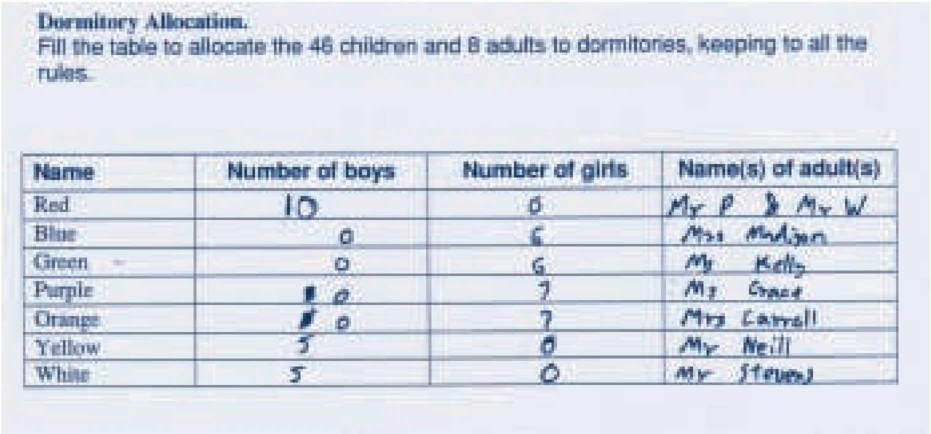
Table 2: Dormitories

Name	Number of beds
Red	12
Blue	8
Green	8
Purple	8
Orange	8
Yellow	6
White	6

Dormitory rules:

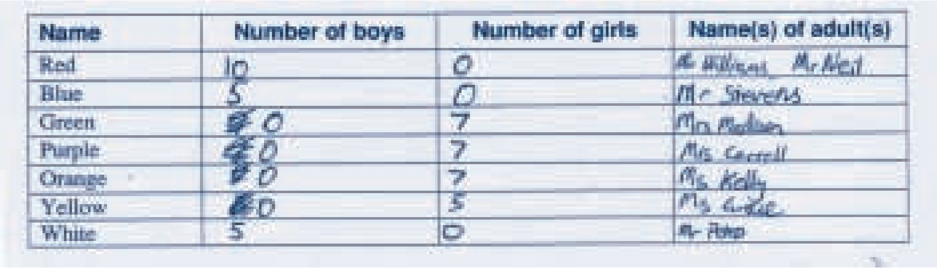
1. Boys and girls must sleep in separate dormitories.
2. At least one adult must sleep in each dormitory.
3. The adult(s) in a dormitory must be of the same gender as the children.

Two levels of performance can be distinguished, with a full credit response being awarded on the PISA problem scale at proficiency Level 3, with a partial credit response being awarded at proficiency Level 2.



Dormitory Allocation.
Fill the table to allocate the 46 children and 8 adults to dormitories, keeping to all the rules.

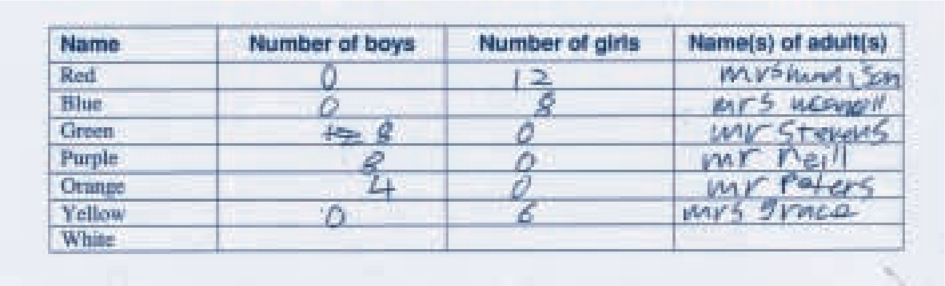
Name	Number of boys	Number of girls	Name(s) of adult(s)
Red	10	0	Mr P & Mr W
Blue	0	6	Mrs Madison
Green	0	6	Ms Kelly
Purple	0	7	Ms Grace
Orange	0	7	Mrs Carroll
Yellow	5	0	Mr Neill
White	5	0	Mr Stevens



Name	Number of boys	Number of girls	Name(s) of adult(s)
Red	10	0	Mr Williams Mr Neil
Blue	5	0	Mr Stevens
Green	0	7	Mrs Madison
Purple	0	7	Ms Carroll
Orange	0	7	Ms Kelly
Yellow	0	5	Ms Grace
White	5	0	Mr Peters

To gain a full credit six conditions needed to be satisfied, whilst partial credit was awarded to students who incorrectly provided one or two of the anticipated answers.

Full credit answers represent a PISA score of 649, whilst a partial credit response represents a PISA score of only 529.

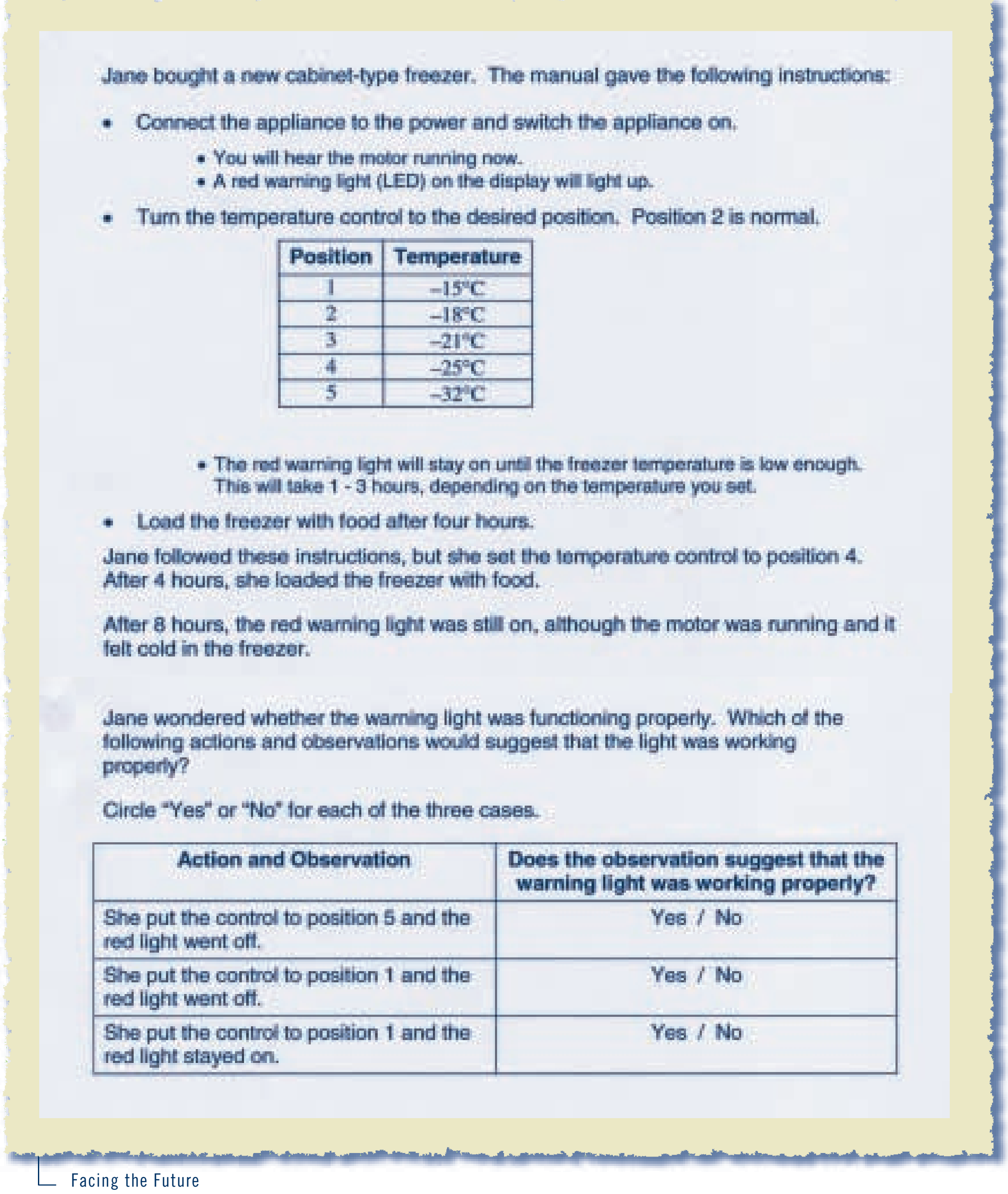


Name	Number of boys	Number of girls	Name(s) of adult(s)
Red	0	12	mrs Hutchinson
Blue	0	8	mrs mcConnell
Green	~~15~~ 8	0	mr Stevens
Purple	8	0	mr Neill
Orange	4	0	mr Peters
Yellow	0	6	mrs grace
White			

TROUBLE SHOOTING unit example

FREEZER

The final type of problem solving example *Trouble Shooting* assesses students' actions when confronted with a system or mechanism that is underperforming in some way. The open constructed-response problem requires students to consider the main features of the system, and the actions or responses that are expected of each of the features. Once understood, students must then be able to identify the causal-response relationships between interrelated parts, and the role that such links play in the overall function of the mechanism or system of interest. The number of interrelated variables complicates the problem, plus the varied numbers of representations that have to be considered in order to fully understand the system or mechanisms, from directions or instructions.



Jane bought a new cabinet-type freezer. The manual gave the following instructions:

- Connect the appliance to the power and switch the appliance on.
    - You will hear the motor running now.
    - A red warning light (LED) on the display will light up.
- Turn the temperature control to the desired position. Position 2 is normal.

Position	Temperature
1	–15°C
2	–18°C
3	–21°C
4	–25°C
5	–32°C

- The red warning light will stay on until the freezer temperature is low enough. This will take 1 - 3 hours, depending on the temperature you set.
- Load the freezer with food after four hours.

Jane followed these instructions, but she set the temperature control to position 4. After 4 hours, she loaded the freezer with food.

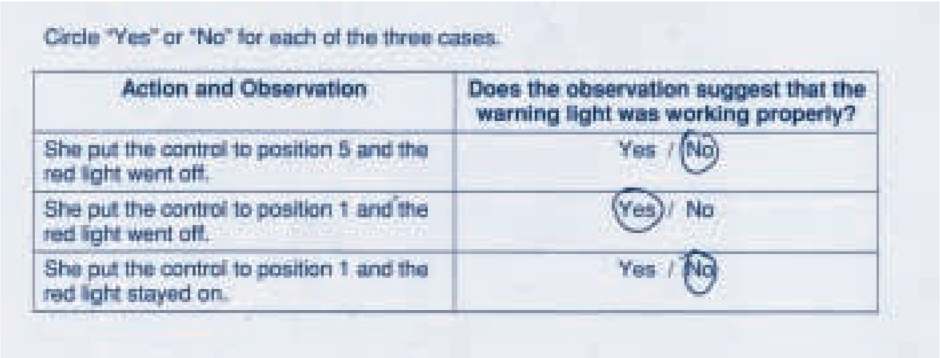
After 8 hours, the red warning light was still on, although the motor was running and it felt cold in the freezer.

Jane wondered whether the warning light was functioning properly. Which of the following actions and observations would suggest that the light was working properly?

Circle "Yes" or "No" for each of the three cases.

Action and Observation	Does the observation suggest that the warning light was working properly?
She put the control to position 5 and the red light went off.	Yes / No
She put the control to position 1 and the red light went off.	Yes / No
She put the control to position 1 and the red light stayed on.	Yes / No

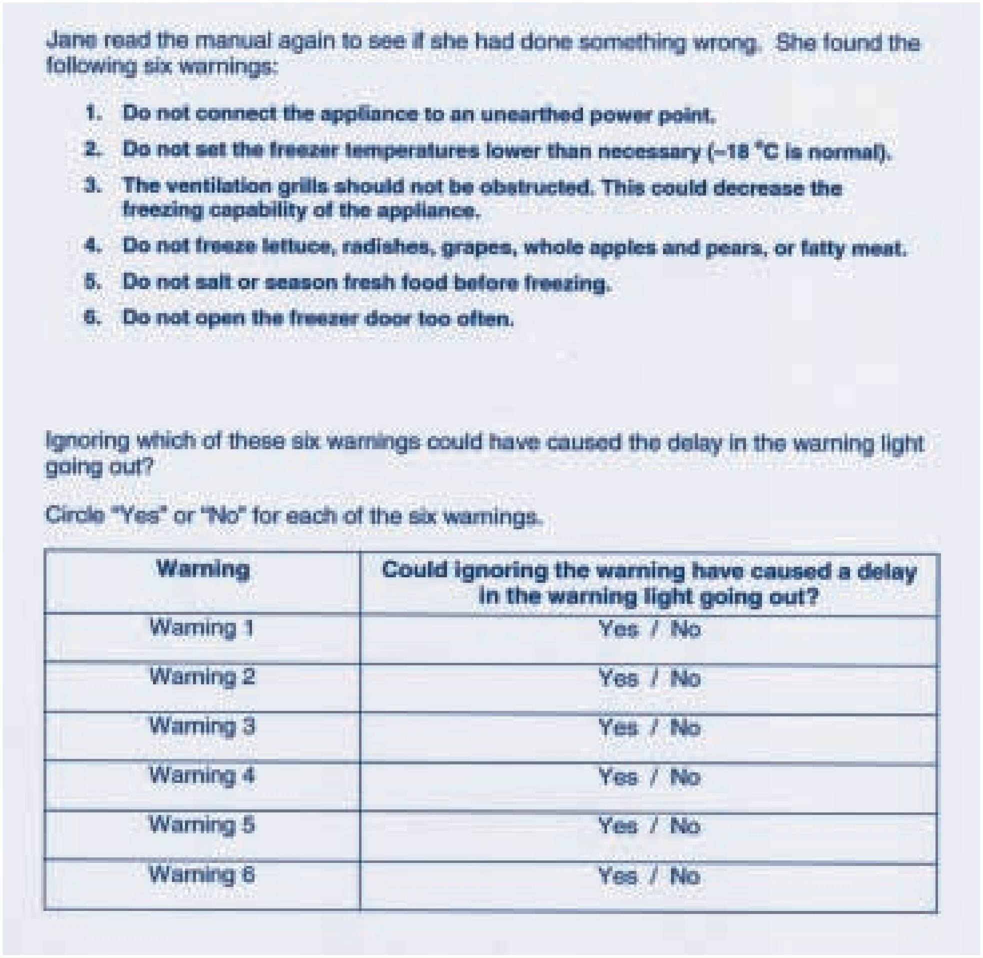
This multiple-choice question involving a freezer problem required students to diagnose the working of the freezer warning light. Working through the three tests proposed within the question, students need to recognise, and comprehend, the effect of altering the freezer control setting to generate warmer or cooler conditions. Correctly answering all aspects of the question places students at proficiency level 2, with a PISA scale score of 573.



Circle "Yes" or "No" for each of the three cases.

Action and Observation	Does the observation suggest that the warning light was working properly?
She put the control to position 5 and the red light went off.	Yes / [✓ No]
She put the control to position 1 and the red light went off.	[✓ Yes] / No
She put the control to position 1 and the red light stayed on.	Yes / [✓ No]

An additional multiple-choice question draws on students' outside experience with freezers, or similar appliances, at a common-sense level of knowledge. The problem poses a series of six options, confronting students with warnings from the operating manual associated with possible freezer malfunctioning.



Jane read the manual again to see if she had done something wrong. She found the following six warnings:

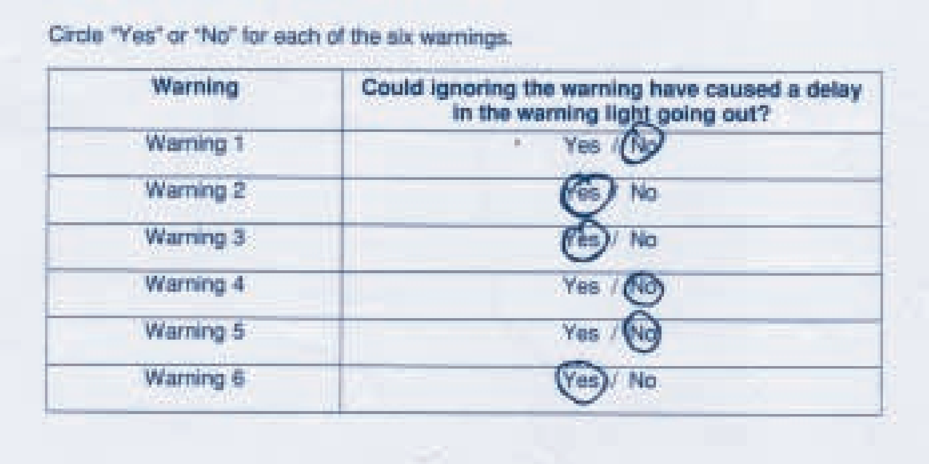
1. **Do not connect the appliance to an unearthed power point.**
2. **Do not set the freezer temperatures lower than necessary (–18 °C is normal).**
3. **The ventilation grills should not be obstructed. This could decrease the freezing capability of the appliance.**
4. **Do not freeze lettuce, radishes, grapes, whole apples and pears, or fatty meat.**
5. **Do not salt or season fresh food before freezing.**
6. **Do not open the freezer door too often.**

Ignoring which of these six warnings could have caused the delay in the warning light going out?

Circle "Yes" or "No" for each of the six warnings.

Warning	Could ignoring the warning have caused a delay in the warning light going out?
Warning 1	Yes / No
Warning 2	Yes / No
Warning 3	Yes / No
Warning 4	Yes / No
Warning 5	Yes / No
Warning 6	Yes / No

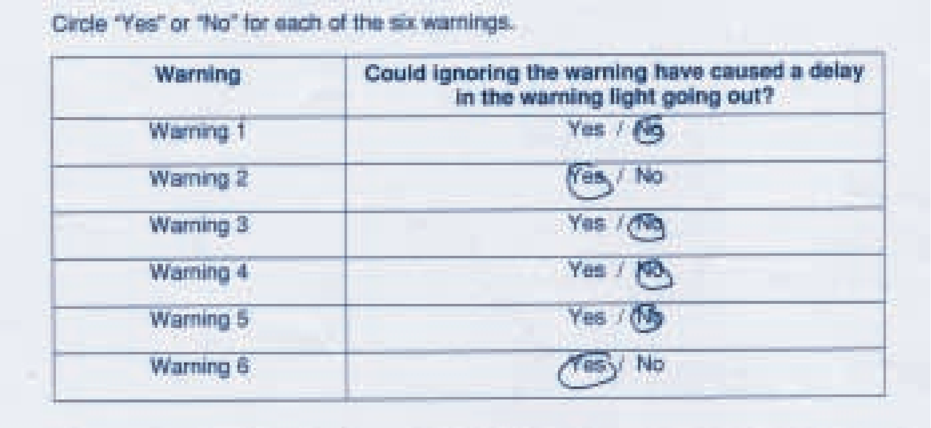
This item represents proficiency Level 2, with a PISA scale score of 551, as each of the decisions is based essentially on a single piece of information, and its relationship to the freezer mechanism. Full credit was given if all information was correct.



Circle "Yes" or "No" for each of the six warnings.

Warning	Could ignoring the warning have caused a delay in the warning light going out?
Warning 1	Yes / [✓ No]
Warning 2	[✓ Yes] / No
Warning 3	[✓ Yes] / No
Warning 4	Yes / [✓ No]
Warning 5	Yes / [✓ No]
Warning 6	[✓ Yes] / No

Partial credit was given when only one error was made.



Circle "Yes" or "No" for each of the six warnings.

Warning	Could ignoring the warning have caused a delay in the warning light going out?
Warning 1	Yes / [✓ No]
Warning 2	[✓ Yes] / No
Warning 3	Yes / [✓ No]
Warning 4	Yes / [✓ No]
Warning 5	Yes / [✓ No]
Warning 6	[✓ Yes] / No

The three problem-solving units selected illustrate how problems may differ in difficulty and type, and have also provided a variety of examples of student performance; from understanding problems to the solution of problems, and the communication of results.

Summary

Problem solving had a specific and clearly articulated definition in the PISA assessment. The assessment of problem solving was designed to assess the degree to which students could solve problems situated in contexts that were discipline-free and drew on students' knowledge from a variety of sources.

The design of the assessment placed particular emphasis on testing each student's ability to understand a problem situation, identify relevant information or constraints, represent possible alternatives or solution paths, select a solution strategy, solve the problem, check or reflect on the solution, and communicate the solution and reasoning behind it. As well as discussing student performance in terms of mean scores and standard errors, a set of three proficiency levels were devised that allowed students to be categorised as *emergent problem solvers* (Below Level 1), *basic problem solvers* (Level 1), *reasoning, decision-making problem solvers* (Level 2) and *reflective, communicative problem solvers* (Level 3).

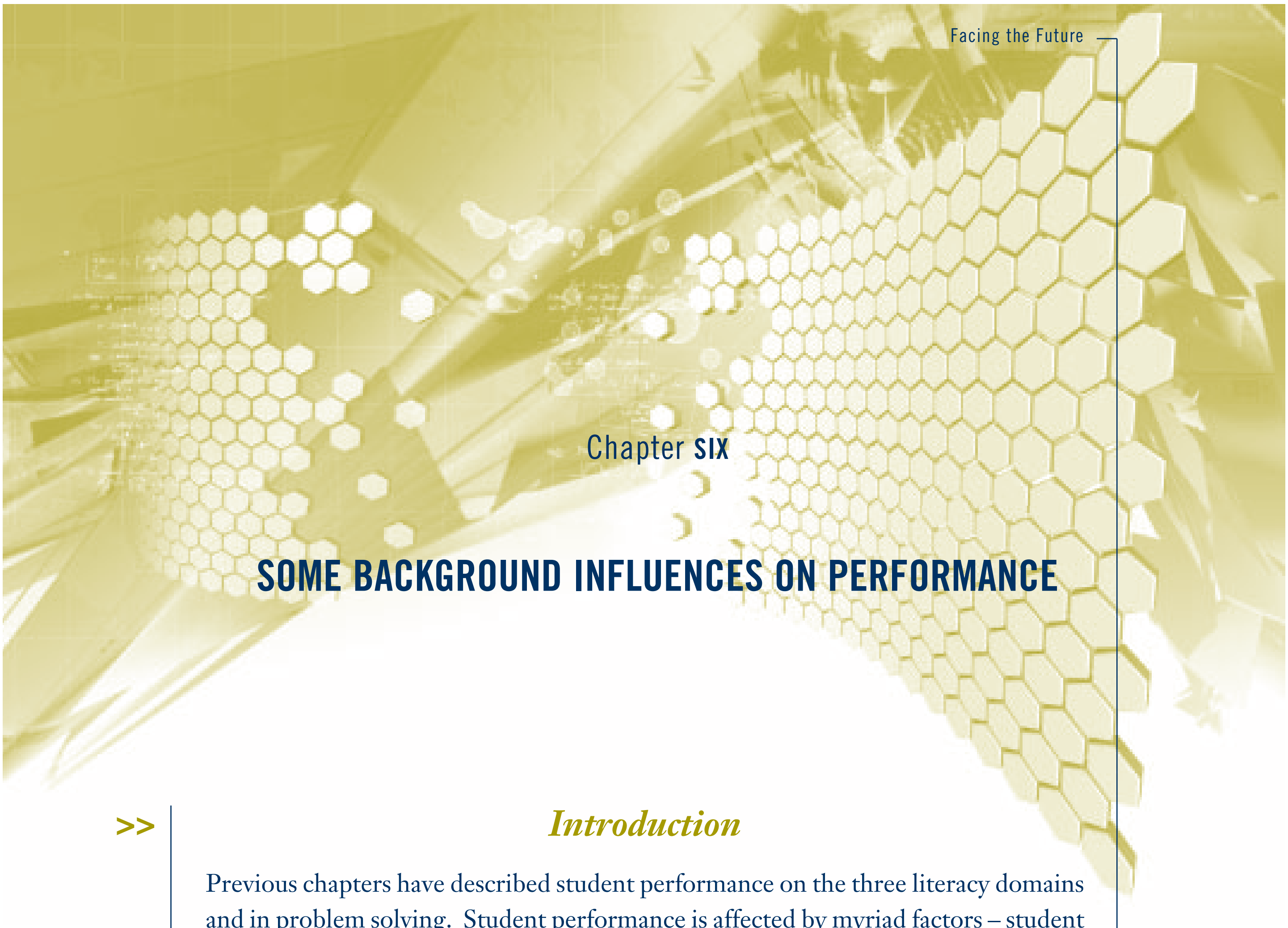
Problem solving was found to correlate strongly with *mathematical literacy*, and the magnitude of the correlations was similar to those between the *mathematical literacy* subscales. Australia scored relatively better in problem solving than in *mathematical literacy*, although the difference was not large. Australia's score of 530 was significantly higher than the OECD average, and only Korea, Hong Kong-China, Finland and Japan outperformed it. The average student in Australia was situated at proficiency Level 2, with a further quarter of Australian students performing at Level 3. Almost two-thirds of Australian students performed at Level 2 or 3, which the OECD argues means they are well-prepared for future workforce requirements.

Performance in problem solving varied among states, although in general there were more similarities than differences. Performance by students in the Australian Capital Territory and Western Australia was significantly better than that of students in any other state, with the exception of South Australia.

There were no systematic gender differences in problem solving across countries. Parents' occupational status, however, has a strong association with performance in many areas. It is important that students from a wide range of socioeconomic backgrounds are capable of dealing with problem solving situations approximating real-life situations. While there were differences found for Australian students in the levels of problem-solving performance between the highest and lowest quartiles on the socioeconomic index of occupational status, these were of a moderate size, and on average students from the lowest socioeconomic quartile still achieved at proficiency Level 2.

Levels of performance were generally found to be significantly higher among non-Indigenous students as compared to Indigenous students, and for students in metropolitan areas compared with students in regional or rural areas. There were no differences in performance based on immigrant status.

Finally, this chapter provided some examples of the items to illustrate the PISA problem solving scale, the proficiency levels, and to help elucidate the meanings of the levels of performance.



Chapter SIX

SOME BACKGROUND INFLUENCES ON PERFORMANCE

Introduction

Previous chapters have described student performance on the three literacy domains and in problem solving. Student performance is affected by myriad factors – student home background, attitudes, motivations, learning preferences and the learning environment have been found to influence student performance.

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 ensure equitable educational opportunities are achieved. This chapter provides a description of the background factors that were obtained in PISA and the relationships between those factors and performance in PISA.

After completing an assessment booklet, students were asked to answer questions about themselves, their home and their school environment. In terms of home background the Student Questionnaire sought information about parents' occupations, parents' educational attainments as well as home resources such as books, cultural possessions and computer resources. The questionnaire also sought information about family structure, the country of birth of the student and their parents, the language spoken at home and whether they were an Indigenous person. Information about students' educational intentions and occupational aspirations also formed part of the questionnaire. This chapter focuses on these characteristics of the students and their backgrounds. The following chapter (Chapter 7) is concerned with information from the same questionnaire about matters more directly related to learning: such as attitudes and beliefs about mathematics learning, learning strategies and preferences, attitudes to school, relationships with teachers and peers, and perceptions of the school and classroom environments[1].

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[1] Compared with the international Student Questionnaire, the PISA 2003 Australian Student Questionnaire included some additional questions as well as adaptations of two questions, to collect data that were considered nationally relevant and potentially contributing to the further understanding of student performance.

The Student Questionnaire took students 30 to 40 minutes to complete. Data collected in the Student Questionnaire were used to construct several indices that summarised student responses on a series of related questions. Theoretical considerations and existing research evidence were used to inform the construction of the indices. Structural equation modelling was used to confirm the theoretically expected results of the indices and to validate their comparability across countries. Details about the indices and how they are defined are contained in Appendix 4.

>> *Parents' occupational status*

Information on parents' occupations was collected in the Student Questionnaire. Students were asked to report (in an open-ended response) their mothers' and fathers' occupations and to state whether each parent was in full-time paid work, part-time paid work, not working but looking for a paid job or "other". 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 (HISEI). This index captures the attributes of occupations that relate parental education to income and is thus taken as an index of socioeconomic status. In PISA the value of the index is based on whichever of the father's or mother's occupation is the highest and is thus designated as HISEI. Values on the 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 48.8. Australia, along with Canada, had a mean of 52.6, following behind Norway (54.6) and the United States (54.6) and Iceland (53.7). Indonesia had the lowest value on the index of occupational status with a mean of 33.6. Within Australia, the mean on the HISEI ranged from 58.6 in the Australian Capital Territory to 50.0 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 (*mathematical*, *reading* and *scientific literacy*) domains were similar at around 0.31. This is a moderate correlation, and indicates that a student's score in each of the domains increases with an increase in their HISEI score. The correlation between HISEI and performance in problem solving was 0.29. These relationships are presented in Figure 6.1, which shows the regression lines that represent the average relationship between performance and parental occupation. The steeper the slope of the line the stronger the effect of parental occupation on performance. The position of the line indicates average performance. The higher the line is on the performance axis the greater is the average performance.

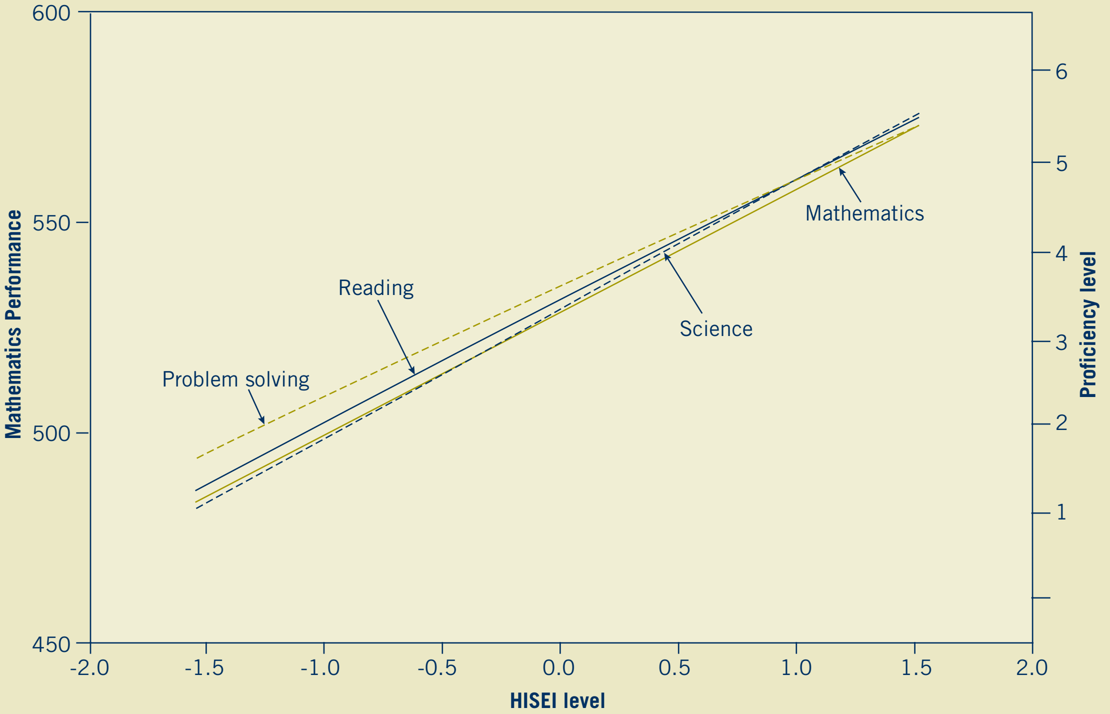


Figure 6.1 *Mathematical*, *Reading*, *Scientific Literacy* and Problem Solving Scores by HISEI Level in Australia for PISA 2003

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.

An alternative way of expressing the relationship between performance and parental occupation is to compare the average performance of students from each of the quarters of the HISEI distribution. Students in the highest quarter of HISEI performed 69 points higher in problem solving, 77 points higher in *reading literacy*, 79 points higher in *mathematical literacy* and 83 points higher in *scientific literacy*, than students in the lowest quarter. This pattern is represented in Figure 6.2.

Figure 6.3 shows a set of regression lines for performance (in reading and mathematics in PISA 2000 and PISA 2003) against HISEI for Australia and for the OECD average. The patterns shown in Figure 6.3 indicate that there has been little change in the association between performance in either *reading literacy* or *mathematical literacy* between 2000 and 2003 and that the associations are similar for both performance domains. Greater detail is provided in Table 6.1. In *mathematical literacy* in PISA 2003 (but not in either reading or mathematics in 2000), the strength of the relationship between HISEI and performance (the slope of the line) in Australia is significantly lower than the OECD average. This means that parental occupation, as measured by HISEI, has less effect on student performance in Australia than on average in OECD countries.

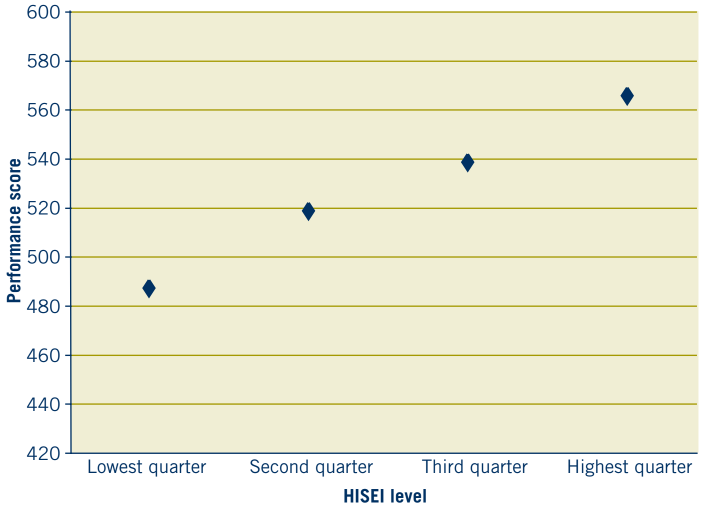
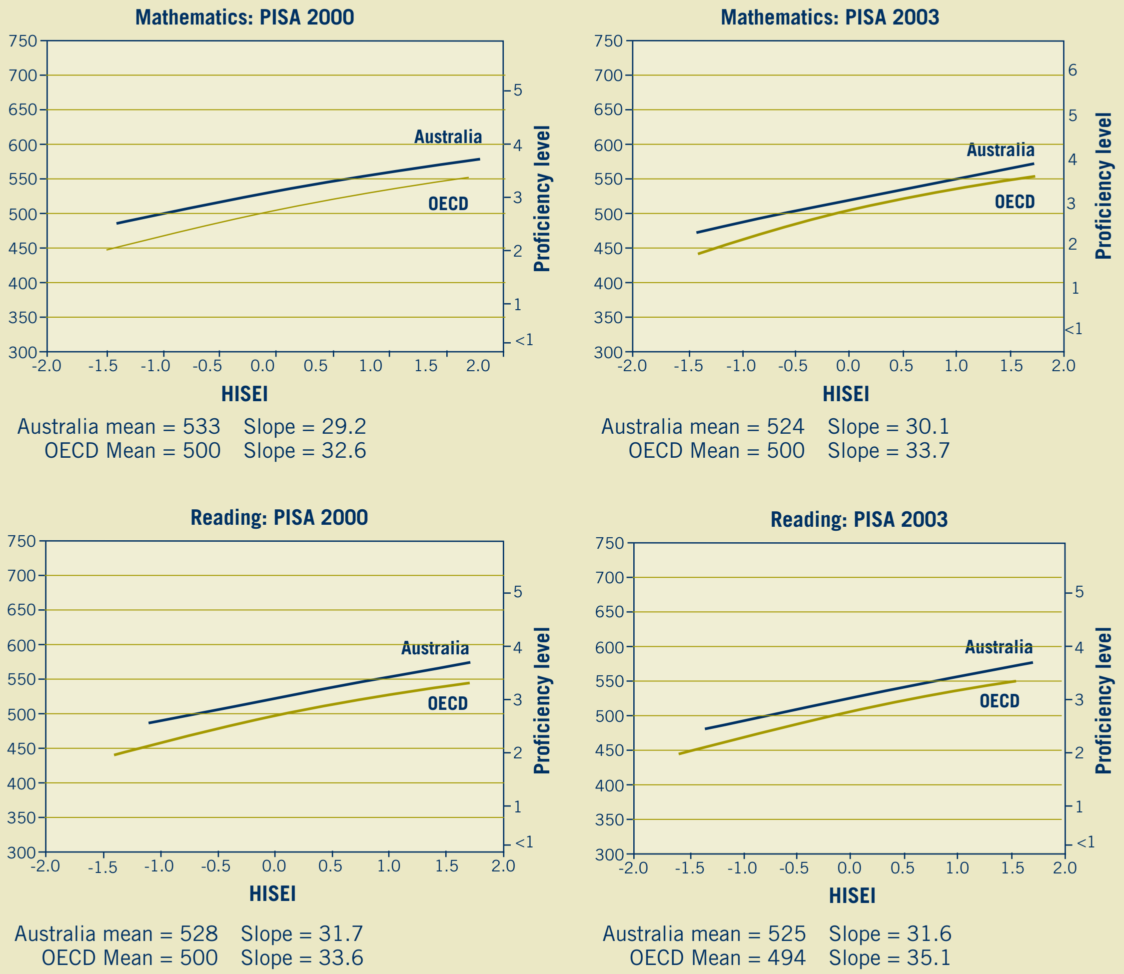


Figure 6.2 Relationship between HISEI and *Mathematical Literacy* Performance in Australian PISA 2003[2]



Australia mean = 533 Slope = 29.2
OECD Mean = 500 Slope = 32.6

Australia mean = 524 Slope = 30.1
OECD Mean = 500 Slope = 33.7

Australia mean = 528 Slope = 31.7
OECD Mean = 500 Slope = 33.6

Australia mean = 525 Slope = 31.6
OECD Mean = 494 Slope = 35.1

Figure 6.3 Associations of Performance in *Reading Literacy* and *Mathematical Literacy* with HISEI in PISA 2000 and PISA 2003

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[2] Because *mathematical literacy* is the major domain in PISA 2003, the relationship between various factors and *mathematical literacy* performance only has been illustrated.

Table 6.1 HISEI and Performance on *Mathematical* and *Reading Literacy*

	PISA 2000 Reading		PISA 2000 Mathematics		PISA 2003 Mathematics	
	Slope	S.E.	Slope	S.E.	Slope	S.E.
Iceland	19.3	(1.45)	16.5	(2.10)	14.4	(1.51)
Finland	20.8	(1.76	19.1	(1.61)	21.7	(1.29)
Japan					23.0	(3.12)
Mexico	31.8	(2.28)	30.0	(2.58)	23.5	(1.88)
Canada	25.7	(0.98)	21.2	(1.03)	24.4	(1.17)
Spain	26.5	(1.61)	27.6	(2.35)	25.4	(1.43)
Korea	14.6	(2.12)	21.9	(2.30)	26.4	(3.28)
Italy	26.4	(1.84)	21.3	(2.49)	27.1	(1.88)
Ireland	30.3	(1.79)	25.9	(2.22)	27.4	(1.89)
Sweden	27.1	(1.50)	30.6	(2.00)	28.7	(1.79)
Denmark	29.1	(1.89)	24.8	(2.04)	28.9	(1.71)
Norway	29.7	(2.02)	25.9	(2.41)	29.2	(1.62)
Greece	28.1	(2.51)	30.5	(3.24)	29.4	(2.11)
New Zealand	31.9	(2.14)	31.0	(2.56)	29.4	(1.65)
Australia	31.7	(2.10)	29.2	(2.25)	30.1	(1.35)
United States	33.5	(2.71)	35.9	(3.19)	30.2	(1.37)
Switzerland	40.2	(2.17)	34.0	(2.00)	30.3	(1.71)
Austria	35.2	(2.07)	31.1	(2.66)	30.7	(1.92)
France	30.8	(1.91)	26.9	(2.18)	31.6	(1.93)
Netherlands					32.3	(2.03)
Slovak Republic					33.2	(1.83)
Luxembourg	39.2	(2.02)	33.2	(2.04)	33.7	(1.56)
Portugal	38.4	(2.14)	33.9	(2.40)	34.3	(1.70)
Poland	35.4	(2.72)	35.3	(2.97)	35.2	(1.82)
Czech Republic	43.2	(1.68)	41.8	(2.36)	37.5	(1.97)
Germany	45.3	(2.10)	39.9	(2.46)	38.0	(1.95)
Turkey					38.1	(5.87)
Belgium	38.2	(2.23)	38.1	(2.71)	39.8	(1.71)
Hungary	39.2	(2.38)	41.6	(2.95)	40.8	(2.17)
OECD average	33.6	(0.44)	32.6	(0.55)	33.7	(0.40)

Notes:

1. Slope refers to the change in score for a one standard deviation change (16.3 units) in the international socioeconomic index of occupational status (HISEI).
2. S.E. refers to the standard error of the slope.
3. Only OECD countries satisfying criteria for inclusion in PISA 2003 tables have been shown. Data for partner countries are contained in the international report (OECD, 2004a).
4. Countries are ordered from top to bottom of the table by increasing slope in PISA 2003 mathematics.

Mathematics: PISA 2000	**Mathematics: PISA 2003**
Australia Mean = 533 Slope = 29.2 OECD Mean = 500 Slope = 32.6	Australia Mean = 524 Slope = 30.1 OECD Mean = 500 Slope = 33.7
Reading: PISA 2000	**Reading: PISA 2003**
Australia Mean = 528 Slope = 31.7 OECD Mean = 500 Slope = 33.6	Australia Mean = 525 Slope = 31.6 OECD Mean = 494 Slope = 35.1

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 and 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 and a university degree.

Forty per cent of Australian students had at least one parent who had completed a university degree; 14 per cent who had completed a TAFE diploma; 30 per cent who had completed Year 12 or a TAFE training certificate; two per cent who completed Year 10 or 11 plus a training course; 11 per cent completed no more than Year 10; one per cent had completed no more than primary school and two per cent had selected the 'none of the above' category.

There was a moderately strong positive relationship in Australia between parents' education and student performance[3]. The correlation coefficient was 0.24 for *scientific literacy* and 0.23 for both *mathematical literacy* and *reading literacy* as well as for problem solving.

In all participating countries there was a significant positive relationship between parental educational level and student performance in *mathematical literacy*. Further information can be found in the international report (OECD 2004a).

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. Fourteen per cent of Australian students had more than 500 books in their home, about a fifth had each of 201 to 500 books and 101 to 200 books; about a third had 26 to 100 books; about a tenth had 11 to 25 books and five per cent has 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.

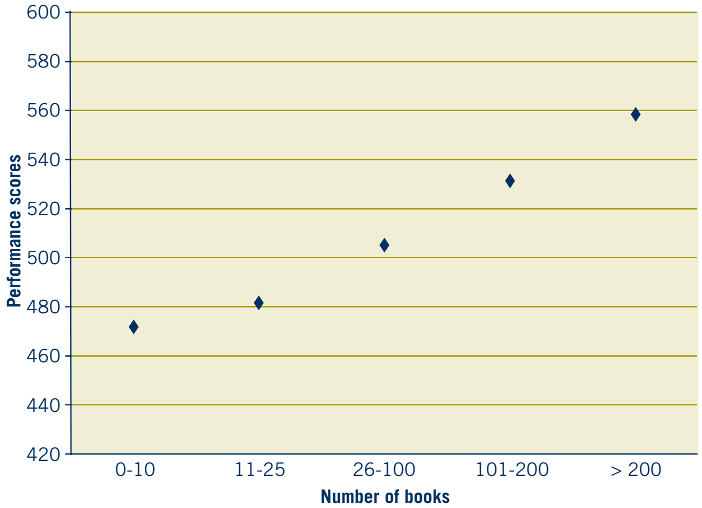

Figure 6.4
Relationship between Books in the Home and *Mathematical Literacy* Performance

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[3] The categories of parental education were treated as ordinal categories: primary school; no more than Year 10; Year 10 or 11 plus a training course; Year 12 or a TAFE training certificate; TAFE diploma; and a university degree.

Figure 6.4 shows the positive relationship between student performance and the number of books a student has in their home by indicating the mean performance in *mathematical literacy* for each of five categories of books in the home. The correlation coefficients between performance and the number of books in the home were approximately 0.30 for each of the three literacy domains and for problem solving. On average, a student whose home had between 201 and 500 books scored 76 points higher in *mathematical literacy* and *reading literacy*, and 89 points higher in *scientific literacy* than a student who had between 11 and 25 books in their home. On average, students scored about 16, 15 and 13 points higher in *scientific literacy* performance, *mathematical literacy* performance and *reading literacy* performance respectively per increase in each category of the books in the home variable.

>> 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 (97 per cent) Australian students had a dictionary and a calculator, 90 per cent had a desk, 83 per cent had a place to study and 80 per cent of students had books to help their schoolwork. Australia's mean on the home educational resources index was 0.10. Correlation coefficients between educational resources in the home and performance were similar across *mathematical*, *reading*, *scientific literacy* ($r = 0.22$) and problem solving ($r = 0.21$). On average, students scored about 15 points higher per unit increase in the educational resources in the home index.

>> Computer resources in the home

Students were also asked about the availability of computer resources at home. Almost all Australian students (94 per cent) had computer facilities they could use for their schoolwork, 67 per cent had educational software and 85 per cent of students had a link to the internet in their homes. The correlation coefficients between computer resources and performance were similar for each of the assessment areas. (r for *mathematical literacy* = 0.24; r for both *reading literacy* and problem solving = 0.23; and r for *scientific literacy* = 0.22).

>> 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 37 per cent of Australian students having classical literature (e.g., Shakespeare), 40 per cent having books of poetry and 55 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 -0.12. The mean for females was higher at -0.05 than the mean for males -0.19. There was a positive relationship between cultural possessions and student performance. The correlation coefficients between both *scientific* and *reading literacy* and cultural possessions were very slightly higher (0.26 and 0.24 respectively) than the correlation coefficients of cultural possessions with problem solving ($r = 0.22$) and *mathematical literacy* ($r = 0.21$). On average, students scored 20 points higher for problem solving, 17 points higher for *scientific literacy*, 15 points higher for *reading literacy* and 11 points higher for *mathematical literacy* per unit increase in the cultural possessions in the home index.

>> 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. This composite index was based on the Highest International Socioeconomic Index of Occupational Status (HISEI) of the parents or guardians, the highest level of education of the parents converted into years of education, an index of the educational resources and index of cultural posessions in the home[4]. This could be regarded as a broader measure of socioeconomic, or family background than HISEI. 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, 2004a) discusses the relationship between socioeconomic background and student performance mostly in terms of ESCS. In order that all the links are maintained the present national report refers to both ESCS and HISEI.

Figure 6.5 shows the relationship between HISEI and mathematics performance, and ESCS and mathematics performance. As can be seen from this figure, the relationships of performance with HISEI and ESCS are very similar although the slope using the ESCS index is slightly steeper than the slope using the HISEI.

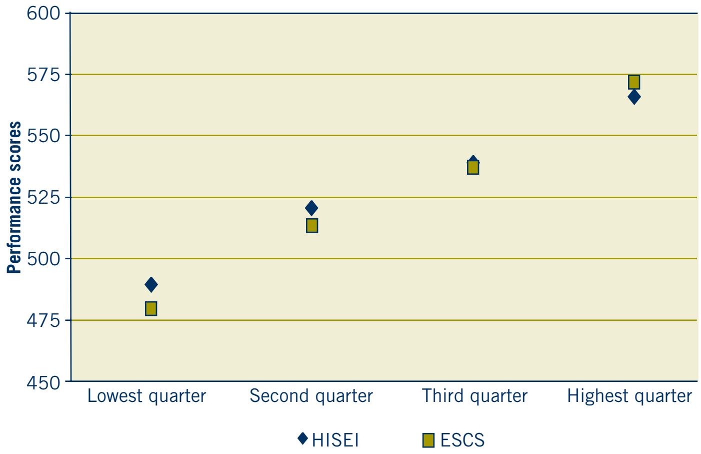

Figure 6.5
Relationship between HISEI and ESCS and *Mathematical Literacy* Performance, Australia, PISA 2003

Socioeconomic gradients

The terms 'socioeconomic gradient' or 'social gradient' refers to the relationship between an outcome and socioeconomic background. In the case of PISA the outcome considered is students' performance. In PISA there is a significant relationship between student performance and their socioeconomic background as measured by

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[4] The ESCS index used in PISA 2003 has been modified since PISA 2000. Details of the adjustments (the main change was to omit the estimates of family wealth that were based on household possessions) can be found in the international report. However the differences have very little impact on the results with the relationship between the PISA 2000 and PISA 2003 indices highly correlated ($R^2 = 0.96$).

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[5]. The line is referred to as the social gradient and generally indicates that students with disadvantaged socioeconomic backgrounds (or lower levels of ESCS) are more likely to have performed at a lower level in PISA.

Four types of information are relevant to a consideration of social gradients;

- 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 *slope* of the graph is an indication of how strongly students' results are associated with ESCS or socioeconomic background. A steeper slope indicates a greater difference in performance between low ESCS students and high ESCS students. Education systems typically aim to decrease the differences in performance between the different social groups. Greater equity would thus be indicated by a flatter gradient. In other words there would be a smaller difference in performance between students with a high ESCS and those with a low ESCS.
- The length of the line indicates the *range* of ESCS and is indicated on the graphs in this chapter. These are plotted between the 5th percentile of ESCS and the 95th percentile of ESCS. A smaller range indicates less difference in ESCS between the highest and lowest ESCS levels of the sample. The range can be measured by projecting the starting point and finishing point of the gradient onto the horizontal axis.
- 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 also relevant to consider how closely individual results fit to the line of best fit. In other words are points representing performance and ESCS for individual students situated close to the line of best fit or are they widely scattered about it. This aspect of the social gradient is represented as 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 relationship between mathematics performance and socioeconomic background as measured by ESCS for Australia and the OECD as a whole is shown in Figure 6.6. The vertical axis on the left hand side of the figure represents scores on the PISA 2003 overall *mathematical literacy* scale, which has a mean of 500 and a standard deviation of 100 for OECD countries. The banded horizontal regions on the graph represent the six proficiency levels (and an area below Level 1) that have been defined for the *mathematical literacy* scales for PISA 2003, which were discussed in Chapter 2. The horizontal axis on the graph represents the index of ESCS, which has a range of –3 to +3, with a mean of zero and a standard deviation of 1 for all OECD countries combined. Each dot on the graph represents a fraction of the sampled students.

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[5] The gradients shown are regression lines which can be thought of as averages of the results from all the students in each of the samples.

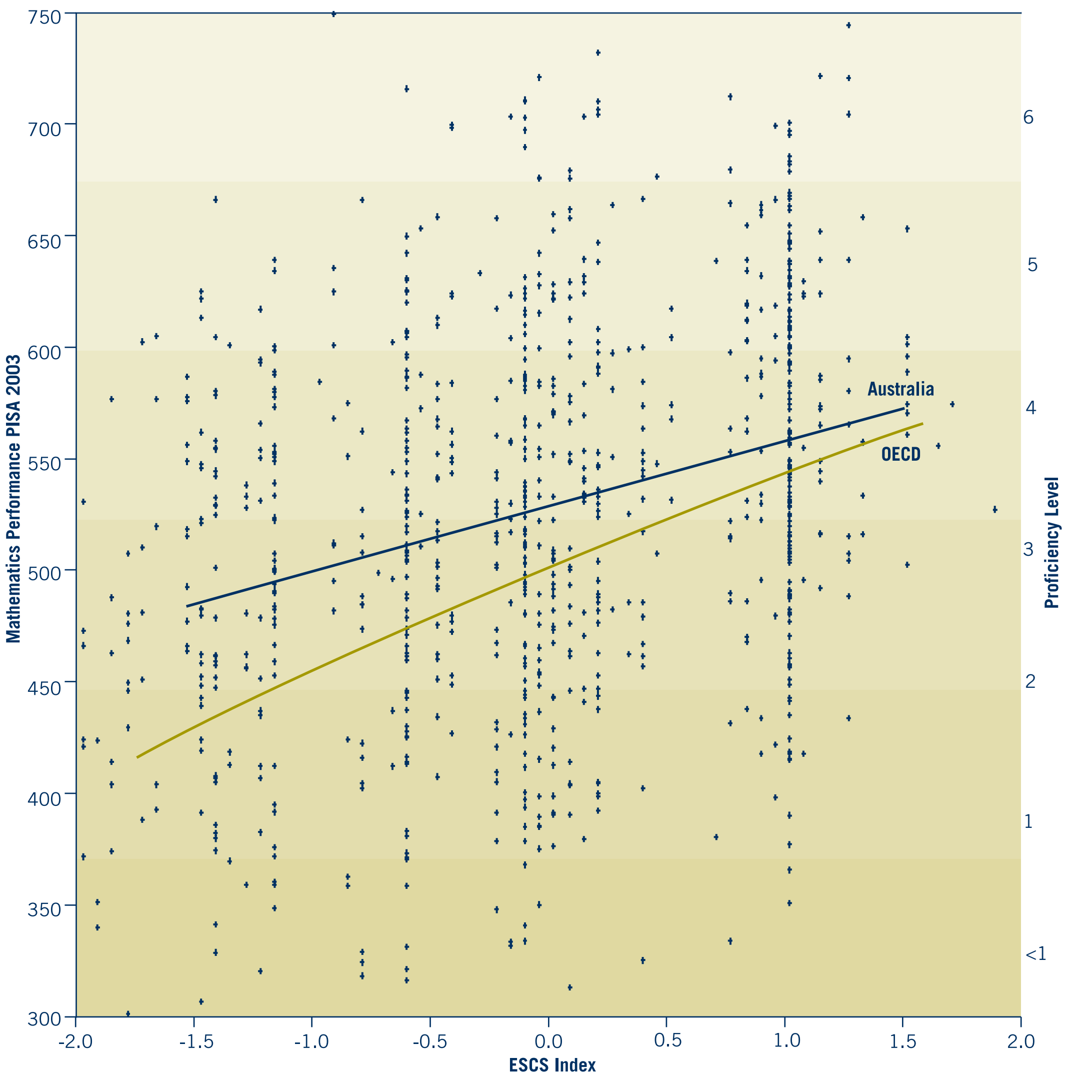

Figure 6.6 Overall *Mathematical Literacy* by ESCS Index for Australia and the OECD

Differences among countries

Figure 6.7 provides the social gradients for selected countries without the scatter plots of student scores. Further information about the means and slopes for a wider range of countries is recorded in Table 6.2. Table 6.2 is included because it is not possible to represent a large number of countries graphically and retain any clarity, and because it contains information that is not easily represented in a graph.

Prior to discussing the results it is important to note that care should be taken in interpreting the association between performance and socioeconomic background (as measured by ESCS), especially when it is expressed as a single line. The line represents an average indication of the association between performance and socioeconomic background. If all students were situated on the line, it would mean that mathematics performance could be predicted accurately simply by knowing a student's socioeconomic background. This, however, is not the case, as there is a diverse range of scores that students demonstrate which are not on the line. In fact the range of results is considerable, with a large number of low socioeconomic status students achieving high scores and, conversely, students with a high ESCS achieving low scores[6]. This is why information about the percentage of variation in performance that can be accounted for by the ESCS index is displayed in Table 6.2.

[6] The gathering of the student dots in 'bands' is a result of the way the ESCS is calculated.

Table 6.2 Relationship Between Student Performance in Mathematics and the PISA Index of Economic, Social and Cultural Status (ESCS) in PISA 2000 and PISA 2003

	PISA 2000						PISA 2003					
	Unadjusted mean score		Slope of ESCS Gradient		Strength of relationship		Unadjusted mean score		Slope of ESCS Gradient		Strength of relationship	
	Mean	S.E.	Slope	S.E.	%	S.E.	Mean	S.E.	Slope	S.E..	%	S.E.
Australia	533	(3.5)	44	(2.6)	17.1	(1.8)	524	(2.1)	42	(2.2)	13.7	(1.2)
Austria	515	(2.5)	36	(2.6)	12.4	(1.7)	506	(3.3)	43	(2.3)	16.3	(1.6)
Belgium	520	(3.9)	49	(2.7)	19.3	(1.8)	529	(2.3)	55	(1.7)	24.2	(1.3)
Brazil	334	(3.7)	35	(3.0)	16.7	(2.8)	356	(4.8)	35	(3.1)	15.3	(2.4)
Canada	533	(1.4)	30	(1.2)	9.8	(0.7)	532	(1.8)	34	(1.4)	10.5	(0.8)
Czech Republic	498	(2.8)	59	(2.8)	21.3	(1.9)	516	(3.5)	51	(2.1)	19.4	(1.4)
Denmark	514	(2.4)	36	(2.3)	14.4	(1.8)	514	(2.7)	44	(2.0)	17.6	(1.4)
Finland	536	(2.1)	26	(1.7)	8.7	(1.1)	544	(1.9)	33	(1.6)	10.8	(1.0)
France	517	(2.7)	38	(2.4)	15.5	(1.9)	511	(2.5)	43	(2.2)	19.6	(1.8)
Germany	490	(2.5)	54	(2.8)	22.8	(2.4)	503	(3.3)	47	(1.7)	22.8	(1.5)
Greece	447	(5.6)	37	(3.4)	13.3	(2.3)	445	(3.9)	37	(2.2)	15.9	(1.9)
Hong Kong-China	560	3.26	27	(3.3)	5.7	(1.5)	550	(4.5)	31	(2.9)	6.5	(1.3)
Hungary	488	(4.0)	60	(3.1)	26.2	(2.4)	490	(2.8)	55	(2.3)	27.0	(1.8)
Iceland	514	(2.3)	24	(2.6)	6.7	(1.4)	515	(1.4)	28	(1.7)	6.5	(0.8)
Indonesia	367	(4.5)	20	(4.0)	5.4	(2.0)	360	(3.9)	21	(2.6)	7.0	(1.6)
Ireland	503	(2.7)	32	(1.8)	13.4	(1.4)	503	(2.4)	39	(2.0)	16.3	(1.6)
Italy	457	(2.9)	25	(2.2)	7.4	(1.3)	466	(3.1)	34	(2.0)	13.5	(1.3)
Japan	557	(5.5)					534	(4.0)	46	(4.1)	11.6	(1.7)
Korea	547	(2.8)	32	(2.4)	11.0	(1.5)	542	(3.2)	41	(3.1)	14.2	(1.9)
Latvia	463	(4.5)	31	(3.8)	5.6	(1.3)	483	(3.7)	38	(2.3)	10.6	(1.3)
Liechtenstein	514	(7.0)	33	(8.6)	10.6	(4.7)	536	(4.1)	55	(5.9)	20.9	(3.7)
Luxembourg	446	(2.0)	32	(1.9)	17.1	(1.8)	493	(1.0)	35	(1.2)	17.1	(1.0)
Macao-China							423	(6.7)	45	(4.8)	1.9	(0.9)
Mexico	387	(3.4)	30	(2.2)	17.8	(2.6)	385	(3.6)	29	(1.9)	17.1	(2.1)
Netherlands							538	(3.1)	45	(2.4)	18.6	(1.7)
New Zealand	537	(3.1)	42	(2.6)	16.1	(1.8)	523	(2.3)	44	(1.6)	16.8	(1.2)
Norway	499	(2.8)	34	(2.7)	10.5	(1.6)	495	(2.4)	44	(1.7)	14.1	(1.1)
Poland	470	(5.5)	44	(3.6)	14.0	(2.1)	490	(2.5)	45	(1.8)	16.6	(1.2)
Portugal	454	(4.1)	34	(2.1)	16.6	(2.2)	466	(3.4)	29	(1.2)	17.5	(1.5)
Russian Federation	478	(5.5)	38	(4.0)	7.2	(1.5)	468	(4.2)	39	(2.3)	10.0	(1.1)
Serbia							437	(3.8)	36	(2.0)	14.1	(1.4)
Slovak Republic							498	(3.3)	53	(2.6)	22.2	(1.9)
Spain	476	(3.1)	33	(2.0)	14.8	(1.8)	485	(2.4)	33	(1.7)	14.1	(1.3)
Sweden	510	(2.5)	38	(2.2)	12.1	(1.5)	509	(2.6)	42	(2.1)	15.3	(1.3)
Switzerland	529	(4.4)	44	(2.3)	17.1	(1.8)	527	(3.4)	47	(2.1)	16.8	(1.3)
Thailand	432	(3.6)	26	(3.0)	8.4	(1.9)	417	(3.0)	27	(2.6)	11.7	(1.9)
Tunisia							359	(2.5)	24	(2.4)	13.0	(2.4)
Turkey							423	(6.7)	45	(4.8)	22.3	(3.7)
United Kingdom	529	(2.5)	42	(2.0)	18.8	(1.8)						
United States	493	(7.6)	50	(2.8)	23.7	(2.6)	483	(2.9)	45	(1.6)	19.0	(1.2)
Uruguay							422	(3.3)	38	(2.1)	15.9	(1.6)
OECD average	500	(0.7)	42	(0.6)	17.9	(0.4)	500	(0.6)	45	(0.4)	20.3	(0.3)

Notes.

1. Slope is indicated as the score point difference associated with one unit (i.e. one standard deviation) on the ESCS.
2. Strength of relationship is the percentage of variation in student performance explained by variation in ESCS.
3. S.E. refers to the standard error.

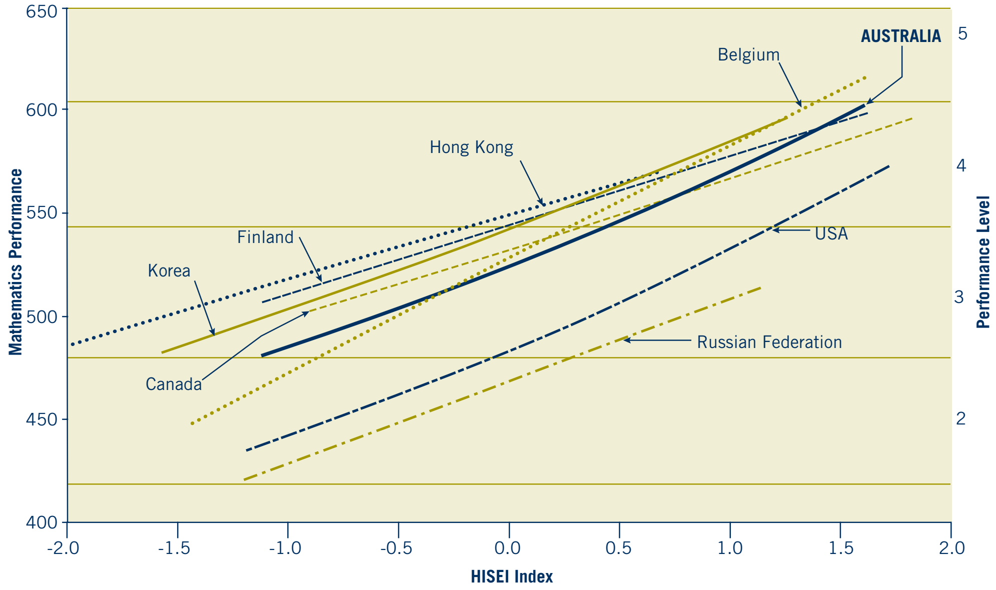

Figure 6.7 *Mathematical Literacy* Scores by ESCS Index in Selected Countries, PISA 2003

Care should also be taken in interpreting an increased slope of the graph as indicating a general inequality in a society. Socioeconomic gradients refer to the relationship between an outcome and a particular measure of socioeconomic background, whereas inequality refers generally to the extent to which wealth or income are distributed across members of a society. Although countries with relatively steep gradients may tend to have greater income inequality, and those with shallow gradients may have relatively less income inequality, this is not necessarily the case. The steepness is an indicator of how well students of different socioeconomic backgrounds do in a particular assessment.

The analysis of gradients is a means of characterising student performance and providing guidance for educational policy. Socioeconomic gradients can be used to compare results across the countries and to provide an opportunity to examine changes in gradients that occur from one cycle of PISA to future cycles. It can be noted that Australia's mean on the overall *mathematical literacy* scale was 524, compared to the international mean of 500. The slope of the gradient for Australia in Figure 6.6 follows the general pattern for the OECD as a whole – students with lower ESCS scored less well in the assessment. In Australia the slope is 42.4 which means that for a one standard deviation increase in the ESCS index, there is an associated increase of 42.4 score points in *mathematical literacy* performance. For the OECD average the slope is just a little steeper than this with an increase of 45 points in performance being associated with one standard deviation increase in the ESCS index. It can also be seen that the range of ESCS in Australia is slightly less than that of the OECD average. That is, in Australia, the relationship between socioeconomic background and mathematics performance is less strong than the OECD on average.

The association between performance in *mathematical literacy* and socioeconomic background in Australia can be compared to the association in other countries. In Figure 6.7 Australia's results are shown compared to those for Hong Kong-China, Finland, Belgium, Korea, Canada, the Russian Federation and the United States. These countries are chosen to illustrate a range of different social gradients.

Firstly, the level of the Australian line is above that of the United States, which is a reflection of the fact that Australia has a higher mean performance score than the United States. The lines for Finland and Hong Kong-China are generally at a level higher than Australia's and they are less steep than for Australia. This indicates that in these two countries there is less difference in the scores obtained in PISA between the low ESCS students and the high ESCS students, indicating a relatively high degree of equity in these two countries. Hong Kong-China has a slope of 31.4 (expressed as the change associated with one standard deviation difference in ESCS), while Finland's slope is 34.4. In contrast, the slope for Belgium of 55.2 is amongst the steepest of the countries in PISA 2003 (there are several countries for which the slope is equally steep so just one has been represented). The slope of the line linking performance in *mathematical literacy* with ESCS in PISA 2003 for Australia is less steep than for the OECD average (but the difference is only just significant). The Australian slope is less steep than that for Hungary and Belgium but more steep than Finland, Iceland or Canada. In PISA 2000 the corresponding slope for Australia was not significantly different for the slope for the OECD (although it appeared a little steeper).

Another feature that this graph demonstrates is that there is less difference, generally, between the countries at high levels of ESCS than there is at low levels – the slopes appear to converge slightly at high 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 *mathematical literacy* performance, from country to country, than students with relatively low levels of socioeconomic background. This convergence suggests that the impact of educational experiences on student performance may be greatest for students from lower socioeconomic backgrounds.

Both the length of the line and the position of the extremities show the range of ESCS in a country. The line begins at the 5th percentile of ESCS and finishes at the 95th percentile. It can be seen in Figure 6.5 that Hong Kong-China scores are between -2.0 to 0.7, compared to Australia's range of -1.1 to 1.6, meaning that although the difference between the lower end and upper is 2.7 for both countries, the general level of ESCS in Hong Kong-China is lower.

The data in Table 6.2 show that the relationship between *mathematical literacy* and ESCS in PISA 2003 (as reflected in the percentage of variation in mathematical performance explained by ESCS) was significantly less strong in Australia than for the OECD average. The strength of this relationship was less strong in Australia than in countries such as the United States, the Czech Republic, the Slovak Republic, Germany, Belgium and Hungary. In other words in Australia, student background as reflected in the ESCS was not so strong a determinant of *mathematical literacy* than in these countries. The relationship was stronger in Australia in PISA 2003 than in countries such as Macao-China, Iceland, Hong Kong-China and Indonesia. In PISA 2000 the strength of the relationship between *mathematical literacy* and ESCS had not been significantly different for the OECD average but it had been significantly steeper than in countries such as Hong Kong-China, Iceland, the Russian Federation, Italy, Finland, Canada, Norway, Korea and Sweden.

Differences among domains

Figure 6.8 displays the relationships between performance and ESCS for each of domains of mathematics, reading, science and problem solving in Australia. Those data indicate that the slopes for each of the domains were very similar. The least steep of the slopes was for problem solving. The slope for mathematics was just a little less than for reading which was in turn a little less steep than science.

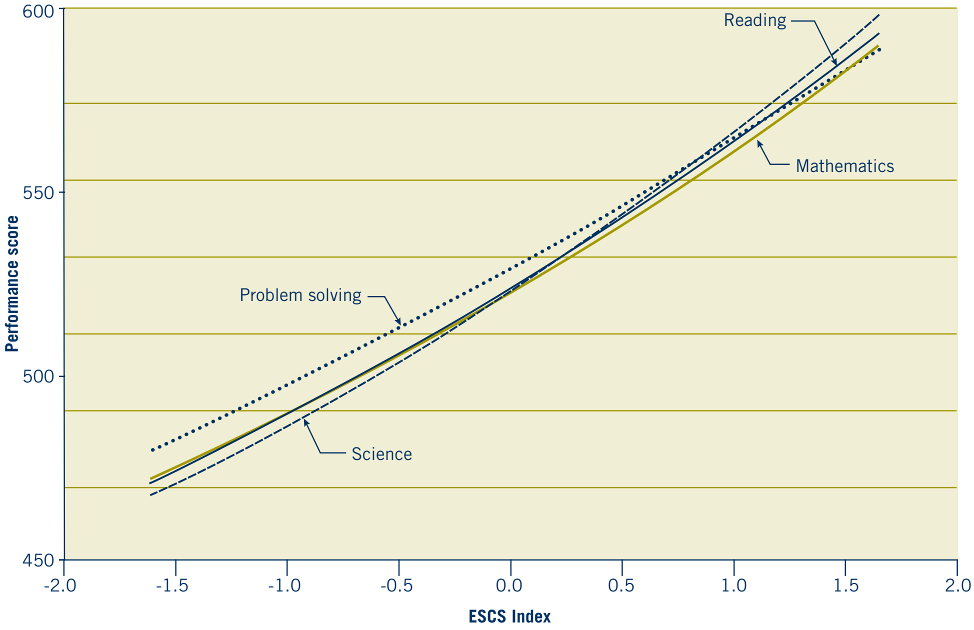

Figure 6.8 *Mathematical*, *Reading*, *Scientific Literacy* and Problem Solving Scores by ESCS Index in Australia

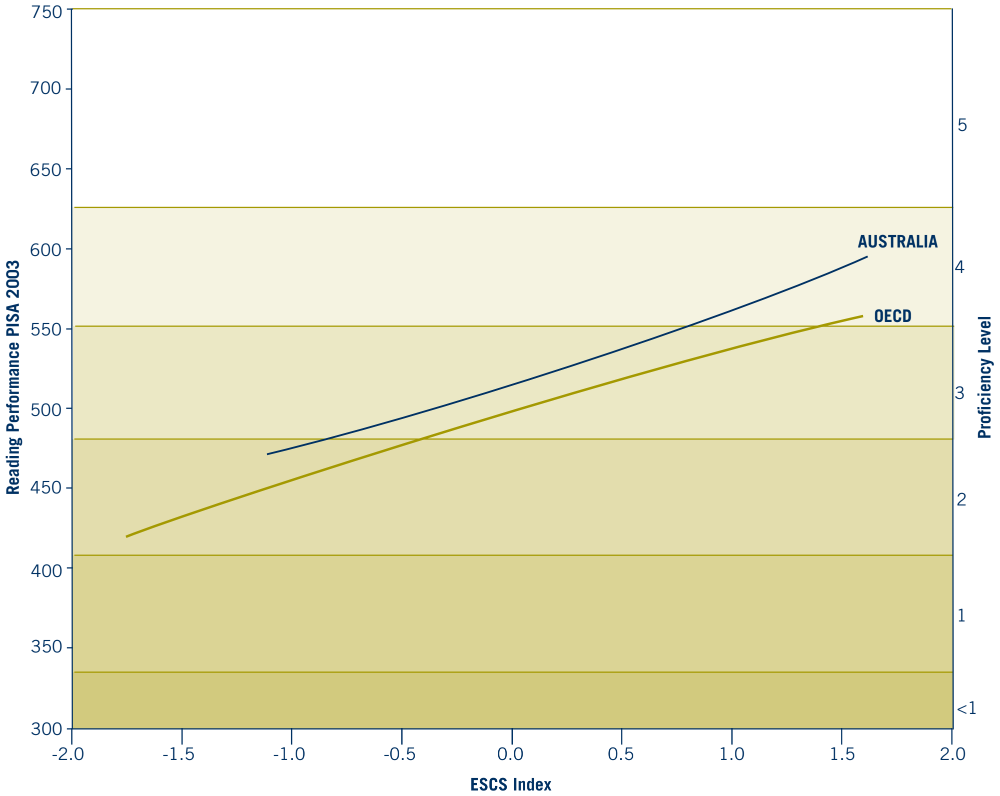

Figure 6.9 *Reading Literacy* by ESCS Index for Australia and the OECD, PISA 2003

Figure 6.9 shows the relationship between reading performance and ESCS for Australia and for the OECD average in 2003. It can be seen that for reading the pattern was similar to that for mathematics. Performance on *reading literacy* in Australia was higher than the OECD average and slope of the social gradient was similar to that for the OECD average, that is, it is not significantly different to the OECD average.

The next section of this chapter examines the relationship between *mathematical literacy* performance and a number of other factors related to students' background.

>> *Family structure*

Students were asked who usually lived at home and their responses were grouped into four categories:

- nuclear family (student lives with a mother and a father);
- single parent family (student lives with one of mother, father, female or male guardian) ;
- mixed family (student lives with mother and male guardian, father and female guardian or two guardians); and
- other family combinations (including other relatives).

Almost 70 per cent of the Australian PISA students lived in a nuclear family. On average, these students performed at a significantly higher level than students living in other family structures (Figure 6.10). The eight per cent of students living in a mixed family performed slightly higher than the twenty per cent of students living in a single parent family. The three per cent of students living in an other family structure performed less well compared to students living in other types of family groups. However, it should be noted that this analysis has not allowed for differences in other associated factors, such as socioeconomic background.

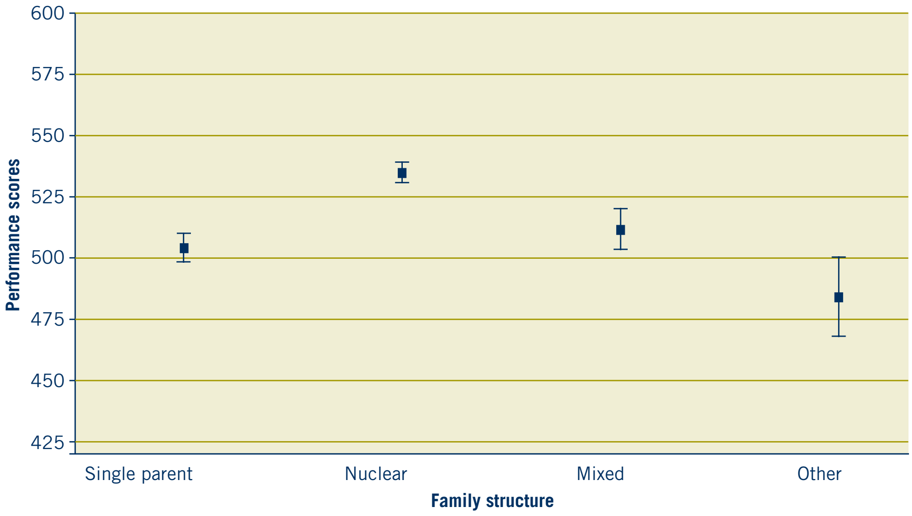

Figure 6.10 Relationship between Family Structure and *Mathematical Literacy* Performance, Australia, PISA 2003

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Country of birth and immigration status

The Australian PISA Student Questionnaire asked students to indicate their country of birth from a list of 14 countries, including Australia. An additional category was available for students to specify their country of birth if it was not included in the previous categories. For the purposes of reporting by immigration status a collapsed variable is used. 'Australian-born' students are identified as those students who were born in Australia, with at least one of their parents born here. 'First-generation' students were those students who were born in Australia but whose parents were foreign-born. 'Foreign-born students' are those students who were foreign-born and whose parents were also foreign-born. Seventy seven per cent of the students were Australian-born. Twelve per cent of students were first-generation students and eleven per cent of students were identified as foreign-born students.

The effect of immigration status on performance was slightly different across the assessment areas. For *mathematical literacy*, performance was not significantly affected by the immigration status of the student. Although there were no significant differences on *reading* or *scientific literacy* performance between the Australian and first-generation students or between the first-generation and foreign-born students, significant differences were found between the Australian-born and foreign-born students. In PISA 2000 there were no significant differences based on immigration status for *reading literacy*. The *reading* and *scientific literacy* performance of Australian born students was significantly higher than that of the foreign-born students. No significant differences were found between the first-generation and foreign-born students. Performances across the three literacy domains and for problem solving are shown in Figure 6.11, and the means are shown in Table 6.3.

Table 6.3 Means and Standard Errors for all Domains by Immigration Status

	Australian-born students		First-generation students		Foreign-born students	
	Mean	SE	Mean	SE	Mean	SE
Mathematical Literacy	527	2.1	522	4.7	525	4.9
Reading Literacy	529	2.2	525	4.6	517	5.0
Scientific Literacy	529	2.1	520	4.7	515	5.5
Problem Solving	534	2.1	521	4.0	523	4.8

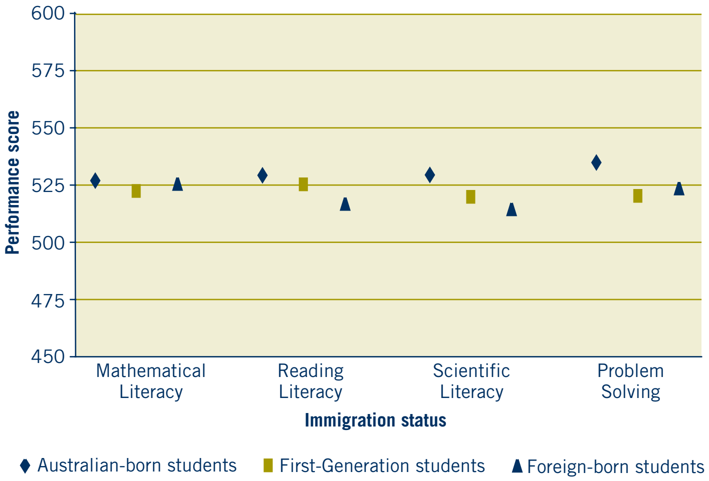

Figure 6.11 Relationship between Immigrant Status and *Mathematical Literacy* Performance, Australia, PISA 2003

Language spoken at home

Students were asked what language they speak at home most of the time.[7] Ninety-one per cent of students participating in PISA spoke English at home. Asian languages were spoken in the home most of the time by four per cent of students, followed by European languages (three per cent of students) and Middle Eastern languages (two per cent of students). A very small percentage (0.05) spoke an Indigenous Australian language at home most of the time. Students from Tasmania, then Queensland and Western Australia had the highest percentages speaking English most of the time at home. Students from New South Wales had the highest percentage of Asian language speakers and students from the Australian Capital Territory and Victoria had the highest percentage of European language speakers.

As for immigrant status, the relationship between language spoken at home and student performance was negative (i.e. those students who spoke English in the home most of the time performed at a higher level than those student who spoke a language other than English in the home. However the effects are very small. The correlation coefficients for *scientific literacy* was -0.07, for both *reading literacy* and problem solving the coefficient was -0.06 and for *mathematical literacy* the correlation coefficient was -0.04.

Students' educational intentions

Although students' educational intentions might not be a background factor in the same sense as parental occupational status they do represent an orientation to education beyond school that has been developed over preceding years. Students were asked about their future educational plans and the level of education they expect to achieve. About sixty per cent of Australian students expected to complete a university degree, eight per cent a TAFE diploma, 23 per cent Year 12 or a TAFE training certificate and six per cent expected to complete no more than Year 10, 11 or a training course.

Significantly more females intended to complete a university degree or TAFE diploma than males. A higher percentage of males than females intended to complete a Year 12 or TAFE training certificate or Year 10 or 11 plus a training course or Year 10 than females.

The association between students' educational intentions and performance in PISA was found to be one of the strongest of all student factors: for *mathematical literacy*, *scientific literacy* and *reading literacy*, $r = 0.46$. Although these correlation coefficients identify the strength of the association between two variables, the direction of the causality is not clear. An intention to pursue further education could result in enhanced performance or a high level of performance could result in an increased disposition to continue in education.

Figure 6.12 shows this relationship for *mathematical literacy*. Students intending to complete a university degree scored, on average, 130 points higher in *mathematical literacy*, 147 points in *scientific literacy* and 155 points in *reading literacy* compared to those students who intended on completing only Year 10.

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[7] Language spoken at home in PISA 2003 has been modified since PISA 2000. Subsequently comparisons cannot be made between this variable.

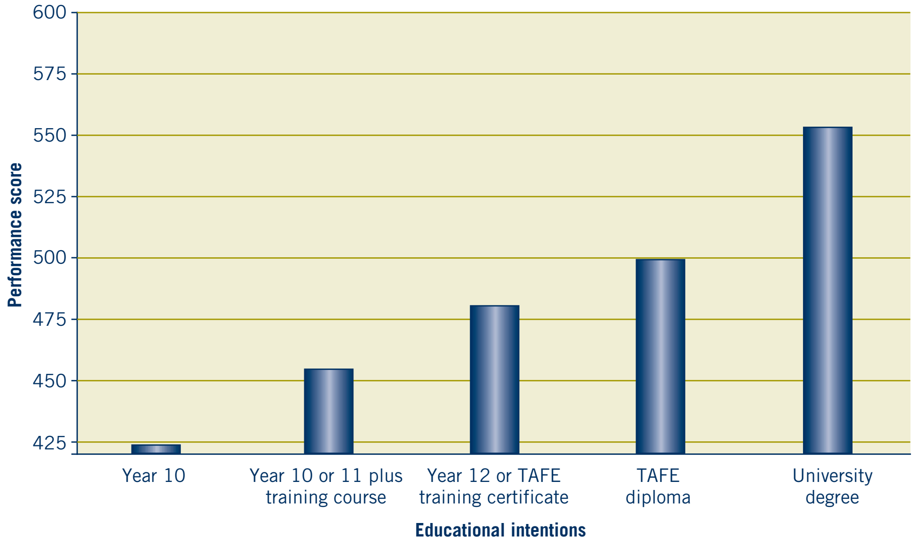


Figure 6.12. Relationship between Students' Educational Intentions and *Mathematical Literacy* Performance, Australia, PISA 2003

Students' occupational aspirations

Students' occupational aspirations have a similar influence on performance in PISA 2003 as students' educational intentions, although not quite as strong. The index was constructed using the same methods as the parents' occupational index. Students were asked to provide details about their anticipated occupation at 30 years of age. An index of students' occupational aspirations was constructed by coding the open-ended responses using the International Standard Classification of Occupations (ISCO) and then transforming these values onto an index similar to HISEI, ranging from 0 to 90.

Students' expected occupation was based on data from 25 countries, ranging from Mexico with the highest mean (63.4) to Austria with the lowest mean (51.0) on this index. Australia had a mean of 57.6, compared to the OECD average of 59.2.

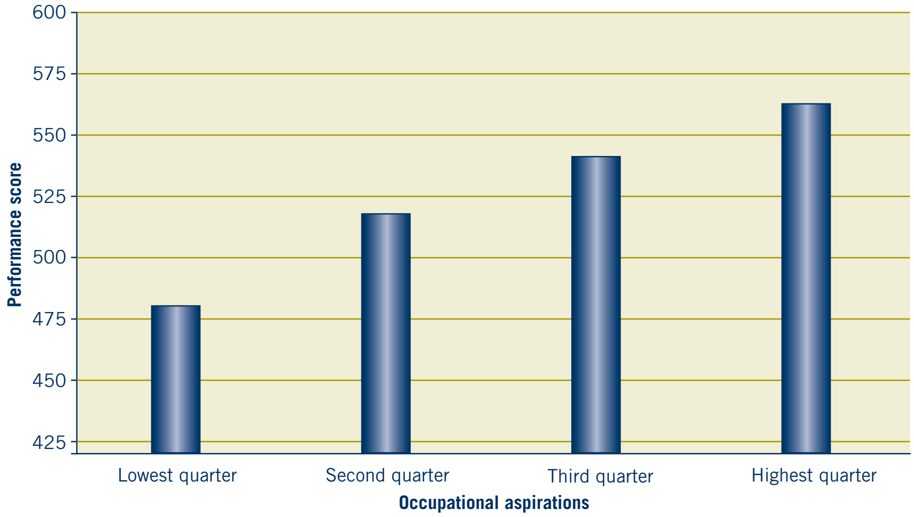


Figure 6.13 Relationship between Students' Occupational Aspirations and *Mathematical Literacy* Performance, Australia, PISA 2003

The correlation coefficients between students' expected occupation and performance in PISA in Australia was slightly lower than that for students' educational aspirations. The correlation coefficient was slightly higher for *reading literacy* at 0.37 than for either *mathematical literacy* and *scientific literacy* (0.34). The pattern has been represented in Figure 6.13.

>> *Summary*

This chapter examined the effects of student background factors on *mathematical literacy*, and in particular on the effects of socioeconomic background. Aspects of student's home background such as educational and computer resources, cultural possessions and parents' educational attainments were each correlated positively with mathematics performance (the correlation coefficients were a little greater than 0.2 for each of these items). Socioeconomic background was measured in two ways, first with the *PISA International Socioeconomic Index of Occupational Status* (HISEI) based on parental occupations and second, using the PISA *Index of Economic, Social and Cultural Status* (ESCS) which was a broader measure that incorporated parents'occupation, education, home educational resources and number of books in the home.

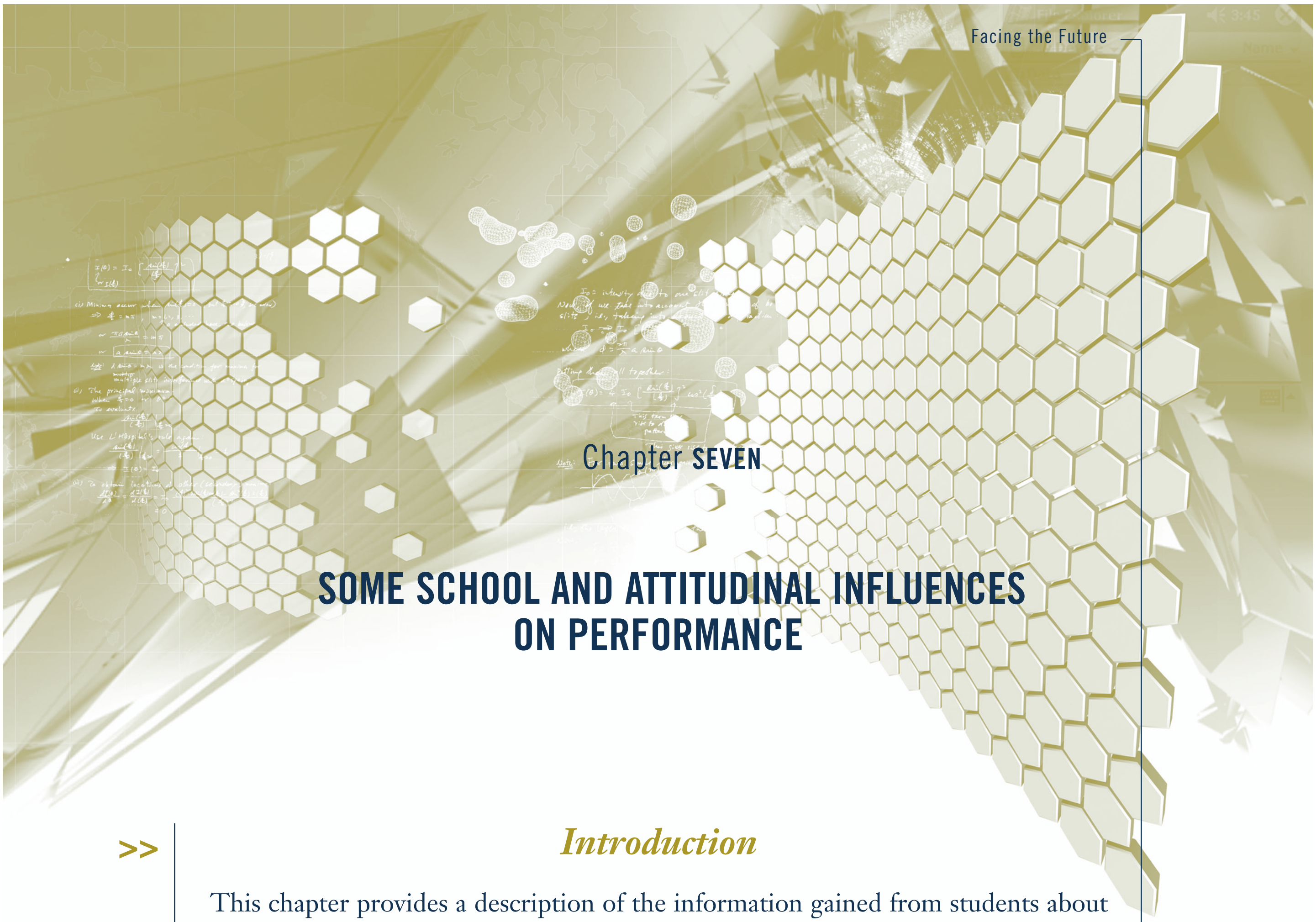
The relationship between socioeconomic background and performance followed a similar trend in Australia as in other countries. There was a moderately strong association between socioeconomic background and performance in *mathematical*, *reading* and *scientific* literacy, as well as problem solving. The relationship between socioeconomic background and performance can be looked at in terms of slope and scatter.

The slope indicates on average how much difference in performance is associated with a given difference in socioeconomic background. For *mathematical literacy* in PISA 2003 the slope was just a little less than for the OECD average (although the difference was not significant). The slope for Australia was less steep than that for Hungary and Belgium but more steep than Finland, Iceland or Canada. In PISA 2000 the corresponding slope for Australia was a little steeper (but still not significantly different from) than the slope for the OECD average.

Scatter refers to the extent to which results for individuals are scattered around the average line rather than being close to it. It indicates the strength of the relationship and is measured by the percentage of the variation in performance accounted for by socioeconomic background. In Australia for PISA 2003 the strength of the relationship between socioeconomic background and performance in *mathematical literacy* was less than for the OECD on average. The strength of this relationship was less strong in Australia than in countries such as the United States, Germany or Belgium, indicating that student background as reflected in the ESCS was not so strong a determinant of *mathematical literacy* in Australia as in these countries. The relationship was stronger in Australia than in countries such as Finland, Iceland or Hong Kong-China. In PISA 2000 the strength of the corresponding relationship in Australia was not significantly different from that of the OECD on average.

The effects of several other characteristics of students or their families were investigated. Students living in nuclear families were found to do better than those in other types of family structures, although this was also by far the most typical family structure. For *mathematical literacy*, performance was not significantly affected by the immigration status of the student, and the relationship between language spoken at home and student performance was weakly negative, however these effects are very small. The association between students' educational intentions and performance in PISA was found to be one of the strongest of all student factors, and the relationship between students' expected occupation and performance in PISA was also substantial, although slightly lower than that for students' educational aspirations.

Student background characteristics have an effect on performance, as do a number of school and classroom characteristics. The influence of these characteristics, as well as the effects of student motivation, learning strategies, and beliefs and attitudes about mathematics on *mathematical literacy*, will be examined in Chapter 7. In addition, results of a multilevel analysis investigating the effects of all of the student, class and school characteristics described in these chapters will be reported and discussed.



Chapter SEVEN

SOME SCHOOL AND ATTITUDINAL INFLUENCES ON PERFORMANCE

Introduction

This chapter provides a description of the information gained from students about their schools and classroom environment, and their attitudes, motivations, learning strategies and preferences. Following this, the relationships between these factors and student performance in PISA are examined. Results are provided within both an international and national context. The chapter continues with a multivariate analysis of the association of student factors (including student background, attitudes and beliefs and learning strategies) and school factors on student performance. A model for *mathematical literacy* is developed to identify those factors most likely to affect student performance. The chapter concludes with a commentary on the factors related to student performance in PISA.

School environment

The school setting potentially plays a role in influencing student attitudes, behaviour and performance. The results from PISA 2000 suggested that a supportive environment, which included a climate characterised by high expectations and good teacher-student relations, influenced students' performance. PISA asked students about their attitude to school as well as their relationships with teachers and their peers.

Attitudes towards School

PISA collected information about students' attitudes to school by asking them to think about what they have learned in school and answer to what extent they agreed with the following statements:

- School has done little to prepare me for adult life when I leave school.
- School has been a waste of time.
- School has helped give me confidence to make decisions.
- School has taught me things which could be useful in a job.

Using the four items listed above, an index summarising *students' attitudes to school* was constructed. The index, like all the indices that involve student responses to multiple questions was scaled using a weighted maximum likelihood estimate (OECD, 2004a). 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 attitudes of Australian students towards school were more positive, by a quarter of a standard deviation, than for the OECD average. Australia had the seventh highest mean score on this index (Figure 7.1). Tunisian students, with a mean score of three quarters of a standard deviation above the OECD average, were the most positive in their *attitudes towards school*. Students with the least positive *attitudes towards school* were in Japan and Hong Kong-China. These countries had mean scores half a standard deviation below the OECD average.

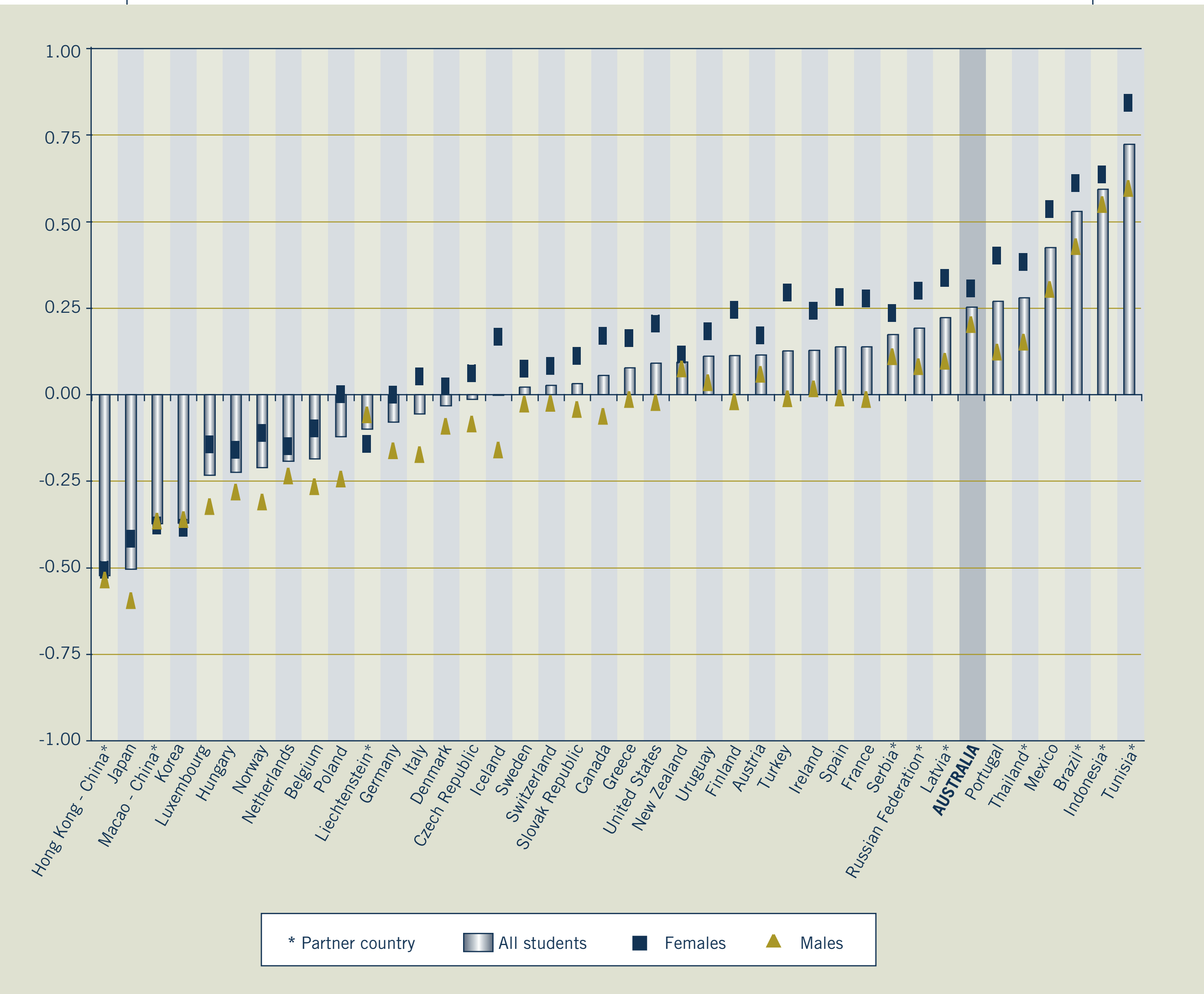


Figure 7.1 *Attitude Towards School* Index by Country and Gender

Almost 90 per cent of countries, including Australia, recorded significant gender differences in *attitudes towards school*, with females having more positive *attitudes towards school* than males. Australian females had a mean a third of a standard deviation above the OECD average compared to a fifth of a standard deviation above the OECD average for males. Iceland and Turkey reported the largest gender differences of about a third of a standard deviation with females reporting more positive *attitudes towards school*.

Although the relationship between *attitudes towards school* and student performance was positive, the correlation was relatively weak. In Australia, the relevant correlation coefficients were 0.15 for *mathematical literacy*, 0.18 for *scientific literacy*, 0.19 for r*eading literacy*, and 0.16 for problem solving.

Student-teacher relations

Students were asked to indicate the extent to which they agreed with the following statements with reference to all the teachers at their school:

- Students get along well with most teachers.
- Most teachers are interested in students' well-being.
- Most of my teachers really listen to what I have to say.
- If I need extra help, I will receive it from my teachers.
- Most of my teachers treat me fairly.

An index, *student-teacher relations*, was constructed using the items listed above. Figure 7.2 shows that Australia had a mean score of 0.2 on the *student-teacher relations* index, indicating Australian students reported more favourable relationships with their teachers than the OECD average. Students from the United States, Sweden, Canada and Portugal had mean scores similar to Australia. Students from Mexico, Thailand, Brazil and Indonesia recorded higher levels of satisfaction with *student-teacher relations* with mean scores exceeding 0.5. Students from Japan and Luxembourg had the lowest levels of satisfaction with student-teacher relations with mean scores of about -0.4.

In some countries, males reported more favourable *student-teacher relations* than females. The largest of the gender differences in this direction were found in Serbia. However in many more countries, females reported more favourable *student-teacher relations* than males. The largest of these were in Spain and Iceland where the gender differences were approximately a fifth of a standard deviation. Australian females reported more favourable *student-teacher relations* than their male counterparts, with the mean scores being 0.28 and 0.13 respectively.

In Australia, the relationship between *student-teacher relations* and performance in PISA is relatively similar to that for the relationship between attitudes towards school and student performance. The correlation between both *reading literacy* and problem solving and *student-teacher relations* is 0.2. The correlation coefficients between *student-teacher relations* and *mathematical literacy* and *scientific literacy* are 0.18 and 0.19 respectively. On average, students scored 14 points higher in *mathematical literacy* performance per unit on the *student-teacher relations* index.

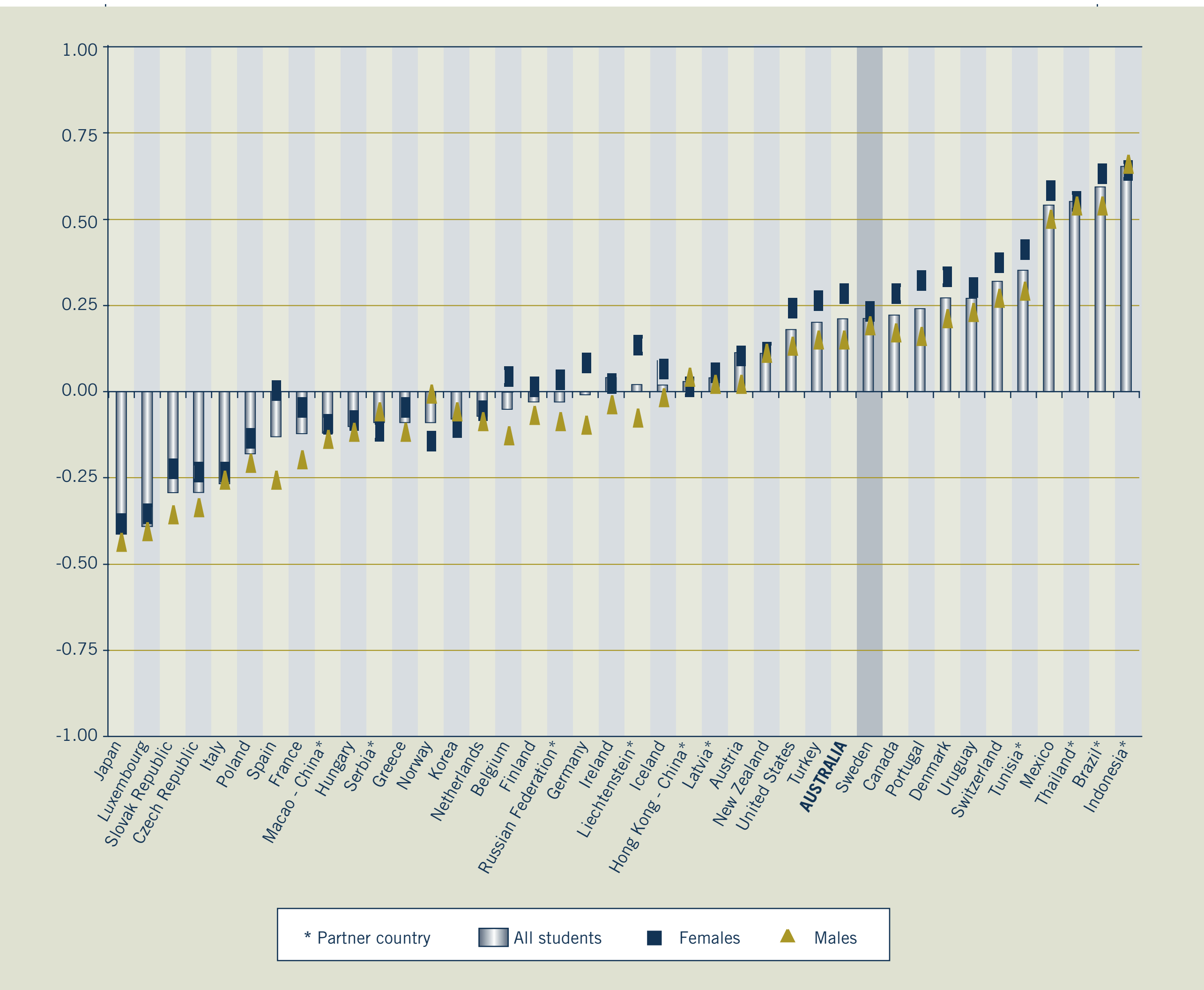


Figure 7.2 *Student-Teacher Relations* Index by Country and Gender

Sense of belonging

PISA collected information on the students' perceptions about their sense of belonging to their school. Students were asked to indicate whether they agreed with the following statements:

- I feel like an outsider (or left out of things).
- I make friends easily.
- I feel like I belong.
- I feel awkward and out of place.
- Other students seem to like me.
- I feel lonely.

The above items were used to construct the *sense of belonging* index. Australia's mean on the *sense of belonging* index was 0.04, around the OECD average. Macao-China, Hong Kong-China and Japan reported the lowest *sense of belonging* with scores more than a half a standard deviation below the OECD average. Austria reported the highest *sense of belonging* with a mean of almost a half a standard deviation above the OECD average (Figure 7.3).

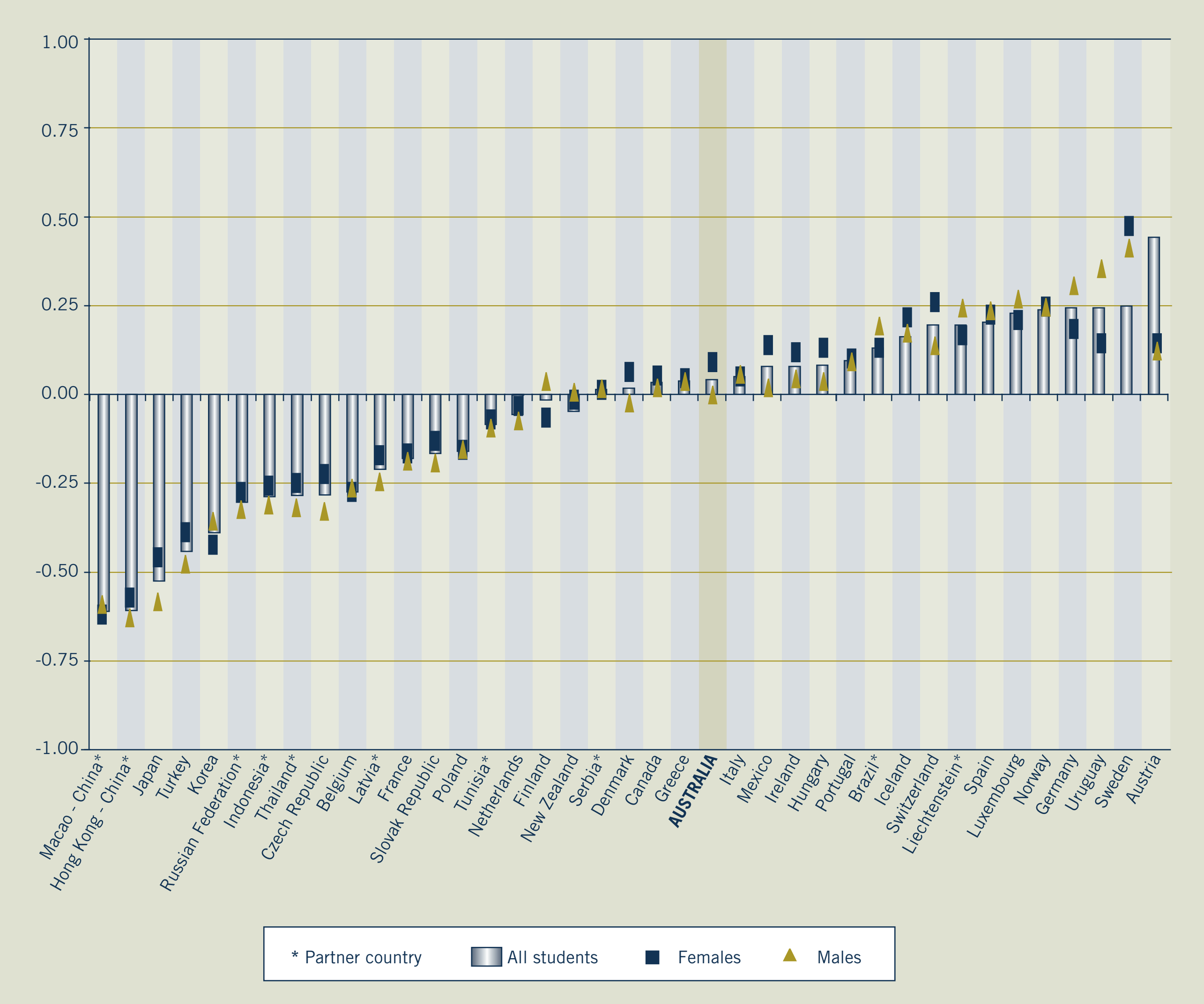


Figure 7.3 *Sense of Belonging* Index by Country and Gender

Significant gender differences were found in about half the countries, but there was no clear pattern. Among the countries where females had a greater *sense of belonging* than males were Australia, Hungary, Belgium and Japan. On the other hand, males from Uruguay and Germany had higher mean scores than females. The mean for Australian females was 0.09 compared to a mean for Australian males at the OECD average (0.0).

In Australia, *sense of belonging* and student performance were barely correlated with each other. The correlation coefficient with *sense of belonging* scores was 0.03 for *mathematical literacy*, 0.04 for *scientific literacy*, 0.05 for problem solving and 0.06 for *reading literacy*.

Classroom environment

The classroom setting is another influence on students that may help in understanding their performance. PISA examined the influence of supportive teacher practices and the disciplinary climate in mathematics lessons on student performance.

Teacher support

Students reported the frequency with which the following teaching practices occured in their mathematics lessons:

- The teacher shows an interest in every student's learning.
- The teacher gives extra help when students need it.
- The teacher helps students with their learning.
- The teacher continues teaching until the students understand.
- The teacher gives students an opportunity to express opinions.

The statements were used to create an index for classroom environment related to *teacher support*. Students from Thailand and Brazil reported the highest levels of *teacher support*, with means of 0.56 and 0.67 respectively. At the other end of the spectrum, students from Japan and Austria reported the lowest levels of *teacher support*, with means more than a third of a standard deviation below the OECD average. Australia's mean, the eleventh highest on the *teacher support* index, was 0.25, which was significantly above the OECD average (Figure 7.4).

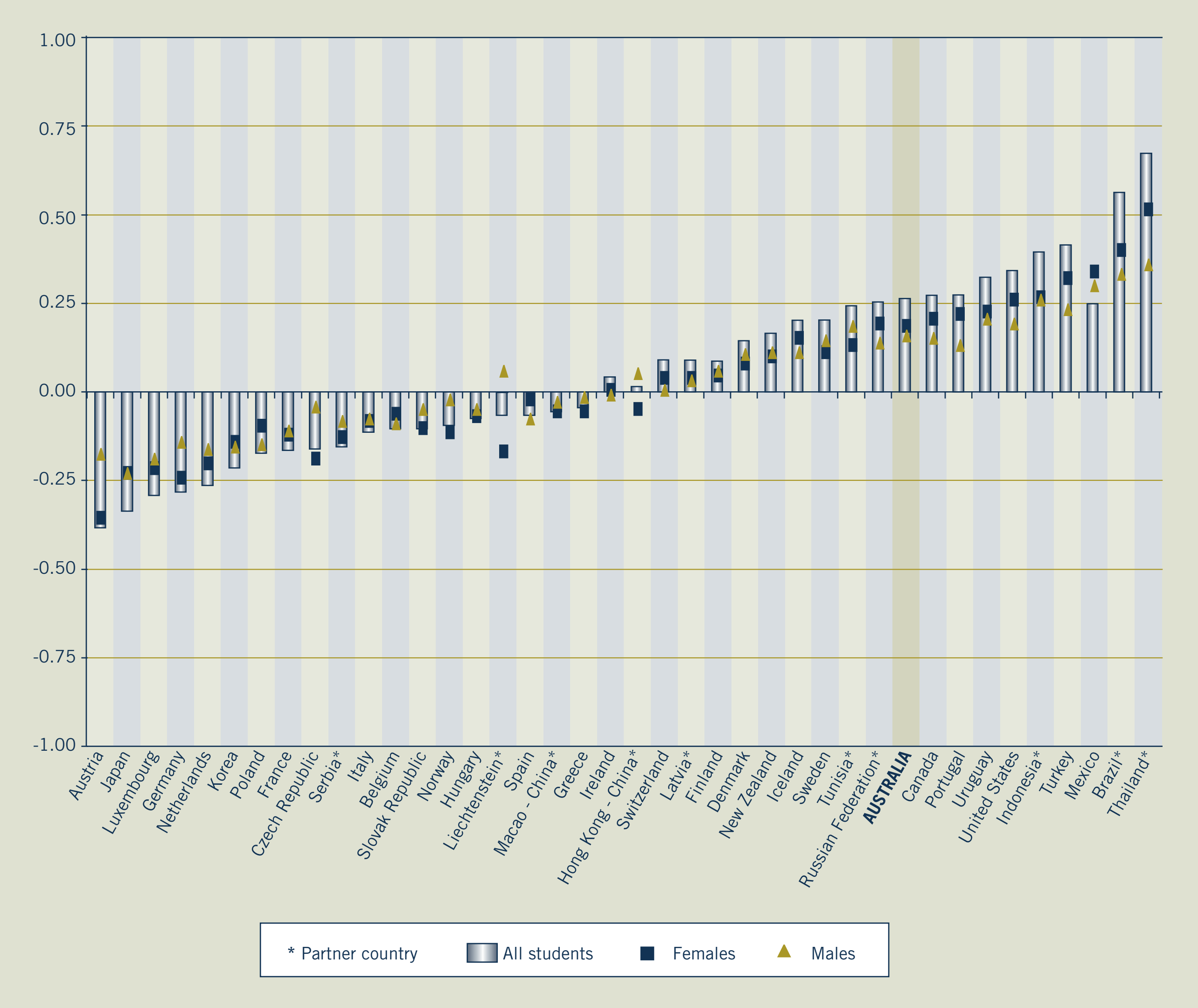


Figure 7.4 *Teacher Support* Index by Country and Gender

There was no significant difference in Australia between males and females. In about half the countries, gender differences were in favour of males, with Liechtenstein and Austria reporting the largest differences of about a third of a standard deviation. On the other hand, gender differences in favour of females were largest in Thailand with the difference about a quarter of a standard deviation above the OECD average.

In Australia, there was a weak positive association between *teacher support* and *mathematical literacy* performance (r = 0.11). Figure 7.5 shows students in the highest quarter scored about 28 points higher than students in the lowest quarter.

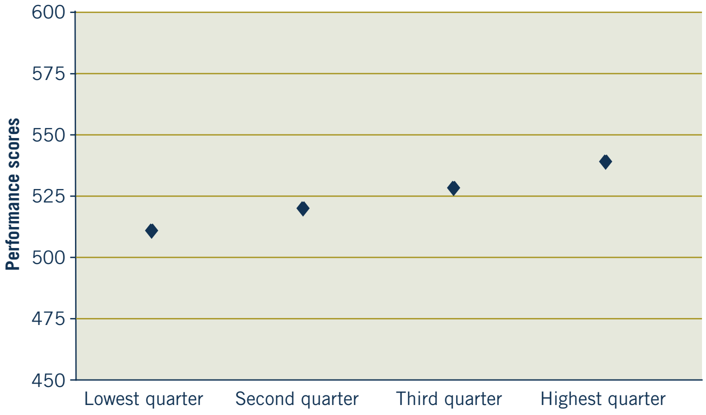


Figure 7.5
Relationship between *Teacher Support* and *Mathematical Literacy* Performance for Australian Students

On average, students scored eight points higher on *mathematical literacy* performance per unit increase in the *teacher support* index.

Disciplinary climate

In addition to teacher support, a second factor affecting classroom climate was examined. Students were asked about disruptive behaviours and how frequently they occur in their mathematics lessons. Students were asked their level of agreement with the following items:

- Students don't listen to what the teacher says.
- There is noise and disorder.
- The teacher has to wait a long time for students to quieten down.
- Students cannot work well.
- Students don't start working for a long time after the lesson begins.

These items listed above were combined to create the *disciplinary climate* index. On average, Australian students' perception of the *disciplinary climate* did not differ from the OECD average. The highest score (most positive) on the index was for the Russian Federation (0.49), followed by Japan (0.44). Lowest on the index was Brazil (-0.35) and Norway (-0.25). This can be seen in Figure 7.6.

In all countries, females had a more positive perception of *disciplinary climate* than males. The largest gender differences, a third of a standard deviation, occurred in Japan, Italy and Thailand. In Australia, females had a mean of 0.04 compared to the mean for males of -0.06 on the index.

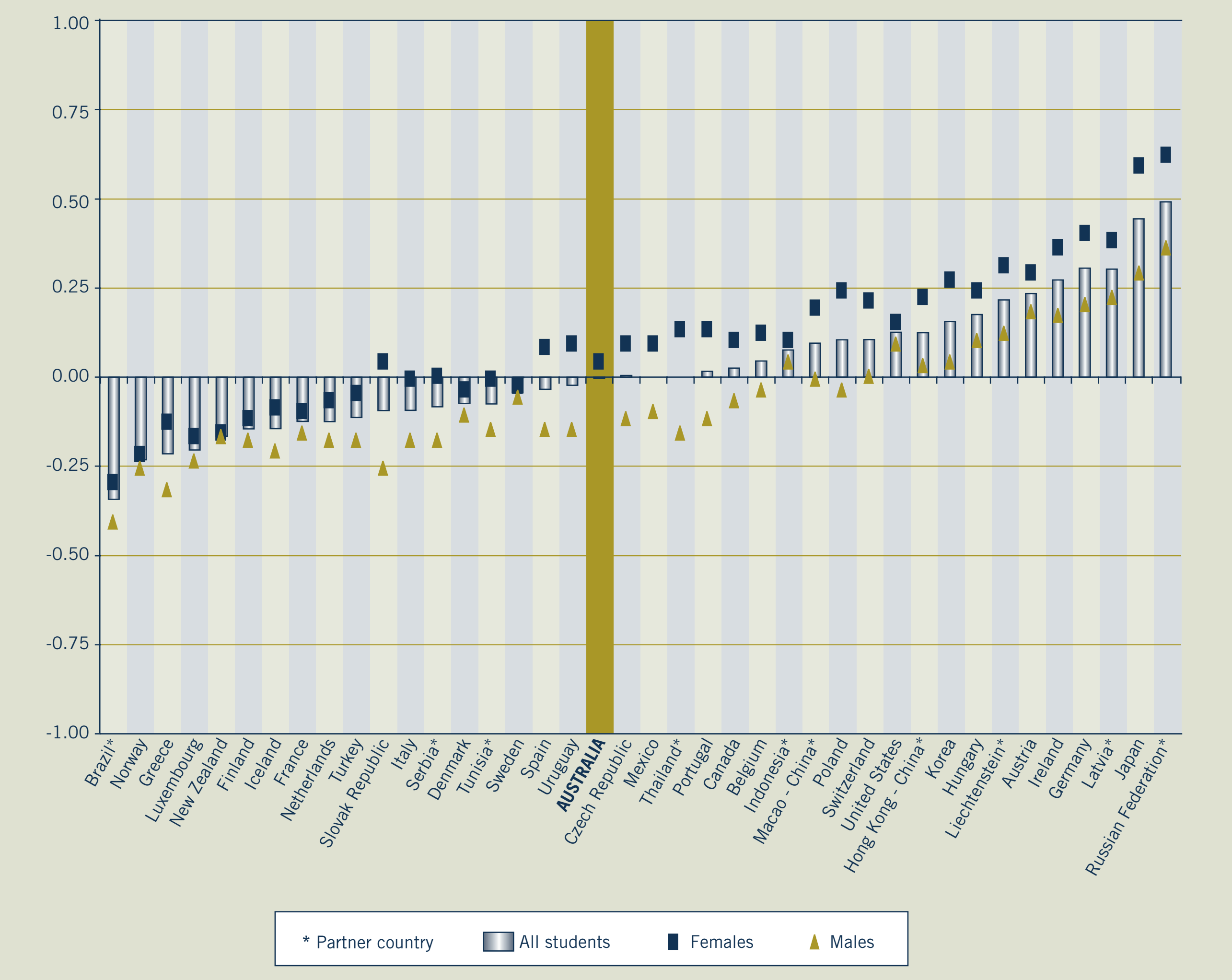


Figure 7.6 *Disciplinary Climate* Index by Country and Gender

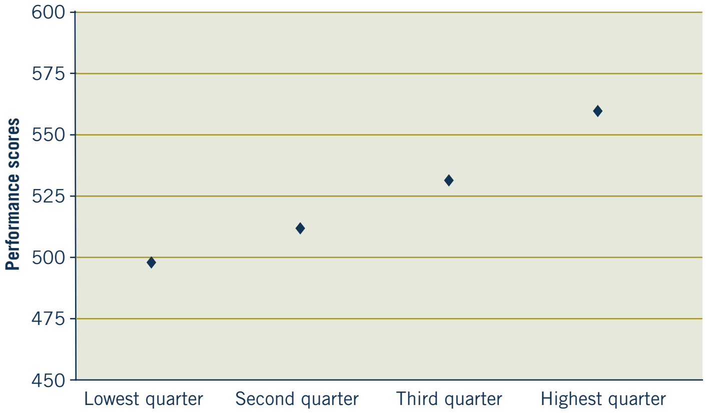


Figure 7.7 Relationship between *Disciplinary Climate* and *Mathematical Literacy* Performance for Australian Students

Figure 7.7 shows the association between *disciplinary climate* and *mathematical literacy* performance for Australian students (r = 0.23). This was stronger than the relationship between *teacher support* and *mathematical literacy* performance. There was a 62 point difference on the *mathematical literacy* performance between students in the highest and lowest quarter on this index.

Disciplinary climate explained five per cent of the variation[1] in *mathematical literacy* performance. On average, students scored 15 points higher on *mathematical literacy* performance per unit increase in the *disciplinary climate* index.

[1] When the proportion of variance in *mathematical literacy* explained by the index is less than five per cent, it is considered to be trivial and will not be reported. If the proportion of variance is required, it can be calculated by the reader as the square of the correlation coefficient.

Students' motivation to learn mathematics

Motivation is an important factor in initiating and directing learning. Students are encouraged to learn by both internal and external incentives; their interest in a subject, the praise from a teacher, the score on a test, or the long term goal of attaining a tertiary qualification. Two indices were developed in PISA to assess students' motivation to learn mathematics. The *interest and enjoyment in mathematics* index focuses on students' own, or internal, motivations to learn and the *instrumental motivation in mathematics* index, which focuses on the external rewards that encourage students to learn.

Interest and enjoyment in mathematics

Students were asked to think about their views on mathematics and indicate their agreement on the following statements:

- I enjoy reading about mathematics.
- I look forward to my mathematics lessons.
- I do mathematics because I enjoy it.
- I am interested in the things I learn in mathematics.

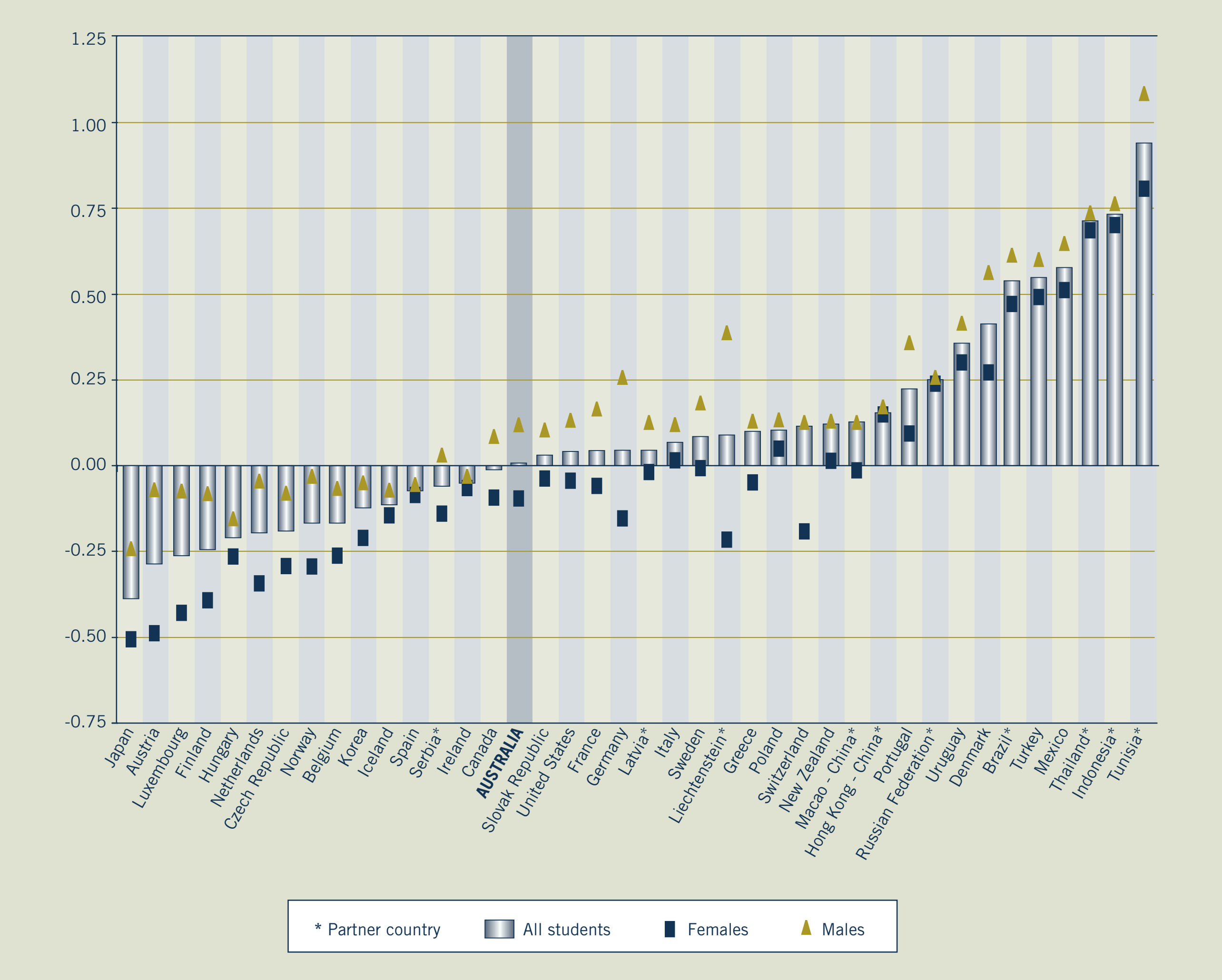


Figure 7.8 *Interest and Enjoyment in Mathematics* Index by Country and Gender

The index on *interest and enjoyment in mathematics* was constructed using these items. Australia's mean on the *interest and enjoyment in mathematics* index was 0.01 and thus not significantly different from the OECD average. Figure 7.8 shows that the country with the highest level of *interest and enjoyment in mathematics* was Tunisia, with a value one standard deviation above the OECD average. On the other hand, the lowest levels of *interest and enjoyment in mathematics* were recorded in Japan (-0.39), Austria (-0.28) and Luxembourg (-0.26).

The *interest and enjoyment in mathematics* index illustrates the differing reporting of attitudes among countries. For example, three of the highest performing countries – the Netherlands, Finland and Korea -- but not Hong Kong-China, had means on this index that were below the OECD average. Students in these countries performed at a high level in mathematics but expressed less *interest and enjoyment in mathematics* than students in other OECD countries. The means for English-speaking countries were concentrated around the OECD average (-0.05 for Ireland, -0.01 for Canada, 0.04 for the United States), except for New Zealand whose mean was 0.12.

In the majority of countries there were significant gender differences, with males reporting higher levels of *interest and enjoyment in mathematics* than females. The mean for Australian males was 0.12 and the mean for females was -0.10.

In Australia, there was a relatively weak positive association between the *interest and enjoyment in mathematics* index and mathematics performance ($r = 0.19$). There were 48 points on *mathematical literacy* performance between the students in the lowest quarter and students in the highest quarter on this index (Figure 7.9).

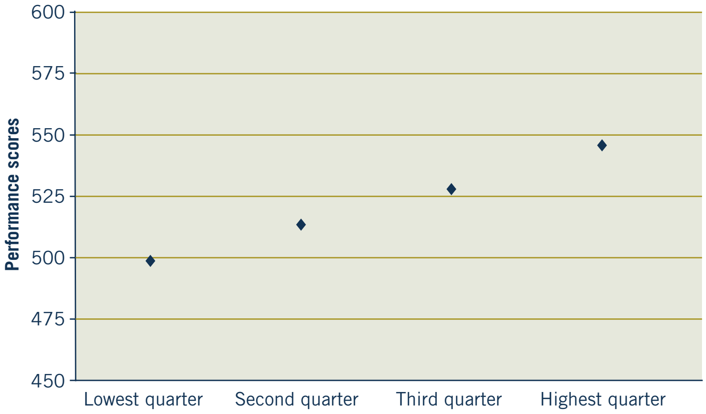


Figure 7.9
Relationship between *Interest and Enjoyment in Mathematics* and *Mathematical Literacy* Performance for Australian Students

On average, students scored 17 points higher per unit increase on the *interest and enjoyment in mathematics* index.

Instrumental motivation in mathematics

Other than having a general interest in mathematics, how do 15-year-olds assess the relevance of mathematics to their life, and what role does 'extrinsic' or 'instrumental' motivation play in mathematics performance? Students' levels of *instrumental motivation* were measured by seeking their responses to statements about the importance of mathematics for their future study and career prospects. Students were asked their level of agreement for each of the following questions:

- Making an effort in mathematics is worth it because it will help me in the work that I want to do later on.

- Learning mathematics is important because it will help me with the subjects that I want to study further on in school.
- Mathematics is an important subject for me because I need it for what I want to study later on.
- I will learn many things in mathematics that will help me get a job.

Figure 7.10 shows the country means on the index of *instrumental motivation* derived from the list of statements above. Students from Mexico and Tunisia had the highest scores on the *instrumental motivation* scale, one half a standard deviation above the OECD average, while students from Japan and Austria had the lowest scores (means of -0.66 and -0.49 respectively). Australia had a mean of 0.23, indicating Australian students were more influenced by *instrumental motivation* than the OECD overall.

Of the high performing countries, three countries had means on this index that were below the OECD average (Korea -0.44; the Netherlands -0.26; and Hong Kong-China -0.12). Finland had a mean just above the OECD average at 0.06. Among the English speaking countries, Ireland had a mean of 0.10, the United States (0.17), Canada (0.23) and New Zealand (0.29).

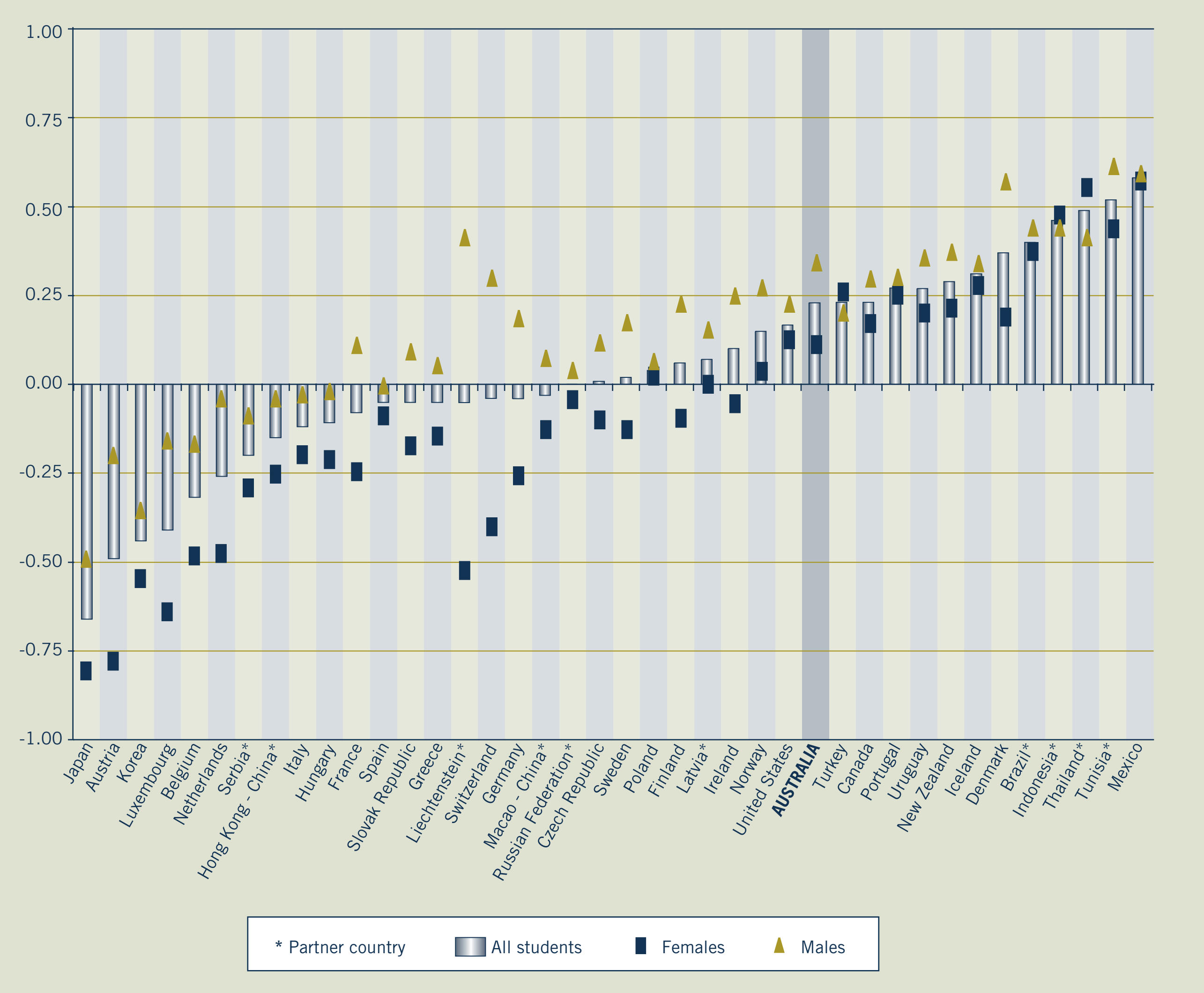


Figure 7.10 *Instrumental Motivation in Mathematics* Index by Country and Gender

Significant gender differences on the *instrumental motivation* index were found in the majority of countries. In all except one country (Thailand), males reported higher levels of *instrumental motivation* than females. The largest gender difference, of almost one standard deviation, was in Liechtenstein. We have already seen in Chapter 2 that gender differences in *mathematical literacy* were also greatest in Liechtenstein, with males substantially out-performing females. The gender difference in Australia was about one quarter of a standard deviation: almost double that of the *interest and enjoyment in mathematics* index. The mean for Australian females on the *instrumental motivation* index was 0.11 and the mean for Australian males was 0.34.

The positive relationship between *instrumental motivation* and *mathematical literacy* performance ($r = 0.17$) was similar to the relationship between *interest and enjoyment in mathematics* and *mathematical literacy* performance for Australian students (Figure 7.11). Students in the highest quarter scored 40 points higher than students in the lowest quarter. On average, students scored 17 points higher per unit increase on the *instrumental motivation* index.

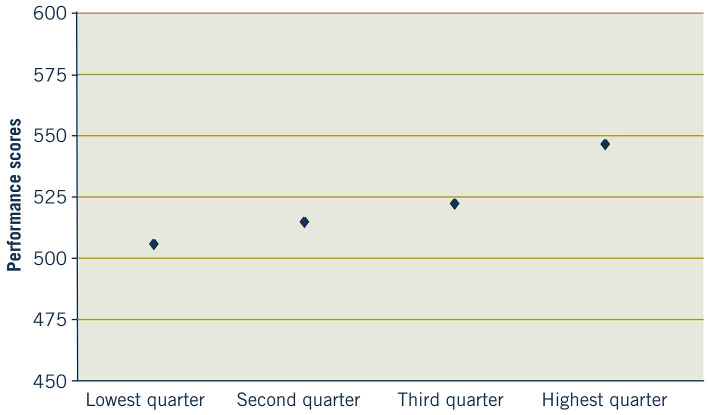


Figure 7.11 Relationship between *Interest and Enjoyment in Mathematics* and *Mathematical Literacy* Performance for Australian Students

Student attitudes and beliefs about learning mathematics

Autonomous learning requires both a critical, realistic assessment of the difficulty of a task, and the ability to invest enough energy in a task to accomplish it. As they progress through school, students form views about their own competence and learning abilities. These views have been shown to have considerable impact on the way a student sets goals, uses strategies and evaluates his or her own performance. PISA collected information on *mathematics self-efficacy*, *mathematics self-concept* and *mathematics anxiety*. *Mathematics self-efficacy* relates to a student's beliefs about their capability to successfully learn mathematics. *Self-efficacy* may play an important role in learning because it provides the foundation for motivation and influences the level of effort and persistence a student applies to performing a task and attaining a particular outcome. *Mathematics self-concept* relates to a student's perception of their own mathematical competence, and belief in one's own abilities is highly relevant to successful learning (Marsh, 1993). *Mathematical anxiety* is a third factor assessed in PISA. Students can perceive mathematics in general or specific mathematical tasks as being potentially intimidating. Subsequently, students feel helpless and uneasy which in turn affects their motivation, their persistence and their performance in mathematics.

Mathematics self-efficacy

Students were asked to what extent they believe in their own ability to manage learning situations effectively and to overcome difficulties by indicating their confidence in completing a range of mathematical tasks:

- Using a bus or train timetable to work out how long it would take to get from one place to another.
- Calculating how much cheaper a TV would be after a 30% discount.
- Calculating how many square metres of tiles you need to cover a floor.
- Understanding graphs presented in newspapers.
- Solving an equation like $3x+5=17$.
- Finding the actual distance between two places on a map with a 1:10,000 scale.
- Solving an equation like $2(x+3)=(x+3)(x-3)$.
- Calculating the petrol consumption rate of a car.

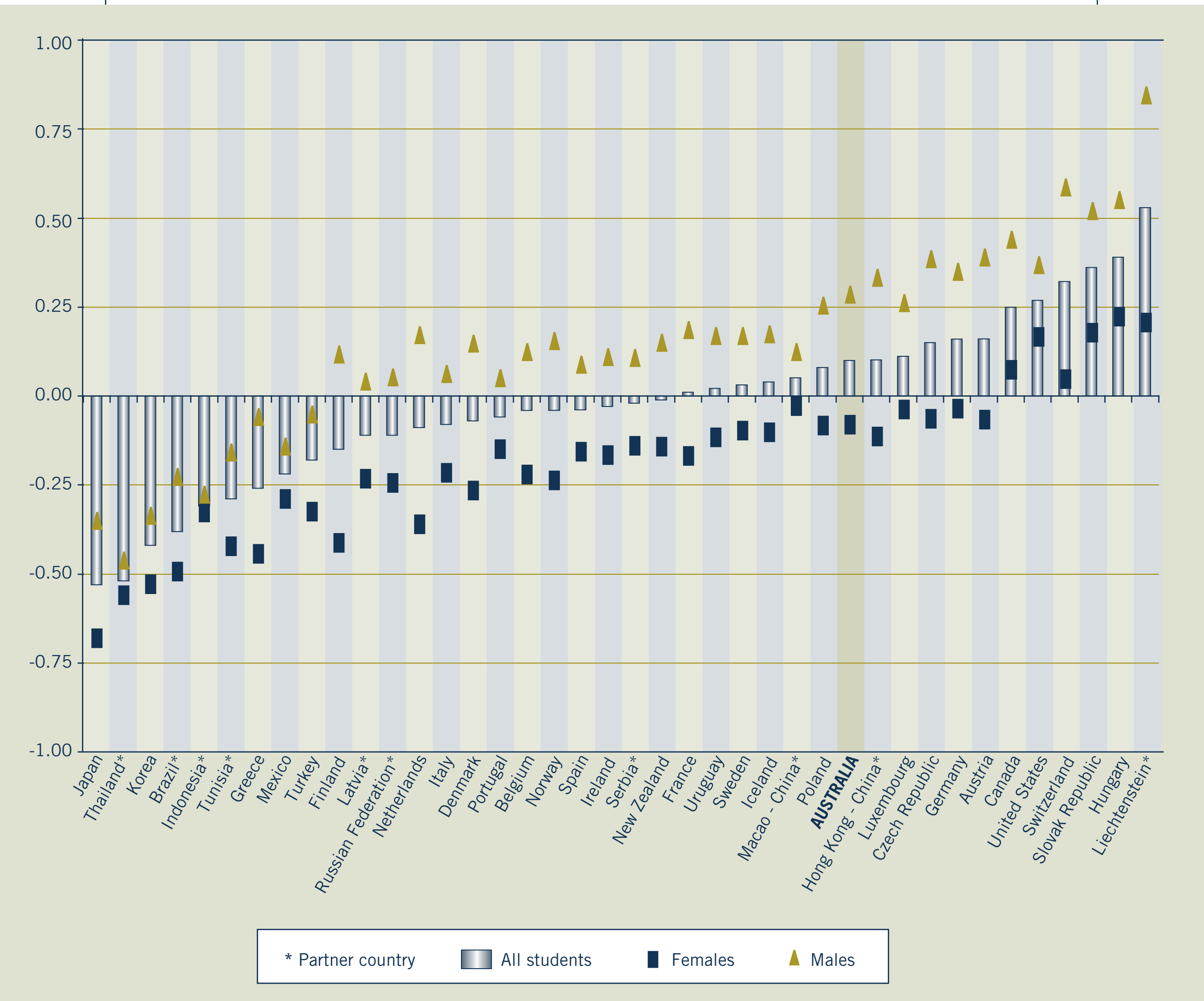


Figure 7.12 *Mathematics Self-Efficacy* Index by Country and Gender

The index of *mathematics self-efficacy* was constructed using the statements listed on the previous page. Students from Liechtenstein had the highest levels of *mathematics self-efficacy* with a mean of 0.53. High performing countries, such as Finland, Korea and the Netherlands had means below the OECD average, indicating that students in these countries had lower levels of *mathematics self-efficacy* compared to the OECD overall (Figure 7.12).

Among the English-speaking countries, Ireland and New Zealand had means close to the OECD mean at – 0.03 and 0.01 respectively but the means for Canada and the United States were a quarter of a standard deviation above the OECD average (0.25 and 0.27 respectively). Australian students reported slightly higher levels of *mathematics self-efficacy* than the OECD average with a mean of 0.10.

There were significant gender differences in all PISA countries on the *mathematics self-efficacy* index with males having higher levels of *mathematics self-efficacy* than females. Students from Liechtenstein had the largest gender differences, approximately two-thirds of a standard deviation, followed by students from Switzerland, the Netherlands and Finland, with differences of about half a standard deviation. In Australia, males scored 0.28 and females 0.29. The gender difference was thus 0.37, which was around the same as the average difference for the OECD (0.34).

Of all the attitudinal and student belief factors examined by PISA 2000 in the Student Questionnaire, *mathematics self-efficacy* had the strongest association with *mathematical literacy* performance for Australian students ($r = 0.52$). Figure 7.13 shows the strong positive relationship between *self-efficacy* and *mathematical literacy* performance. Students in the highest quarter scored 132 points higher than students in the lowest quarter. *Mathematics self-efficacy* explained 27 per cent of the variation on *mathematical literacy* performance, with an increase of 50 points in *mathematical literacy* performance per unit increase in the *mathematics self-efficacy* index.

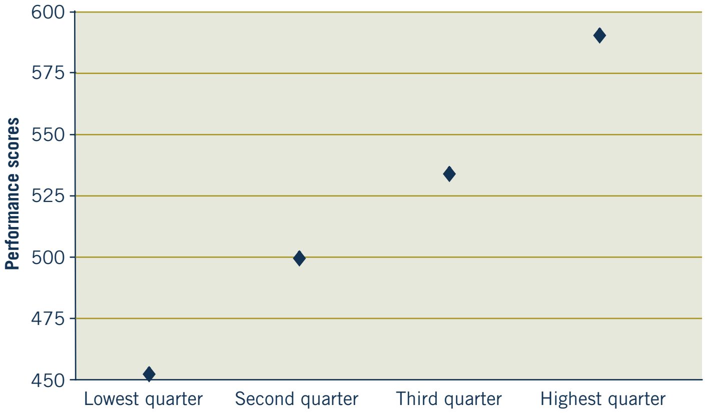


Figure 7.13 Relationship between *Mathematics Self-Efficacy* and *Mathematical Literacy* Performance for Australian Students

Mathematics self-concept

PISA collected information on student beliefs about their own mathematical competence. There is research about the learning process that has shown that students need to believe in their own capacities before making the necessary investment in learning strategies that can lead to improved performance (Zimmerman, 1999). Students were asked about how they felt when studying mathematics by indicating their level of agreement with the following statements:

- I am just not good at mathematics.
- I get good marks in mathematics.
- I learn mathematics quickly.
- I have always believed that mathematics is one of my best subjects.
- In my mathematics class, I understand even the most difficult work.

Figure 7.14 shows the means by country and gender for the *mathematics self-concept* index. Students from the Asian countries (Japan, Korea, Hong Kong-China and Macao-China) reported the lowest *mathematics self-concept* with a mean of at least a fifth of a standard deviation below the OECD average. On the other hand, the United States and Denmark reported the highest means of a quarter of a standard deviation above the PISA mean. Australia, along with Sweden, the Russian Federation, Liechtenstein and Switzerland reported a mean of 0.13 on the *mathematics self-concept* index.

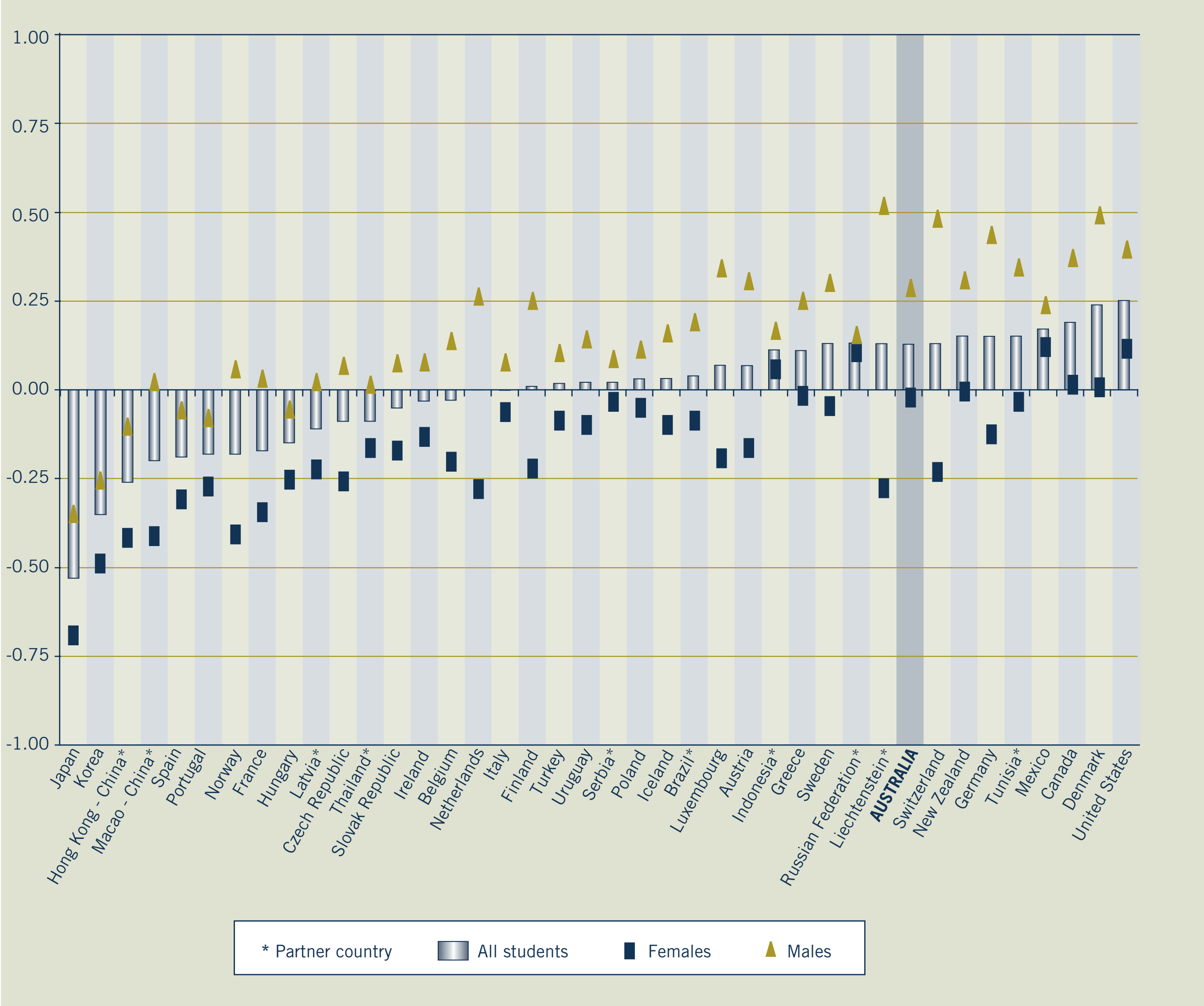


Figure 7.14 *Mathematics Self-Concept* Index by Country and Gender

In all countries, males had a significantly higher *mathematics self-concept* than females. The largest gender differences were found in Liechtenstein and Switzerland, with more than three-quarters of a standard deviation difference between males and females. The smallest gender differences were found in the Russian Federation and Indonesia. In Australia, the gender difference was almost one-third of a standard deviation, with a mean for males of 0.28 compared to a mean of -0.03 for females.

Figure 7.15 shows the relationship between *mathematics self-concept* and *mathematical literacy* performance for Australian students. *Mathematics self-concept* has a moderately strong positive relationship with mathematics performance (r = 0.41). On comparing the correlations of the student attitudinal factors in Australia, *mathematics self-concept* had the second highest correlation coefficient of all student factors assessed in PISA. The difference between the highest and the lowest quarter is 100 points.

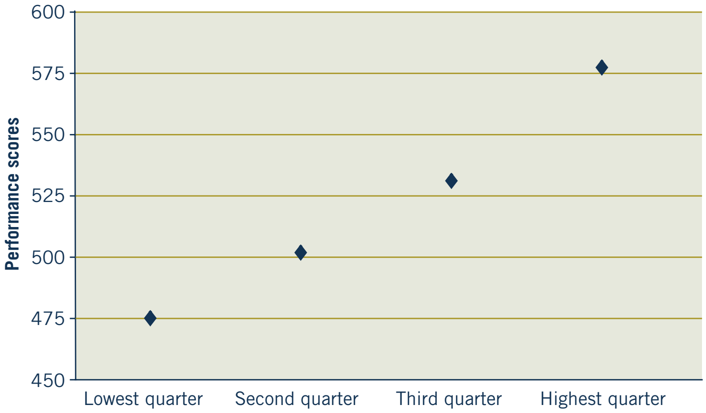


Figure 7.15 Relationship between *Mathematics Self-Concept* and *Mathematical Literacy* Performance for Australian Students

Mathematics self-concept explained 17 per cent of the variance in *mathematical literacy*, with an increase of one unit on the *mathematics self-concept* index increasing mathematics performance by 42 points.

Mathematics anxiety

Students were asked about feelings of helplessness and the emotional stress they have when dealing with mathematics. PISA collected information about students' mathematics anxiety by asking them to think about mathematics and answer to what extent they agreed with the following statements:

- I often worry that it will be difficult for me in mathematics classes.
- I get tense when I have to do mathematics homework.
- I get nervous doing mathematics problems.
- I feel helpless when doing a mathematics problem.
- I worry that I will get poor marks in mathematics.

The items were used to construct an index representing *mathematics anxiety*. Figure 7.16 shows that students from Sweden and Denmark reported the lowest levels of *mathematics anxiety*, about half a standard deviation below the OECD average. Students from Brazil and Tunisia reported the highest levels of *mathematics anxiety* of more than a half a standard deviation above the OECD average. Australian students reported lower levels of *mathematics anxiety* (mean of -0.05).

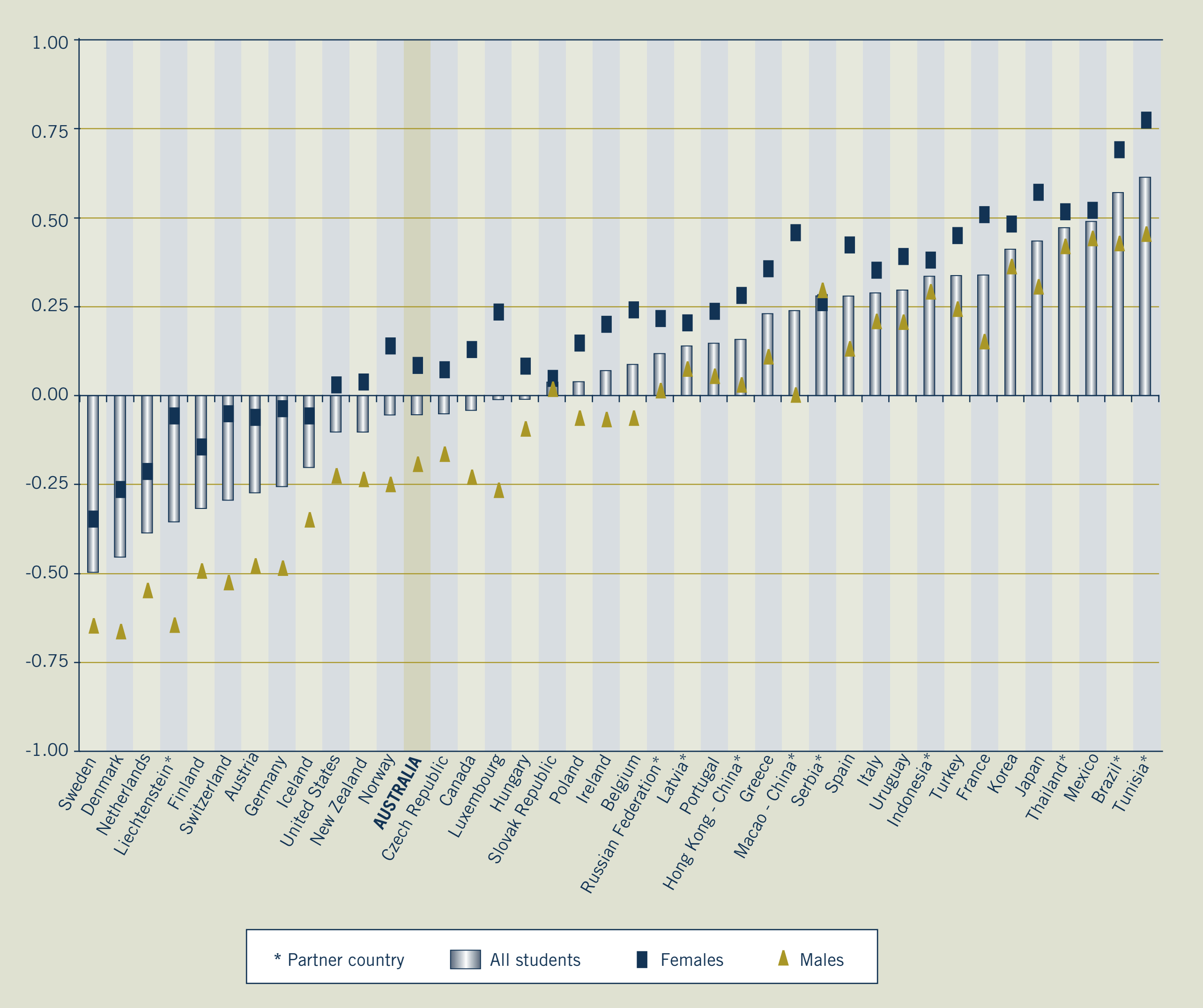


Figure 7.16 *Mathematics Anxiety* Index by Country and Gender

All except two countries (Poland and Serbia) had significant gender differences on the *mathematics anxiety* index, with females reporting higher levels of *mathematics anxiety* than males. The largest gender differences were found in Liechtenstein, with a difference of more than half a standard deviation, followed by Luxembourg and Switzerland with differences of half a standard deviation. In Australia, the mean for females was 0.09 compared to the mean for males of -0.19.

Figure 7.17 shows the negative association between *mathematics anxiety* and mathematics performance for Australian students (r = -0.36). Students reporting a high level of *mathematics anxiety* performed at a lower level than those students who reported less *mathematics anxiety*. There was an 86 point difference between the lowest and highest quarters of mathematics anxiety on *mathematical literacy* performance.

Mathematics anxiety explained 12 per cent of the variance in *mathematical literacy* performance, with a decrease of 38 points in *mathematical literacy* performance per unit increase in the *mathematics anxiety* index.

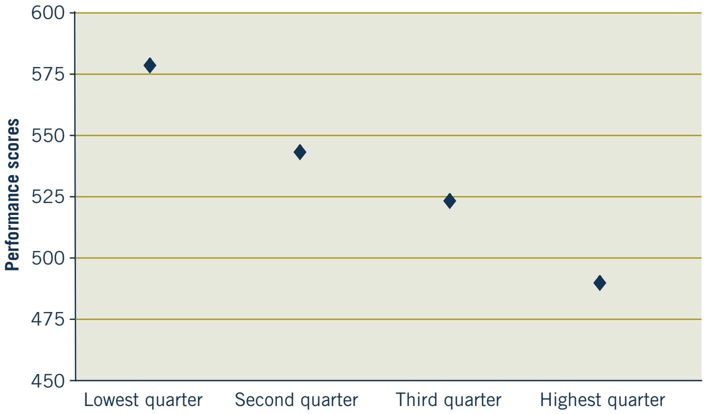


Figure 7.17
Relationship between *Mathematics Anxiety* and *Mathematical Literacy* Performance for Australian Students

>> *Students' learning strategies in mathematics*

Learning is more than acquiring knowledge, it involves being able to process information efficiently, relate it to existing knowledge and apply it to different situations. Students need to take an active role in managing and regulating their own learning. PISA focuses on three kinds of learning strategies – memorisation, elaboration and control strategies. Students provided information about their learning strategies by indicating their agreement to a range of statements.

Memorisation strategies

Memorisation strategies include rote learning facts or rehearsal of examples. If the learner's goal is simply retrieval of information, then this strategy is adequate, however it rarely leads to deep understanding.

Students were asked to think about the different ways of studying mathematics and to what extent they agreed with the following statements:

- I go over some problems in mathematics so often that I feel as if I could solve them in my sleep.
- When I study for mathematics, I learn as much as I can off by heart.
- In order to remember the method for solving a mathematics problem, I go through examples again and again.
- To learn mathematics, I try to remember every step in a procedure.

An index on *memorisation strategies* was based on responses from students to the above items. One of the highest performing countries in *mathematical literacy*, Korea, had one of the lowest means of -0.35 on this index. Students from Japan had the lowest mean, half a standard deviation below the OCED average. The three other countries performing significantly higher than Australia in *mathematical literacy*, Hong Kong-China, Finland and the Netherlands had similar means of -0.15, -0.19 and -0.16 respectively. Students from Indonesia and Mexico reported the highest means, half a standard deviation above the OECD average. All English-speaking countries had means above the OECD average, ranging from 0.11 in Ireland to 0.31 in the United States. Australia's mean on the *memorisation strategies* index was 0.17 (Figure 7.18).

In eleven countries, the gender difference on the *memorisation strategy* index was significantly in favour of females. The largest gender difference in favour of females was found in France, where females scored about a fifth of a standard deviation higher than males. In nine countries, males reported significantly higher use of *memorisation strategies* than females. The largest differences were found in Norway, with a quarter of a standard deviation, and in Denmark and Tunisia with a difference of a fifth of a standard deviation. In Australia, the mean for males was not significantly different from that of females.

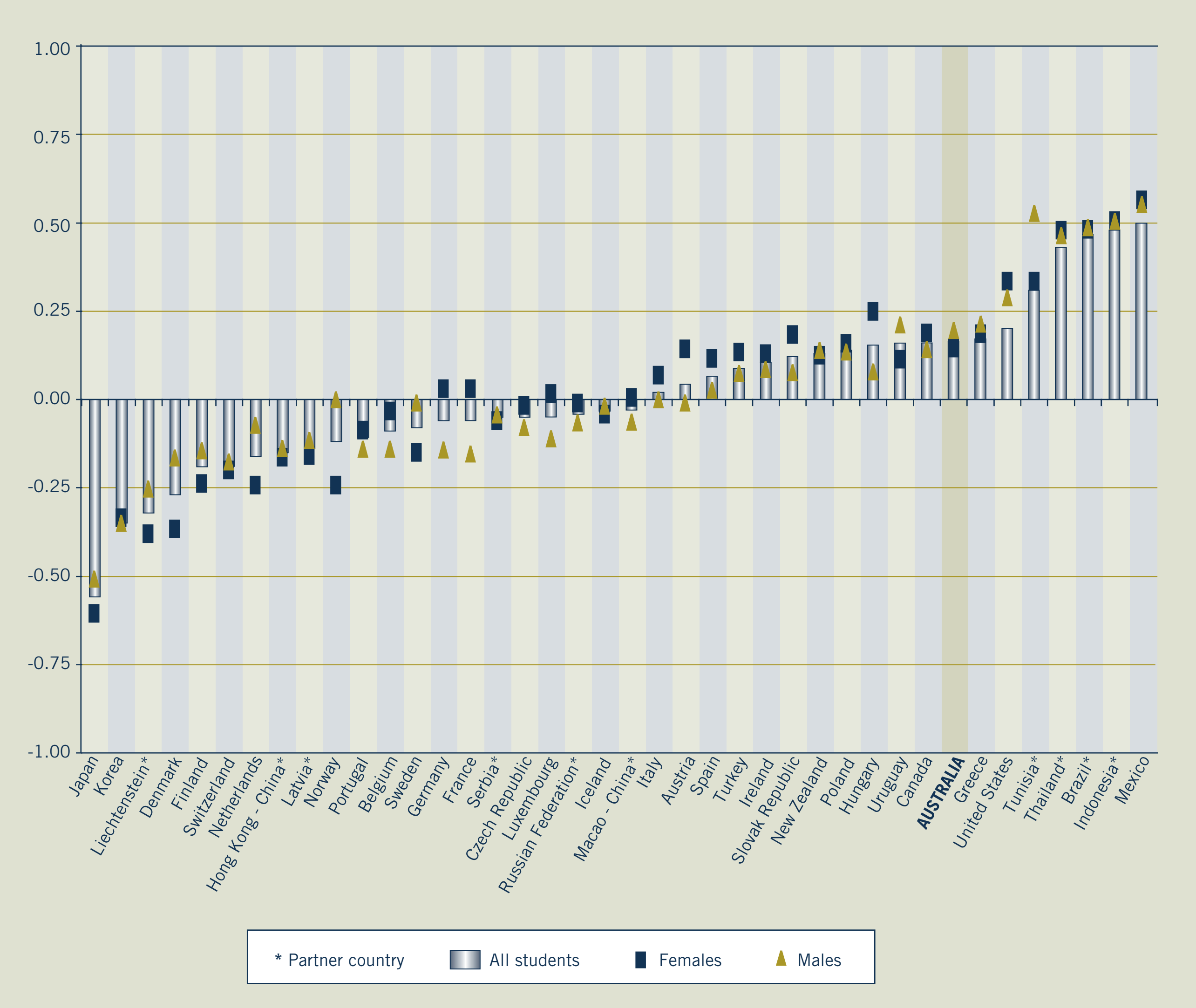


Figure 7.18 *Memorisation Strategies* Index by Country and Gender

There was only a 20 point difference between the highest and lowest quarters of the *memorisation* index for *mathematical literacy*. Frequent use of *memorisation* tends to be weakly but positively associated with *mathematical literacy* performance (r = 0.10) in Australia.

Elaboration strategies

Elaboration strategies involve a student integrating new information with their existing knowledge base or prior learning, by exploring how the material relates to things learned in other contexts, or how the information could be applied in other contexts. In doing so, they acquire an understanding of new information, rather than the more superficial *memorisation* strategies.

The *elaboration strategies* index is based on students' responses to:

- When I am solving mathematics problems, I often think of new ways to get the answer.
- I think how the mathematics I have learnt can be used in everyday life.
- I try to understand new concepts in mathematics by relating them to things I already know.
- When I am solving a mathematics problem, I often think about how the solution might be applied to other interesting questions.
- When learning mathematics, I try to relate the work to things I have learnt in other subjects.

Figure 7.19 shows that students from Tunisia and Mexico reported the highest levels of *elaboration strategies* with means of 0.94 and 0.85 respectively. On the other hand, students from Japan reported the lowest levels of *elaboration strategies* with a mean of -0.75. Australia's mean (0.06) was not significantly different from the OECD average.

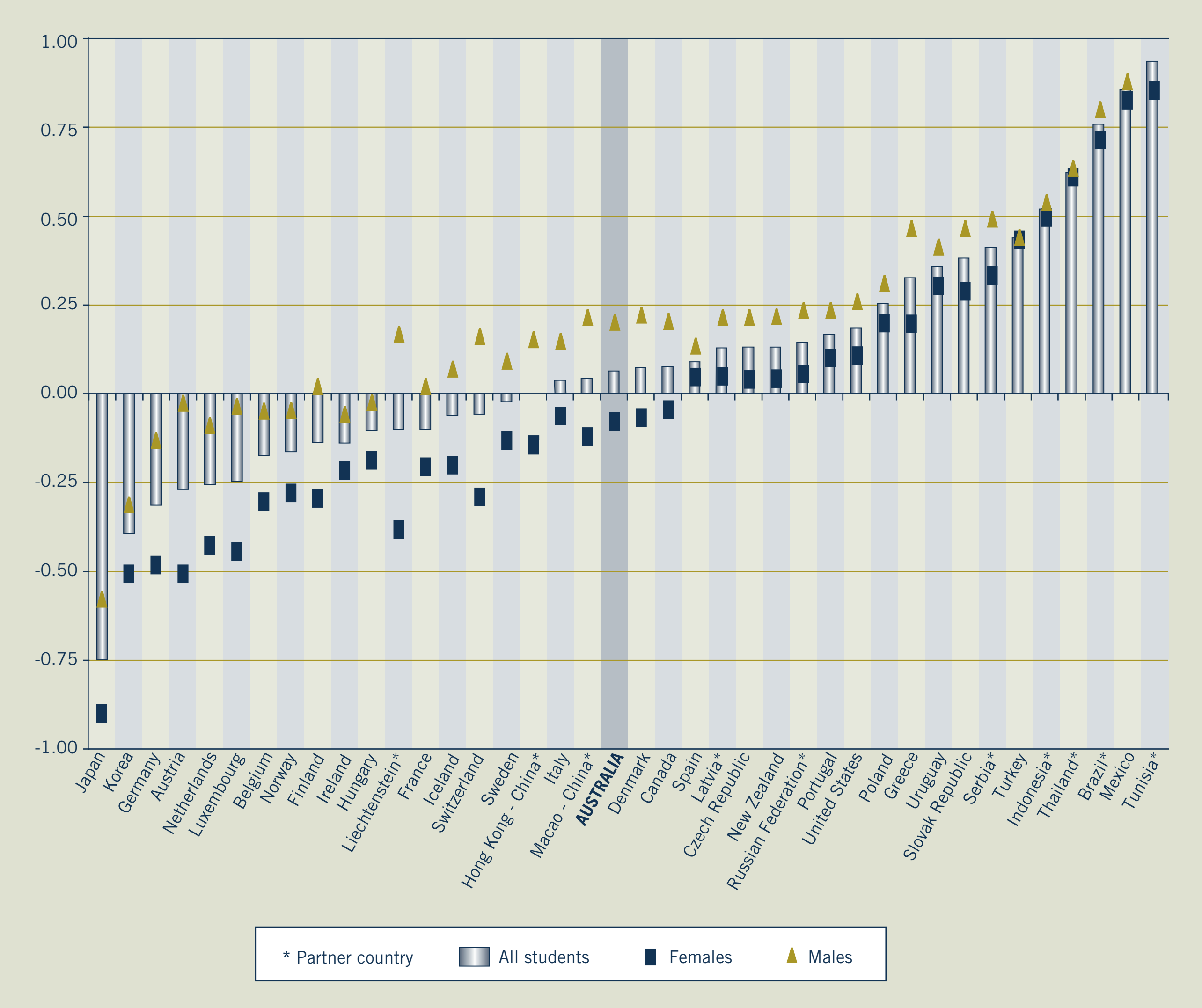


Figure 7.19 *Elaboration Strategies* Index by Country and Gender

Significant gender differences were found in all but two countries (Turkey and Thailand) with males reporting higher levels on the *elaboration strategies* index than females. The largest gender difference of half a standard deviation was found in Liechtenstein. Australian males recorded a mean of 0.20 compared to the -0.08 mean for Australian females. The difference of 0.28 was similar to the average for the OECD of 0.23.

In Australia, the use of *elaboration strategies* was only weakly related to performance in *mathematical literacy* in a curvilinear manner as shown in Figure 7.20.

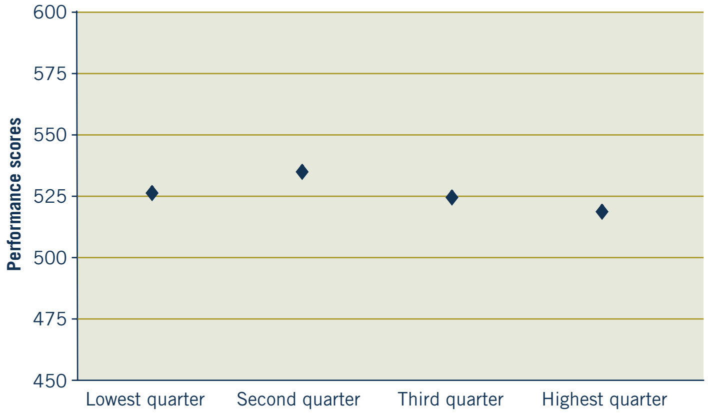


Figure 7.20
Relationship between *Elaboration Strategies* and *Mathematical Literacy* Performance for Australian Students

At first glance, this relationship is difficult to explain. It is, however, a common pattern internationally, and can be seen in the OECD averages. The proportion of variance explained is almost zero in every country. One explanation may lie in the way students respond to the items. The majority of students agree or strongly agree that they try and relate new concepts to existing knowledge, but the majority also disagree that they try to relate their work to things they have learned in other subjects. It is unclear what students are conveying with their responses to these items, which leads to the lack of clarity in the relationship with *mathematical literacy*.

Control strategies

Students who use control strategies are able to manage their own learning: they check what they have learned, assess what they still need to learn and adapt information they have learned to new situations. The *control strategies* index was constructed using the student responses to the following statements:

- When I study for a mathematics test, I try to work out what are the most important parts to learn.
- When I study mathematics, I make myself check to see if I remember the work I have already done.
- When I study mathematics, I try to figure out which concepts I still have not understood properly.
- When I cannot understand something in mathematics, I always search for more information to clarify the problem.
- When I study mathematics, I start by working out exactly what I need to learn.

The Australian result on the *control strategies* index (0.01) was not significantly different from the OECD average. Lowest on the index was Japan (with a mean about a half a standard deviation below the OECD average), followed by Korea and Finland, two of the highest performing countries in *mathematical literacy*. Highest on the index were Tunisia and Brazil (over a half a standard deviation above the OECD average). These are presented in Figure 7.21.

Significant gender differences were found in about 70 per cent of countries. In all but one country (Japan), females were more likely to use *control strategies* than males. The largest difference, of about a third of a standard deviation, was in Germany. Australian females (mean of 0.05) used *control strategies* more often than Australian males (mean of -0.02). This difference was similar to that for the OECD on average (-0.12).

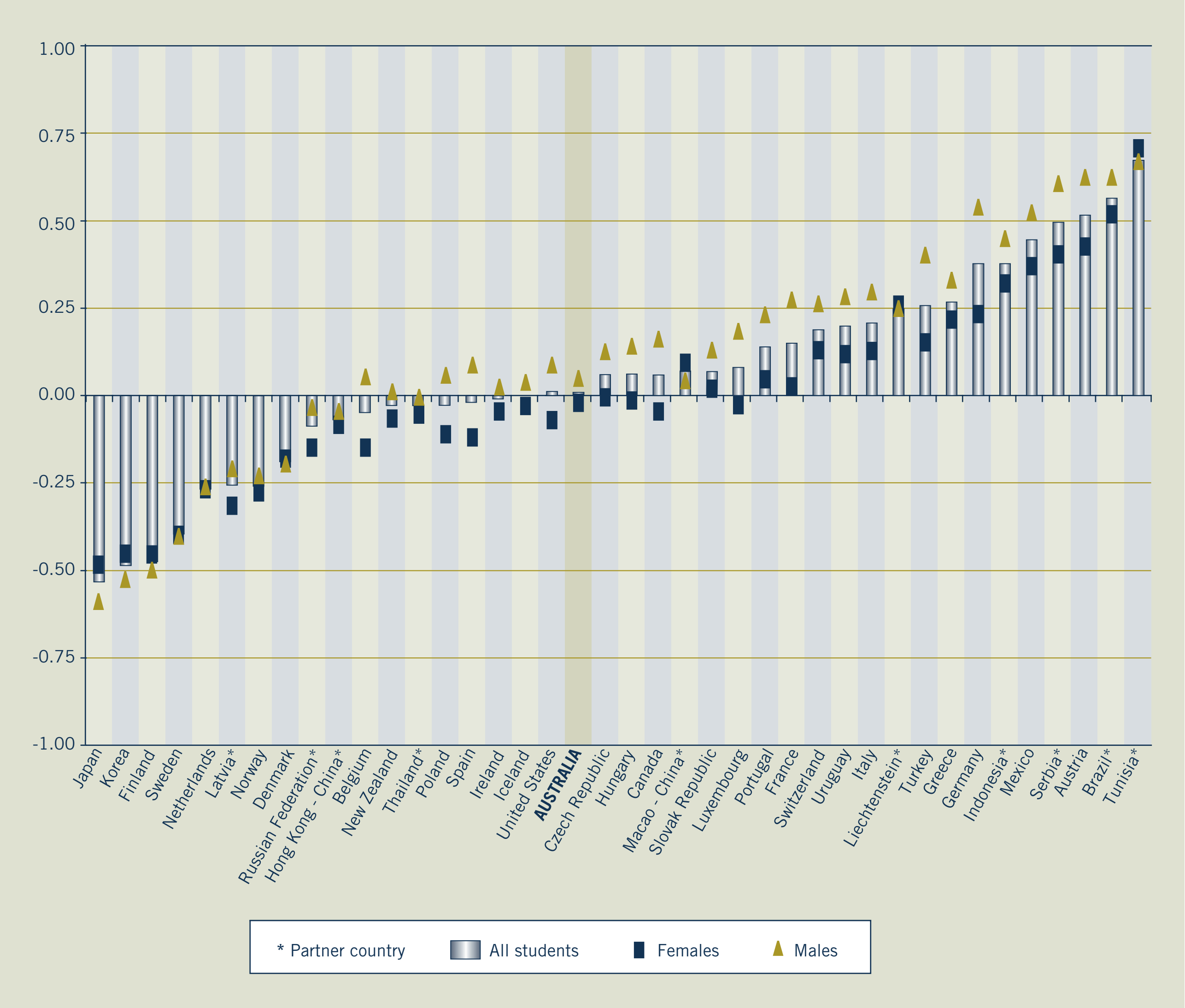


Figure 7.21 *Control Strategies* Index by Country and Gender

In Australia, *control strategies* were related to mathematics performance ($r = 0.15$) as shown in Figure 7.22. Students in the highest quarter scored 23 points higher than students in the lowest quarter, students scored 13 points higher per unit increase in the *control strategy* index.

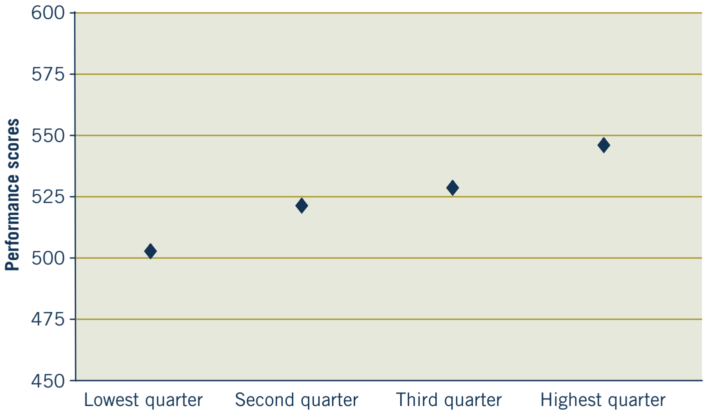


Figure 7.22 Relationship between *Control Strategies* and *Mathematical Literacy* Performance for Australian Students

Learning preferences in mathematics

Students play an active role in learning and rely on different learning strategies. Effective learners also have different preferences towards learning mathematics. PISA assessed two types of learning preferences – competitive and cooperative learning. Competitive learning refers to students being motivated to perform at a higher level than their peers, whereas cooperative learning relates to the extent a student prefers to work with others when learning.

Competitive learning

The index of competitive learning was derived from students' reports on their agreement on the following statements:

- I would like to be the best in my class in mathematics.
- I try very hard in mathematics because I want to do better in tests than the other students.
- I make a real effort in mathematics because I want to be one of the best.
- In mathematics I always try to do better than the other students in my class.
- I do my best in mathematics when I try to do better than others.

The above items were used to form the *competitive learning preferences* index. Students from Tunisia had the highest mean, at one standard deviation above the OECD average, on the *competitive learning preferences* index. Other countries who used *competitive learning preferences* more often were Mexico, Turkey and Indonesia, with means of at least two-thirds of a standard deviation above the OECD average. Students from Japan, Hungary and the Netherlands had means about half a standard deviation below the OECD average. Australia's mean on the competitive learning index was one-third of a standard deviation above the OECD average (Figure 7.23).

Males were more likely have a higher mean than females on the *competitive learning preferences* index. The largest gender differences, in favour of males, were found in Liechtenstein, with two-third of a standard deviation and Switzerland, with a half a standard deviation. In Australia, males reported significantly higher levels (mean of 0.43) on the *competitive learning preferences* than females (mean of 0.19).

In Australia, greater use of *competitive learning preferences* was found to be weakly positively associated with mathematics performance (r = 0.13). Figure 7.24 shows there was 29 score points difference between students in the highest and lowest quarter on the *competitive learning preferences* index.

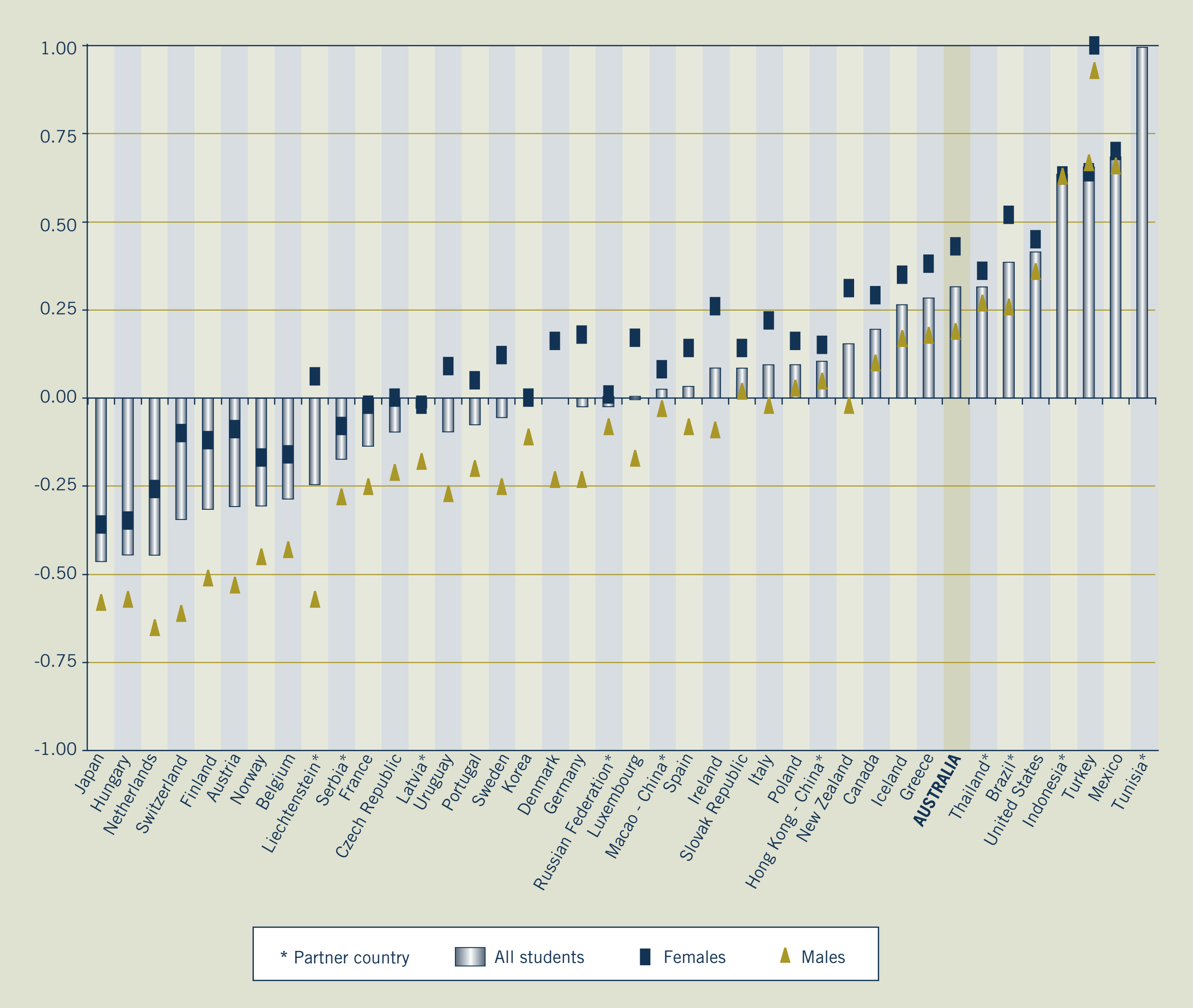


Figure 7.23 *Competitive Learning Preferences* Index by Country and Gender

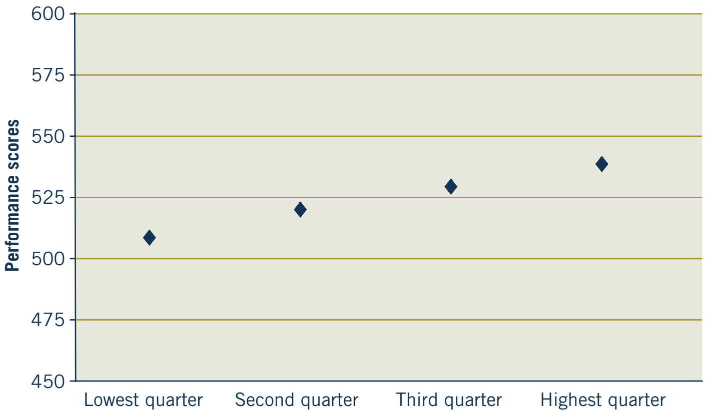


Figure 7.24 Relationship between *Competitive Learning Preferences* and *Mathematical Literacy* Performance for Australian Students

Cooperative learning

Students were asked to indicate the extent they agreed with the following statements that related to cooperative learning in mathematics classes:

- In mathematics I enjoy working with other students in groups.

- When we work on a project in mathematics, I think it is a good idea to combine the ideas of all the students in a group.
- I do my best work in mathematics when I work with other students.
- In mathematics, I enjoy helping others to work well in a group.
- In mathematics I learn most when I work with other students in my class.

An index on *cooperative learning preferences* was constructed using the above statements. Figure 7.25 shows students from Korea and Japan were least likely to prefer *cooperative learning* with means of three-quarters of a standard deviation below the OECD average. At the other end of the index, students from Tunisia and Brazil were the most likely to use *cooperative learning* with means of about two-thirds of a standard deviation above the OECD mean. Australia's mean was not significantly different from the OECD mean (0.09).

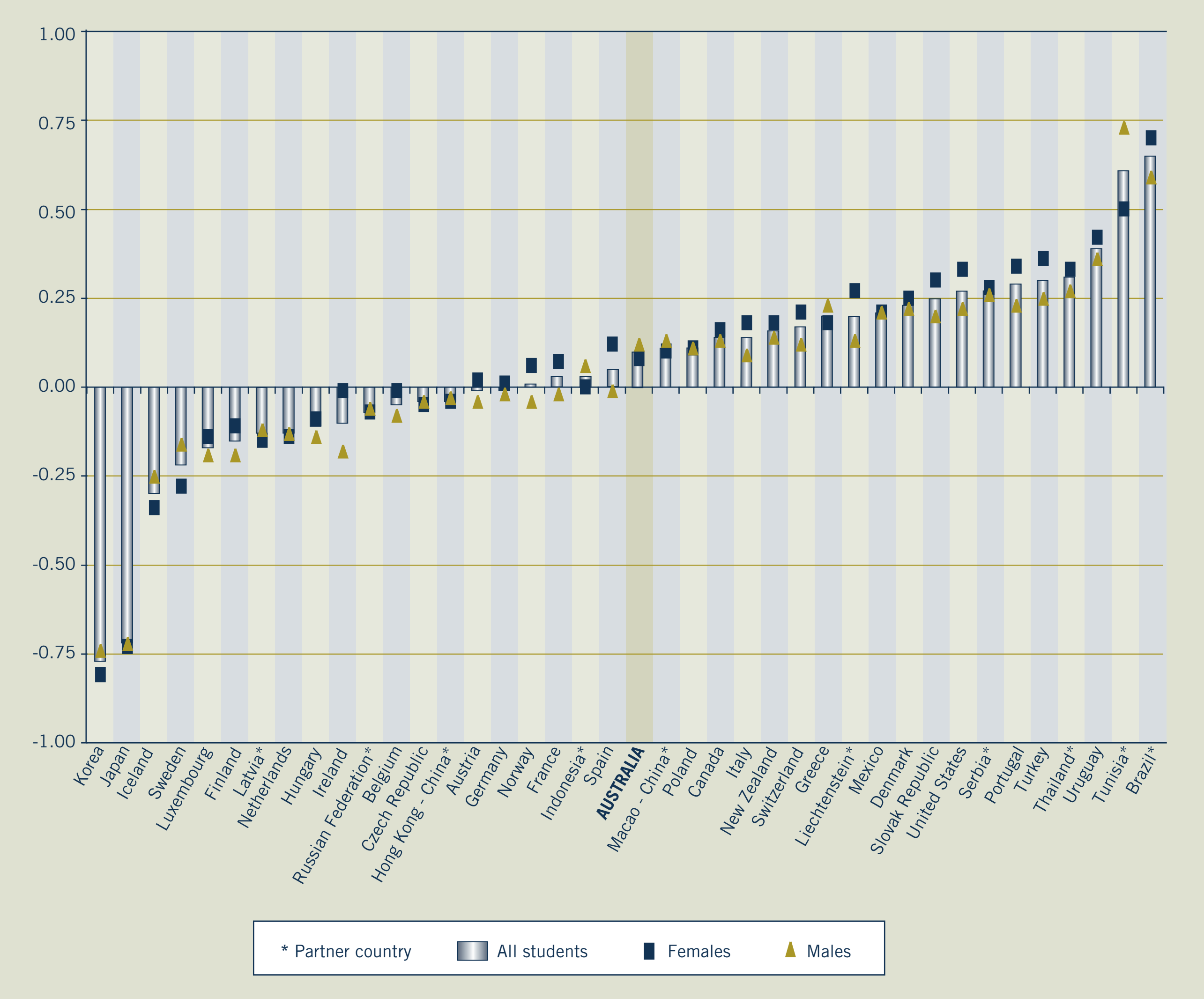


Figure 7.25 *Cooperative Learning Preferences* Index by Country and Gender

In some countries, females reported higher means, and in other countries, males reported higher means on the *cooperative learning preferences* index. Tunisia had the largest gender difference, in favour of males, of a quarter of a standard deviation. The largest gender difference, in favour of females, was found in Ireland, with a difference of almost a fifth of a standard deviation.

In Australia the relationship between *cooperative learning preferences* and mathematics was curvilinear and weak as shown in Figure 7.26.

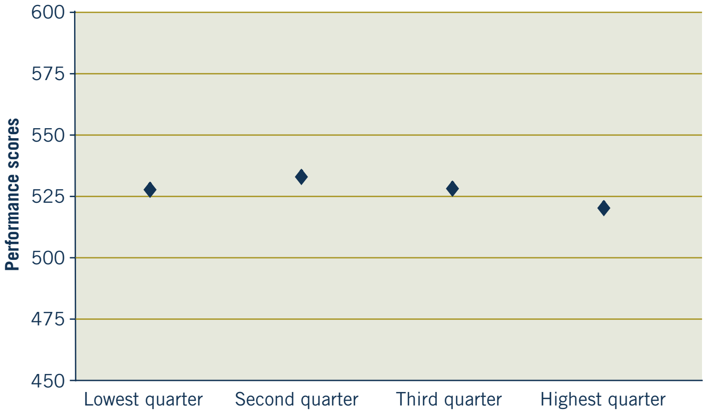


Figure 7.26 Relationship between *Cooperative Learning Preferences* and *Mathematical Literacy* Performance for Australian Students

Multilevel analysis

Student performance is influenced by myriad factors. Students bring with them abilities, values, attitudes and beliefs that have been established in the home environment. At school, these values, attitudes and beliefs contribute to learning, and subsequently performance. These factors can be influenced by the student's interaction in the classroom and school environment, and schools attempt to mitigate the effects of low socioeconomic status by implementing strategies that it is hoped will promote equity.

Multilevel analysis enables an assessment of the relative importance of factors at different levels (school or student) on an outcome. Hierarchical linear models or multilevel models are used for analysing data in a clustered sample. In PISA the sampling procedure proceeded in two stages – first, schools were sampled, and then a sample of students within the school was selected. Level 1 variables or factors are related to the students and level 2 variables or factors are related to classroom and school characteristics. Using Hierarchical Linear Modelling (HLM), this section examines a number of student and school factors in helping to provide some insight about the influence of various factors on the performance of Australian students. HLM indicates the amount of variance explained by factors and the amount of variance that occurs within-schools and between-schools. The process was to construct a model that included factors that were thought to contribute to explaining the variance in performance. Factors considered to influence performance were included in the model and factors that were found to be not significant were removed from the model.

Multilevel analysis for mathematical literacy performance

In creating a model for mathematics performance, student and school factors were added to the model sequentially. The factors included in each sequence were:

- Student background factors - consisting of economic, social and cultural status (derived from parents' educational and occupational status, educational resources and cultural possessions in the home), family structure, immigration status, language spoken at home, computer resources in the home, books in the home and students' educational aspirations.

- Attitudes and beliefs - consisting of interest and enjoyment in mathematics, instrumental motivation, mathematics self-efficacy, mathematics self-concept and mathematics anxiety.
- School factors - consisting of attitudes towards school, student-teacher relations and sense of belonging.
- Classroom factors - consisting of teacher support and disciplinary climate
- Learning strategies/preferences – consisting of memorisation, elaboration, control strategies, competitive learning preferences and cooperative learning preferences.

All factors in the model were indices except for books in the home and students' educational aspirations, which were based on categorical data (see previous section for categories).

The null model (that is, with no explanatory factors included) indicated that of the total amount of variation in *mathematical literacy* performance, 20 per cent was between-schools and 80 per cent was within-schools. In the first model, student background factors were included, and these factors accounted for a total of 23 per cent of the variation in *mathematical literacy* performance. These factors explained 51 per cent of the between-school variation and 16 per cent of the within-school variation.

Student attitudes and beliefs were then added to the model and were found to explain 40 per cent on the total variance in mathematics performance. These factors accounted for an additional ten per cent of between-school variance, and an additional 18 per cent of within-school variance.

When school and class factors were added to the model, there was only a small increase in the variation explained between-schools (an additional one per cent when school factors were added to the model and an additional two per cent when classroom factors were added to the model). School factors explained an additional one per cent within-school variance, however, classroom factors did not explain any of the within-school variation. The addition of learning strategies and preferences into the model explained three per cent of the variation between-schools and three per cent of the variation within-schools. The abovementioned student and school factors explained a total of 44 per cent of the total variation in *mathematical literacy* performance, of which of 67 per cent was between-school variance and 38 per cent was within-school variance.

Next, level 2 factors were included in the model. The most important factor at the school level is the mean socioeconomic background of the school, explaining a further 13 per cent of between school variance and a further three per cent of the total variation in *mathematical literacy* performance. The effect of student, school and classroom factors on *mathematical literacy* performance are shown in Table 7.1. This model helps to explain 47 per cent of the total variation in *mathematical literacy* performance. These factors account for 80 per cent of the between-school variance and 38 per cent of the within-school variance. Only factors, which were significant, remained in the model. The remaining variance is likely to be explained by characteristics not assessed in PISA.

Table 7.1 Effects of Student, School and Classroom Factors on *Mathematical Literacy* Performance

	Coefficient	Standard error
Intercept	522.85**	1.61
Student Level Factors		
Student background		
Economic, social and cultural status	4.80**	1.30
Books in the home	5.93**	0.58
Computer resources in the home	5.68**	1.17
Students' educational intentions	14.65**	0.69
School factors		
Student-teacher relations	5.03**	0.88
Sense of belonging	-8.25**	0.75
Classroom factors		
Disciplinary climate	5.34**	0.83
Attitudes and beliefs		
Interest and enjoyment in mathematics	-8.47**	1.26
Mathematics self-efficacy	29.25**	1.23
Mathematics anxiety	-6.43**	1.28
Mathematics self-concept	23.02**	1.28
Learning strategies/preferences		
Memorisation strategies	-4.94**	1.22
Elaboration strategies	-14.71**	1.07
Control strategies	3.23**	1.23
Coooperative learning preferences	-3.70**	1.20
School Level Factors[2]		
Mean socioeconomic background	2.31**	0.20
Between school variance explained	80%	
Within school variance explained	38%	
Total variance explained	47%	

** $p < 0.001$

The model shows that students' *mathematics self-efficacy* and *mathematics self-concept* play an important role in influencing mathematics performance. On average, students scored 29 points higher per unit increase in the *mathematics self-efficacy* index and 23 points higher per unit increase in the *mathematics self-concept* index. Students who have higher levels of *mathematics self-efficacy and self-concept* will tend to do better than those students who have lower levels. On the other hand, students' level of *mathematics anxiety* affects mathematics performances negatively, by decreasing mathematics performance by about six points per unit increase on the *mathematics anxiety* index. Students who have higher levels of feeling helpless

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[2] Other school factors which were included in the model were not significant and have been removed.

and are emotionally stressed will tend not to perform as well as those students who are not anxious about mathematics. The relationship between students' *interest and enjoyment in mathematics* and mathematics performance shows that students do not necessarily need to have high levels of interest or enjoy doing mathematics to perform well. On average, students scored eight points lower per unit index on the *interest and enjoyment in mathematics* index.

Students' educational intentions had the strongest influence of the student background factors (*economic, social and cultural status*, *books in the home*, *computer resources in the home* and *students' educational intentions*). Those students who intend on completing higher levels of educational qualifications tend to do better on mathematics performance. The other student background factors also improve mathematics performance, on average, by about 6 points per unit increase in each index.

Student-teacher relations had a positive influence on mathematics performance, with an increase of five points per unit increase in the *student-teacher relations* index. Students view relationships with their teachers differently from their *sense of belonging* at school. Although students who have good relationships with their teachers tend to do better in mathematics performance, they do not need to feel a *sense of belonging* at school to do well in mathematics. Students who reported higher levels of a *sense of belonging* at school performed at a lower level on mathematics performance than those students who reported lower levels of a *sense of belonging* at school. On average, students scored eight points lower per unit increase in the *sense of belonging* index.

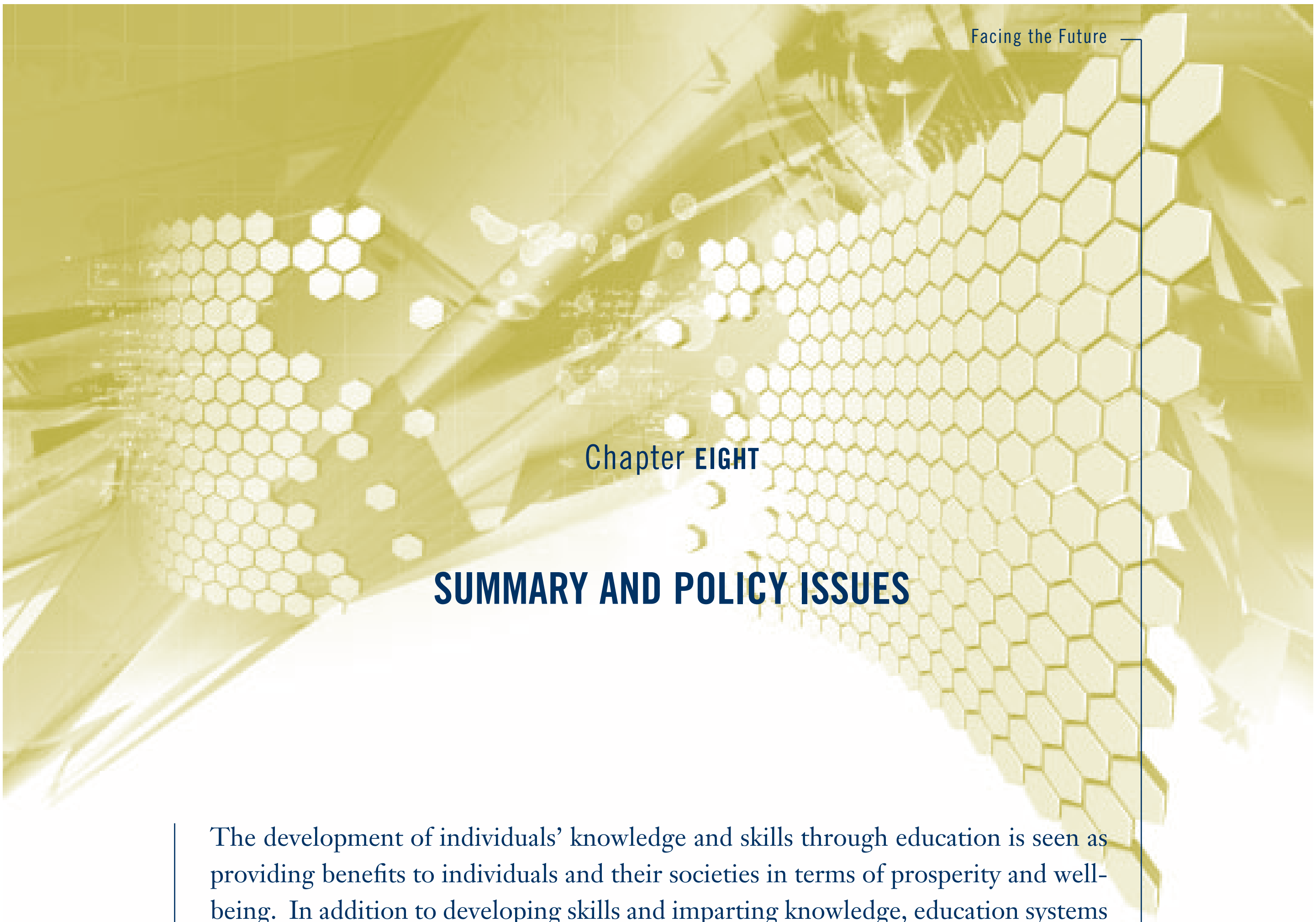
In the classroom, mathematics performance is increased in an environment that is quiet and orderly and where students are eager to learn. On average, students scored about five points higher on mathematics performance per unit increase in the *disciplinary climate* index.

This analysis suggests that the factors that may have the greatest influence on Australian students' *mathematical literacy*, as assessed in PISA, are the attitudes and beliefs of students, in particular *mathematics self-efficacy* and *mathematics self-concept*, which stand out above any of the other factors incorporated into the model.

The learning strategies and preferences assessed in PISA provide useful information on their influence on mathematics performance. Students who are able to manage their own learning perform at a higher level on mathematics. On average, students score three points higher per unit increase in the *control strategy* index. The influence of *memorisation and elaboration strategies* and *cooperative learning preferences* had a negative impact on mathematics performance with a five, 15 and four points decrease per unit increase in each of the indices respectively. Mathematics performance is not increased by the frequent use of *memorisation strategies* or elaboration strategies. More exploratory work is required to gain an understanding of the interactions between learning strategies and mathematics performance.

Summary

This chapter provided a picture of the factors related to students' *mathematical literacy* performance. The relationships between several student characteristics including student attitudes; motivations; and learning strategies and preferences and the impact of attitudes towards school and the classroom climate were discussed in terms of the influence they have on *mathematical literacy* performance. The associations of *mathematics self-efficacy* and *mathematics self-concept* with *mathematical literacy* performance were higher than the correlations for other factors. A multilevel regression analysis was conducted to examine the effects of student, class and school variables on performance in *mathematical literacy*. The model found that approximately 20 per cent of the variation in *mathematical literacy* was between-schools variance, while 80 per cent was situated within-schools. A number of different models were fitted, the final model accounting for 80 per cent of the between-schools variance and 38 per cent of the within-schools variance. The most significant positive influences on performance in the multilevel analysis were found to be *mathematics self-efficacy and self-concept*.



Chapter EIGHT

SUMMARY AND POLICY ISSUES

The development of individuals' knowledge and skills through education is seen as providing benefits to individuals and their societies in terms of prosperity and well-being. In addition to developing skills and imparting knowledge, education systems can strengthen the basis for and disposition towards learning beyond school. Many education systems monitor student performance at various points in schooling to provide information about how well young people are being prepared for life. Comparative international studies can provide a context within which to interpret national results. PISA is an initiative by governments 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. It examines differences in performance between males and females and between socioeconomic groups. By examining these differences on a comparative basis it can draw attention to variations in relationships considered to be immutable within any one national context. It 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' motivation to learn, their beliefs about themselves and their learning strategies.

PISA, an initiative of the Organisation for Economic Cooperation and Development (OECD) in Paris, began in 1998, and its first international assessment was carried out in 2000. 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 opportunities. The second cycle of PISA, carried out in 2003, was conducted in 41[1] countries with a

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[1] Although the United Kingdom participated in PISA 2003, they did not meet the required sample criteria and thus their results are not reported.

little over a quarter of a million students. Further assessment cycles are planned for at least the next decade (work on PISA 2006 is already well advanced). The core domains of learning chosen for assessment in PISA are *reading, mathematical and scientific literacy*, and in 2003 the domain of problem solving was assessed, although there are no plans at present for this to be repeated in subsequent cycles. *Reading literacy* was the major domain in PISA 2000, *mathematical literacy* in PISA 2003, and *scientific literacy* will be the focus in PISA 2006. Data on each of these three domains are gathered in each cycle, but 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' reflects the focus of these broader skills. 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.

A consortium led by the Australian Council for Educational Research implemented PISA 2003 internationally. Other members of the consortium were The Netherlands National Institute for Educational Measurement (CITO), the Educational Testing Service (ETS) and Westat Inc. of the United States, and the National Institute for Educational Research (NIER) in Japan.

>> PISA in Australia

In Australia, 321 schools and just over 12 500 students participated in PISA. The assessment was carried out between mid-July and the end of August 2003, a few months later than in Northern Hemisphere countries so that students would be at approximately the same stage of the school year. Australia took a larger sample than is usual for two major reasons:

- Smaller states and Indigenous students were oversampled so that reliable estimates can be drawn for their populations; and
- The PISA 2003 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 cannot be traced.

A brief summary of Australia's performance results is presented next. This is followed by a summary of findings on contextual variables in relation to performance. The final section will discuss some policy issues arising from the findings.

>> *Australian performance from international andnational perspectives*

Australia's students acquitted themselves very well in PISA 2003, in all domains. Australia's result was above the OECD average in the four domains of *mathematical*, *scientific* and *reading literacy*, in problem solving, and in each of the *mathematical literacy* subscales. Australian performance in *mathematical literacy* in comparison to other countries in PISA 2003 is shown in the tables of multiple comparisons included in Appendix 3.

Four countries outperformed Australia in *mathematical literacy* in PISA 2003 – Hong Kong-China, Finland, Korea, and the Netherlands. In PISA 2000 only two countries performed better than Australia – Japan and Hong Kong-China, and Australia's results were statistically similar to those of Finland and Korea. Australia's results were statistically not different to those of Japan. (Comparisons cannot be made with the Netherlands, as their data were excluded from the 2000 report because of an insufficient sample.)

Australia performed similarly to (i.e. not statistically different from) countries such as Japan, Canada, Belgium, Macao-China, Switzerland, New Zealand, the Czech Republic and Denmark. They performed better than students in countries such as Iceland, France, Sweden, Austria, Germany, Ireland, Slovak Republic, Norway, Luxembourg, Poland, Hungary, Spain, Latvia, the United States, the Russian Federation, Portugal, Italy, Greece and several other countries.

As in PISA 2000, only one country achieved significantly better results than Australia in *reading literacy* – Finland. Three countries achieved better results than Australia in *scientific literacy* – Finland, Japan and Korea. In PISA 2000, only Korea and Japan outperformed Australia. Four countries performed significantly better than Australia in problem solving – Korea, Hong Kong-China, Finland and Japan.

Based on the content of the PISA assessment measures together with a consideration of students' performances across all of the participating OECD countries, six levels of *mathematical literacy* proficiency were defined and used for reporting purposes. As well as for the *mathematical literacy* measure as a whole, levels were defined for the four overarching ideas that underpin the content of the PISA mathematics framework. These four overarching ideas are *quantity*, *space and shape*, *change and relationships* and *uncertainty*. To accompany each of these, descriptive scales were developed to enhance the meaning of the PISA results. Thus in addition to having students grouped by their proficiency levels, it is also possible to obtain a picture of the skills and knowledge that students at each level typically possess.

Level 6 is the highest proficiency level and Level 1 is the lowest. In each country there were students who were unable to do even the simplest items in the PISA assessment. It is not known what the mathematical skills of these students are, and hence they are classified as not reaching level 1. Four per cent of Australia's students were not achieving at this level, compared with eight per cent in the OECD as a whole.

At the other end of this scale, six per cent of Australia's students achieved the highest *mathematical literacy* proficiency level, slightly above the OECD average of four per cent. The country with the highest proportion of students achieving proficiency Level 6 was Hong Kong-China, with 11 per cent of its students at this level. In Australia, seven per cent of students reached proficiency Level 6 in *space and shape* (highest were Korea and Hong Kong-China, with 16 per cent), *change and relationships* (highest was Belgium with 12 per cent), and *uncertainty* (highest was Hong Kong-China with 13 per cent), and five per cent reached this level in *quantity* (highest were Hong Kong-China and Belgium, with nine per cent).

Students at Level 6 in *mathematical literacy* succeeded in doing some very sophisticated mathematics tasks. They were able to conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations. Students at this level are capable of advanced mathematical thinking and reasoning, and can apply their insight and understanding along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for attacking novel situations.

In terms of other proficiency levels, 20 per cent of Australian students were placed at Level 5 or higher in *mathematical literacy*, just over 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 15 per cent at Level 5 or higher, 34 per cent at Level 4 or higher, and 58 per cent at Level 3 or higher. Only 14 per cent of Australian students did not reach at least Level 2, compared with the OECD average of 21 per cent. Four per cent of Australia's students were not achieving at the basic PISA proficiency level, Level 1, compared with eight per cent in the OECD as a whole. Students performing below proficiency Level 1 were not necessarily incapable of performing any mathematical operation, but were unable to utilise mathematical skills in a given situation, as required by the easiest PISA tasks.

Five proficiency levels were defined for *reading literacy* in PISA 2000, and three have been defined for the problem-solving component of PISA 2003. No proficiency levels have yet been defined for *scientific literacy*.

Australia ranked third in terms of the percentage of students performing at least at Level 4 in *reading literacy* (42 per cent), behind Finland (48 per cent) and Korea (43 per cent). About 12 per cent of Australian students are performing below proficiency Level 2 in reading, lower than the OECD average (19 per cent), but higher than that of the highest performing country, Finland (six per cent). In problem solving, more than one-quarter of Australian students were performing at the highest proficiency level. The OECD average was 18 per cent.

The performance of all of the states and territories in *mathematical literacy*, on average, was either at or above the OECD average. Although there were differences in scores between the states and territories in all domains, not many of the apparent differences were statistically significant. However the Australian Capital Territory was placed highest or equal highest on every performance chart and the Northern Territory was placed lowest.

In *reading literacy*, the Australian Capital Territory, Western Australia, South Australia and New South Wales achieved means which were statistically similar when they were compared simultaneously while Queensland, Victoria, Tasmania and the Northern Territory also were statistically similar with each other in terms of their mean scores.

In *scientific literacy*, the Australian Capital Territory and Western Australia achieved means that were statistically similar. While the Australian Capital Territory performed significantly better than the remaining states, Western Australia performed significantly better than Queensland, Victoria, Tasmania and the Northern Territory but not significantly better than South Australia or New South Wales. Victoria, Tasmania and Northern Territory also were statistically similar to each other in terms of their mean scores in *scientific literacy*.

In problem solving, the average performance of students in the Australian Capital Territory and Western Australia was significantly higher than the average achieved by students in all other states with the exception of South Australia. Students from the Australian Capital Territory, Western Australia, South Australia and New South Wales attained a higher average score than students in the Northern Territory, however the performance of students in Victoria and Tasmania was not significantly different than the performance of students in the Northern Territory.

There was no gender difference in the mean scores for *mathematical literacy* in Australia, however almost twice as many males as females achieved the highest PISA proficiency level. Gender differences were found in the subscales *space and shape* and *uncertainty*, in which males scored higher than females, but not in *quantity* or *change and relationships*. As in PISA 2000, the gender difference in favour of females in *reading literacy* was large, about 0.4 of a standard deviation, and this was larger than the OECD average. There was no evidence of a gender gap in Australia for *scientific literacy* or problem solving in PISA 2003.

The performance level of Indigenous students relative to the performance of non-Indigenous students is an enduring concern. Altogether, 815 Indigenous students were assessed in PISA 2003. On average, the performance of Indigenous Australians in *mathematical literacy* was about half a standard deviation below the OECD average, while non-Indigenous students achieved, on average, a little more than one-quarter of a standard deviation above the OECD average. This is around one proficiency level lower for Indigenous Australians compared to non-Indigenous Australians. Similar results were evident for *reading* and *scientific literacy* and for problem solving.

Indigenous students were over-represented in the lowest categories of mathematics proficiency and under-represented in the highest category. However, 30 per cent of them demonstrated skills at least at proficiency Level 3, and around one per cent demonstrated skills at the very highest proficiency level.

Performance in *mathematical literacy* was also analysed according to whether the student's home language was English, and according to whether their school was located in a major urban area, a provincial city, or a relatively remote area. There were only nine per cent of students who did not speak English at home most of the time, and these students did not perform as well on the *mathematical literacy* assessment as those whose home language was English. Students in major urban areas performed better in *mathematical literacy* than students in provincial cities and students in remote areas, and students in provincial cities performed better than their counterparts in remote areas.

Two measures of socioeconomic background were defined and used in this report. HISEI, based on the higher of parents' occupations, was significantly related to student performance in all domains. ESCS, based on parents' education and occupation, number of books as well as access to home and cultural resources, was also significantly related to student performance in all domains.

There were a number of measures other than performance that help provide background information about students. Analysing student responses, PISA can tell three useful things about student approaches to learning. The first is the extent to which students in different countries have certain self-identified characteristics that may help them to learn. Secondly, the PISA results show to what degree particular characteristics are associated with performance. Third, they show how motivation, self-related beliefs and emotional factors are linked to the adoption of effective learning strategies, and thus can help students become lifelong learners. On each of these measures, Australia's results were either at or above the OECD average.

Australian students were significantly more positive on the *teacher support* index, the *attitudes towards school* index, had a higher *self-concept* in mathematics, reported more favourable *student-teacher relationships*, and scored higher on the *instrumental motivation* index than students on average in the OECD countries. While both males and females reported similar levels of *teacher support*, females had significantly more *positive attitudes towards school*, and indicated a higher level of positive relationships with their teachers than males, while males reported significantly stronger *self-concept* in mathematics and had a much stronger sense of *instrumental motivation* than females.

Australian students' perceptions of the *classroom disciplinary climate*, their means on the *interest and enjoyment* index, and their average level of *anxiety in mathematics* were similar to the OECD average. However, in Australia, males reported higher levels of *interest and enjoyment* in mathematics than females, and while females had more positive views of the disciplinary climate than males, they also reported significantly higher levels of *anxiety in mathematics.*

Factors related to performance

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The relationship between socioeconomic background (either ESCS or HISEI) and performance is described in terms of slope and scatter. The slope indicates on average how much difference in performance is associated with a given difference in socioeconomic background. Scatter refers to the extent to which results for individuals are scattered around the average line rather than being close to it. It indicates the strength of the relationship and is measured by the percentage of the variation in performance accounted for by socioeconomic background.

For *mathematical literacy* in PISA 2003 the slope (using ESCS as the measure of socioeconomic background) was just a little less than for the OECD average (although the difference was not significant). The slope for Australia was less steep than that for Hungary and Belgium but more steep than Finland, Iceland or Canada. In PISA 2000 the corresponding slope for Australia was a little steeper (but still not significantly different from) the slope for the OECD average.

In Australia for PISA 2003 the strength of the relationship between socioeconomic background and performance in *mathematical literacy* was less than for the OECD on average. Figure 8.1 provides a comparison between countries of the strength of relationship between socioeconomic background and mean country performance in *mathematical literacy*. It can be seen that for this indicator of socioeconomic background and *mathematical literacy* Australia falls in the high performance – high equity quadrant. This appears different from the pattern in PISA 2000 relating to *reading literacy* (where Australia was recorded as just falling in the low equity quadrant) but in fact a relatively small change has resulted in a different classification. The strength of this relationship was less strong in Australia than in countries such as the United States, Germany or Belgium, indicating that student background as reflected in the ESCS was not so strong a determinant of *mathematical literacy* in Australia as in these countries. The relationship was stronger in Australia than in Finland or Hong Kong-China, for example. In PISA 2000 the strength of the corresponding relationship involving *mathematical literacy* in Australia was not significantly different from that of the OECD on average.

Students' socioeconomic background was included together with measures of many other factors in multilevel analyses. The multilevel analysis found that, all other things equal, the most influential of the student background factors on mathematics performance was the student's educational intentions. Those students who have high aspirations (in this instance who intend completing higher levels of educational qualifications) tended to perform at a higher level in *mathematical literacy*. Gender was not found to have a significant effect. Other significant student background influences were ESCS, books in the home, and computer resources in the home.

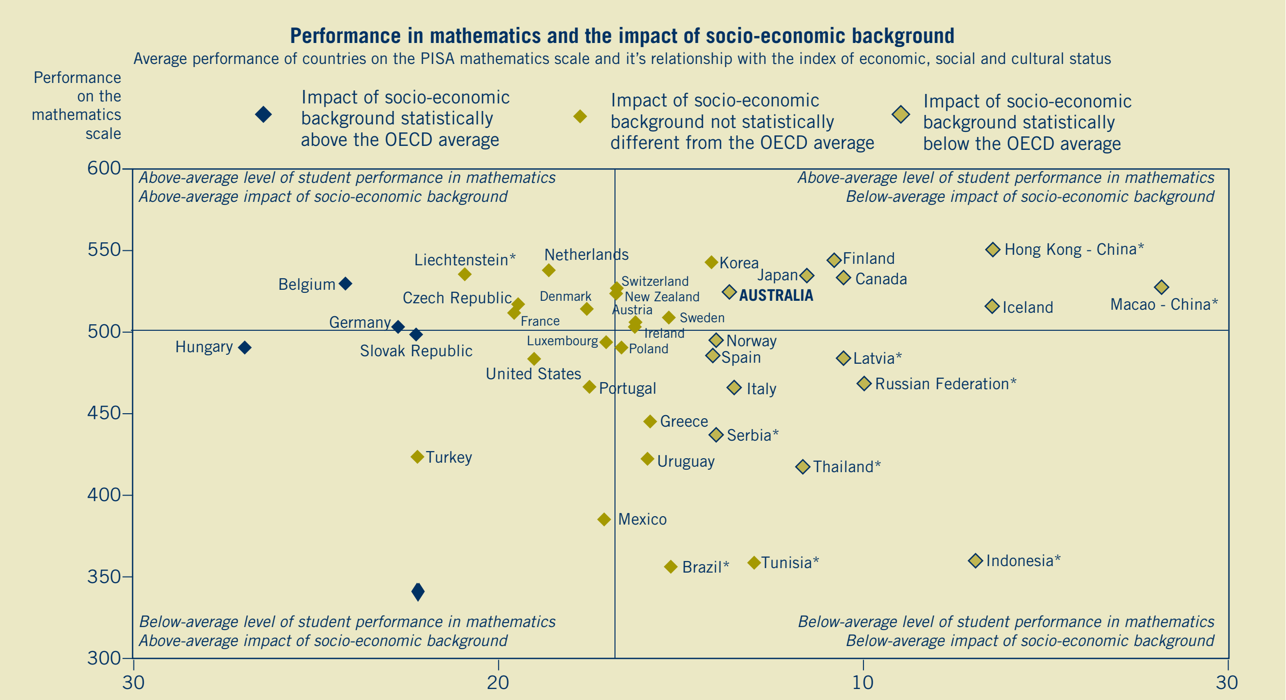

Figure 8.1 Between-Country Comparisons of Performance in *Mathematical Literacy* and the Strength of the Relationship of Socioeconomic Background (as measured by ESCS)

The multilevel analysis also found that, all other things equal, good *student-teacher relationships* had a positive effect on *mathematical literacy* performance, but *sense of* *belonging* had a negative effect – students who reported higher levels on the *sense of belonging* index performed at a lower level in *mathematical literacy* than students who reported lower levels. There was also a significant positive relationship between students' perceptions of their classroom disciplinary climate and mathematics performance, in that mathematics performance is increased in an environment that is quiet and orderly, and where students are eager to learn. *Mathematics anxiety* was negatively related to performance in mathematics, with those students having high levels of anxiety performing at lower levels than students with low levels of anxiety, and the use of *elaboration*, *memorisation* or *cooperative learning* strategies was negatively related to performance.

However the strongest relationships were found between *mathematics self-efficacy* and mathematics performance and between *mathematics self-concept* and mathematics performance. Both students' academic *self-concept* and *self-efficacy* – students' confidence in their abilities and their belief that investment in learning can help them overcome difficulties – are clearly important outcomes of education and strong predictors of success.

Policy issues

Mathematics is an important tool in daily life and an important foundation for many other fields of study. PISA assesses *mathematical literacy* which is described as 'the capacity to see how mathematics can be used in the real world and to engage in mathematics to meet one's needs' (OECD, 2004a). Of course *mathematical literacy* is a continuous measure without a natural cut-off point at which students could be deemed mathematically literate. There are various levels of mathematical proficiency related to a person's capacity to analyse, reason and communicate effectively when using mathematics.

PISA 2003 measured student performance in four areas of mathematics: *space and shape*, *change and relationships*, *quantity*, and *uncertainty*. The PISA mathematics assessment was based on mathematical problems set in real-world contexts that were related to their personal lives, learning, work, community issues or scientific phenomena. Students were asked to identify features of a problem that might be amenable to mathematical investigation and to use the relevant mathematical competencies to solve the problem.

Australia's PISA results for *mathematical literacy*, as the major domain in the 2003 assessment, are encouraging. There are obviously areas in which performance could improve, but Australia's results in PISA are significantly higher than those of the OECD as a whole, and either statistically similar to, or higher than, those in most other countries with which we would usually compare ourselves.

The relationship between socioeconomic background and performance in *mathematical literacy* was found to be less in Australia than for the OECD on average, but there still exists a distinct advantage for those students with higher socioeconomic backgrounds, no matter which way this is defined. In terms of policy and practice, while schools are not able to influence students' socioeconomic backgrounds, they are able to introduce policies that help to counteract the effects of disadvantage. Although many schools already do this there is work to be done because the differences observed are greater than would be considered desirable in relation to our national aspirations.

While there are no significant gender differences overall, males tend to be over-represented at the upper levels of performance, although equally represented in the lower levels. An explanation for this may lie in the attitudes and beliefs held by females towards mathematics. Females appear to retain, to a much greater extent than males, a negative attitude towards mathematics and towards their own abilities in the subject. This is reflected in their lesser tendency to study mathematics and related disciplines at tertiary level. PISA suggests a reason for this, finding that there are much larger gender differences at age 15 in approaches to learning mathematics than in performance itself. Females appear to be less engaged, more anxious, and less confident in mathematics than males. This finding suggests that approaches to reducing these gender differences need to start at an early age in order to increase females' engagement in mathematics and build their confidence in their mathematical abilities.

The low level of performance by most Indigenous students continues to be a concern. While some Indigenous students performed well in PISA *mathematical literacy*, this was a very small proportion of the overall sample and a much greater proportion was performing at the lower levels of the proficiency levels. It is important for Indigenous students to continue to receive additional support to raise their performance levels.

Students who are well motivated, confident in their own abilities and who regularly adopt effective learning strategies, whatever their gender, Indigenous status, or socioeconomic level, 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 continue to learn throughout life.

A goal of Australia's education systems is to provide equal and high quality opportunities in learning for all of our students. The PISA survey helps to indicate how well we are succeeding in this respect in comparison with other countries, providing benchmarks over time against which we can measure improved student performance.

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Appendix **ONE**

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 2005 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 2003 is given first, followed by details of its implementation in Australia.

>> *PISA internationally*

International consortium

PISA 2003 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), the Educational Testing Service (ETS) and Westat Inc. of the United States, and the National Institute for Educational Policy Research (NIER) in Japan. The same consortium is also implementing PISA 2006.

Collaborative development

PISA is an international assessment that has been jointly developed by the OECD's participating countries. Through their National Project Managers and National Advisory Committees, 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 Subject Matter 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, mostly 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 four Subject Matter Expert Groups (SMEGs) for PISA 2003 consisted of subject matter and technical experts from participating countries. Each assessment domain – that is, each of mathematical, scientific and reading literacy and problem solving – had its own SMEG. These groups, together with the TAG, linked the policy objectives as 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 from eight to 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 2003 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 2003, an expanded framework for the assessment of mathematical literacy as a major domain was undertaken, as well as the framework for the new assessment of problem solving as a cross-curricular competency. 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 scientific literacy frameworks remained essentially the same for PISA 2003.

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 1000 from Australia. Ten assessment booklets were used, as practice for the Main Study, and there were two 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

The PISA Main Study was administered between March and May 2003 in Northern Hemisphere countries (except in the United Kingdom and the United States where testing was completed in July and October respectively). All Southern Hemisphere countries administered PISA between April and August 2003. Within the majority of countries, between approximately 4000 and 9000 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) or sub-national comparisons could be made (e.g., Mexico, Indonesia, Belgium and the Slovak Republic) 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 2003, 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 2003 there were seven mathematics clusters, two science clusters, two reading clusters and two problem solving 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 assessing students and their family background, academic environments and self-regulated learning, the Student Questionnaire also included optional sections to assess Educational Career 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.

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. As outlined below, members of the consortium developed the quality monitoring procedures, which were submitted to the PGB for review and endorsement.

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 developed 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. For all but a small number of countries, a team of sampling experts from ACER selected the sample of schools for the main study. Countries were also 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 in the 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. Some countries were also visited in a similar way prior to 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 the 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. Worldwide, PQMs attended about 600 such sessions for the Main Study.

Marking of responses to open-ended items

Over 40 per cent of items from each of the four domains (mathematics, reading, science and problem solving were open-ended, necessitating judgment marking. Standardised Marking Guides were developed by consortium staff but were 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 markers was used as for Test Administrators, in that NPMs or their designated staff first attended international training sessions and then trained the markers in their country.

Reliability studies were carried out to ensure that markers were applying the criteria consistently, and to quantify any variation between markers. Monitoring of consistency in applying the marking criteria was required to be done on a daily basis so that systematic errors could be corrected. In the Main Study, four markers in each country were required to mark all of the items in their subject area from 100 of each the booklets one to six, eight, ten and twelve. A cross-national study of marker reliability was also undertaken. The 180 booklets (60 of each of three booklet types) that had already been marked four times within a country were sent to be marked a fifth time by an experienced marker in another same-language country. These data were collected to ensure the reliability of marking 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 the 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 the 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) was formed to guide 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 mid-May to mid-June 2002. A summary of its scope is presented here.

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, 27 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 'all students born in 1986'. It was decided by the TAG that the least error-prone way to obtain lists of students from schools for sampling purposes would be to ask for all students born within a calendar year to be identified. In accordance with the international sampling manual, ACER staff randomly selected 50 students from each school. Fifty students from each school were randomly selected by ACER staff, according to procedures specified in the international sampling manual. Of the 1331 age-eligible students selected, 965 students participated in the PISA Field Trial.

Adaptations to manuals, assessment booklets and questionnaires

Minimal adaptations for Australia were required to the administrative manuals, Marking Guides, assessment booklets and questionnaires. Amendments to assessment booklets such as vocabulary and changes to students' names used in assessment items (for example, 'Jouni' was changed to 'Tony') 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 was 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 10 to 20 minutes to be taken before starting the questionnaire. Nine experienced teachers were employed by ACER to conduct the Field Trial sessions. Training of test administrators took place at ACER in early May 2002.

Marking

Almost half of the field trial items were open-ended and required markers to code the students' responses. Training in the marking procedures and internationally prepared Marking Guides was conducted during early June and involved seven markers, marking across the three domains of mathematical and scientific literacy and problem solving. The marking process also included multiple marking from half of the 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 the third week of July until the end of August 2003, with slight variations between states due to holiday dates and some students' work experience commitments.

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 321 of 355 schools and 83 per cent of the selected students taking part.

Obtaining the school sample

Permission was sought from state and territory Education Departments and Catholic Education Offices to approach the schools that had been randomly selected to participate in PISA. The Associations of Independent Schools in each state and territory were also notified of the selected main and replacement sample schools. In most states, letters endorsing the value of PISA were sent from the Education Department to the selected government schools, recommending that they take part in the study.

Schools were mostly approached from late February to early March by letter, with an accompanying information package about PISA. Many schools responded quickly but others typically required several follow-up phone calls before their participation was confirmed.

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 language spoken at home and on parents' and respondent's countries of birth 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.

As well as recommending minor adaptations to terminology and vocabulary in the tests, the questions incorporated into the Student Questionnaire in PISA 2000 were retained. The additional items included Indigenous status and time spent in a range of out-of-school activities.

Test Administrators

Thirty-nine Test Administrators external to the schools administered all test sessions. Most were employed by ACER on a casual basis and had also been involved in PISA 2000. All were highly experienced, trained teachers, many of whom were also experienced in conducting test sessions according to standardised procedures. In Victoria, Test Administrators came from ACER's team of casual employees who work as testers on a wide range of projects. In all other states, Education Departments assisted by locating appropriate persons for ACER to use in this role. These were recently retired teachers or teachers on maternity or other temporary leave, all based in capital cities. Many had to travel extensively to cover the non-metropolitan schools in the sample.

All Test Administrators were brought to ACER for a one-day training session in mid-July 2003. The sessions were highly useful – to establish a sense of common purpose among the diverse group of Test Administrators who had mostly 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 usually administered in a single morning. The exceptions were in two schools where the test and questionnaire sessions took place at different times (the student questionnaire was completed in the afternoon in one school and the next day in the other school). 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, 323 regular and approximately 100 follow-up testing sessions took place. Although the majority of follow-up sessions were held within the specified main testing period of six weeks, some sessions were held in September. Fifty-five per cent of testing sessions were carried out in classrooms, 20 per cent in the school library, 15 per cent in the school hall and 12 per cent in a range of areas such as common or meeting rooms or the computer room.

Marking processes

Seventeen mathematical/scientific literacy and problem solving markers and 13 reading literacy markers and were used for the whole duration of the marking. All markers were experienced secondary teachers, not currently teaching. Training of mathematical/scientific/reading literacy and problem solving markers in use of the Marking Guide occurred in mid August, two weeks before the end of the testing. Marking of mathematics and science items was begun at this time, as all marking and data entry had to be completed within three months of the end of the testing period. By doing this, it was hoped that some of the booklets would be ready for the reading markers to begin marking by the end of August, when their training session was held.

Following the procedures specified by the IPC, marking 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, marking was done by item. The specified procedures for randomly allocating booklets to markers were followed.

'Table leaders' (very experienced markers) were used to field queries from individual markers, to review with individual markers 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 marking process generally.

The marking across all domains was completed in approximately six weeks. In addition to improved Marking Guides, revised after the Field Trial, the expertise and experience of the table leaders ensured that the work progressed well.

Data entry

Up to eight operators were used to enter the assessment data from the booklets and the multiple marking sheets, and the questionnaire data. All data were entered in just under one month, using KeyQuest. Checking and cleaning steps, which took a further two weeks, were then undertaken prior to the Australian data being sent to the IPC.

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, the training and monitoring of markers 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 TWO

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 PISA 2003 to become a cohort of the Longitudinal Surveys of Australian Youth (LSAY) 2003. Table A2.1 gives the details of the Australian sample design.

Table A2.1 Designed PISA School Sample by State and Sector

		Sector		
State/Territory	Catholic	Government	Independent	Total
NSW	21	58	11	90
VIC	14	39	11	64
QLD	10	35	10	55
SA	7	20	7	34
WA	8	27	7	42
TAS	4	15	2	21
NT	3	12	4	19
ACT	7	20	3	30
TOTAL	74	226	55	355

Stratification variables used in Australia when selecting the sample were state/territory and sector (government, Catholic and independent).[1] School location, in terms of metropolitan or country, was also taken into account in the sam-

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[1] The stratum codes for sector were necessary for accuracy of sampling. They are not used for reporting purposes in PISA 2003 and are not included in the PISA databases.

pling. For this purpose, the Australia Post classification of postcodes was used. 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 the Australian Bureau of Statistics. 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, remote off shore and very remote mainland schools and schools instructing in a language other than English. These schools catered for a total of less than one per cent of the 15 year-old students in Australia. In addition, institutions in the Technical and Further Education (TAFE) sector were also excluded, because there was one per cent of 15-year-olds in them.

Achieved sample

Main Sample

The response rate achieved was sufficiently high to meet the requirements set down by the OECD, although it was necessary to approach some extra schools to replace those schools that declined to be part of the project.

Schools that chose not to participate gave a number of reasons for this. These included those which declared no interest in studies such as this (32 schools); those already involved in a research study this year (eight schools) and perceived staffing problems (five schools).

In all, 321 schools participated in the study (including 310 originally sampled schools and 11 extra or replacement schools). The achieved Australian PISA school sample is included as Table 1.1 in Chapter 1.

The 321 schools represented a weighted response rate of 90.4 per cent. The international standards specified by the OECD required a response rate of at least 85 per cent (weighted) of first selected schools.

The total number of students selected to participate in the survey was 16 303.

This allowed for approximately twenty schools who did not have the full complement of 50 eligible students. In these cases, all the age-eligible students at the school were selected. Overall, the participating students constituted an unweighted response rate of 81.9 per cent per cent and a weighted response rate of 83.3 per cent, meeting the international requirement of a minimum of 80 per cent of sampled students taking part.

Special indigenous sample

The National Advisory Committee recommended a process of oversampling Indigenous students to reliably report results for this minority group. To achieve this, all age-eligible Indigenous students in the sampled PISA schools were invited to participate in the survey.

Approximately 1300 Indigenous students were sampled in PISA 2003, with just over 800 Indigenous students participating in PISA 2003. 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.

All Indigenous students are included in the PISA 2003 National and International Databases. This is unlike the PISA 2000 database, where only the Indigenous students who were sampled as part of the main survey were included in the International Database, whereas all Indigenous students were included in National Database.

Absentees

Of the eligible students participating in PISA, 1969 students were absent on the day of the assessment session. Overall, the absentee rate was 12.1 per cent. Of the sampled students, the Australian Capital Territory and Tasmania had absentee rates under one per cent and Victoria and New South Wales, the highest, at 2.5 and 2.3 per cent respectively. The testing took place in mid-winter and reports received from School Contacts indicated there was a high incidence of flu in 2003. Students who were absent on the day of the assessment are shown by state in Table A2.2.

Table A2.2 Absentees and Refusals in Australia by State

	Absentees	Refusals
NSW	383	189
VIC	405	192
QLD	331	85
SA	210	148
WA	242	100
TAS	96	95
NT	211	43
ACT	91	140
TOTAL	1969	992

Refusals

In addition to the students who were absent from school, there were 992 whose parents refused permission for them to participate, or they chose to refuse themselves. The student tracking form did not distinguish between parent and student refusal. These students constituted 6.1 per cent of the sampled students. The lowest refusal rate was in the Northern Territory at 0.5 per cent and the highest in New South Wales and Victoria at 1.2 per cent. The details are listed in Table A2.3.

Other non-participants

There was also a group of approximately 550 students who were eligible and selected to participate in the survey, but who had left school before the testing, had transferred to another school or 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).

Exclusions

In all, there were 228 students excluded by the School Contact from the PISA assessment. In PISA 2003, 33 students were excluded on the basis of a functional disability (exclusion 1); 133 students were excluded because of an intellectual disability (exclusion 2) and 62 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.

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 = students with a severe physical or sensory disability. These are students who have a moderate to severe permanent physical disability in such a way that they cannot perform in the PISA testing situation (physically disabled students who can respond to the test should be included in the testing).

2 = students with a severe intellectual or emotional disability. These are students who are considered in the professional opinion of the School Psychologist, School Principal, or other qualified professional to be intellectually disabled or who have been psychologically tested as such. The category also includes students who would be emotionally or mentally unable to follow even the general instructions of the assessment. Students should not be excluded solely because of poor academic performance or disciplinary problems.

3 = students with limited proficiency in English. These are students who are virtually unable to read or speak English and would be unable to overcome the language barrier in the test situation. Typically, a student who has received **less than one year of instruction in English** should be excluded. All others should be included.

>> International sampling results

Internationally, the desired minimum number of students to be assessed per country was specified as 4500. 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 2003 Target Populations and Samples

COUNTRY	Population and sample information												Coverage indices	
	(1) Total population of 15-year-olds	(2) Total enrolled population of 15-year-olds	(3) Total in national desired target population	(4) School-level exclusions	(5) Total in national desired target population after school exclusions and before within-school exclusions	(6) Percentage of school-level exclusions	(7) Number of participating students	(8) Weighted number of participating students	(9) Number of excluded students	(10) Weighted number of excluded students	(11) Within-school exclusion rate (%)	(12) Overall exclusion rate (%)	(13) Coverage Index 1: Coverage of national desired population	(14) Coverage Index 2: Coverage of national enrolled population
	SF 2[a]	SF 2[b]	SF 3[a]	SF 3[b]	SF 3[c]	3[b] /3[a]		P		E	E / (P+E)		P/(P+E) * (3[c]/3[a])	P/(P+E) * (3[c]/2[b])
Australia	268,164	250,635	248,035	1,615	246,420	0.65	12,551	235,591	228	3,612	1.51	2.15	0.98	0.97
Austria	94,515	89,157	89,049	0	89,049	0.00	4,597	85,931	60	1,099	1.26	1.62	0.98	0.98
Belgium	120,802	118,190	118,185	561	117,624	0.47	8,796	111,831	102	1,193	1.06	1.53	0.98	0.98
Canada	398,865	399,744	397,520	0	397,520	0.00	27,953	330,436	1,993	18,328	5.26	6.83	0.93	0.93
Czech Republic	130,679	126,428	126,348	1,072	125,276	0.85	6,320	121,183	22	218	0.18	1.20	0.99	0.99
Denmark	59,156	58,200	58,188	628	57,560	1.08	4,218	51,741	214	2,321	4.29	5.33	0.95	0.95
Finland	61,107	61,107	61,107	1,324	59,783	2.17	5,796	57,884	79	725	1.24	3.38	0.97	0.97
France	809,053	809,053	774,711	18,056	756,655	2.33	4,300	734,579	51	8,158	1.10	3.40	0.97	0.93
Germany	951,800	919,017	916,869	5,600	911,269	0.61	4,660	884,358	61	11,533	1.29	1.89	0.98	0.98
Greece	111,286	108,942	108,314	104	108,210	0.10	4,627	105,131	144	2,652	2.46	3.19	0.97	0.97
Hungary	129,138	125,927	123,762	2,421	121,341	1.96	4,765	107,044	62	1,065	0.99	3.94	0.96	0.96
Iceland	4,168	4,112	4,112	26	4,086	0.63	3,350	3,928	79	79	1.97	2.59	0.97	0.97
Ireland	61,535	59,801	58,906	834	58,072	1.42	3,880	54,850	139	1,619	2.87	4.29	0.96	0.96
Italy	561,304	575,628	574,611	0	574,611	0.00	11,639	481,521	188	6,794	1.39	1.88	0.98	0.98
Japan	1,365,471	1,328,498	1,328,498	13,592	1,314,906	1.02	4,707	1,240,054	0	0	0.00	1.02	0.99	0.99
Korea	606,722	606,722	606,370	1,505	604,865	0.25	5,444	533,504	24	2,283	0.43	0.87	0.99	0.99
Luxembourg	4,204	4,204	4,204	0	4,204	0.00	3,923	4,080	66	66	1.59	1.59	0.98	0.98
Mexico	2,192,452	1,273,163	1,273,163	46,472	1,226,691	3.65	29,983	1,071,650	34	7,264	0.67	4.30	0.96	0.96
Netherlands	194,216	194,216	194,216	2,559	191,657	1.32	3,992	184,943	20	1,041	0.56	1.87	0.98	0.98
New Zealand	55,440	53,293	53,160	194	52,966	0.36	4,511	48,638	263	2,411	4.72	5.07	0.95	0.95
Norway	56,060	55,648	55,531	294	55,237	0.53	4,064	52,816	139	1,563	2.87	3.39	0.97	0.96
Poland	589,506	570,994	569,294	14,600	554,694	2.56	4,383	534,900	75	7,517	1.39	3.91	0.96	0.96
Portugal	109,149	102,834	99,216	143	99,073	0.14	4,608	96,857	84	1,450	1.47	2.30	0.98	0.98
Slovak Republic	84,242	82,354	81,890	932	80,958	1.14	7,346	77,067	109	1,341	1.71	2.96	0.97	0.97
Spain	454,064	418,005	418,005	1,639	416,366	0.39	10,791	344,372	591	25,619	6.92	7.29	0.93	0.93
Sweden	109,482	112,258	112,258	1,476	110,782	1.31	4,624	107,104	144	3,085	2.80	4.20	0.96	0.96
Switzerland	83,247	81,045	81,020	1,096	79,924	1.35	8,420	86,491	194	893	1.02	4.39	0.96	0.96
Turkey	1,351,492	727,064	725,030	795	724,235	0.11	4,855	481,279	0	0	0.00	0.73	0.99	0.99
United Kingdom[1]	768,180	736,785	736,785	7,909	728,876	1.07	9,535	698,579	270	15,062	2.11	5.40	0.95	0.95
United States	3,979,116	3,979,116	3,979,116	0	3,979,116	0.00	5,456	3,147,089	534	246,991	7.28	7.28	0.93	0.93
Brazil*	3,618,332	2,359,854	2,348,405	0	2,348,405	0.00	4,452	1,952,253	5	2,142	0.11	0.11	1.00	0.99
Hong Kong*	75,000	72,631	72,631	601	72,030	0.83	4,478	72,484	8	103	0.14	0.97	0.99	0.99
Indonesia*	4,281,895	3,113,548	2,968,756	7,611	2,961,145	0.26	10,761	1,971,476	0	0	0.00	0.31	1.00	0.95
Latvia*	37,544	37,275	37,138	1,419	35,719	3.82	4,627	33,643	44	380	1.12	4.89	0.95	0.95
Liechtenstein*	402	348	348	0	348	0.00	332	338	5	5	1.46	1.46	0.99	0.99
Macao-China*	8,318	6,939	6,939	0	6,939	0.00	1,250	6,547	4	13	0.20	0.20	1.00	1.00
Russian Federation*	2,496,216	2,367,173	2,366,285	23,445	2,342,840	0.99	5,974	2,153,373	35	14,716	0.68	1.66	0.98	0.98
Serbia*	98,729	92,617	92,617	3,789	88,828	4.09	4,405	68,596	15	241	0.35	5.66	0.94	0.94
Thailand*	927,070	778,267	778,267	7,597	770,670	0.98	5,236	637,076	5	563	0.09	1.06	0.99	0.99
Tunisia*	164,758	164,758	164,758	553	164,205	0.34	4,721	150,875	1	31	0.02	0.36	1.00	1.00
Uruguay*	53,948	40,023	40,023	0	40,023	0.00	5,835	33,775	18	80	0.24	0.38	1.00	1.00

SOURCE: International PISA 2003 Report, Table A3.1

* Partner country

1. Response rate is too low to ensure comparability. For details see the PISA 2003 Technical Report.

Population coverage

Table A2.3 describes the target population of the countries participating in PISA 2003. Further information on the target population and the implementation of PISA sampling standards can be found in the *PISA 2003 Technical Report.*

- **Column 1** shows the total number of 15-year-olds according to the most recent available information, which in most countries was the year 2002 as the year before the assessment.

- **Column 2** shows the number of 15-year-olds enrolled in schools (as defined above), which 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.

- **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.

- **Column 7** shows the ***number of students participating in PISA 2003***. 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.

  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 9** indicates the total number of ***excluded students, which is further described and classified into specific categories in Table A3.2***. The number of excluded students

- **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).

- **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 obtained by multiplying the percentage of school-level exclusions (Column 6) by 100, minus the percentage of students excluded within schools (Column 11) and adding the percentage of students excluded within schools (Column 11) to the result.

- **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 9) divided by the weighted number of participating and excluded students (Columns 9 plus Column 11), times the nationally defined target population (Column 5) divided by the national desired target population (times 100).

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 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 2003 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 **THREE**

STATISTICAL TABLES

FIGURE A3.1 SUMMARY DESCRIPTIONS OF SIX LEVELS OF PROFICIENCY ON THE MATHEMATICS / SPACE AND SHAPE SCALE

Summary Description	What students can typically do
LEVEL 6	
Six per cent of all students across the OECD area can perform tasks at Level 6 on the space and shape scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Solve complex problems involving multiple representations and often involving sequential calculation processes; identify and extract relevant information and link different but related information; use reasoning, significant insight and reflection; and generalise results and findings, communicate solutions and provide explanations and argumentation.	- Interpret complex textual descriptions and relate these to other (often multiple) representations - Use reasoning involving proportions in non-familiar and complex situations - Show significant insight to conceptualise complex geometric situations or to interpret complex and unfamiliar representations - Identify and combine multiple pieces of information to solve problems - Devise a strategy to connect a geometrical context with known mathematical procedures and routines - Carry out a complex sequence of calculations, for example volume calculations or other routine procedures in an applied context, accurately and completely - Provide written explanations and argument based on reflection, insight and generalisation of understandings
LEVEL 5	
Sixteen per cent of all students across the OECD area can perform tasks at least Level 5 on the space and shape scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Solve problems that require appropriate assumptions to be made, or that involve working with assumptions provided; use well-developed spatial reasoning, argument and insight to identify relevant information and to interpret and link different representations; work strategically and carry out multiple and sequential processes.	- Use spatial/geometrical reasoning, argument, reflection and insight into two- and three-dimensional objects, both familiar and unfamiliar - Make assumptions or work with assumptions to simplify and Solve a geometrical problem in a real-world setting, eg involving estimation of quantities in a real-world situation, and communicate explanations - Interpret multiple representations of geometric phenomena - Use geometric constructions - Conceptualise and devise multi-step strategy to solve geometrical problems - Use well-known geometrical algorithms but in unfamiliar situations, such as Pythagoras's theorem; and calculations involving perimeter, area and volume
LEVEL 4	
Thirty-three per cent of all students across the OECD area can perform tasks at least Level 4 on the space and shape scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Solve problems that involve visual and spatial reasoning and argumentation in unfamiliar contexts; link and integrate different representations; carry out sequential processes; apply well-developed skills in spatial visualisation and interpretation.	- Interpret complex text to solve geometric problems - Interpret sequential instructions; follow a sequence of steps - Interpretation using spatial insight into non-standard geometric situations - Use a two-dimensional model to work with 3-D representations of unfamiliar geometric situation - Link and integrate two different visual representations of a geometric situation - Develop and implement a strategy involving calculation in geometric situations - Reason and argument about numeric relationships in a geometric context - Perform simple calculations (eg multiply multi-digit decimal number by an integer, numeric conversions using proportion and scale, calculate areas of familiar shapes)

<table>
<tr><th colspan="2">LEVEL 3</th></tr>
<tr><th colspan="2">Fifty-five per cent of all students across the OECD area can perform tasks at least Level 3 on the space and shape scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Solve problems that involve elementary visual and spatial reasoning in familiar contexts; link different representations of familiar objects; use elementary problem solving skills (devising simple strategies); apply simple algorithms.</td><td>- Interpret textual descriptions of unfamiliar geometric situations
- Use basic problem-solving skills, such as devising a simple strategy
- Use visual perception and elementary spatial reasoning skills in a familiar situation
- Work with a given familiar mathematical model
- Perform simple calculations such as scale conversions (using multiplication, basic proportional reasoning)
- Apply routine algorithms to solve geometric problems (eg calculate lengths within familiar shapes)</td></tr>
<tr><th colspan="2">LEVEL 2</th></tr>
<tr><th colspan="2">Seventy-five per cent of all students across the OECD area can perform tasks at least Level 2 on the space and shape scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Solve problems involving a single mathematical representation where the mathematical content is direct and clearly presented; use basic mathematical thinking and conventions in familiar contexts.</td><td>- Recognise simple geometric patterns
- Use basic technical terms and definitions and apply basic geometric concepts (eg symmetry)
- Apply a mathematical interpretation of a common-language relational term (eg 'bigger') in a geometric context
- Create and use a mental image of an object, both two- and three-dimensional
- Understand a visual two-dimensional representation of a familiar real-world situation
- Apply simple calculations (eg subtraction, division by 2-digit number) to solve problems in a geometric setting</td></tr>
<tr><th colspan="2">LEVEL 1</th></tr>
<tr><th colspan="2">Eighty-nine per cent of all students across the OECD countries area can perform tasks at least Level 1 on the space and shape scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Solve simple problems in a familiar context using familiar pictures or drawings of geometric objects and applying counting or basic calculation skills.</td><td>- Use a given two-dimensional representation to count or calculate elements of a simple three-dimensional object</td></tr>
</table>

Source: PISA International PISA 2003 Report

FIGURE A3.2 SUMMARY DESCRIPTIONS OF SIX LEVELS OF PROFICIENCY ON THE MATHEMATICS/CHANGE AND RELATIONSHIPS SCALE

Summary Description	What students can typically do
LEVEL 6	
Five per cent of all students across the OECD area can perform tasks at Level 6 on the change and relationships scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Use significant insight, abstract reasoning and argumentation skills and technical knowledge and conventions to solve problems and to generalise mathematical solutions to complex real-world problems.	- Interpret complex mathematical information in the context of an unfamiliar real-world situation - Interpret periodic functions in a real-world setting, perform related calculations in the presence of constraints - Interpret complex information hidden in the context of an unfamiliar real-world situation - Interpret complex text and use abstract reasoning (based on insight into relationships) to solve problems - Insightful use of algebra or graphs to solve problems; ability to manipulate algebraic expressions to match a real-world situation - Problem solving based on complex proportional reasoning - Multi-step problem solving strategies involving the use of formula and calculations - Devise a strategy and solve the problem by using algebra or trial-and-error - Identify a formula which describes a complex real-world situation, generalise exploratory findings to create a summarising formula - Generalise exploratory findings in order to do some calculations - Apply deep geometrical insight to work with and generalise complex patterns - Conceptualise complex percentage calculation - Coherently communicate logical reasoning and arguments
LEVEL 5	
Sixteen per cent of all students across the OECD area can perform tasks at least Level 5 on the change and relationships scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Solve problems by making advanced use of algebraic and other formal mathematical expressions and models. Link formal mathematical representations to complex real-world situations. Use complex and multi-step problem solving skills, reflect on and communicate reasoning and arguments.	- Interpret complex formulae in a scientific context - Interpret periodic functions in a real-world setting, perform related calculations - Use advanced problem solving strategies:F - Interpret and link complex information - Interpret and apply constraints - Identify and carry out a suitable strategy - Reflect on the relationship between an algebraic formula and its underlying data - Use complex proportional reasoning, e.g. related to rates - Analyse and apply a given formula in a real-life situation - Communicate reasoning and argument
LEVEL 4	
Thirty-five per cent of all students across the OECD area can perform tasks at least Level 4 on the change and relationships scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Understand and work with multiple representations, including explicitly mathematical models of real-world situations to solve practical problems. Employ considerable flexibility in interpretation and reasoning, including in unfamiliar contexts, and communicate the resulting explanations and arguments.	- Interpret complex graphs, and read one or multiple values from graphs - Interpret complex and unfamiliar graphical representations of real-world situations - Use multiple representations to solve a practical problem - Relate text-based information to a graphic representation and communicate explanations - Analyse a formula describing a real-world situation - Analyse three-dimensional geometric situations involving volume and related functions - Analyse a given mathematical model involving a complex formula - Interpret and apply word formulae, and manipulate and use linear formulae that represent real-world relationships - Carry out a sequence of calculations involving percentage, proportion, addition or division

<table>
<tr><th colspan="2">LEVEL 3</th></tr>
<tr><th colspan="2">Fifty-seven per cent of all students across the OECD area can perform tasks at least Level 3 on the change and relationships scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Solve problems that involve working with multiple related representations (a text, a graph, a table, a formula), including some interpretation, reasoning in familiar contexts, and communication of argument.</td><td>- Interpret unfamiliar graphical representations of real-world situations
- Identify relevant criteria in a text
- Interpret text in which a simple algorithm is hidden and apply that algorithm
- Interpret text and devise a simple strategy
- Link and connect multiple related representations (e.g. two related graphs, text and a table, a formula and a graph)
- Use reasoning involving proportions in various familiar contexts and communicate reasons and argument
- Apply a text given criterion or situation to a graph
- Use a range of simple calculation procedures to solve problems, including ordering data, time difference calculations, linear interpolation</td></tr>
<tr><th colspan="2">LEVEL 2</th></tr>
<tr><th colspan="2">Seventy-seven per cent of all students across the OECD area can perform tasks at least Level 2 on the change and relationships scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Work with simple algorithms, formulae and procedures to solve problems; link text with a single representation (graph, table, simple formula); use interpretation and reasoning skills at an elementary level.</td><td>- Interpret a simple text and link it correctly to graphical elements
- Interpret a simple text that describes a simple algorithm and apply that algorithm
- Interpret a simple text and use proportional reasoning or a calculation
- Interpret a simple pattern
- Interpret and use reasoning in a practical context involving a simple and familiar application of motion, speed and time relationships
- Locate relevant information in graph, and read values directly from graph
- Correctly substitute numbers to apply a simple numeric algorithm or simple algebraic formula</td></tr>
<tr><th colspan="2">LEVEL 1</th></tr>
<tr><th colspan="2">Ninety per cent of all students across the OECD area can perform tasks at least Level 1 on the change and relationships scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Locate relevant information in a simple table or graph; follow direct and simple instructions to read information directly from a simple table or graph in a standard or familiar form; perform simple calculations involving relationships between two familiar variables.</td><td>- Make a simple connection of text to a specific feature of a simple graph and read off a value from the graph
- Locate and read a specified value in a simple table
- Perform simple calculations involving relationships between two familiar variables</td></tr>
</table>

Source: PISA International PISA 2003 Report

FIGURE A3.3 SUMMARY DESCRIPTIONS OF SIX LEVELS OF PROFICIENCY ON THE MATHEMATICS/QUANTITY SCALE

Summary Description	What students can typically do
LEVEL 6	
Four per cent of all students across the OECD area can perform tasks at Level 6 on the quantity scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Conceptualise and work with models of complex mathematical processes and relationships; work with formal and symbolic expressions; use advanced reasoning skills to devise strategies for solving problems and to link multiple contexts; use sequential calculation processes; formulate conclusions, arguments and precise explanations.	- Conceptualise complex mathematical processes such as exponential growth, weighted average, as well as number properties and numeric relationships - Interpret and understand complex information, and link multiple complex information sources - Use advanced reasoning concerning proportions, geometric representations of quantities, combinatorics and integer number relationships - Interpret and understand formal pure mathematical expressions of relationships among numbers, including in a scientific context - Perform sequential calculations in a complex and unfamiliar context, including working with large numbers - Formulate conclusions, arguments and precise explanations - Devise a strategy (develop heuristics) for working with complex mathematical processes
LEVEL 5	
Fifteen per cent of all students across the OECD area can perform tasks at least Level 5 on the quantity scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Work effectively with models of more complex situations to solve problems; use well-developed reasoning skills, insight and interpretation with different representations; carry out sequential processes; communicate reasoning and argument.	- Interpret complex information about real-world situations (including graphs, drawings and complex tables) - Link different information sources (such as graphs, tabular data and related text) - Extract relevant data from a description of a complex situation and perform calculations - Use problem solving skills (e.g. interpretation, devising a strategy, reasoning; systematic counting) in real-world contexts that involve substantial mathematisation - Communicate reasoning and argument - Make an estimation using daily life knowledge - Calculate relative and/or absolute change
LEVEL 4	
Thirty-five per cent of all students across the OECD area can perform tasks at least Level 4 on the quantity scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Work effectively with simple models of complex situations; use reasoning skills in a variety of contexts, interpret different representations of the same situation; analyse and apply quantitative relationships; use a variety of calculation skills to solve problems.	- Accurately apply a given numeric algorithm involving a number of steps - Interpret complex text descriptions of a sequential process - Relate text-based information to a graphic representation - Perform calculations involving proportional reasoning, divisibility or percentages in simple models of complex situations - Perform systematic listing and counting of combinatorial outcomes - Identify and use information from multiple sources - Analyse and apply a simple system - Interpret complex text to produce a simple mathematical model

LEVEL 3	
Fifty-nine per cent of all students across the OECD area can perform tasks at least Level 3 on the quantity scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Use simple problem solving strategies including reasoning in familiar contexts; interpret tables to locate information; carry out explicitly described calculations including sequential processes.	- Interpret a text description of a sequential calculation process, and correctly implement the process - Use basic problem-solving processes (devise a simple strategy, look for relationships, understand and work with given constraints, use trial and error, simple reasoning) - Perform calculations including working with large numbers, calculations with speed and time, conversion of units (e.g. from annual rate to daily rate) - nterpret tabular information, locate relevant data from a table - Conceptualise relationships involving circular motion and time - Interpret text and diagram describing a simple pattern
LEVEL 2	
Seventy-nine per cent of all students across the OECD area can perform tasks at least Level 2 on the quantity scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Interpret simple tables to identify and extract relevant information; carry out basic arithmetic calculations; interpret and work with simple quantitative relationships.	- Interpret a simple quantitative model (e.g. a proportional relationship) and apply it using basic arithmetic calculations - Interpret simple tabular data, link textual information to related tabular data - Identify the simple calculation required to solve a straight-forward problem - Perform simple calculations involving the basic arithmetic operations, as well as ordering numbers
LEVEL 1	
Ninety-one per cent of all students across the OECD area can perform tasks at least Level 1 on the quantity scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Solve problems of the most basic type in which all relevant information is explicitly presented, the situation is straight forward and very limited in scope, the required computational activity is obvious and the mathematical task is basic, such as a simple arithmetic operation.	- Interpret a simple, explicit mathematical relationship, and apply it directly using a calculation - Read and interpret a simple table of numbers, total the columns and compare the results

Source: PISA International PISA 2003 Report

FIGURE A3.4 SUMMARY DESCRIPTIONS OF SIX LEVEL OF PROFICIENCY ON THE MATHEMATICS/UNCERTAINTY SCALE

Summary Description	What students can typically do
LEVEL 6	
Four per cent of all students across the OECD area can perform tasks at Level 6 on the uncertainty scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Use high-level thinking and reasoning skills in statistical or probabilistic contexts to create mathematical representations of real-world situations; use insight and reflection to solve problems, and to formulate and communicate arguments and explanations.	- Interpret and reflect on real world situations using probability knowledge and carry out resulting calculations using proportional reasoning, large numbers and rounding - Show insight into probability in a practical context - Use interpretation, logical reasoning and insight at a high level in an unfamiliar probabilistic situation - Use rigorous argumentation based on insightful interpretation of data - Employ complex reasoning using statistical concepts - Show understanding of basic ideas of sampling and carry out calculations with weighted averages, or using insightful systematic counting strategies - Communicate complex arguments and explanations
LEVEL 5	
Fifteen per cent of all students across the OECD area can perform tasks at least Level 5 on the uncertainty scale	
To reach this level, students had to:	**Specifically, these students are able to:**
Apply probabilistic and statistical knowledge in problem situations that are somewhat structured and where the mathematical representation is partially apparent. Use reasoning and insight to interpret and analyse given information, to develop appropriate models and to perform sequential calculation processes; communicate reasons and arguments.	- Interpret and reflect on the outcomes of an unfamiliar probabilistic experiment - Interpret text using technical language and translate to an appropriate probability calculation - Identify and extract relevant information, and interpret and link information from multiple sources (e.g. from text, multiple tables, graphs) - Use reflection and insight into standard probabilistic situations - Apply probability concepts to analyse a non-familiar phenomenon or situation - Use proportional reasoning and reasoning with statistical concepts - Use multistep reasoning based on data - Carry out COMPLEX modelling involving the application of probability knowledge and statistical concepts (e.g. randomness, sample, independence) A29 - Use calculations including addition, proportions, multiplication of large numbers, rounding, to solve problems in non-trivial statistical contexts - Carry out a sequence of related calculations - Carry out and communicate probabilistic reasoning and argument

<table>
<tr><th colspan="2">LEVEL 4</th></tr>
<tr><th colspan="2">Thirty-four per cent of all students across the OECD area can perform tasks at least Level 4 on the uncertainty scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Use basic statistical and probabilistic concepts combined with numerical reasoning in less familiar contexts to solve simple problems; carry out multi-step or sequential calculation processes; use and communicate argumentation based on interpretation of data.</td><td>- Interpret text, including in an unfamiliar (scientific) but straight-forward context
- Show insight into aspects of data from tables and graphs
- Translate text description into appropriate probability calculation
- Identify and select data from various statistical graphs and carry out basic calculation
- Show understanding of basic statistical concepts and definitions (probability, expected value, randomness, average)
- Use knowledge of basic probability to solve problems
- Construct a basic mathematical explanation of a verbal real-world quantitative concept (‘huge increase’)
- Use mathematical argumentation based on data
- Use numerical reasoning
- Carry out multi-step calculations involving the basic arithmetic operations, and working with percentage
- Draw information from a table and communicate a simple argument based on that information</td></tr>
<tr><th colspan="2">LEVEL 3</th></tr>
<tr><th colspan="2">Fifty-eight per cent of all students across the OECD area can perform tasks at least Level 3 on the uncertainty scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Interpret statistical information and data, and link different information sources; basic reasoning with simple probability concepts, symbols and conventions and communication of reasoning.</td><td>- Interpret tabular information
- Interpret and read from non-standard graphs
- Use reasoning to identify probability outcomes in the context of a complex but well-defined and familiar probability experiment
- Insight into aspects of data presentation, e.g. number sense, link related information from two different tables; link data to suitable chart type
- Communicate common-sense reasoning</td></tr>
<tr><th colspan="2">LEVEL 2</th></tr>
<tr><th colspan="2">Seventy-nine per cent of all students across the OECD area can perform tasks at least Level 2 on the uncertainty scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Locate statistical information presented in familiar graphical form; understand basic statistical concepts and conventions.</td><td>- Identify relevant information in a simple and familiar graph
- Link text to a related graph, in a common and familiar form
- Understand and explain simple statistical calculations (the average)
- Read values directly from a familiar data display, such as a bar graph</td></tr>
<tr><th colspan="2">LEVEL 1</th></tr>
<tr><th colspan="2">Ninety-three per cent of all students across the OECD area can perform tasks at least Level 1 on the uncertainty scale</th></tr>
<tr><th>To reach this level, students had to:</th><th>Specifically, these students are able to:</th></tr>
<tr><td>Understand and use basic probabilistic ideas in familiar experimental contexts.</td><td>- Understand basic probability concepts in the context of a simple and familiar experiment (e.g. involving dice or coins)
- Systematic listing and counting of combinatorial outcomes in a limited and well-defined game situation</td></tr>
</table>

Source: PISA International PISA 2003 Report

TABLE A3.1 MEAN SCORE, VARIATION AND GENDER DIFFERENCES IN STUDENT PERFORMANCE ON THE MATHEMATICS SCALE

Country	All students				Gender differences						Percentiles											
	Mean		Standard deviation		Males		Females		Difference (M - F)		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Mean Score	S.E.	Mean Score	S.E.	Score dif.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																						
Australia	524	(2.1)	95	(1.5)	527	(3.0)	522	(2.7)	5	(3.8)	364	(4.4)	399	(3.4)	460	(2.8)	592	(2.5)	645	(3.0)	676	(3.5)
Austria	506	(3.3)	93	(1.7)	509	(4.0)	502	(4.0)	8	(4.4)	353	(6.6)	384	(4.4)	439	(4.0)	571	(4.2)	626	(4.0)	658	(5.0)
Belgium	529	(2.3)	110	(1.8)	533	(3.4)	525	(3.2)	8	(4.8)	334	(6.5)	381	(4.6)	456	(3.4)	611	(2.5)	664	(2.4)	693	(2.4)
Canada	533	(1.8)	87	(1.0)	541	(2.1)	530	(1.9)	11	(2.1)	386	(3.1)	419	(2.5)	474	(2.2)	593	(2.1)	644	(2.6)	673	(3.4)
Czech Republic	517	(3.5)	96	(1.9)	524	(4.3)	509	(4.4)	15	(5.1)	358	(6.2)	392	(5.7)	449	(4.6)	584	(4.0)	641	(4.3)	672	(4.9)
Denmark	514	(2.7)	91	(1.4)	523	(3.4)	506	(3.0)	17	(3.2)	361	(4.4)	396	(4.5)	453	(3.7)	578	(3.1)	632	(3.7)	662	(4.7)
Finland	544	(1.9)	84	(1.1)	548	(2.5)	541	(2.1)	7	(2.7)	406	(3.8)	438	(2.8)	488	(2.2)	603	(2.3)	652	(2.8)	680	(3.1)
France	511	(2.5)	92	(1.8)	515	(3.6)	507	(2.9)	9	(4.2)	352	(6.0)	389	(5.6)	449	(3.7)	575	(3.0)	628	(3.6)	656	(3.5)
Germany	503	(3.3)	103	(1.8)	508	(4.0)	499	(3.9)	9	(4.4)	324	(6.1)	363	(5.6)	432	(4.7)	578	(3.5)	632	(3.5)	662	(3.6)
Greece	445	(3.9)	94	(1.8)	455	(4.8)	436	(3.8)	19	(3.6)	288	(5.4)	324	(5.1)	382	(4.6)	508	(4.3)	566	(5.3)	598	(5.1)
Hungary	490	(2.8)	94	(2.0)	494	(3.3)	486	(3.3)	8	(3.5)	335	(5.6)	370	(4.2)	426	(3.0)	556	(3.9)	611	(4.7)	644	(4.6)
Iceland	515	(1.4)	90	(1.2)	508	(2.3)	523	(2.2)	-15	(3.5)	362	(4.1)	396	(2.7)	454	(2.8)	578	(1.9)	629	(3.0)	658	(3.8)
Ireland	503	(2.4)	85	(1.3)	510	(3.0)	495	(3.4)	15	(4.2)	360	(4.7)	393	(3.2)	445	(3.4)	562	(3.0)	614	(3.6)	641	(3.3)
Italy	466	(3.1)	96	(1.9)	475	(4.6)	457	(3.8)	18	(5.9)	307	(6.4)	342	(5.9)	401	(4.3)	530	(3.0)	589	(3.6)	623	(3.7)
Japan	534	(4.0)	101	(2.8)	539	(5.8)	530	(4.0)	8	(5.9)	361	(8.2)	402	(6.3)	467	(5.4)	605	(4.4)	660	(6.1)	690	(6.6)
Korea	542	(3.2)	92	(2.1)	552	(4.4)	528	(5.3)	23	(6.8)	388	(4.6)	423	(4.5)	479	(3.7)	606	(4.2)	659	(5.4)	690	(6.8)
Luxembourg	493	(1.0)	92	(1.0)	502	(1.9)	485	(1.5)	17	(2.8)	339	(3.9)	373	(2.7)	430	(2.2)	557	(1.9)	611	(3.2)	641	(2.7)
Mexico	385	(3.6)	85	(1.9)	391	(4.3)	380	(4.1)	11	(3.9)	247	(5.4)	276	(4.7)	327	(4.3)	444	(4.5)	497	(4.7)	527	(5.6)
Netherlands	538	(3.1)	93	(2.3)	540	(4.1)	535	(3.5)	5	(4.3)	385	(6.9)	415	(5.8)	471	(5.4)	608	(3.8)	657	(3.2)	684	(3.4)
New Zealand	524	(2.3)	98	(1.2)	531	(2.8)	516	(3.2)	15	(3.9)	359	(4.1)	394	(3.9)	455	(2.9)	593	(2.2)	650	(3.2)	682	(2.9)
Norway	495	(2.4)	92	(1.2)	498	(2.8)	492	(2.9)	6	(3.2)	344	(4.0)	376	(3.4)	433	(2.9)	560	(3.3)	614	(3.6)	645	(3.9)
Poland	490	(2.5)	90	(1.3)	493	(3.0)	488	(2.9)	6	(3.1)	343	(5.8)	376	(3.6)	428	(3.1)	553	(2.9)	607	(3.3)	640	(3.5)
Portugal	466	(3.4)	88	(1.7)	472	(4.2)	460	(3.4)	12	(3.3)	321	(6.3)	352	(5.3)	406	(5.0)	526	(3.5)	580	(3.3)	610	(3.7)
Slovak Republic	498	(3.3)	93	(2.3)	507	(3.9)	489	(3.6)	19	(3.7)	342	(6.9)	379	(5.8)	436	(4.6)	565	(3.8)	619	(3.5)	648	(4.1)
Spain	485	(2.4)	89	(1.3)	490	(3.4)	481	(2.2)	9	(3.0)	335	(5.1)	369	(3.5)	426	(3.0)	546	(3.1)	597	(3.5)	626	(3.7)
Sweden	509	(2.6)	95	(1.8)	512	(3.0)	506	(3.1)	7	(3.3)	353	(5.3)	387	(4.4)	446	(3.0)	576	(3.2)	631	(3.8)	662	(4.8)
Switzerland	527	(3.4)	98	(2.1)	535	(4.7)	518	(3.6)	17	(4.9)	359	(4.8)	396	(4.2)	461	(3.6)	595	(4.9)	652	(5.2)	684	(6.8)
Turkey	423	(6.7)	105	(5.3)	430	(7.9)	415	(6.7)	15	(6.2)	270	(5.8)	300	(5.0)	351	(5.3)	485	(8.5)	560	(14.2)	614	(22.7)
United States	483	(2.9)	95	(1.3)	486	(3.3)	480	(3.2)	6	(2.9)	323	(4.9)	357	(4.5)	418	(3.7)	550	(3.4)	607	(3.9)	638	(5.1)
OECD total	489	(1.1)	104	(0.7)	494	(1.3)	484	(1.3)	10	(1.4)	315	(2.1)	352	(1.7)	418	(1.6)	563	(1.1)	622	(1.3)	655	(1.8)
OECD average	500	(0.6)	100	(0.4)	506	(0.8)	494	(0.8)	11	(0.8)	332	(1.3)	369	(1.1)	432	(0.9)	571	(0.7)	628	(0.7)	660	(1.0)
Partner Countries																						
Brazil	356	(4.8)	100	(3.0)	365	(6.1)	348	(4.4)	16	(4.1)	203	(6.0)	233	(5.3)	286	(4.6)	419	(6.2)	488	(9.5)	528	(11.4)
Hong Kong-China	550	(4.5)	100	(3.0)	552	(6.5)	548	(4.6)	4	(6.6)	374	(11.1)	417	(8.0)	485	(6.9)	622	(3.7)	672	(4.1)	700	(4.0)
Indonesia	360	(3.9)	81	(2.1)	362	(3.9)	359	(4.6)	3	(3.4)	233	(5.2)	261	(4.8)	306	(3.5)	412	(4.8)	466	(6.5)	499	(7.7)
Latvia	483	(3.7)	88	(1.7)	485	(4.8)	482	(3.6)	3	(4.0)	339	(5.9)	371	(5.1)	424	(3.9)	544	(4.7)	596	(4.4)	626	(5.0)
Liechtenstein	536	(4.1)	99	(4.4)	550	(7.2)	521	(6.3)	29	(10.9)	362	(19.7)	408	(9.8)	470	(7.6)	609	(7.9)	655	(9.5)	686	(16.4)
Macao-China	527	(2.9)	87	(2.4)	538	(4.8)	517	(3.3)	21	(5.8)	382	(8.8)	415	(6.0)	467	(4.4)	587	(4.0)	639	(5.5)	668	(8.3)
Russian Federation	468	(4.2)	92	(1.9)	474	(5.3)	463	(4.2)	10	(4.4)	319	(5.5)	351	(5.0)	406	(4.8)	530	(5.0)	588	(5.3)	622	(6.1)
Serbia	437	(3.8)	85	(1.6)	438	(4.2)	436	(4.5)	1	(4.4)	299	(4.4)	329	(4.5)	379	(4.0)	493	(4.8)	546	(5.1)	579	(5.3)
Thailand	417	(3.0)	82	(1.8)	415	(4.0)	419	(3.4)	-4	(4.2)	290	(4.0)	316	(3.1)	361	(2.9)	469	(3.8)	526	(4.7)	560	(6.4)
Tunisia	359	(2.5)	82	(2.0)	365	(2.7)	353	(2.9)	12	(2.5)	229	(3.8)	256	(3.5)	303	(2.6)	412	(3.6)	466	(4.8)	501	(6.8)
Uruguay	422	(3.3)	100	(1.6)	428	(4.0)	416	(3.8)	12	(4.2)	255	(4.3)	291	(3.8)	353	(4.1)	491	(3.8)	550	(4.4)	583	(4.7)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate too low to ensure comparability (see Annex A3).

Note: Values that are statistically significant are indicated in bold (see Annex A4).

Source: PISA International PISA 2003 Report

TABLE A3.2 MEAN SCORE, VARIATION AND GENDER DIFFERENCES IN STUDENT PERFORMANCE ON THE MATHEMATICS/SPACE AND SHAPE SCALE

Country	All students				Gender differences						Percentiles											
	Mean		Standard deviation		Males		Females		Difference (M - F)		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Mean score	S.E.	Mean score	S.E.	Score dif.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																						
Australia	521	(2.3)	104	(1.7)	526	(3.2)	515	(2.9)	12	(3.9)	347	(4.7)	385	(3.8)	450	(3.3)	592	(2.6)	653	(3.1)	687	(3.8)
Austria	515	(3.5)	112	(1.7)	525	(4.4)	506	(4.3)	19	(5.2)	334	(5.5)	371	(5.6)	438	(4.4)	592	(3.8)	661	(5.0)	698	(6.8)
Belgium	530	(2.3)	111	(1.4)	538	(3.2)	520	(3.3)	18	(4.6)	342	(4.9)	382	(4.2)	453	(3.4)	610	(3.1)	670	(2.5)	704	(2.4)
Canada	518	(1.8)	95	(0.9)	530	(2.1)	511	(2.2)	20	(2.5)	361	(3.5)	395	(2.6)	453	(2.0)	583	(2.4)	640	(2.7)	674	(2.8)
Czech Republic	527	(4.1)	119	(2.3)	542	(4.8)	512	(5.1)	30	(5.7)	330	(7.4)	373	(6.9)	445	(4.7)	611	(4.8)	681	(5.2)	721	(5.1)
Denmark	512	(2.8)	103	(1.6)	521	(3.4)	504	(3.3)	16	(3.7)	339	(6.5)	380	(5.5)	444	(3.9)	584	(3.3)	645	(3.9)	677	(4.2)
Finland	539	(2.0)	92	(1.2)	540	(2.6)	538	(2.4)	2	(3.0)	386	(4.2)	421	(3.1)	477	(2.4)	602	(2.4)	658	(3.5)	690	(3.6)
France	508	(3.0)	102	(2.0)	517	(4.3)	499	(3.2)	18	(4.7)	333	(7.6)	374	(5.8)	439	(3.9)	579	(3.4)	638	(4.3)	670	(5.1)
Germany	500	(3.3)	112	(1.9)	506	(4.0)	494	(4.0)	12	(4.7)	311	(5.3)	350	(4.7)	422	(5.0)	579	(4.0)	641	(4.4)	679	(4.9)
Greece	437	(3.8)	100	(1.6)	447	(4.7)	428	(3.8)	19	(4.0)	273	(5.1)	310	(4.4)	371	(4.4)	505	(4.3)	565	(5.1)	601	(6.3)
Hungary	479	(3.3)	109	(2.2)	486	(3.8)	471	(3.9)	15	(4.0)	304	(5.8)	341	(5.0)	404	(3.7)	554	(4.2)	623	(6.5)	665	(6.2)
Iceland	504	(1.5)	94	(1.5)	496	(2.4)	511	(2.3)	-15	(3.7)	344	(5.1)	380	(3.5)	441	(2.6)	569	(2.3)	622	(3.0)	654	(3.7)
Ireland	476	(2.4)	95	(1.5)	489	(3.0)	463	(3.4)	26	(4.3)	324	(4.4)	354	(3.6)	412	(3.3)	542	(2.9)	599	(4.5)	632	(4.2)
Italy	470	(3.1)	109	(1.8)	480	(4.7)	462	(4.1)	18	(6.3)	287	(6.2)	329	(5.9)	398	(4.3)	545	(3.3)	610	(3.4)	648	(4.3)
Japan	553	(4.3)	110	(2.9)	558	(6.3)	549	(4.2)	9	(6.3)	366	(6.7)	410	(6.8)	481	(5.1)	629	(4.8)	690	(6.0)	726	(7.6)
Korea	552	(3.8)	117	(2.5)	563	(5.1)	536	(6.2)	27	(8.0)	360	(5.6)	401	(5.1)	472	(4.3)	634	(5.1)	701	(6.9)	742	(7.9)
Luxembourg	488	(1.4)	100	(1.2)	503	(2.2)	474	(2.0)	28	(3.3)	324	(4.1)	360	(2.9)	420	(2.0)	557	(1.9)	618	(3.2)	653	(4.0)
Mexico	382	(3.2)	87	(1.4)	390	(4.1)	374	(3.5)	16	(3.8)	240	(6.4)	269	(5.1)	322	(3.8)	441	(3.6)	494	(4.3)	525	(4.6)
Netherlands	526	(2.9)	94	(2.3)	530	(3.7)	522	(3.4)	8	(4.3)	370	(5.9)	403	(5.5)	461	(4.9)	593	(3.5)	648	(3.5)	678	(4.6)
New Zealand	525	(2.3)	106	(1.3)	534	(2.7)	516	(3.3)	18	(3.9)	350	(5.1)	388	(4.3)	451	(3.3)	600	(2.5)	660	(3.0)	695	(4.0)
Norway	483	(2.5)	103	(1.3)	486	(3.1)	479	(3.5)	7	(4.3)	312	(4.5)	350	(4.0)	413	(2.9)	554	(3.5)	615	(3.9)	652	(3.7)
Poland	490	(2.7)	107	(1.9)	497	(3.2)	484	(3.3)	13	(3.7)	318	(5.0)	355	(4.2)	418	(3.5)	562	(3.4)	628	(3.9)	669	(5.6)
Portugal	450	(3.4)	93	(1.7)	458	(4.2)	443	(3.5)	15	(3.5)	298	(5.8)	331	(5.2)	387	(4.7)	513	(3.6)	572	(4.1)	607	(4.2)
Slovak Republic	505	(4.0)	117	(2.3)	522	(4.7)	487	(4.1)	35	(4.5)	315	(6.4)	356	(6.2)	425	(5.5)	587	(4.2)	657	(4.4)	696	(5.8)
Spain	477	(2.6)	92	(1.4)	486	(3.5)	467	(2.4)	19	(3.0)	324	(4.4)	358	(4.0)	415	(3.0)	539	(3.2)	595	(3.5)	627	(4.8)
Sweden	498	(2.6)	100	(1.7)	504	(3.0)	493	(3.2)	10	(3.5)	334	(5.0)	371	(4.0)	432	(3.5)	566	(3.3)	627	(3.8)	661	(4.3)
Switzerland	540	(3.5)	110	(2.1)	552	(5.3)	527	(3.7)	25	(5.6)	353	(5.8)	397	(5.6)	467	(3.9)	616	(4.6)	679	(5.7)	714	(6.0)
Turkey	417	(6.3)	102	(5.1)	423	(7.6)	411	(6.2)	12	(6.0)	266	(6.1)	297	(5.3)	349	(4.7)	476	(8.0)	548	(14.0)	601	(22.5)
United States	472	(2.8)	98	(1.4)	480	(3.3)	464	(3.1)	15	(3.2)	315	(4.8)	347	(4.2)	404	(3.6)	538	(3.4)	601	(3.6)	637	(4.2)
OECD total	486	(1.0)	112	(0.7)	494	(1.4)	478	(1.3)	16	(1.6)	304	(2.0)	342	(1.6)	408	(1.4)	563	(1.3)	632	(1.3)	672	(1.8)
OECD average	496	(0.6)	110	(0.4)	505	(0.8)	488	(0.8)	17	(0.9)	316	(1.4)	354	(1.2)	421	(0.9)	572	(0.7)	639	(0.8)	677	(1.0)
Partner Countries																						
Brazil	350	(4.1)	96	(2.3)	358	(5.2)	343	(4.0)	15	(4.1)	198	(5.5)	229	(4.9)	284	(4.5)	412	(5.3)	475	(6.8)	513	(9.2)
Hong Kong-China	558	(4.9)	111	(2.9)	561	(6.8)	556	(5.0)	4	(6.8)	367	(7.3)	412	(9.7)	485	(7.4)	638	(3.6)	697	(4.6)	729	(4.8)
Indonesia	361	(3.7)	88	(1.9)	369	(3.7)	353	(4.2)	16	(2.9)	219	(5.0)	251	(4.2)	301	(3.9)	418	(5.1)	476	(6.1)	510	(6.6)
Latvia	486	(4.0)	102	(1.7)	494	(5.2)	480	(3.9)	14	(4.2)	318	(6.7)	354	(5.1)	418	(4.6)	555	(4.4)	616	(5.6)	652	(6.3)
Liechtenstein	538	(4.6)	107	(4.3)	557	(7.9)	518	(7.1)	39	(12.1)	354	(16.1)	394	(11.4)	469	(10.5)	613	(9.2)	669	(12.6)	706	(14.3)
Macao-China	528	(3.3)	97	(3.3)	540	(5.1)	517	(4.3)	23	(6.8)	369	(9.5)	402	(10.1)	463	(6.4)	595	(4.7)	652	(7.2)	687	(8.7)
Russian Federation	474	(4.7)	112	(2.0)	485	(5.8)	464	(5.0)	21	(5.0)	289	(6.0)	332	(5.5)	399	(4.9)	549	(5.9)	620	(6.6)	661	(7.5)
Serbia	433	(3.9)	96	(1.8)	434	(4.3)	431	(4.9)	3	(4.9)	280	(4.4)	312	(3.7)	368	(4.3)	495	(4.7)	557	(6.4)	593	(6.1)
Thailand	424	(3.3)	90	(1.8)	426	(4.3)	422	(3.8)	5	(4.7)	283	(4.8)	311	(3.7)	363	(3.3)	483	(4.1)	543	(5.3)	580	(6.8)
Tunisia	359	(2.6)	92	(1.7)	367	(2.8)	351	(3.2)	16	(3.0)	208	(4.0)	242	(3.6)	298	(2.7)	418	(3.2)	476	(4.8)	513	(6.4)
Uruguay	412	(3.0)	101	(1.7)	423	(3.6)	402	(3.4)	21	(3.6)	245	(3.7)	279	(4.5)	343	(4.2)	481	(3.7)	541	(4.2)	576	(6.2)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate too low to ensure comparability (see Annex A3).

Note: Values that are statistically significant are indicated in bold (see Annex A4).

Source: PISA International PISA 2003 Report

TABLE A3.3 MEAN SCORE, VARIATION AND GENDER DIFFERENCES IN STUDENT PERFORMANCE ON THE MATHEMATICS/CHANGE AND RELATIONSHIPS SCALE

Country	All students				Gender differences						Percentiles											
	Mean		Standard deviation		Males		Females		Difference (M - F)		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Mean score	S.E.	Mean score	S.E.	Score dif.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																						
Australia	525	(2.3)	98	(1.8)	528	(3.2)	523	(2.8)	4	(3.8)	360	(4.9)	398	(3.7)	459	(3.0)	594	(2.7)	648	(3.3)	681	(4.7)
Austria	500	(3.6)	102	(1.8)	502	(4.4)	497	(4.4)	5	(5.0)	331	(6.3)	366	(4.8)	428	(4.4)	572	(4.0)	633	(4.1)	666	(4.6)
Belgium	535	(2.4)	117	(1.6)	539	(3.6)	531	(3.5)	8	(5.1)	332	(5.6)	375	(4.5)	454	(4.0)	623	(2.8)	680	(2.2)	711	(2.4)
Canada	537	(1.9)	92	(0.9)	546	(2.2)	532	(2.0)	14	(2.3)	382	(3.4)	418	(2.6)	474	(2.5)	601	(2.3)	654	(2.7)	685	(2.9)
Czech Republic	515	(3.5)	100	(1.8)	521	(4.5)	508	(4.0)	13	(4.9)	353	(6.4)	388	(5.8)	446	(3.9)	585	(4.6)	647	(5.2)	681	(5.0)
Denmark	509	(3.0)	98	(1.8)	520	(3.7)	499	(3.3)	21	(3.5)	345	(6.0)	382	(4.5)	443	(3.9)	578	(3.2)	634	(3.9)	665	(5.1)
Finland	543	(2.2)	95	(1.4)	549	(2.8)	537	(2.4)	11	(2.8)	387	(5.1)	422	(3.7)	480	(2.6)	609	(2.7)	664	(3.0)	695	(3.2)
France	520	(2.6)	100	(2.1)	522	(4.0)	518	(3.2)	4	(5.0)	345	(7.0)	386	(5.8)	454	(3.8)	591	(2.5)	644	(3.3)	674	(4.2)
Germany	507	(3.7)	109	(1.7)	514	(4.3)	502	(4.4)	12	(4.4)	323	(6.8)	362	(6.4)	430	(4.5)	588	(4.5)	645	(3.9)	678	(3.7)
Greece	436	(4.3)	107	(1.7)	445	(5.2)	427	(4.4)	18	(4.2)	256	(5.8)	296	(5.5)	364	(5.1)	509	(5.6)	572	(4.6)	607	(5.7)
Hungary	495	(3.1)	99	(2.1)	499	(3.6)	490	(3.6)	10	(3.9)	332	(5.5)	367	(5.0)	427	(3.4)	563	(4.2)	623	(5.1)	656	(4.5)
Iceland	510	(1.4)	97	(1.2)	505	(2.4)	514	(2.3)	-10	(3.8)	345	(4.1)	383	(3.5)	444	(2.3)	579	(2.4)	633	(2.6)	662	(3.8)
Ireland	506	(2.4)	88	(1.4)	512	(3.1)	500	(3.5)	13	(4.4)	357	(4.4)	393	(4.6)	448	(3.4)	568	(2.8)	618	(2.6)	645	(3.6)
Italy	452	(3.2)	103	(1.9)	463	(4.9)	442	(4.0)	21	(6.3)	281	(6.5)	319	(6.4)	382	(4.6)	522	(3.6)	585	(3.4)	622	(3.6)
Japan	536	(4.3)	112	(3.0)	539	(6.4)	533	(4.3)	6	(6.6)	342	(8.3)	389	(7.0)	462	(5.5)	616	(4.6)	676	(6.6)	709	(7.6)
Korea	548	(3.5)	100	(2.4)	558	(4.7)	533	(5.8)	25	(7.3)	383	(5.8)	420	(5.0)	480	(4.5)	617	(4.3)	674	(5.8)	708	(6.7)
Luxembourg	487	(1.2)	102	(1.0)	494	(2.5)	480	(1.8)	14	(3.7)	315	(4.0)	354	(3.5)	417	(2.2)	559	(1.9)	616	(2.8)	651	(4.5)
Mexico	364	(4.1)	99	(1.9)	368	(4.9)	360	(4.6)	8	(4.4)	199	(6.6)	237	(4.9)	297	(4.5)	432	(5.0)	491	(5.7)	525	(5.2)
Netherlands	551	(3.1)	94	(2.0)	554	(3.8)	548	(3.7)	6	(4.3)	398	(5.3)	426	(4.7)	482	(5.0)	623	(3.8)	675	(2.9)	703	(3.8)
New Zealand	526	(2.4)	103	(1.5)	534	(2.8)	517	(3.4)	17	(4.1)	352	(5.4)	390	(4.9)	456	(3.6)	598	(2.7)	657	(2.9)	691	(3.9)
Norway	488	(2.6)	98	(1.3)	490	(3.2)	486	(3.1)	4	(3.3)	325	(4.7)	360	(4.4)	421	(3.2)	555	(3.4)	614	(3.9)	646	(3.6)
Poland	484	(2.7)	100	(1.7)	488	(3.1)	481	(3.4)	8	(3.6)	323	(5.4)	357	(4.6)	417	(3.1)	552	(3.1)	613	(3.9)	650	(5.0)
Portugal	468	(4.0)	99	(2.2)	475	(4.8)	462	(4.0)	13	(3.8)	301	(7.0)	338	(6.8)	401	(5.6)	537	(4.1)	594	(3.4)	626	(4.7)
Slovak Republic	494	(3.5)	105	(2.3)	502	(4.1)	486	(3.9)	16	(4.2)	320	(7.7)	360	(5.7)	424	(4.8)	569	(3.8)	629	(3.9)	664	(4.7)
Spain	481	(2.8)	99	(1.4)	485	(3.8)	477	(2.6)	8	(3.3)	310	(4.3)	350	(4.2)	416	(3.6)	550	(3.2)	606	(4.0)	637	(3.7)
Sweden	505	(2.9)	111	(1.9)	506	(3.4)	504	(3.9)	1	(4.3)	318	(6.4)	362	(4.2)	431	(3.6)	582	(3.5)	648	(4.5)	684	(5.5)
Switzerland	523	(3.7)	112	(2.2)	530	(5.1)	515	(3.9)	15	(5.3)	329	(5.6)	375	(5.5)	449	(3.7)	599	(4.5)	662	(5.8)	700	(7.4)
Turkey	423	(7.6)	121	(5.4)	426	(9.1)	420	(7.4)	6	(7.2)	238	(9.1)	276	(7.1)	341	(6.7)	496	(10.0)	578	(15.6)	633	(22.9)
United States	486	(3.0)	98	(1.6)	488	(3.4)	483	(3.3)	6	(2.9)	318	(6.5)	355	(4.8)	421	(3.6)	555	(3.3)	611	(3.7)	642	(3.7)
OECD total	489	(1.2)	113	(0.8)	493	(1.4)	484	(1.4)	10	(1.5)	295	(2.5)	339	(2.2)	414	(1.6)	568	(1.4)	632	(1.3)	667	(1.5)
OECD average	499	(0.7)	109	(0.5)	504	(0.8)	493	(0.8)	11	(0.9)	313	(1.5)	356	(1.2)	426	(1.0)	576	(0.7)	637	(0.8)	672	(0.9)
Partner Countries																						
Brazil	333	(6.0)	124	(3.4)	344	(7.3)	324	(5.5)	20	(4.7)	140	(7.0)	180	(6.4)	247	(6.0)	414	(6.9)	498	(10.9)	548	(12.0)
Hong Kong-China	540	(4.7)	106	(2.9)	540	(6.8)	539	(4.8)	1	(7.2)	351	(10.6)	397	(8.8)	471	(7.1)	617	(4.3)	668	(4.4)	699	(5.1)
Indonesia	334	(4.6)	105	(2.6)	336	(4.4)	332	(5.4)	4	(3.4)	164	(6.8)	202	(6.4)	263	(4.7)	402	(5.7)	469	(6.9)	510	(8.9)
Latvia	487	(4.4)	101	(1.6)	487	(5.3)	488	(4.3)	-1	(4.0)	319	(5.2)	355	(4.8)	419	(5.0)	556	(5.4)	615	(5.5)	649	(6.0)
Liechtenstein	540	(3.7)	107	(3.8)	552	(7.4)	526	(6.5)	26	(12.1)	362	(12.7)	401	(10.2)	467	(7.6)	619	(7.4)	673	(11.5)	705	(13.3)
Macao-China	519	(3.5)	99	(2.9)	529	(5.0)	509	(4.6)	20	(6.6)	356	(10.1)	388	(7.3)	449	(6.2)	590	(5.0)	644	(5.7)	675	(9.0)
Russian Federation	477	(4.6)	100	(2.1)	479	(6.0)	475	(4.5)	3	(5.1)	309	(6.9)	348	(5.8)	411	(5.2)	544	(5.3)	604	(5.3)	641	(6.9)
Serbia	419	(4.0)	99	(1.7)	420	(4.5)	418	(4.9)	1	(4.9)	257	(5.1)	293	(4.7)	353	(4.7)	485	(4.5)	546	(5.3)	582	(7.4)
Thailand	405	(3.4)	93	(2.1)	400	(4.5)	409	(4.0)	-10	(5.1)	261	(4.4)	289	(3.9)	341	(3.8)	465	(4.2)	528	(6.1)	568	(7.5)
Tunisia	337	(2.8)	103	(1.9)	342	(3.0)	331	(3.3)	11	(3.0)	169	(4.2)	205	(3.7)	267	(3.7)	406	(4.0)	469	(4.9)	508	(5.3)
Uruguay	417	(3.6)	115	(1.7)	420	(4.2)	414	(4.2)	5	(4.4)	219	(5.3)	262	(4.5)	339	(4.9)	497	(3.8)	561	(4.6)	600	(5.6)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate too low to ensure comparability (see Annex A3).

Note: Values that are statistically significant are indicated in bold (see Annex A4).

Source: PISA International PISA 2003 Report

TABLE A3.4 MEAN SCORE, VARIATION AND GENDER DIFFERENCES IN STUDENT PERFORMANCE ON THE MATHEMATICS/QUANTITY SCALE

Country	All students				Gender differences						Percentiles											
	Mean		Standard deviation		Males		Females		Difference (M - F)		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Mean score	S.E.	Mean score	S.E.	Score dif.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																						
Australia	517	(2.1)	97	(1.5)	518	(2.9)	516	(2.7)	1	(3.7)	352	(4.3)	390	(3.4)	451	(2.8)	585	(2.3)	639	(2.7)	671	(3.1)
Austria	513	(3.0)	86	(1.7)	515	(3.7)	512	(3.7)	3	(4.2)	370	(4.6)	400	(5.3)	454	(3.5)	574	(3.4)	622	(3.6)	651	(4.1)
Belgium	530	(2.3)	110	(1.8)	530	(3.3)	529	(3.3)	1	(4.7)	332	(7.8)	383	(5.4)	460	(3.4)	610	(2.2)	662	(2.2)	690	(2.4)
Canada	528	(1.8)	94	(0.9)	533	(2.2)	528	(1.9)	5	(2.2)	370	(3.0)	407	(2.8)	466	(2.3)	593	(1.9)	647	(2.6)	677	(2.8)
Czech Republic	528	(3.5)	98	(2.1)	531	(4.2)	525	(4.5)	6	(5.1)	361	(7.3)	398	(6.4)	462	(4.6)	597	(3.4)	651	(3.9)	682	(3.9)
Denmark	516	(2.6)	92	(1.6)	520	(3.2)	511	(2.9)	9	(3.1)	360	(5.4)	395	(3.9)	454	(3.1)	580	(2.9)	632	(3.8)	661	(4.5)
Finland	549	(1.8)	83	(1.1)	550	(2.3)	547	(2.1)	3	(2.3)	410	(3.9)	441	(3.2)	494	(2.4)	607	(2.2)	654	(2.3)	683	(2.8)
France	507	(2.5)	95	(1.8)	508	(3.8)	506	(2.9)	2	(4.4)	341	(7.3)	381	(5.4)	445	(3.6)	574	(2.8)	626	(3.4)	656	(3.8)
Germany	514	(3.4)	106	(1.9)	515	(4.2)	514	(3.8)	1	(4.4)	325	(6.8)	369	(6.4)	445	(4.7)	590	(4.0)	645	(3.2)	673	(3.2)
Greece	446	(4.0)	100	(1.7)	458	(4.9)	435	(4.0)	23	(4.0)	279	(5.0)	316	(4.8)	379	(4.7)	514	(5.0)	573	(5.6)	609	(5.7)
Hungary	496	(2.7)	95	(1.9)	497	(3.3)	495	(3.2)	2	(3.6)	335	(5.7)	371	(5.2)	433	(4.1)	565	(3.4)	616	(3.4)	644	(3.7)
Iceland	513	(1.5)	96	(1.3)	500	(2.5)	528	(2.3)	-29	(3.9)	347	(4.0)	386	(3.4)	449	(3.0)	583	(2.2)	633	(2.8)	664	(4.6)
Ireland	502	(2.5)	88	(1.3)	506	(3.1)	497	(3.5)	9	(4.3)	353	(5.3)	388	(4.3)	442	(3.4)	564	(3.0)	615	(3.1)	644	(3.2)
Italy	475	(3.4)	106	(2.0)	481	(5.0)	469	(4.4)	13	(6.5)	297	(6.9)	336	(6.1)	404	(5.0)	548	(3.8)	610	(3.6)	645	(3.4)
Japan	527	(3.8)	102	(2.5)	528	(5.6)	525	(3.7)	3	(5.7)	351	(8.5)	393	(6.5)	462	(5.1)	598	(4.1)	652	(5.3)	682	(6.4)
Korea	537	(3.0)	90	(1.9)	546	(4.0)	524	(4.9)	22	(6.2)	386	(5.1)	421	(4.5)	477	(3.8)	599	(3.6)	650	(4.6)	680	(5.9)
Luxembourg	502	(1.1)	91	(1.1)	506	(2.2)	497	(1.6)	9	(3.2)	345	(3.8)	382	(3.3)	440	(2.3)	565	(2.3)	617	(2.8)	647	(3.6)
Mexico	394	(3.9)	95	(1.9)	400	(4.8)	388	(4.3)	12	(4.5)	237	(6.5)	270	(5.5)	329	(4.7)	460	(4.8)	517	(5.1)	550	(4.8)
Netherlands	528	(3.1)	97	(2.4)	526	(4.2)	530	(3.6)	-4	(4.7)	367	(7.0)	400	(6.1)	461	(4.6)	600	(3.2)	651	(3.3)	681	(4.1)
New Zealand	511	(2.2)	99	(1.3)	517	(2.7)	505	(3.2)	12	(3.9)	346	(4.6)	381	(4.2)	443	(3.5)	580	(3.0)	638	(2.5)	669	(3.5)
Norway	494	(2.2)	94	(1.1)	494	(2.8)	494	(2.7)	-0	(3.3)	336	(4.0)	372	(4.0)	431	(3.3)	559	(3.2)	614	(2.7)	645	(4.3)
Poland	492	(2.5)	89	(1.7)	493	(2.9)	491	(3.0)	2	(3.3)	342	(5.1)	376	(5.0)	434	(3.4)	553	(2.8)	605	(3.6)	634	(3.8)
Portugal	465	(3.5)	94	(1.8)	473	(4.1)	459	(3.7)	14	(3.3)	308	(7.1)	343	(6.3)	401	(5.0)	529	(3.3)	585	(3.7)	618	(4.0)
Slovak Republic	513	(3.4)	94	(2.3)	519	(4.0)	506	(3.6)	13	(3.6)	352	(7.6)	391	(6.2)	451	(4.7)	578	(3.3)	630	(3.1)	659	(3.6)
Spain	492	(2.5)	97	(1.3)	495	(3.6)	490	(2.2)	5	(3.1)	327	(5.5)	365	(4.6)	429	(3.6)	561	(2.9)	614	(3.2)	645	(4.3)
Sweden	514	(2.5)	90	(1.7)	515	(2.9)	512	(3.2)	3	(3.6)	364	(5.0)	398	(3.6)	454	(2.9)	575	(3.6)	628	(3.8)	659	(5.1)
Switzerland	533	(3.1)	96	(1.7)	536	(4.4)	529	(3.2)	7	(4.6)	366	(4.8)	405	(3.7)	471	(3.8)	600	(3.6)	652	(5.4)	682	(6.3)
Turkey	413	(6.8)	112	(5.1)	421	(8.0)	404	(6.6)	18	(6.3)	242	(6.7)	277	(5.4)	337	(5.6)	481	(8.9)	559	(14.3)	614	(21.3)
United States	476	(3.2)	105	(1.5)	479	(3.6)	474	(3.6)	4	(3.4)	300	(5.9)	337	(5.4)	406	(4.4)	551	(3.3)	611	(3.8)	645	(5.7)
OECD total	487	(1.1)	108	(0.7)	491	(1.4)	484	(1.3)	6	(1.5)	303	(2.5)	344	(1.9)	415	(1.6)	564	(1.1)	623	(1.2)	657	(1.5)
OECD average	501	(0.6)	102	(0.4)	504	(0.8)	498	(0.8)	6	(0.8)	325	(1.4)	366	(1.2)	433	(0.9)	573	(0.6)	629	(0.7)	661	(0.8)
Partner Countries																						
Brazil	360	(5.0)	109	(3.0)	370	(6.3)	352	(4.8)	18	(4.5)	188	(5.3)	223	(5.6)	286	(5.0)	432	(6.5)	502	(9.8)	545	(10.6)
Hong Kong-China	545	(4.2)	99	(2.6)	544	(6.1)	547	(4.1)	-3	(6.1)	369	(9.2)	413	(7.7)	483	(6.0)	615	(3.6)	665	(3.9)	694	(4.6)
Indonesia	358	(4.3)	91	(2.4)	359	(4.1)	357	(5.0)	2	(3.1)	213	(4.8)	244	(4.6)	295	(4.4)	416	(5.4)	475	(6.9)	514	(9.5)
Latvia	482	(3.6)	85	(1.4)	483	(4.4)	480	(3.6)	3	(3.4)	339	(6.8)	371	(5.5)	426	(4.1)	539	(4.2)	589	(4.5)	618	(4.4)
Liechtenstein	534	(4.1)	93	(4.5)	544	(7.0)	523	(5.7)	21	(9.9)	369	(16.2)	410	(14.3)	474	(7.2)	601	(6.2)	648	(10.6)	675	(11.0)
Macao-China	533	(3.0)	87	(2.3)	542	(4.3)	525	(4.2)	17	(6.0)	388	(7.8)	418	(5.9)	472	(5.6)	594	(4.1)	645	(5.3)	669	(7.6)
Russian Federation	472	(4.0)	92	(1.7)	476	(5.0)	469	(4.2)	6	(4.4)	316	(5.7)	353	(4.8)	411	(4.8)	535	(4.6)	590	(4.5)	623	(4.9)
Serbia	456	(3.8)	89	(1.6)	455	(4.2)	458	(4.7)	-3	(4.7)	311	(3.9)	341	(4.4)	396	(4.6)	518	(4.6)	570	(4.7)	602	(5.9)
Thailand	415	(3.2)	93	(2.1)	412	(4.1)	417	(3.8)	-5	(4.9)	269	(4.6)	299	(3.5)	351	(3.5)	475	(4.1)	537	(6.0)	576	(6.7)
Tunisia	364	(2.8)	88	(2.1)	372	(2.9)	357	(3.3)	16	(2.7)	225	(3.1)	255	(3.4)	303	(3.2)	422	(3.8)	481	(5.5)	518	(6.4)
Uruguay	430	(3.2)	109	(1.6)	436	(3.9)	424	(3.8)	12	(4.1)	246	(5.4)	286	(4.6)	356	(4.1)	506	(4.0)	566	(3.7)	602	(5.1)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate too low to ensure comparability (see Annex A3).

Note: Values that are statistically significant are indicated in bold (see Annex A4).

Source: PISA International PISA 2003 Report

TABLE A3.5 MEAN SCORE, VARIATION AND GENDER DIFFERENCES IN STUDENT PERFORMANCE ON THE MATHEMATICS/UNCERTAINTY SCALE

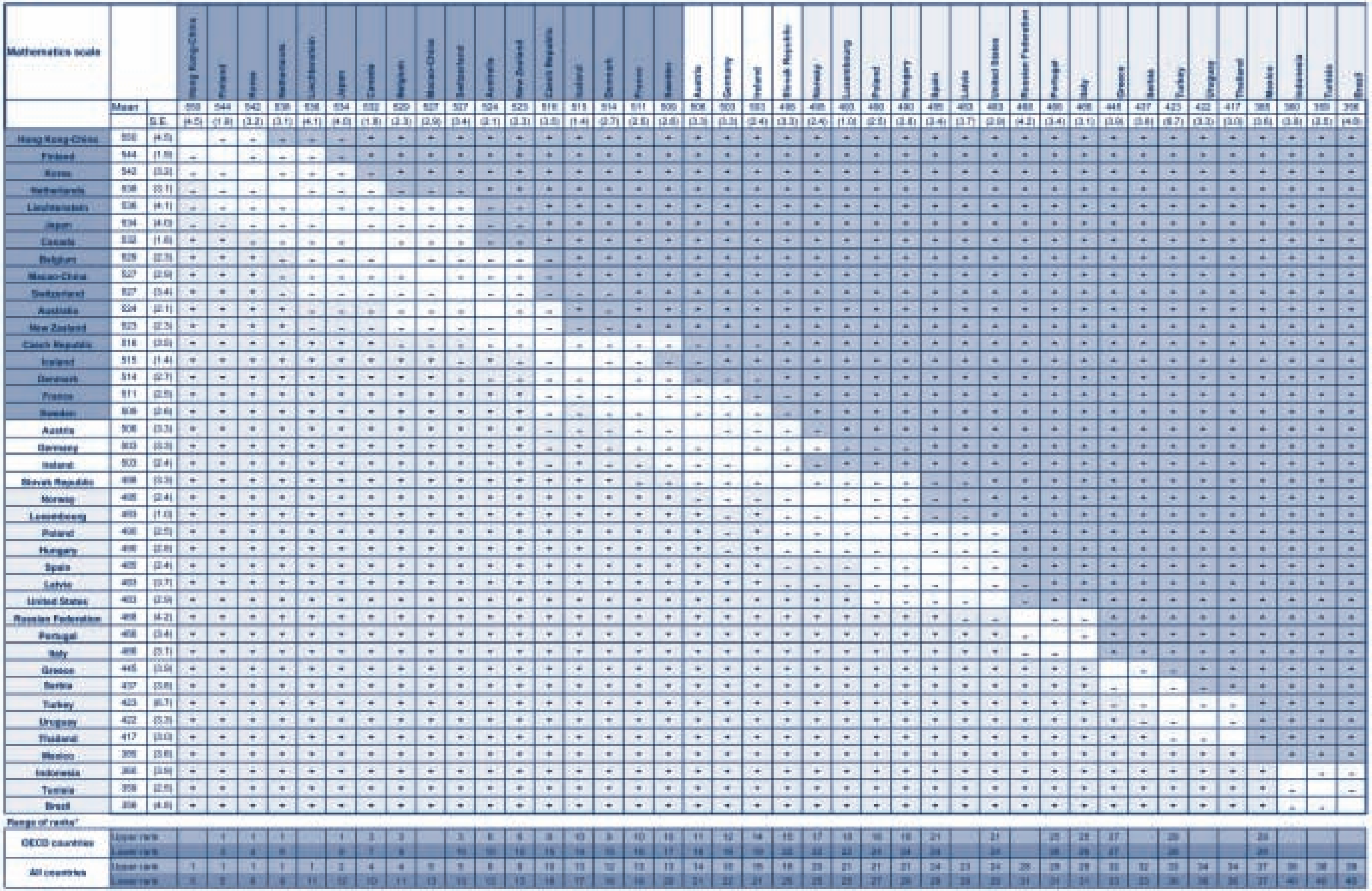
Country	All students				Gender differences						Percentiles											
	Mean		Standard deviation		Males		Females		Difference (M - F)		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Mean score	S.E.	Mean score	S.E.	Score dif.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																						
Australia	531	(2.2)	98	(1.6)	535	(3.0)	527	(2.7)	7	(3.7)	367	(4.0)	404	(3.5)	464	(2.9)	600	(2.7)	655	(3.1)	686	(3.5)
Austria	494	(3.1)	95	(1.7)	498	(3.8)	490	(4.0)	8	(4.6)	340	(4.4)	372	(4.3)	427	(3.7)	560	(3.8)	618	(4.4)	649	(4.7)
Belgium	526	(2.2)	106	(1.5)	529	(3.2)	522	(3.2)	7	(4.7)	348	(4.9)	383	(4.1)	450	(3.6)	605	(2.4)	661	(2.3)	692	(2.4)
Canada	542	(1.8)	87	(0.9)	551	(2.2)	538	(1.9)	13	(2.3)	397	(3.2)	429	(2.4)	483	(2.1)	602	(2.0)	653	(2.6)	682	(3.1)
Czech Republic	500	(3.1)	91	(1.7)	509	(3.9)	492	(3.8)	17	(4.6)	357	(5.4)	385	(3.9)	436	(3.2)	564	(3.8)	620	(4.2)	652	(4.4)
Denmark	516	(2.8)	92	(1.6)	527	(3.4)	505	(3.0)	22	(3.2)	363	(5.2)	396	(4.9)	454	(3.4)	580	(3.1)	632	(3.6)	661	(4.3)
Finland	545	(2.1)	85	(1.1)	551	(2.6)	539	(2.3)	12	(2.6)	403	(3.4)	437	(4.1)	489	(2.6)	602	(2.4)	652	(3.6)	683	(3.3)
France	506	(2.4)	92	(1.7)	512	(3.5)	501	(2.8)	11	(4.2)	349	(6.0)	384	(4.2)	443	(3.6)	572	(2.6)	622	(3.3)	651	(3.2)
Germany	493	(3.3)	98	(1.7)	502	(3.9)	484	(3.8)	18	(4.0)	331	(5.5)	365	(4.1)	423	(4.0)	564	(3.4)	618	(3.5)	649	(4.0)
Greece	458	(3.5)	88	(1.5)	469	(4.3)	449	(3.7)	20	(3.7)	313	(5.4)	345	(4.4)	398	(3.8)	519	(3.8)	572	(5.1)	605	(5.0)
Hungary	489	(2.6)	86	(1.8)	493	(3.2)	485	(3.0)	8	(3.3)	351	(4.7)	380	(4.3)	430	(3.0)	548	(3.4)	601	(3.6)	631	(4.5)
Iceland	528	(1.5)	95	(1.4)	524	(2.4)	532	(2.4)	-8	(3.8)	368	(4.9)	405	(3.4)	463	(2.5)	595	(2.6)	648	(3.2)	678	(3.9)
Ireland	517	(2.6)	89	(1.4)	525	(3.2)	509	(3.7)	16	(4.6)	371	(5.6)	403	(4.5)	456	(3.5)	580	(3.4)	633	(3.4)	661	(3.5)
Italy	463	(3.0)	95	(1.7)	475	(4.5)	451	(3.8)	24	(5.9)	306	(6.4)	339	(5.2)	399	(4.2)	528	(3.1)	585	(3.1)	620	(3.4)
Japan	528	(3.9)	98	(2.6)	535	(5.6)	521	(3.8)	14	(5.7)	359	(7.1)	399	(6.7)	463	(4.9)	597	(4.2)	649	(5.7)	681	(7.5)
Korea	538	(3.0)	89	(2.0)	547	(4.1)	525	(5.2)	22	(6.6)	390	(4.8)	423	(4.1)	477	(4.0)	600	(3.4)	651	(5.0)	682	(5.7)
Luxembourg	492	(1.1)	96	(1.0)	503	(2.2)	482	(1.8)	22	(3.5)	332	(5.0)	369	(2.5)	427	(2.1)	559	(2.2)	615	(2.9)	648	(3.6)
Mexico	390	(3.3)	80	(1.5)	392	(3.8)	388	(3.6)	5	(3.5)	262	(4.7)	289	(3.9)	335	(3.3)	442	(4.4)	495	(5.0)	528	(5.7)
Netherlands	549	(3.0)	90	(2.0)	554	(3.6)	545	(3.7)	10	(4.1)	403	(5.2)	431	(5.1)	483	(5.1)	617	(3.7)	667	(3.6)	693	(3.2)
New Zealand	532	(2.3)	99	(1.3)	538	(2.7)	527	(3.3)	12	(3.9)	368	(5.6)	403	(4.5)	463	(3.1)	601	(2.6)	662	(2.7)	695	(3.6)
Norway	513	(2.6)	98	(1.1)	518	(3.0)	508	(3.2)	10	(3.3)	352	(3.9)	386	(4.2)	445	(3.4)	580	(3.8)	640	(3.9)	675	(3.8)
Poland	494	(2.3)	85	(1.7)	495	(2.8)	492	(2.8)	3	(3.2)	355	(6.1)	387	(4.2)	437	(3.0)	552	(2.7)	603	(3.4)	631	(3.4)
Portugal	471	(3.4)	83	(1.8)	476	(4.1)	466	(3.5)	10	(3.1)	333	(5.8)	363	(5.5)	414	(4.7)	528	(3.2)	578	(2.9)	605	(4.1)
Slovak Republic	476	(3.2)	87	(1.8)	484	(3.8)	467	(3.4)	17	(3.5)	335	(6.0)	364	(5.4)	416	(3.8)	537	(3.6)	589	(3.5)	619	(3.7)
Spain	489	(2.4)	88	(1.4)	493	(3.3)	485	(2.2)	8	(2.8)	340	(5.2)	376	(4.2)	432	(3.0)	549	(3.1)	600	(2.9)	628	(3.9)
Sweden	511	(2.7)	101	(1.7)	515	(3.2)	506	(3.4)	9	(3.7)	345	(5.0)	384	(4.7)	442	(3.4)	581	(3.6)	640	(3.9)	675	(4.8)
Switzerland	517	(3.3)	100	(2.1)	526	(4.7)	506	(3.7)	21	(5.2)	346	(4.6)	384	(3.8)	450	(3.5)	587	(4.2)	642	(5.6)	676	(6.9)
Turkey	443	(6.2)	98	(5.0)	451	(7.3)	432	(6.1)	19	(5.7)	299	(5.0)	328	(4.3)	375	(4.8)	499	(8.2)	571	(13.9)	622	(22.2)
United States	492	(3.0)	99	(1.5)	493	(3.4)	490	(3.1)	3	(2.8)	328	(5.6)	363	(4.8)	424	(3.8)	560	(3.2)	621	(3.5)	654	(5.1)
OECD total	492	(1.1)	102	(0.7)	497	(1.3)	487	(1.2)	11	(1.3)	323	(1.9)	359	(1.7)	421	(1.4)	564	(1.2)	623	(1.2)	657	(1.6)
OECD average	502	(0.6)	99	(0.4)	508	(0.7)	496	(0.8)	13	(0.8)	339	(1.1)	374	(1.0)	434	(0.9)	571	(0.7)	629	(0.7)	662	(0.9)
Partner Countries																						
Brazil	377	(3.9)	84	(2.7)	385	(4.9)	369	(3.7)	15	(3.4)	250	(4.2)	276	(3.7)	320	(3.5)	427	(5.0)	485	(7.7)	525	(9.4)
Hong Kong-China	558	(4.6)	101	(3.1)	564	(6.6)	552	(4.6)	12	(6.7)	382	(10.1)	423	(8.3)	493	(6.6)	630	(3.7)	680	(4.3)	709	(4.9)
Indonesia	385	(2.9)	66	(1.5)	382	(2.8)	387	(3.4)	-5	(2.4)	281	(4.2)	303	(3.5)	340	(2.7)	427	(3.6)	471	(4.6)	499	(6.2)
Latvia	474	(3.3)	84	(1.4)	474	(4.2)	474	(3.1)	-0	(3.3)	337	(5.4)	366	(4.6)	417	(3.9)	530	(4.0)	582	(4.0)	611	(4.8)
Liechtenstein	523	(3.7)	96	(3.7)	538	(6.9)	508	(5.6)	31	(10.5)	356	(20.2)	394	(16.9)	461	(5.8)	594	(6.8)	641	(8.3)	673	(16.6)
Macao-China	532	(3.2)	88	(2.6)	541	(4.5)	523	(4.2)	18	(5.9)	391	(11.8)	421	(7.3)	473	(5.9)	592	(5.1)	644	(5.7)	673	(7.7)
Russian Federation	437	(4.0)	90	(1.6)	441	(5.1)	432	(3.9)	8	(4.2)	293	(4.4)	324	(4.6)	375	(4.2)	496	(4.5)	554	(4.6)	588	(6.4)
Serbia	428	(3.5)	83	(1.5)	431	(4.0)	425	(4.2)	5	(4.2)	294	(4.3)	323	(4.2)	371	(3.6)	485	(4.8)	536	(5.0)	568	(5.3)
Thailand	423	(2.5)	73	(1.8)	420	(3.4)	425	(3.0)	-5	(4.0)	310	(3.4)	333	(3.1)	373	(2.5)	468	(3.2)	518	(4.6)	549	(6.3)
Tunisia	363	(2.3)	71	(1.7)	367	(2.5)	360	(2.8)	7	(2.6)	250	(3.5)	276	(2.6)	317	(2.7)	408	(2.8)	453	(4.8)	483	(6.1)
Uruguay	419	(3.1)	98	(1.7)	423	(3.9)	415	(3.6)	8	(4.1)	258	(4.6)	293	(4.4)	352	(3.9)	486	(4.0)	544	(4.2)	581	(5.2)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate too low to ensure comparability (see Annex A3).

Note: Values that are statistically significant are indicated in bold (see Annex A4).
Source: PISA International PISA 2003 Report

Table A3.6

Multiple comparisons of mean performance on the mathematics scale



* Note: Because data are based on samples, it is not possible to report exact rank order positions for countries. However, it is possible to report the range of rank order positions within which the country mean lies with 95 per cent likelihood.

Instructions: Read across the row for a country to compare performance with the countries listed along the top of the chart. The symbols indicate whether the average performance of the country in the row is significantly lower than that of the comparison

Without the Bonferroni adjustment:

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

With the Bonferroni adjustment:

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

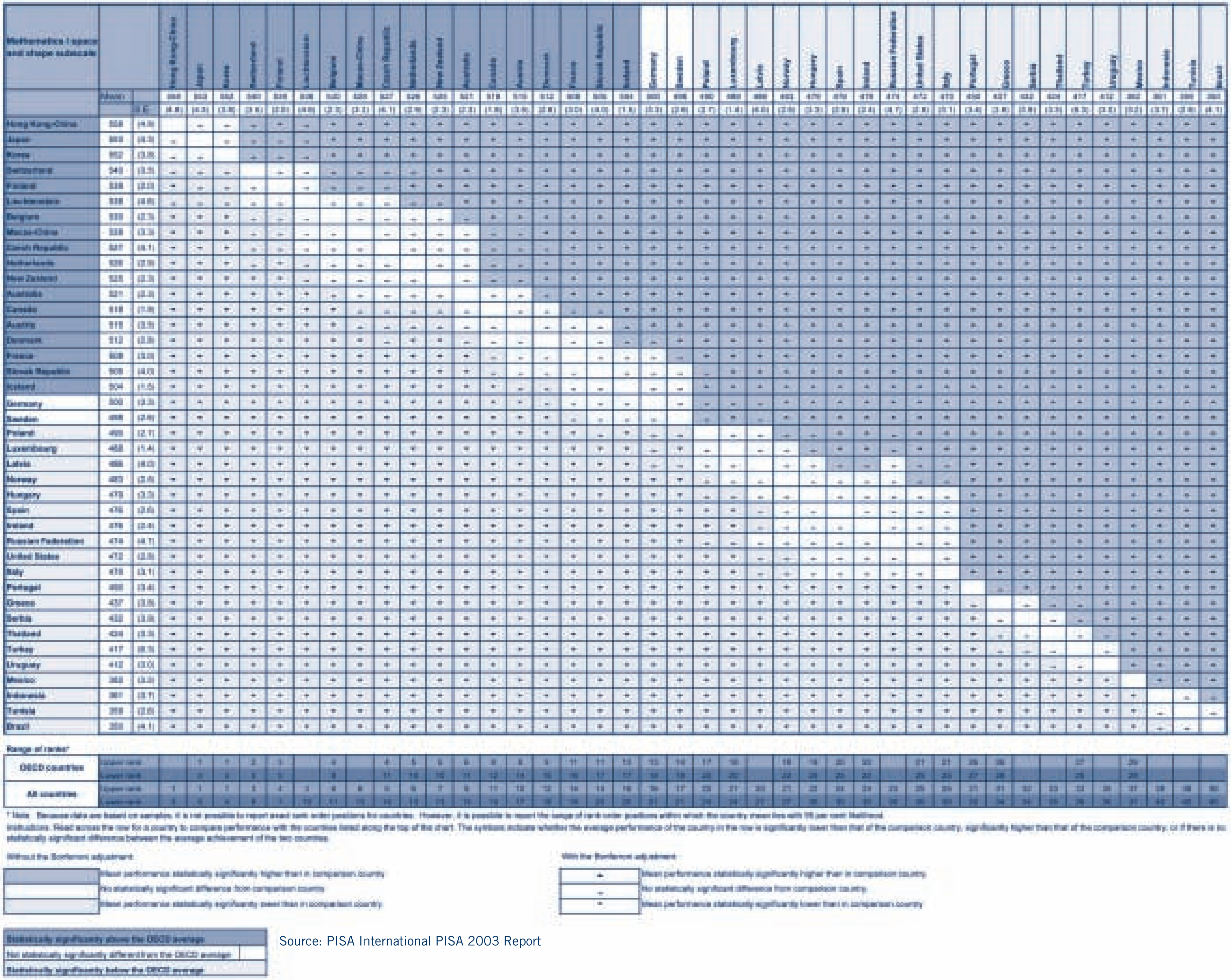
Not statistically significantly different from the OECD average

Statistically significantly below the OECD average

Source: PISA International PISA 2003 Report

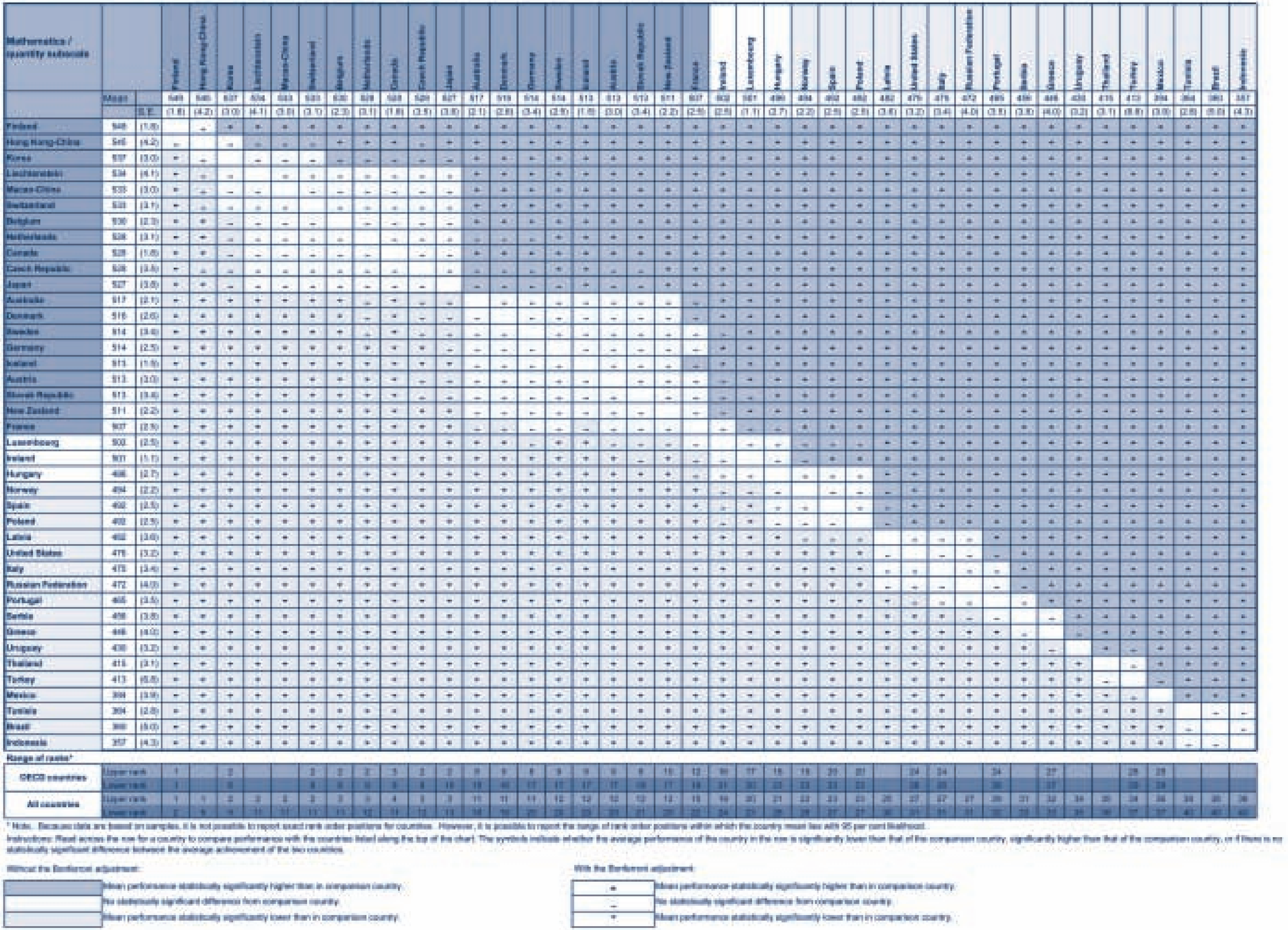
Table A3.7

Multiple comparisons of mean performance on the mathematics/space and shape scale



Source: PISA International PISA 2003 Report

Table A3.8
Multiple comparisons of mean performance on the mathematics/quantity subscale

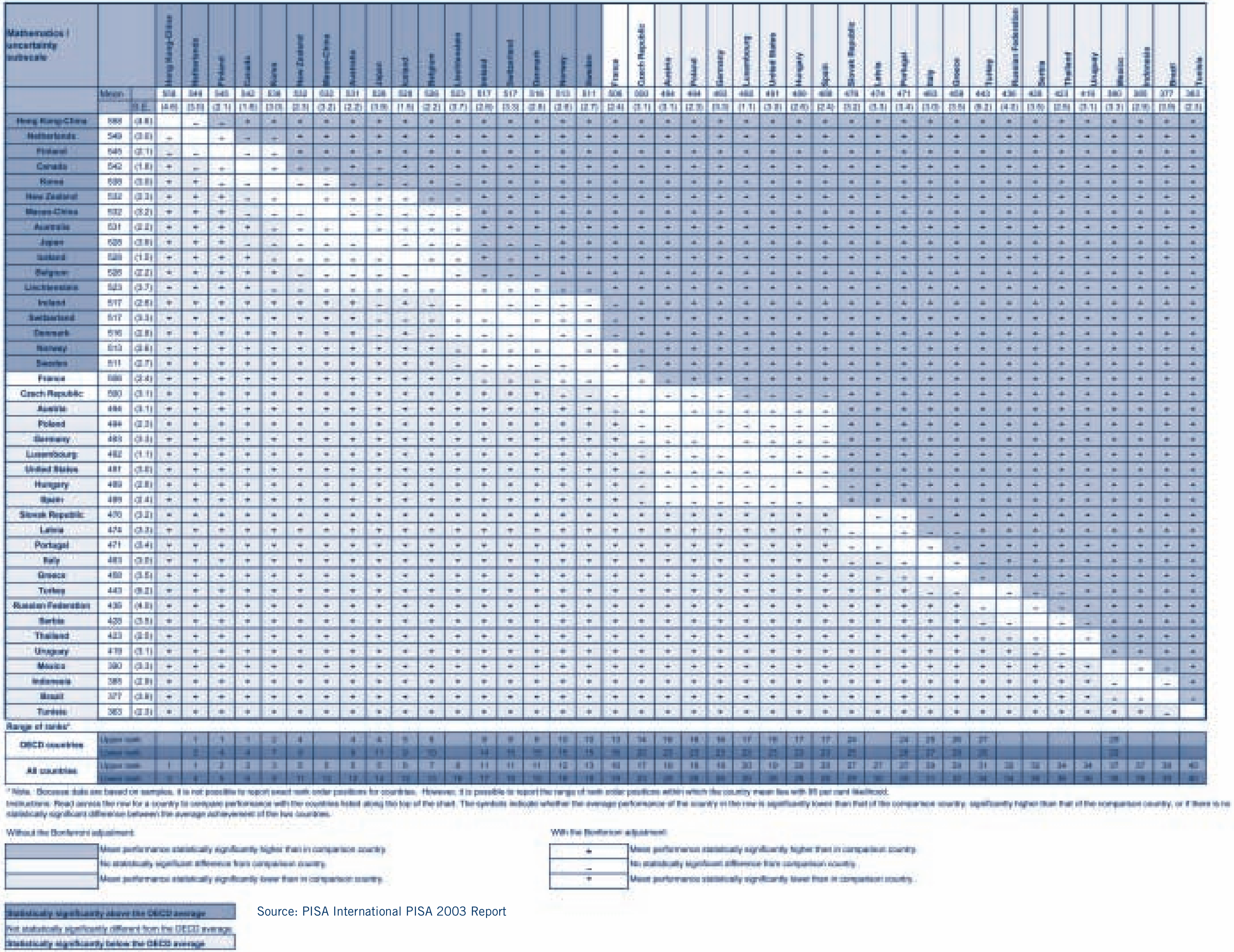


Statistically significantly above the OECD average
Not statistically significantly different from the OECD average
Statistically significantly below the OECD average

Source: PISA International PISA 2003 Report

Table A3.9

Multiple comparisons of mean performance on the mathematics/uncertainty subscale



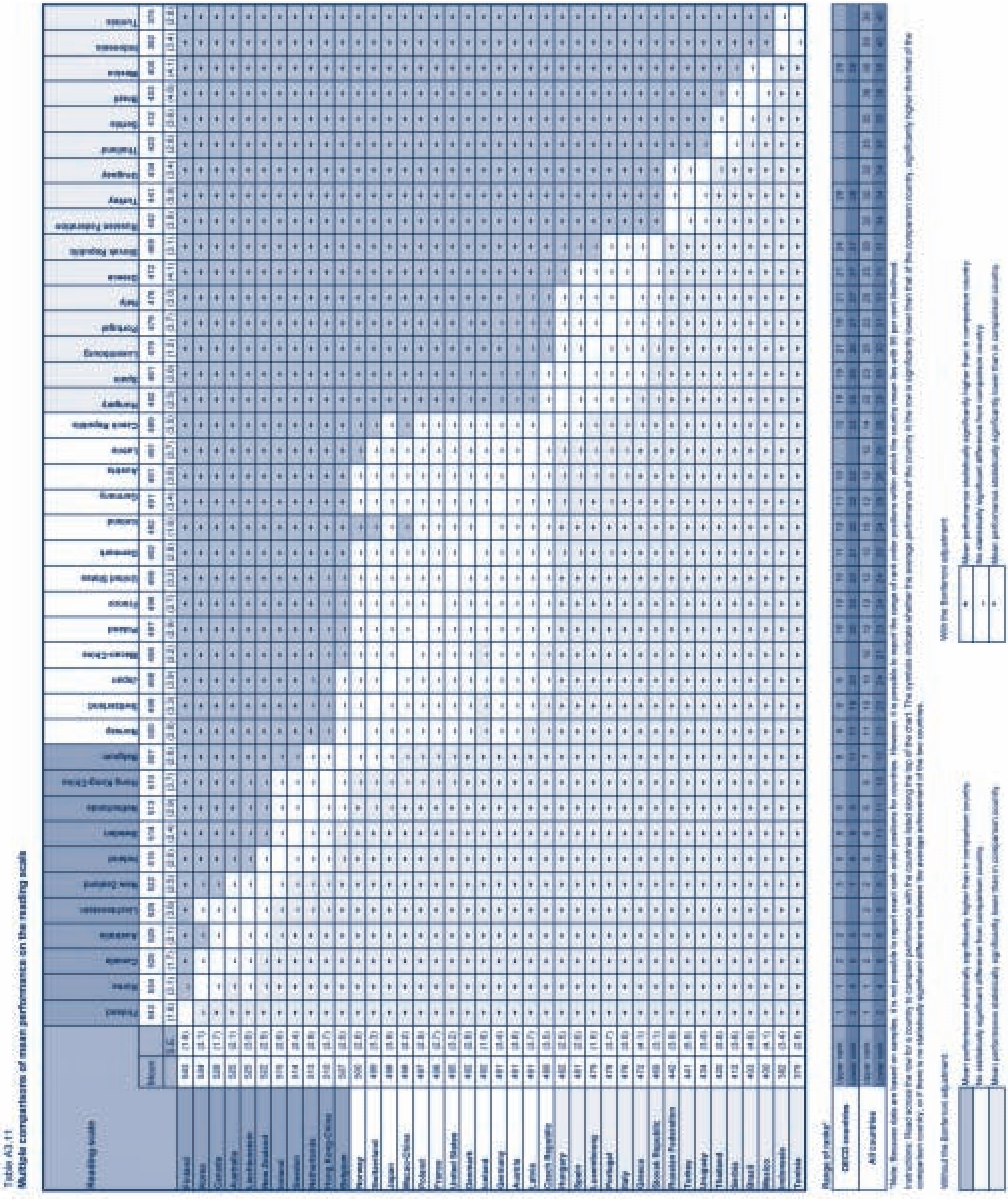
Source: PISA International PISA 2003 Report

TABLE A3.10 MEAN SCORE AND VARIATION IN STUDENT PERFORMANCE ON THE READING SCALE

Country	All students				Percentiles											
	Mean		Standard deviation		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																
Australia	525	(2.1)	97	(1.5)	352	(4.8)	395	(3.6)	464	(3.0)	594	(2.5)	644	(2.7)	673	(3.1)
Austria	491	(3.8)	103	(2.3)	313	(7.5)	354	(6.3)	424	(4.9)	565	(4.2)	617	(3.7)	646	(4.7)
Belgium	507	(2.6)	110	(2.1)	300	(8.4)	355	(6.6)	440	(4.2)	587	(2.1)	635	(2.1)	662	(2.6)
Canada	528	(1.7)	89	(0.9)	373	(3.1)	410	(3.1)	472	(2.3)	590	(2.1)	636	(2.1)	663	(2.5)
Czech Republic	489	(3.5)	96	(2.4)	320	(9.5)	362	(6.9)	428	(4.7)	555	(4.0)	607	(3.8)	636	(4.0)
Denmark	492	(2.8)	88	(1.8)	338	(6.6)	376	(4.6)	438	(4.0)	553	(3.0)	601	(2.7)	627	(3.9)
Finland	544	(1.6)	81	(1.1)	400	(4.8)	437	(3.1)	494	(2.4)	599	(1.7)	641	(2.2)	666	(2.5)
France	496	(2.7)	97	(2.2)	320	(7.7)	367	(7.0)	436	(4.0)	565	(2.8)	614	(2.7)	641	(3.3)
Germany	491	(3.4)	109	(2.3)	295	(6.0)	341	(6.8)	419	(5.6)	572	(3.4)	624	(3.2)	652	(3.9)
Greece	472	(4.1)	105	(2.0)	288	(6.2)	333	(6.2)	406	(5.2)	546	(4.4)	599	(4.4)	631	(5.4)
Hungary	482	(2.5)	92	(1.8)	324	(6.0)	361	(4.2)	422	(3.3)	547	(3.3)	597	(3.4)	625	(5.0)
Iceland	492	(1.6)	98	(1.4)	316	(6.4)	362	(4.8)	431	(2.3)	560	(2.2)	612	(2.8)	640	(3.6)
Ireland	516	(2.6)	87	(1.7)	364	(7.3)	401	(4.6)	460	(3.8)	577	(2.8)	622	(3.0)	647	(3.3)
Italy	476	(3.1)	101	(2.2)	295	(8.6)	341	(6.8)	411	(4.4)	547	(2.5)	598	(2.1)	627	(2.6)
Japan	498	(3.9)	106	(2.5)	310	(7.3)	355	(6.5)	431	(5.4)	574	(3.7)	624	(4.8)	652	(4.7)
Korea	534	(3.1)	83	(2.0)	393	(6.0)	428	(5.2)	484	(4.1)	590	(2.8)	634	(4.1)	660	(5.0)
Luxembourg	479	(1.5)	100	(1.0)	302	(3.8)	344	(2.9)	416	(2.8)	551	(1.9)	601	(2.1)	627	(2.7)
Mexico	400	(4.1)	95	(1.9)	238	(6.1)	274	(5.5)	335	(5.0)	467	(4.3)	521	(6.1)	552	(5.5)
Netherlands	513	(2.9)	85	(2.1)	369	(6.4)	400	(5.2)	454	(4.5)	576	(3.2)	621	(2.9)	645	(4.2)
New Zealand	522	(2.5)	105	(1.5)	338	(6.2)	381	(4.4)	453	(3.5)	596	(2.8)	652	(2.9)	682	(3.4)
Norway	500	(2.8)	103	(1.8)	321	(6.1)	364	(4.7)	434	(3.8)	571	(3.6)	625	(3.9)	656	(3.9)
Poland	497	(2.9)	96	(1.8)	331	(6.3)	374	(5.0)	436	(3.6)	563	(3.1)	616	(3.4)	645	(4.4)
Portugal	478	(3.7)	93	(2.1)	311	(6.6)	351	(7.1)	418	(5.2)	544	(3.5)	592	(3.5)	617	(3.9)
Slovak Republic	469	(3.1)	93	(2.0)	310	(5.7)	348	(5.8)	408	(4.6)	535	(3.2)	587	(3.0)	613	(3.5)
Spain	481	(2.6)	95	(1.5)	313	(5.8)	354	(4.9)	421	(3.4)	548	(2.8)	597	(2.8)	625	(3.1)
Sweden	514	(2.4)	96	(1.9)	349	(6.0)	390	(4.3)	453	(3.4)	582	(2.9)	631	(2.9)	660	(3.6)
Switzerland	499	(3.3)	95	(1.9)	330	(5.8)	373	(5.6)	439	(4.5)	565	(3.7)	615	(3.9)	643	(5.0)
Turkey	441	(5.8)	95	(4.1)	291	(6.1)	324	(5.3)	377	(5.7)	500	(6.6)	562	(11.4)	608	(19.4)
United States	495	(3.2)	101	(1.4)	319	(6.6)	361	(5.2)	429	(4.1)	568	(3.6)	622	(3.6)	651	(4.5)
OECD total	488	(1.2)	104	(0.7)	305	(2.2)	349	(2.2)	420	(1.8)	562	(1.2)	616	(1.2)	646	(1.3)
OECD average	494	(0.6)	100	(0.4)	318	(1.4)	361	(1.3)	430	(1.0)	565	(0.6)	617	(0.6)	646	(0.7)
Partner Countries																
Brazil	403	(4.6)	111	(2.3)	214	(7.3)	256	(7.5)	328	(5.5)	479	(5.1)	542	(5.2)	581	(6.9)
Hong Kong-China	510	(3.7)	85	(2.7)	355	(9.9)	397	(6.7)	461	(5.1)	569	(2.8)	608	(2.9)	630	(3.0)
Indonesia	382	(3.4)	76	(1.8)	254	(5.4)	282	(4.9)	332	(3.7)	433	(4.0)	478	(4.6)	506	(6.1)
Latvia	491	(3.7)	90	(1.7)	335	(6.4)	372	(5.3)	431	(4.9)	554	(3.5)	603	(4.6)	632	(4.6)
Liechtenstein	525	(3.6)	90	(3.4)	365	(15.1)	405	(11.7)	467	(9.1)	588	(5.7)	636	(11.8)	661	(14.3)
Macao-China	498	(2.2)	67	(1.9)	381	(6.2)	409	(5.1)	455	(3.5)	544	(4.4)	583	(3.7)	601	(4.3)
Russian Federation	442	(3.9)	93	(1.8)	281	(6.9)	319	(6.1)	381	(5.4)	507	(3.9)	558	(4.4)	588	(4.7)
Serbia	412	(3.6)	82	(1.6)	274	(5.0)	306	(4.7)	358	(4.0)	467	(4.0)	516	(4.8)	542	(5.9)
Thailand	420	(2.8)	78	(1.5)	293	(4.9)	322	(3.4)	366	(3.1)	472	(3.6)	520	(4.5)	550	(5.3)
Tunisia	375	(2.8)	96	(1.8)	216	(4.7)	251	(3.8)	310	(3.2)	441	(3.5)	497	(4.3)	530	(5.5)
Uruguay	434	(3.4)	122	(2.0)	224	(5.8)	272	(6.0)	355	(4.4)	518	(4.4)	587	(4.5)	628	(6.1)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate too low to ensure comparability

Source: PISA International PISA 2003 Report



Source: PISA International PISA 2003 Report

TABLE A3.12 MEAN SCORE AND VARIATION IN STUDENT PERFORMANCE ON THE SCIENCE SCALE

Country	All students				Percentiles											
	Mean		Standard deviation		5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																
Australia	525	(2.1)	102	(1.5)	351	(4.2)	391	(3.4)	457	(3.1)	596	(2.7)	652	(2.9)	686	(3.7)
Austria	491	(3.4)	97	(1.5)	327	(6.6)	363	(4.1)	423	(4.1)	561	(4.0)	615	(4.1)	644	(4.4)
Belgium	509	(2.5)	107	(1.8)	320	(6.1)	364	(5.0)	436	(3.8)	588	(2.4)	640	(2.5)	669	(2.6)
Canada	519	(2.0)	99	(1.1)	352	(3.9)	389	(3.3)	452	(2.7)	588	(2.4)	644	(3.0)	676	(2.9)
Czech Republic	523	(3.4)	101	(1.7)	357	(5.8)	391	(4.3)	453	(4.2)	594	(3.9)	652	(4.7)	686	(4.5)
Denmark	475	(3.0)	102	(1.7)	306	(6.4)	343	(4.7)	407	(3.9)	547	(3.6)	605	(3.4)	638	(4.4)
Finland	548	(1.9)	91	(1.1)	393	(3.5)	429	(2.6)	488	(2.8)	611	(2.2)	662	(2.9)	691	(3.5)
France	511	(3.0)	111	(2.2)	321	(6.7)	363	(5.5)	435	(4.4)	591	(3.4)	651	(3.2)	682	(4.5)
Germany	502	(3.6)	111	(2.2)	307	(7.1)	351	(5.6)	427	(5.8)	584	(4.0)	640	(3.6)	672	(3.5)
Greece	481	(3.8)	101	(1.7)	315	(5.8)	349	(5.0)	412	(4.5)	552	(4.0)	610	(4.6)	643	(4.9)
Hungary	503	(2.8)	97	(2.0)	340	(5.9)	375	(4.1)	437	(3.1)	572	(3.9)	628	(5.5)	658	(4.6)
Iceland	495	(1.5)	96	(1.4)	331	(5.9)	369	(4.0)	432	(2.8)	562	(2.7)	616	(3.6)	647	(3.6)
Ireland	505	(2.7)	93	(1.3)	348	(6.1)	384	(4.8)	442	(3.7)	572	(3.0)	625	(3.3)	652	(3.4)
Italy	487	(3.1)	108	(2.0)	303	(7.3)	344	(6.3)	415	(4.9)	563	(2.8)	622	(2.7)	656	(3.9)
Japan	548	(4.1)	109	(2.7)	357	(7.0)	402	(6.1)	475	(6.1)	624	(4.2)	682	(6.0)	715	(7.9)
Korea	538	(3.5)	101	(2.2)	365	(6.3)	405	(5.0)	473	(4.8)	609	(4.3)	663	(4.7)	695	(5.8)
Luxembourg	483	(1.5)	103	(1.1)	309	(4.2)	347	(2.6)	413	(2.9)	556	(2.4)	614	(3.1)	645	(2.9)
Mexico	405	(3.5)	87	(2.2)	264	(5.1)	295	(4.8)	347	(3.5)	462	(4.2)	517	(5.3)	551	(6.8)
Netherlands	524	(3.1)	99	(2.2)	363	(6.6)	394	(5.6)	451	(5.3)	599	(4.0)	653	(4.1)	682	(4.3)
New Zealand	521	(2.4)	104	(1.4)	348	(3.9)	382	(4.1)	448	(3.9)	596	(3.3)	653	(3.9)	687	(3.2)
Norway	484	(2.9)	104	(1.8)	312	(5.3)	350	(4.6)	414	(4.0)	557	(3.8)	616	(4.6)	651	(6.1)
Poland	498	(2.9)	102	(1.4)	333	(5.3)	367	(3.5)	426	(4.3)	570	(3.5)	630	(4.1)	666	(6.3)
Portugal	468	(3.5)	93	(1.7)	310	(5.9)	346	(6.2)	405	(5.0)	533	(3.4)	587	(3.7)	618	(4.5)
Slovak Republic	495	(3.7)	102	(3.1)	332	(7.0)	367	(6.0)	428	(4.6)	566	(3.6)	625	(3.8)	657	(3.9)
Spain	487	(2.6)	100	(1.5)	318	(5.8)	355	(4.0)	421	(3.4)	557	(3.1)	613	(3.1)	644	(3.8)
Sweden	506	(2.7)	107	(1.8)	327	(6.5)	368	(4.0)	435	(3.5)	581	(4.0)	642	(4.0)	673	(4.8)
Switzerland	513	(3.7)	108	(1.9)	328	(5.8)	369	(4.6)	440	(4.5)	588	(4.6)	648	(5.9)	683	(6.8)
Turkey	434	(5.9)	96	(4.7)	295	(5.0)	321	(4.7)	367	(4.9)	492	(8.4)	560	(12.8)	609	(20.0)
United States	491	(3.1)	102	(1.3)	322	(5.4)	359	(4.4)	420	(3.8)	564	(3.3)	622	(4.3)	654	(3.5)
OECD total	496	(1.1)	109	(0.7)	316	(1.9)	353	(1.6)	419	(1.7)	574	(1.4)	636	(1.5)	670	(1.7)
OECD average	500	(0.6)	106	(0.4)	324	(1.2)	362	(1.1)	427	(1.0)	575	(0.8)	634	(0.9)	668	(1.0)
Partner Countries																
Brazil	390	(4.3)	98	(2.6)	235	(7.6)	268	(5.2)	323	(4.8)	452	(5.4)	520	(7.6)	560	(7.9)
Hong Kong-China	540	(4.3)	94	(2.8)	373	(9.8)	412	(8.6)	478	(6.9)	608	(3.5)	653	(3.9)	680	(4.3)
Indonesia	395	(3.2)	68	(1.9)	286	(4.5)	310	(4.0)	350	(3.0)	439	(3.8)	483	(5.5)	512	(6.2)
Latvia	489	(3.9)	93	(1.5)	336	(5.6)	370	(5.0)	425	(4.6)	553	(5.1)	609	(4.9)	642	(5.7)
Liechtenstein	525	(4.3)	104	(4.4)	351	(17.3)	389	(8.7)	450	(5.7)	598	(9.1)	659	(10.4)	690	(13.5)
Macao-China	525	(3.0)	88	(3.0)	375	(7.9)	410	(7.7)	465	(5.3)	587	(4.0)	635	(6.2)	663	(9.5)
Russian Federation	489	(4.1)	100	(1.5)	324	(5.6)	359	(5.4)	422	(4.8)	558	(4.5)	617	(4.0)	652	(5.0)
Serbia	436	(3.5)	83	(1.6)	305	(4.5)	332	(3.9)	380	(3.9)	492	(4.4)	545	(5.2)	576	(6.4)
Thailand	429	(2.7)	81	(1.6)	303	(3.6)	329	(3.4)	373	(2.9)	481	(3.5)	537	(4.4)	571	(5.6)
Tunisia	385	(2.6)	87	(1.8)	244	(4.6)	274	(3.8)	325	(2.7)	444	(3.3)	498	(5.0)	530	(6.2)
Uruguay	438	(2.9)	109	(1.8)	257	(3.9)	296	(4.4)	363	(4.0)	516	(4.5)	579	(5.0)	613	(5.3)
United Kingdom1	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m

1. Response rate to low to ensure comparability (see Annex A3).

Source: PISA International PISA 2003 Report

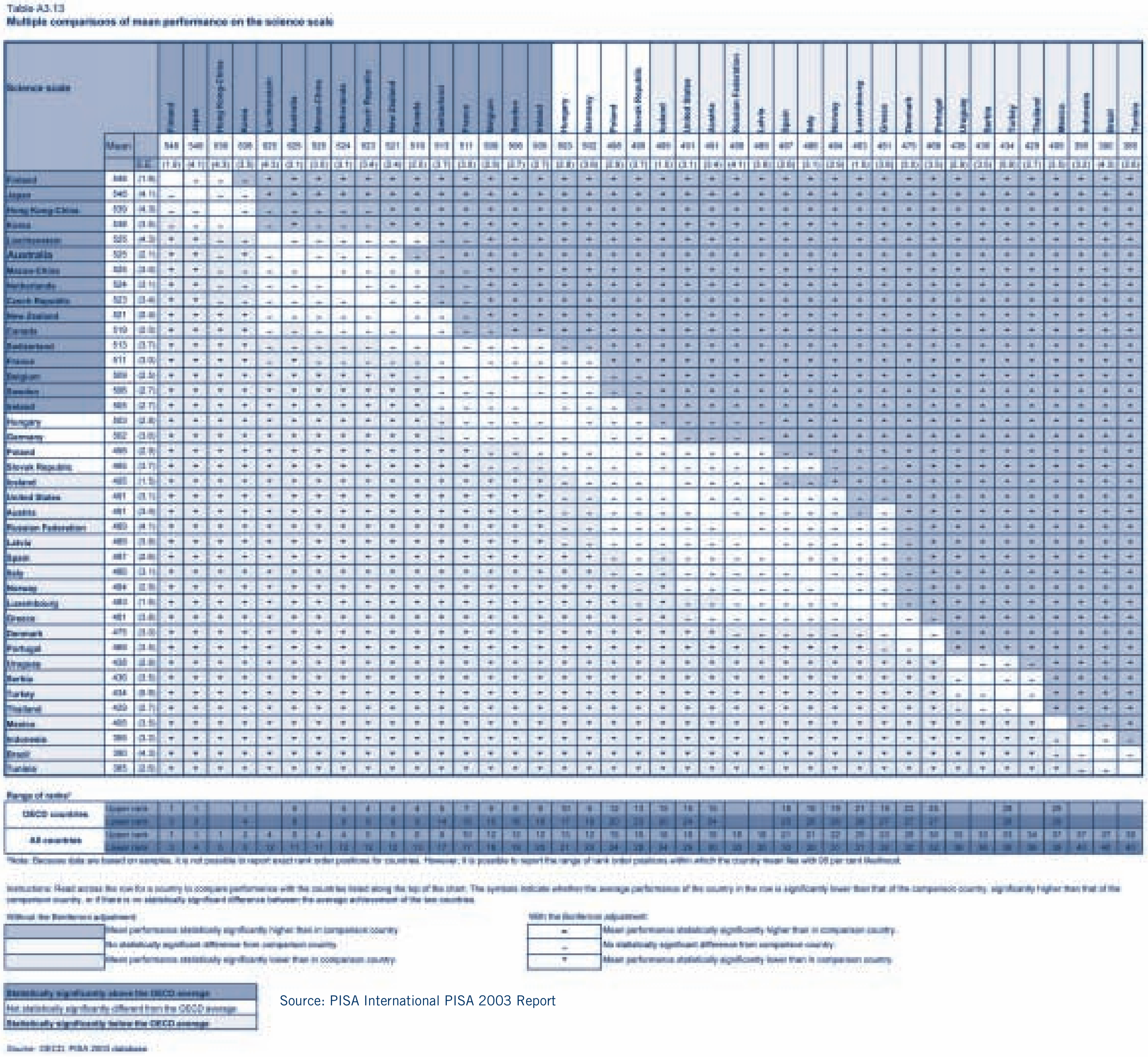


Table A3.13
Multiple comparisons of mean performance on the science scale

Source: PISA International PISA 2003 Report

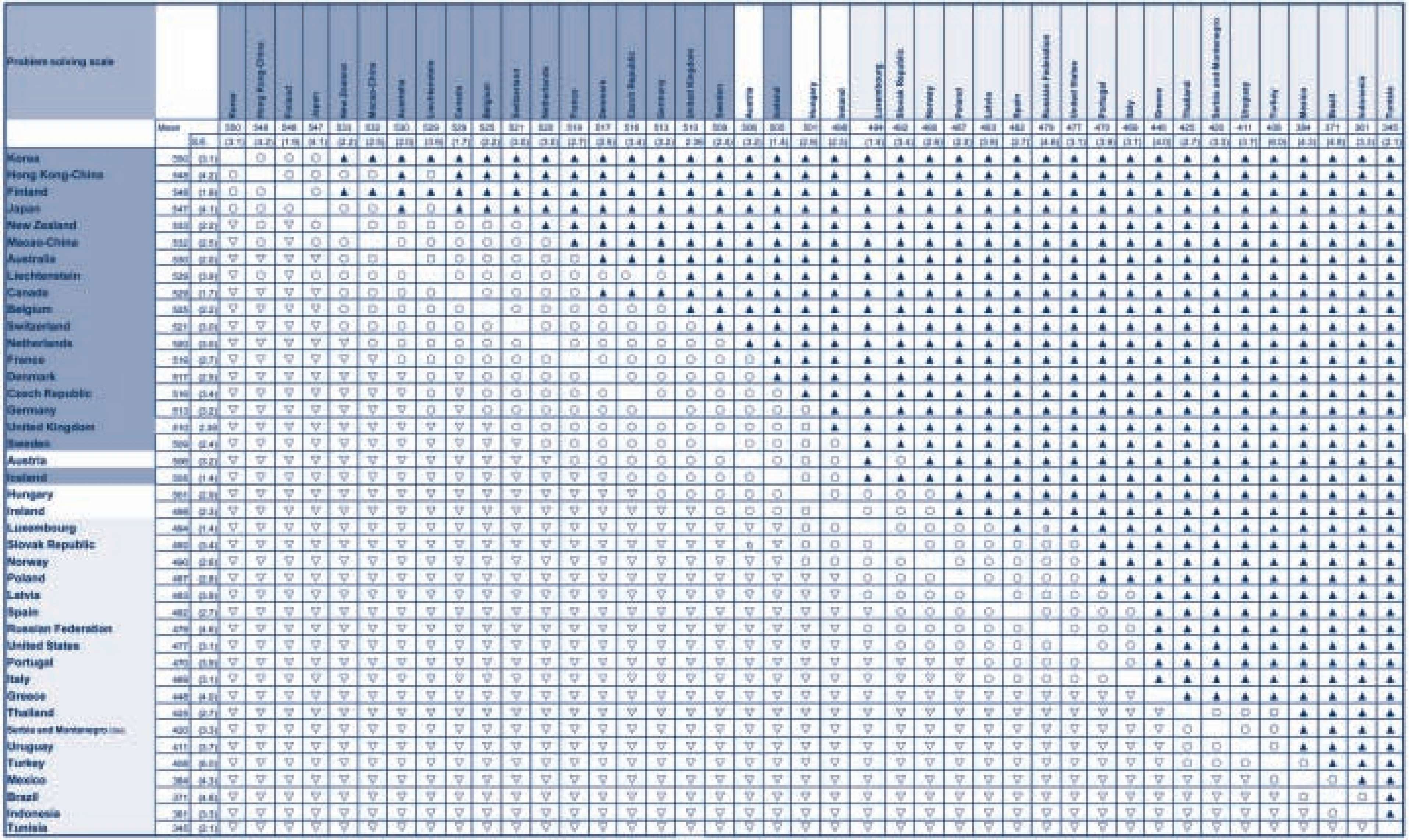
TABLE A3.14 MEAN SCORE AND VARIATION IN STUDENT PERFORMANCE ON THE PROBLEM SOLVING SCALE

Country	Mean		Standard deviation		Percentiles											
					5th		10th		25th		75th		90th		95th	
	Score	S.E.	S.D.	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.	Score	S.E.
OECD Countries																
Australia	530	(2.0)	91	(1.4)	371	(4.1)	409	(3.5)	469	(2.8)	594	(2.1)	644	(2.7)	672	(3.4)
Austria	506	(3.2)	90	(1.7)	357	(5.1)	388	(4.5)	443	(4.1)	569	(4.0)	621	(4.2)	651	(4.6)
Belgium	525	(2.2)	104	(1.5)	340	(5.0)	383	(4.5)	456	(3.3)	602	(2.6)	653	(2.0)	681	(2.0)
Canada	529	(1.7)	88	(0.9)	379	(2.4)	414	(2.8)	471	(2.5)	591	(1.9)	640	(2.1)	669	(2.4)
Czech Republic	516	(3.4)	93	(1.9)	357	(8.6)	394	(6.2)	454	(4.4)	582	(3.6)	634	(3.9)	664	(4.0)
Denmark	517	(2.5)	87	(1.5)	369	(5.0)	402	(4.3)	459	(3.1)	578	(2.8)	627	(3.4)	655	(3.7)
Finland	548	(1.9)	82	(1.2)	409	(4.7)	442	(2.8)	495	(2.5)	604	(2.3)	650	(2.3)	677	(3.6)
France	519	(2.7)	93	(2.1)	358	(6.1)	396	(4.8)	459	(3.9)	586	(3.1)	635	(3.7)	662	(4.5)
Germany	513	(3.2)	95	(1.8)	351	(5.9)	384	(5.4)	447	(4.8)	583	(4.3)	632	(2.7)	658	(3.2)
Greece	449	(4.0)	99	(1.7)	283	(5.6)	319	(5.3)	383	(4.5)	517	(4.6)	575	(5.7)	608	(5.6)
Hungary	501	(2.9)	94	(2.0)	343	(5.8)	378	(4.1)	436	(3.8)	567	(3.9)	622	(4.3)	653	(5.4)
Iceland	505	(1.4)	85	(1.1)	358	(5.5)	393	(3.3)	450	(2.2)	564	(2.0)	609	(2.3)	634	(3.6)
Ireland	499	(2.3)	80	(1.4)	364	(4.5)	395	(3.8)	445	(3.1)	555	(2.7)	601	(2.8)	625	(3.2)
Italy	470	(3.1)	102	(2.1)	289	(8.8)	334	(6.5)	406	(4.7)	540	(3.0)	595	(3.4)	627	(3.6)
Japan	547	(4.1)	105	(2.7)	362	(8.3)	406	(6.8)	481	(5.7)	621	(4.2)	675	(4.6)	705	(6.0)
Korea	550	(3.1)	86	(2.0)	404	(4.6)	438	(5.2)	494	(3.9)	610	(3.5)	658	(4.2)	686	(5.5)
Luxembourg	494	(1.4)	92	(1.0)	339	(3.7)	373	(2.3)	432	(2.4)	558	(2.2)	610	(2.6)	640	(3.4)
Mexico	384	(4.3)	96	(2.0)	227	(5.4)	262	(5.2)	317	(5.2)	451	(5.1)	509	(5.7)	542	(6.5)
Netherlands	520	(3.0)	89	(2.0)	372	(5.9)	402	(5.1)	456	(4.9)	587	(3.6)	636	(3.3)	662	(3.7)
New Zealand	533	(2.2)	96	(1.2)	370	(3.8)	406	(4.2)	468	(3.7)	601	(2.4)	653	(2.5)	682	(2.8)
Norway	490	(2.6)	99	(1.7)	322	(5.5)	361	(4.6)	424	(3.7)	559	(3.3)	615	(4.2)	646	(4.4)
Poland	487	(2.8)	90	(1.7)	338	(5.6)	372	(4.1)	428	(3.1)	548	(3.0)	600	(3.5)	632	(4.5)
Portugal	470	(3.9)	93	(2.1)	311	(7.9)	345	(6.8)	409	(5.7)	534	(3.6)	586	(3.5)	615	(3.5)
Slovak Republic	492	(3.4)	93	(2.4)	337	(7.1)	370	(5.9)	430	(4.7)	558	(3.6)	609	(3.8)	638	(4.2)
Spain	482	(2.7)	94	(1.3)	322	(4.8)	361	(4.1)	421	(3.5)	547	(3.2)	599	(3.9)	629	(3.3)
Sweden	509	(2.4)	88	(1.6)	360	(6.4)	395	(4.4)	451	(3.1)	571	(3.1)	619	(3.8)	647	(3.6)
Switzerland	521	(3.1)	94	(1.9)	358	(5.7)	397	(4.0)	461	(3.3)	587	(3.9)	637	(4.6)	666	(5.2)
Turkey	408	(6.0)	97	(4.4)	257	(7.8)	291	(6.6)	343	(5.2)	467	(7.7)	531	(11.9)	577	(18.6)
United Kingdom	510	(2.4)	93	(1.2)	353	(4.4)	387	(3.6)	446	(2.9)	577	(3.1)	629	(3.7)	659	(4.0)
United States	477	(3.1)	98	(1.3)	312	(5.6)	347	(4.6)	410	(4.1)	548	(3.3)	604	(4.0)	635	(4.2)
OECD total	490	(1.2)	106	(0.8)	308	(2.7)	349	(2.2)	418	(1.7)	566	(1.3)	624	(1.3)	656	(1.4)
OECD average	500	(0.6)	100	(0.5)	328	(1.7)	369	(1.3)	434	(1.1)	571	(0.8)	625	(0.8)	656	(0.8)
Partner Countries																
Brazil	371	(4.8)	100	(2.6)	211	(7.5)	244	(6.1)	302	(4.7)	438	(5.7)	501	(7.3)	538	(8.3)
Hong Kong-China	548	(4.2)	97	(2.9)	376	(10.5)	420	(7.9)	487	(6.1)	617	(3.2)	664	(2.9)	690	(3.7)
Indonesia	361	(3.3)	73	(1.7)	245	(4.2)	270	(3.8)	312	(3.6)	409	(4.1)	457	(5.5)	487	(5.9)
Latvia	483	(3.9)	92	(1.7)	326	(7.0)	362	(6.0)	420	(5.4)	547	(4.6)	599	(4.1)	628	(4.9)
Lichtenstein	530	(3.9)	93	(4.2)	369	(14.9)	404	(11.1)	468	(6.0)	599	(9.3)	644	(10.5)	672	(12.0)
Macao-China	532	(2.5)	81	(2.6)	395	(6.4)	425	(5.6)	478	(3.7)	590	(4.3)	633	(5.4)	659	(6.5)
Russian Federation	479	(4.6)	99	(2.1)	314	(7.7)	351	(7.0)	413	(5.7)	546	(5.1)	604	(5.0)	637	(5.6)
Serbia and Montenegro (Ser.)	420	(3.3)	86	(1.6)	279	(4.2)	311	(4.4)	363	(3.9)	478	(4.2)	530	(4.9)	560	(5.1)
Thailand	425	(2.7)	82	(1.6)	293	(3.9)	322	(3.4)	369	(2.6)	479	(4.0)	532	(4.0)	565	(6.0)
Tunisia	345	(2.1)	80	(1.4)	213	(4.3)	243	(3.1)	291	(2.5)	400	(2.8)	446	(4.1)	474	(5.0)
Uruguay	411	(3.7)	112	(1.9)	224	(5.7)	265	(5.1)	334	(4.7)	488	(5.5)	552	(5.0)	589	(5.7)

Source: PISA International PISA 2003 Report

Table A3.15

Multiple comparisons of mean performance on the problem solving scale



Problem solving scale			Korea	Hong Kong-China	Finland	Japan	New Zealand	Macao-China	Australia	Liechtenstein	Canada	Belgium	Switzerland	Netherlands	France	Denmark	Czech Republic	Germany	United Kingdom	Sweden	Austria	Iceland	Hungary	Ireland	Luxembourg	Slovak Republic	Norway	Poland	Latvia	Spain	Russian Federation	United States	Portugal	Italy	Greece	Thailand	Serbia and Montenegro	Uruguay	Turkey	Mexico	Brazil	Indonesia	Tunisia
	Mean		550	548	548	547	533	532	530	529	529	525	521	520	519	517	516	513	510	509	506	505	501	498	494	492	490	487	483	482	479	477	470	469	448	425	420	411	408	384	371	361	345
		S.E.	(3.1)	(4.2)	(1.9)	(4.1)	(2.2)	(2.5)	(2.0)	(3.9)	(1.7)	(2.2)	(3.0)	(3.0)	(2.7)	(2.5)	(3.4)	(3.2)	2.36	(2.4)	(3.2)	(1.4)	(2.9)	(2.3)	(1.4)	(3.4)	(2.6)	(2.8)	(3.9)	(2.7)	(4.6)	(3.1)	(3.9)	(3.1)	(4.0)	(2.7)	(3.3)	(3.7)	(6.0)	(4.3)	(4.8)	(3.3)	(2.1)
Korea	550	(3.1)		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	548	(4.2)	○		○	○	○	○	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Finland	548	(1.9)	○	○		○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	547	(4.1)	○	○	○		○	○	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	533	(2.2)	▽	○	▽	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	532	(2.5)	▽	○	▽	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	530	(2.0)	▽	▽	▽	▽	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	529	(3.9)	▽	○	▽	○	○	○	○		○	○	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	529	(1.7)	▽	▽	▽	▽	○	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	525	(2.2)	▽	▽	▽	▽	○	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	521	(3.0)	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	520	(3.0)	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	519	(2.7)	▽	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	517	(2.5)	▽	▽	▽	▽	▽	▽	▽	○	▽	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	516	(3.4)	▽	▽	▽	▽	▽	▽	▽	○	▽	○	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	513	(3.2)	▽	▽	▽	▽	▽	▽	▽	○	▽	○	○	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	510	2.36	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	509	(2.4)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	506	(3.2)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	505	(1.4)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	501	(2.9)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	498	(2.3)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	494	(1.4)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○		○	○	○	○	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	492	(3.4)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	▽	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	490	(2.6)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	487	(2.8)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	483	(3.9)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	482	(2.7)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	479	(4.6)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	477	(3.1)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○	○		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	470	(3.9)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○		○	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	469	(3.1)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○	○	○		▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	448	(4.0)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽		▲	▲	▲	▲	▲	▲	▲	▲
Thailand	425	(2.7)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽		○	○	○	▲	▲	▲	▲
Serbia and Montenegro (Ser.)	420	(3.3)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○		○	○	▲	▲	▲	▲
Uruguay	411	(3.7)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○		○	▲	▲	▲	▲
Turkey	408	(6.0)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○	○	○		○	▲	▲	▲
Mexico	384	(4.3)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○		○	▲	▲
Brazil	371	(4.8)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○		○	▲
Indonesia	361	(3.3)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	○		▲
Tunisia	345	(2.1)	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	

Instructions: Read across the row for a country to compare performance with the countries listed along the top of the chart. The symbols indicate whether the average performance of the country in the row is significantly lower than that of the comparison country, significantly higher than that of the comparison country, or if there is no statistically significant difference between the average achievement of the two countries.

With the Bonferroni adjustment:

▲	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

Source: PISA International PISA 2003 Report

TABLE A3.16 INTERNATIONAL SOCIOECONOMIC INDEX OF OCCUPATIONAL STATUS (HISEI) AND PERFORMANCE ON THE MATHEMATICS SCALE, BY NATIONAL QUARTERS OF THE INDEX RESULTS BASED ON STUDENTS' SELF-REPORTS

Country	International socio-economic index of occupational status (highest of the father's or mother's)										Performance on the mathematics scale, by national quarters of the international socio-economic index of occupational status								Change in the mathematics score per 16.4 units of the international socio-economic index of occupational status		Increased likelihood of students in the bottom quarter of the HISEI index distribution scoring in the bottom quarter of the national mathematics performance distribution		Explained variation in student performance (r-square * 100)	
	All students		Bottom quarter		Second quarter		Third quarter		Top quarter		Bottom quarter		Second quarter		Third quarter		Top quarter					
	Mean index	S.E.	Mean index	S.E.	Mean index	S.E.	Mean index	S.E.	Mean index	S.E.	Mean score	S.E.	Mean score	S.E.	Mean score	S.E.	Mean score	S.E.	Change	S.E.	Ratio	S.E.	Percentage	S.E.
OECD Countries																								
Australia	52.6	(0.3)	31.6	(0.1)	48.0	(0.07)	58.3	(0.1)	72.5	(0.1)	489	(2.8)	520	(2.7)	539	(2.7)	566	(2.9)	30.1	(1.35)	2.1	(0.08)	9.61	(0.73)
Austria	47.1	(0.5)	27.3	(0.2)	40.9	(0.11)	51.4	(0.1)	68.7	(0.3)	467	(4.4)	492	(3.7)	524	(3.3)	548	(4.4)	30.7	(1.92)	2.1	(0.12)	10.62	(1.22)
Belgium	50.6	(0.4)	29.0	(0.1)	44.5	(0.13)	56.4	(0.1)	72.5	(0.2)	482	(3.7)	527	(3.2)	556	(2.8)	590	(3.3)	39.8	(1.71)	2.4	(0.11)	15.29	(1.16)
Canada	52.6	(0.3)	31.7	(0.1)	47.7	(0.08)	58.1	(0.1)	72.9	(0.2)	506	(2.0)	531	(2.3)	544	(2.1)	569	(2.8)	24.4	(1.17)	1.8	(0.06)	7.47	(0.66)
Czech Republic	50.1	(0.3)	32.3	(0.2)	45.7	(0.12)	52.5	(0.1)	69.7	(0.2)	486	(4.0)	508	(3.9)	530	(3.9)	570	(4.3)	37.5	(1.97)	1.8	(0.11)	12.60	(1.19)
Denmark	49.3	(0.5)	29.4	(0.2)	44.2	(0.11)	53.2	(0.1)	70.3	(0.3)	481	(3.4)	504	(3.6)	526	(3.9)	554	(3.5)	28.9	(1.71)	1.7	(0.11)	9.14	(1.02)
Finland	50.2	(0.4)	28.7	(0.1)	43.4	(0.16)	56.4	(0.1)	72.4	(0.2)	515	(2.7)	536	(2.7)	552	(2.9)	577	(2.9)	21.7	(1.29)	1.7	(0.08)	7.17	(0.83)
France	48.7	(0.5)	27.6	(0.2)	42.3	(0.15)	53.6	(0.1)	71.2	(0.3)	469	(3.7)	507	(4.2)	525	(3.0)	557	(3.8)	31.6	(1.93)	2.2	(0.14)	13.00	(1.39)
Germany	49.3	(0.4)	29.5	(0.2)	42.6	(0.14)	53.7	(0.1)	71.5	(0.2)	463	(4.9)	505	(3.3)	528	(3.8)	565	(4.0)	38.0	(1.95)	2.3	(0.14)	15.48	(1.38)
Greece	46.9	(0.7)	26.9	(0.1)	38.8	(0.13)	51.8	(0.1)	70.3	(0.4)	409	(4.3)	436	(3.8)	450	(4.5)	493	(5.0)	29.4	(2.11)	1.9	(0.14)	10.53	(1.52)
Hungary	48.6	(0.3)	30.2	(0.2)	42.3	(0.08)	51.6	(0.1)	70.2	(0.2)	450	(3.9)	473	(3.9)	503	(3.4)	548	(3.9)	40.8	(2.17)	2.1	(0.14)	16.88	(1.51)
Iceland	53.7	(0.3)	31.5	(0.2)	48.0	(0.13)	61.7	(0.2)	73.7	(0.3)	497	(3.1)	512	(3.2)	519	(3.1)	538	(3.1)	14.4	(1.51)	1.5	(0.01)	2.68	(0.57)
Ireland	48.3	(0.5)	28.5	(0.2)	42.2	(0.11)	52.7	(0.1)	70.0	(0.3)	471	(3.9)	496	(3.2)	513	(3.1)	541	(3.5)	27.4	(1.89)	1.9	(0.14)	9.96	(1.30)
Italy	46.8	(0.4)	26.9	(0.2)	40.3	(0.11)	50.6	(0.1)	69.5	(0.4)	431	(4.2)	457	(3.9)	478	(3.6)	502	(4.1)	27.1	(1.88)	1.9	(0.10)	8.32	(1.03)
Japan	50.0	(0.3)	33.4	(0.2)	43.9	(0.04)	50.6	(0.1)	72.0	(0.3)	505	(5.1)	534	(4.7)	543	(4.4)	568	(6.4)	23.0	(3.12)	1.7	(0.11)	4.38	(1.00)
Korea	46.3	(0.4)	28.9	(0.2)	43.5	(0.09)	49.4	(0.1)	63.5	(0.4)	511	(4.4)	547	(3.7)	549	(3.6)	568	(6.1)	26.4	(3.28)	1.7	(0.11)	5.49	(1.27)
Luxembourg	48.2	(0.2)	27.3	(0.2)	42.1	(0.13)	52.8	(0.1)	70.5	(0.2)	448	(3.0)	481	(3.0)	509	(2.6)	542	(3.1)	33.7	(1.56)	2.3	(0.12)	13.83	(1.15)
Mexico	40.1	(0.7)	22.2	(0.1)	28.9	(0.04)	42.1	(0.3)	67.3	(0.2)	357	(4.8)	374	(3.9)	394	(3.7)	424	(4.9)	23.5	(1.89)	1.7	(0.16)	9.50	(1.38)
Netherlands	51.3	(0.4)	30.9	(0.3)	45.4	(0.15)	56.9	(0.2)	71.9	(0.2)	502	(4.3)	535	(3.8)	559	(3.5)	584	(3.9)	32.3	(2.03)	2.2	(0.13)	12.56	(1.32)
New Zealand	51.5	(0.4)	30.1	(0.2)	46.2	(0.12)	56.8	(0.2)	72.7	(0.3)	485	(3.8)	515	(3.4)	532	(3.3)	564	(3.4)	29.4	(1.65)	1.9	(0.13)	9.12	(1.01)
Norway	54.6	(0.4)	35.0	(0.2)	49.1	(0.12)	60.6	(0.2)	73.9	(0.2)	461	(3.5)	489	(3.6)	507	(3.5)	533	(3.5)	29.2	(1.62)	1.8	(0.11)	8.90	(0.93)
Poland	45.0	(0.3)	26.9	(0.2)	39.5	(0.11)	49.1	(0.1)	64.4	(0.3)	455	(3.9)	479	(3.2)	498	(3.3)	534	(3.1)	35.2	(1.82)	1.8	(0.12)	12.64	(1.19)
Portugal	43.1	(0.5)	26.4	(0.1)	33.9	(0.08)	46.6	(0.2)	65.5	(0.5)	431	(5.3)	447	(3.4)	481	(3.8)	512	(3.8)	34.3	(1.70)	2.0	(0.13)	14.85	(1.47)
Slovak Republic	48.8	(0.4)	29.3	(0.2)	41.4	(0.1)	53.1	(0.1)	71.5	(0.2)	457	(4.2)	484	(3.3)	523	(3.5)	544	(3.8)	33.2	(1.83)	2.1	(0.11)	13.11	(1.20)
Spain	44.3	(0.6)	26.2	(0.1)	35.5	(0.14)	49.3	(0.1)	66.1	(0.4)	454	(3.6)	475	(2.8)	496	(3.2)	519	(3.3)	25.4	(1.43)	1.8	(0.01)	8.18	(0.90)
Sweden	50.6	(0.4)	30.4	(0.2)	44.1	(0.14)	56.1	(0.2)	71.9	(0.2)	477	(3.7)	501	(3.1)	518	(3.9)	551	(4.2)	28.7	(1.79)	1.8	(0.11)	9.17	(1.03)
Switzerland	49.3	(0.4)	29.4	(0.1)	43.1	(0.14)	53.5	(0.1)	71.1	(0.3)	487	(4.1)	524	(4.1)	538	(4.9)	568	(3.9)	30.3	(1.71)	2.0	(0.01)	9.38	(0.96)
Turkey	41.6	(0.7)	23.7	(0.3)	33.6	(0.15)	47.2	(0.1)	61.8	(0.8)	395	(5.6)	411	(6.7)	420	(7.5)	479	(12.5)	38.1	(5.87)	1.4	(0.12)	11.76	(2.98)
United States	54.6	(0.4)	32.6	(0.2)	49.9	(0.15)	61.4	(0.1)	74.3	(0.2)	448	(3.2)	477	(3.8)	497	(4.0)	530	(3.7)	30.2	(1.37)	2.1	(0.09)	10.33	(0.88)
OECD total	49.2	(0.1)	28.1	(0.1)	42.5	(0.07)	54.1	(0.1)	71.9	(0.1)	440	(1.5)	490	(1.3)	506	(1.1)	536	(1.4)	34.0	(0.74)	2.3	(0.05)	11.6	(0.41)
OECD average	48.8	(0.1)	28.2	(0.1)	42.3	(0.08)	53.2	(0.1)	71.2	(0.1)	456	(0.9)	493	(0.8)	516	(0.7)	548	(0.8)	33.7	(0.40)	2.2	(0.02)	11.7	(0.22)
Partner Countries																								
Brazil	40.1	(0.6)	21.7	(0.3)	32.4	(0.09)	44.4	(0.2)	62.1	(0.6)	317	(4.9)	346	(5.1)	372	(5.3)	410	(8.4)	39.0	(3.63)	1.9	(0.13)	15.16	(2.55)
Hong Kong-China	41.1	(0.4)	25.9	(0.1)	34.9	(0.07)	45.1	(0.1)	58.7	(0.4)	532	(5.5)	547	(5.1)	562	(4.2)	575	(5.6)	22.6	(2.64)	1.5	(0.11)	3.57	(0.82)
Indonesia	33.6	(0.6)	16.0	(0.0)	24.1	(0.15)	34.6	(0.3)	59.9	(0.4)	336	(4.3)	356	(4.1)	361	(4.5)	397	(6.3)	22.0	(2.35)	1.6	(0.12)	8.39	(1.68)
Latvia	50.3	(0.5)	29.1	(0.2)	44.2	(0.16)	54.8	(0.1)	73.0	(0.3)	457	(3.8)	475	(4.3)	494	(4.6)	514	(5.0)	21.0	(1.69)	1.9	(0.14)	6.02	(0.98)
Liechtenstein	50.7	(0.8)	30.8	(0.6)	47.4	(0.52)	55.0	(0.1)	70.0	(0.7)	483	(10.3)	530	(11.2)	553	(9.6)	588	(11.0)	41.2	(5.92)	2.8	(0.54)	14.51	(3.40)
Macao-China	39.4	(0.4)	25.8	(0.3)	34.4	(0.12)	41.7	(0.2)	55.9	(0.5)	522	(5.2)	523	(6.3)	528	(7.5)	541	(7.3)	11.7	(3.97)	0.9	(0.12)	1.01	(0.68)
Russian Federation	49.9	(0.4)	30.8	(0.2)	40.9	(0.01)	54.2	(0.2)	73.6	(0.2)	443	(4.5)	459	(5.3)	473	(4.9)	501	(4.7)	21.4	(1.77)	1.6	(0.12)	5.63	(0.85)
Serbia	48.1	(0.5)	28.3	(0.2)	41.2	(0.12)	51.4	(0.1)	71.4	(0.4)	406	(3.7)	426	(3.8)	449	(4.3)	475	(5.0)	26.0	(1.86)	1.8	(0.12)	9.85	(1.28)
Thailand	36.0	(0.4)	22.1	(0.1)	26.7	(0.13)	35.6	(0.1)	59.6	(0.4)	396	(3.6)	399	(3.4)	427	(4.0)	457	(5.2)	26.6	(2.35)	1.4	(0.11)	9.47	(1.47)
Tunisia	37.5	(0.6)	18.0	(0.2)	29.2	(0.18)	39.6	(0.2)	63.1	(0.4)	331	(3.0)	342	(4.0)	361	(3.8)	406	(6.1)	28.3	(2.56)	1.6	(0.13)	13.87	(2.36)
Uruguay	46.2	(0.5)	25.2	(0.2)	37.8	(0.15)	50.8	(0.1)	70.8	(0.4)	388	(4.8)	415	(4.0)	430	(4.2)	478	(3.8)	31.4	(1.83)	1.8	(0.14)	11.91	(1.28)
United Kingdom1	49.7	(0.4)	28.5	(0.1)	43.0	(0.14)	55.5	(0.1)	71.6	(0.2)	469	(2.9)	500	(3.1)	519	(3.5)	555	(3.4)	31.8	(1.46)	2.1	(0.12)	12.52	(1.08)

1. Response rate too low to ensure comparability (see Annex A3).

Note: Values that are statistically significant are indicated in bold (see Annex A4).

Source: PISA International PISA 2003 Report

TABLE A3.17 INDEX OF ECONOMIC, SOCIAL AND CULTURAL STATUS (ESCS) AND PERFORMANCE ON THE MATHEMATICS SCALE, BY NATIONAL QUARTERS OF THE INDEX

RESULTS BASED ON STUDENTS' SELF-REPORTS

Country	Index of economic, social and cultural status										Performance on the mathematics scale, by national quarters of the index of economic, social and cultural status								Change in the mathematics score per 16.3 units (one standard deviation) of the index of economic, social and cultural status		Increased likelihood of students in the bottom quarter of the ESCS distribution scoring in the bottom quarter of the national mathematics performance distribution		Explained variation in student performance (r-square * 100)	
	All students		Bottom quarter		Second quarter		Third quarter		Top quarter		Bottom quarter		Second quarter		Third quarter		Top quarter							
	Mean index	S.E.	Mean index	S.E.	Mean index	S.E.	Mean index	S.E.	Mean index	S.E.	Mean score	S.E.	Mean score	S.E.	Mean score	S.E.	Mean score	S.E.	Change	S.E.	Ratio	S.E.	Percentage	S.E.
OECD Countries																								
Australia	0.23	0.02	-0.85	(0.01)	-0.03	(0.00)	0.53	(0.00)	1.26	(0.01)	479	(4.1)	513	(2.3)	537	(2.7)	572	(2.9)	42.4	(2.15)	2.3	(0.12)	13.7	(1.19)
Austria	0.06	0.03	-0.98	(0.02)	-0.26	(0.01)	0.29	(0.01)	1.19	(0.02)	462	(4.4)	492	(3.6)	520	(3.1)	556	(4.2)	43.3	(2.30)	2.2	(0.15)	16.0	(1.57)
Belgium	0.15	0.02	-1.07	(0.02)	-0.14	(0.01)	0.51	(0.01)	1.31	(0.01)	465	(3.8)	519	(3.0)	555	(2.6)	599	(2.7)	55.2	(1.72)	3.0	(0.13)	24.1	(1.32)
Canada	0.45	0.02	-0.62	(0.01)	0.16	(0.00)	0.76	(0.01)	1.51	(0.01)	500	(2.2)	527	(2.2)	544	(2.1)	574	(2.7)	34.2	(1.43)	2.1	(0.08)	10.5	(0.82)
Czech Republic	0.16	0.02	-0.80	(0.01)	-0.15	(0.00)	0.35	(0.01)	1.25	(0.01)	468	(3.4)	511	(3.5)	537	(3.7)	575	(4.3)	51.3	(2.15)	2.5	(0.14)	19.5	(1.44)
Denmark	0.20	0.03	-0.89	(0.02)	-0.07	(0.01)	0.49	(0.01)	1.28	(0.02)	464	(3.5)	505	(3.3)	526	(3.2)	565	(3.6)	44.4	(1.96)	2.4	(0.14)	17.6	(1.41)
Finland	0.25	0.02	-0.82	(0.01)	-0.04	(0.01)	0.56	(0.01)	1.30	(0.01)	509	(2.7)	538	(2.3)	553	(2.6)	579	(3.1)	33.1	(1.63)	2.0	(0.08)	10.8	(1.05)
France	-0.08	0.03	-1.27	(0.02)	-0.37	(0.01)	0.24	(0.01)	1.09	(0.02)	458	(4.5)	502	(3.4)	527	(3.0)	562	(3.6)	43.1	(2.20)	2.6	(0.15)	19.6	(1.78)
Germany	0.16	0.02	-1.08	(0.02)	-0.14	(0.01)	0.45	(0.01)	1.42	(0.01)	452	(4.1)	494	(3.5)	534	(3.7)	572	(3.7)	46.6	(1.71)	2.8	(0.17)	22.8	(1.47)
Greece	-0.15	0.05	-1.41	(0.01)	-0.53	(0.01)	0.15	(0.01)	1.19	(0.02)	402	(4.3)	430	(4.1)	452	(3.9)	497	(4.8)	37.0	(2.19)	2.0	(0.14)	15.9	(1.91)
Hungary	-0.07	0.02	-1.14	(0.02)	-0.42	(0.01)	0.15	(0.01)	1.14	(0.01)	427	(4.4)	474	(3.2)	505	(3.4)	554	(4.0)	54.8	(2.27)	2.9	(0.20)	27.0	(1.81)
Iceland	0.69	0.01	-0.39	(0.02)	0.44	(0.01)	1.02	(0.01)	1.69	(0.01)	485	(3.0)	513	(2.7)	518	(3.0)	547	(2.3)	28.2	(1.74)	1.7	(0.01)	6.5	(0.83)
Ireland	-0.08	0.03	-1.20	(0.02)	-0.37	(0.01)	0.19	(0.01)	1.06	(0.02)	458	(3.8)	494	(2.9)	517	(2.9)	544	(3.7)	38.6	(1.96)	2.4	(0.15)	16.2	(1.55)
Italy	-0.11	0.02	-1.41	(0.01)	-0.49	(0.01)	0.22	(0.01)	1.23	(0.02)	417	(4.4)	457	(4.0)	482	(3.5)	507	(4.2)	34.5	(1.96)	2.2	(0.01)	13.6	(1.34)
Japan	-0.08	0.02	-0.99	(0.01)	-0.34	(0.00)	0.15	(0.00)	0.88	(0.01)	487	(5.3)	524	(4.4)	549	(4.8)	576	(6.1)	46.3	(4.14)	2.0	(0.14)	11.6	(1.69)
Korea	-0.01	0.03	-1.21	(0.01)	-0.35	(0.01)	0.20	(0.01)	0.96	(0.02)	497	(4.2)	533	(3.7)	553	(3.7)	587	(6.2)	40.9	(3.08)	2.1	(0.12)	14.2	(1.95)
Luxembourg	0.18	0.01	-1.31	(0.02)	-0.07	(0.01)	0.63	(0.01)	1.49	(0.01)	445	(2.4)	479	(3.1)	506	(2.7)	546	(2.9)	34.8	(1.23)	2.2	(0.11)	17.1	(1.01)
Mexico	-1.13	0.05	-2.61	(0.02)	-1.63	(0.01)	-0.77	(0.01)	0.50	(0.02)	342	(4.4)	370	(3.6)	397	(3.7)	433	(4.6)	29.3	(1.87)	2.2	(0.19)	17.1	(2.06)
Netherlands	0.01	0.02	-0.99	(0.03)	-0.19	(0.01)	0.41	(0.01)	1.17	(0.01)	496	(5.1)	529	(4.0)	554	(3.4)	595	(3.7)	44.7	(2.36)	2.3	(0.17)	18.6	(1.71)
New Zealand	0.21	0.02	-0.98	(0.02)	-0.02	(0.01)	0.54	(0.01)	1.31	(0.01)	473	(3.6)	515	(3.1)	535	(3.2)	579	(2.7)	43.7	(1.62)	2.4	(0.14)	16.8	(1.20)
Norway	0.61	0.02	-0.39	(0.02)	0.33	(0.01)	0.88	(0.01)	1.61	(0.01)	451	(3.0)	486	(3.4)	508	(3.5)	540	(3.4)	44.0	(1.72)	2.1	(0.12)	14.1	(1.09)
Poland	-0.20	0.02	-1.16	(0.01)	-0.53	(0.00)	-0.03	(0.01)	0.92	(0.02)	444	(4.0)	476	(3.0)	502	(3.2)	539	(2.9)	44.8	(1.81)	2.2	(0.12)	16.7	(1.21)
Portugal	-0.63	0.04	-2.20	(0.01)	-1.15	(0.01)	-0.24	(0.01)	1.08	(0.03)	425	(4.3)	453	(3.7)	470	(4.0)	519	(3.5)	28.9	(1.21)	2.2	(0.16)	17.5	(1.50)
Slovak Republic	-0.08	0.03	-1.07	(0.03)	-0.42	(0.00)	0.14	(0.01)	1.02	(0.01)	438	(5.2)	486	(3.0)	517	(3.2)	554	(4.1)	53.2	(2.56)	2.9	(0.14)	22.3	(1.85)
Spain	-0.30	0.04	-1.60	(0.01)	-0.65	(0.01)	0.07	(0.01)	0.99	(0.02)	445	(3.4)	470	(3.2)	497	(2.7)	529	(2.8)	32.9	(1.67)	2.2	(0.11)	14.0	(1.33)
Sweden	0.25	0.02	-0.87	(0.02)	-0.02	(0.00)	0.57	(0.01)	1.34	(0.01)	465	(3.6)	495	(3.1)	522	(3.1)	557	(4.1)	42.1	(2.06)	2.1	(0.01)	15.3	(1.32)
Switzerland	-0.06	0.03	-1.14	(0.02)	-0.31	(0.01)	0.20	(0.00)	1.02	(0.01)	472	(3.8)	521	(3.4)	539	(3.4)	576	(4.5)	47.5	(2.14)	2.5	(0.13)	16.8	(1.27)
Turkey	-0.98	0.06	-2.25	(0.02)	-1.45	(0.01)	-0.73	(0.01)	0.52	(0.04)	380	(4.5)	397	(4.5)	422	(7.0)	496	(12.1)	45.1	(4.82)	1.8	(0.16)	22.3	(3.70)
United States	0.30	0.03	-0.89	(0.02)	0.01	(0.01)	0.64	(0.01)	1.42	(0.00)	431	(3.2)	468	(3.6)	498	(3.1)	539	(3.4)	45.3	(1.58)	2.6	(0.14)	19.0	(1.20)
OECD total	-0.06	0.01	-1.42	(0.01)	-0.36	(0.00)	0.29	(0.00)	1.20	(0.01)	423	(1.5)	481	(1.2)	510	(1.2)	546	(1.4)	47.1	(0.69)	2.9	(0.07)	22.2	(0.60)
OECD average	0.00	0.01	-1.30	(0.01)	-0.30	(0.00)	0.34	(0.00)	1.23	(0.00)	440	(1.0)	491	(0.7)	519	(0.6)	554	(0.8)	44.8	(0.44)	2.7	(0.03)	20.3	(0.35)
Partner Countries																								
Brazil	-0.95	0.05	-2.39	(0.02)	-1.36	(0.01)	-0.54	(0.01)	0.49	(0.03)	319	(5.1)	339	(5.4)	353	(5.5)	417	(7.9)	35.0	(3.14)	1.7	(0.12)	15.3	(2.39)
Hong Kong-China	-0.76	0.03	-1.75	(0.02)	-1.04	(0.00)	-0.55	(0.01)	0.31	(0.02)	518	(5.9)	544	(4.9)	560	(4.7)	582	(6.1)	31.2	(2.94)	1.8	(0.15)	6.5	(1.27)
Indonesia	-1.26	0.04	-2.46	(0.01)	-1.67	(0.01)	-0.99	(0.01)	0.01	(0.02)	341	(3.6)	350	(3.4)	357	(4.4)	394	(6.7)	21.3	(2.63)	1.3	(0.08)	7.0	(1.61)
Latvia	0.12	0.03	-0.84	(0.01)	-0.16	(0.01)	0.38	(0.01)	1.08	(0.01)	448	(4.3)	474	(4.3)	495	(4.3)	519	(5.4)	37.9	(2.27)	2.1	(0.14)	10.5	(1.28)
Liechtenstein	0.01	0.04	-1.03	(0.05)	-0.25	(0.01)	0.28	(0.02)	1.05	(0.03)	481	(9.1)	520	(11.6)	544	(9.5)	602	(8.9)	55.1	(5.86)	3.0	(0.47)	20.6	(3.71)
Macao-China	-0.90	0.02	-2.00	(0.03)	-1.14	(0.01)	-0.61	(0.01)	0.15	(0.03)	507	(5.6)	533	(7.0)	526	(6.1)	544	(5.6)	14.0	(3.25)	1.3	(0.15)	1.9	(0.89)
Russian Federation	-0.09	0.02	-0.99	(0.00)	-0.44	(0.01)	0.13	(0.01)	0.92	(0.01)	436	(4.6)	457	(4.4)	473	(4.9)	509	(4.6)	39.0	(2.28)	1.8	(0.11)	10.0	(1.08)
Serbia	-0.23	0.03	-1.28	(0.01)	-0.57	(0.01)	-0.01	(0.01)	0.95	(0.02)	398	(3.6)	426	(4.3)	445	(4.2)	480	(4.7)	36.1	(1.96)	2.1	(0.15)	14.1	(1.45)
Thailand	-1.18	0.03	-2.27	(0.02)	-1.69	(0.00)	-1.06	(0.01)	0.29	(0.02)	396	(3.6)	398	(3.7)	412	(3.7)	462	(5.8)	27.0	(2.57)	1.3	(0.11)	11.4	(1.94)
Tunisia	-1.34	0.04	-2.83	(0.01)	-1.85	(0.01)	-1.01	(0.00)	0.32	(0.03)	333	(3.1)	340	(2.9)	358	(3.0)	404	(6.3)	24.0	(2.38)	1.4	(0.11)	13.0	(2.43)
Uruguay	-0.35	0.03	-1.71	(0.01)	-0.73	(0.01)	0.03	(0.01)	1.02	(0.02)	379	(4.5)	402	(4.0)	429	(4.2)	481	(4.2)	37.6	(2.09)	1.9	(0.12)	15.9	(1.64)
United Kingdom1	0.12	0.02	-1.00	(0.01)	-0.21	(0.01)	0.40	(0.01)	1.30	(0.01)	461	(3.1)	492	(2.7)	517	(3.3)	566	(3.6)	45.3	(1.79)	2.3	(0.14)	19.7	(1.49)

1. Response rate to low to ensure comparability (see Annex A3)
Note: Values that are statistically significant are indicated in bold (see Annex A4).

Source: PISA International PISA 2003 Report

Appendix **FOUR**

DEFINITION OF VARIABLES

This appendix indicates the variables that were used in analyses of the Australian PISA Student Questionnaire data, and shows the components of each one. More variables were measured, but some were not considered further after analyses showed that they were not significantly related to performance in Australia. Other basic demographic variables were measured in a very straightforward way, and are therefore not included in the table below. Readers are referred to the international report for a complete listing of the variables, should this be of interest.

Each variable was measured in one of the following ways:

- from responses to a list of items to indicate presence or absence or number of the items present;
- on a 2-point scale with response categories: yes; no;
- on a 4-point scale of extent of agreement, for example, with response categories: strongly disagree; disagree; agree; strongly agree; and
- on a 4-point scale of extent of agreement, for example, with response categories: every lesson; most lessons; some lessons and never or hardly ever; and
- on a 4-point scale of extent of confidence, for example, with response categories: not at all confident; not very confident; confident; very confident.

Response categories were used in a consistent way within a set of items. Response categories for some variables were reversed for analysis when questions were asked in a negative way, so that relationships found with performance would be in a positive direction.

Variable	Categories	How defined
STUDENT CHARACTERISTICS AND FAMILY BACKGROUND		
Family Structure	• single parent family • nuclear family • mixed family • other	Student lives with: • one of mother, father, females or male guardian • mother and father • mother and male guardian; father and female guardian; or two guardians • other combinations (including other relatives)
Immigrant Status	• native (Australian-born) • first-generation • non-native (Foreign-born)	(Note that in Australia a list of 14 countries, plus 'other' category was provided. This data was coded internationally to construct the variable immigrant status)
Language Spoken at Home	• English spoken at home • Language other than English spoken at home	(Note that in Australia a list of 11 languages, including English and an Indigenous Australian language, plus 'other' category was provided. This data was coded internationally to construct the variable language spoken at home).
Parents' Educational Attainment	School: None; primary school only; some secondary school, but not more than Year 10; Year 10 or 11 plus training course; Year 12. University: TAFE training certificate; TAFE diploma; university degree.	Based on students' responses on parental education attainment. Highest level of father's and mother's education was coded in accordance with the International Standard Classification of Education (ISCED).
International Socioeconomic Index of Occupational Status (HISEI)	Values range from 0 to 90 (low values indicate low socioeconomic status and high values indicate high socioeconomic status).	Based on students' responses on parental occupation. Highest level of father's and mother's occupation was coded in accordance with the International Standard Classification of Occupations (ISCO).

Variable	**Categories**	**How defined**
Economic, social and cultural status Index (ESCS)	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' responses to the international socioeconomic index of occupational status (HISEI); the highest level of education of the father and mother converted into years of schooling; the number of books in the home as well as access to home educational and cultural resources, obtained by asking students whether they had at their home: a desk to study at, a room of their own, a quiet place to study, a computer they can use for school work, educational software, a link to the Internet, their own calculator, classical literature, books of poetry, works of art, books to help with their school work, and a dictionary. Note: The index used in PISA 2000 was similar to the one used for PISA 2003. However, some adjustments were made. First of all, only 11 questions on home educational resources were common to both surveys. Second, for the question on parental levels of education no distinction had been made in PISA 2000 between university-level and non-university tertiary education. Where comparisons between 2000 and 2003 are made, the index for PISA 2000 was recomputed on the basis of a common methodology used for both assessments. This being said, the correlation between the PISA 2000 and PISA 2003 indices is so high (R^2 0.96) that the difference has very little impact on any of the results.
Students' Occupational Intentions	Values range from 0 to 90 (low values indicate low socioeconomic status and high values indicate high socioeconomic status).	Coded in accordance with the International Standard Classification of Occupations (ISCO).
Home Educational Resources	Variables combined in an index with mean of 0 and standard deviation of 1.	Availability of various items in the home: • a dictionary • a quiet place to study • a desk for study • a calculator • books to help with school work
Cultural Possessions	Variables combined in an index with mean of 0 and standard deviation of 1.	Availability of various items in the home: • classical literature (e.g. Shakespeare) • books of poetry • works of art (e.g. paintings)
Computer Facilities	Variables combined in an index with mean of 0 and standard deviation of 1.	Availability of various items in the home: • computer to use for school work • educational software • link to the internet
Books in the Home	0-10 books; 11-25 books; 26-100 books; 101-200 books; 201-500 books; more than 500 books.	

Variable	Categories	How defined
SCHOOL CLIMATE		
Attitudes towards school	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • School has done little to prepare me for adult life when I leave school. • School has been a waste of time. • School helped give me confidence to make decisions. • School has taught me things which could be useful in a job.
Student-teacher relations	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • Students get along well with most teachers. • Most teachers are interested in students' well-being. • Most of my teachers really listen to what I have to say. • If I need extra help, I will receive if from my teachers. • Most of my teachers treat me fairly.
Sense of belonging	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • I feel like an outsider (or left out of things). • I make friends easily. • I feel like I belong. • I feel awkward and out of place. • Other students seem to like me. • I feel lonely.
CLASSROOM CLIMATE		
Teacher Support	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on the frequency of the following statements: • The teacher shows an interest in every student's learning. • The teacher gives extra help when students need it. • The teacher helps students with their learning. • The teacher continues teaching until the students understand. • The teacher gives students an opportunity to express opinions.
Disciplinary Climate	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on the frequency of the following statements: • Students don't listen to what the teacher says. • There is noise and disorder. • The teacher has to wait a long time for students to quieten down. • Students cannot work well. • Students don't start working for a long time after the lesson begins.

Variable	**Categories**	**How defined**
ATTITUDES AND BELIEFS TOWARDS MATHEMATICS		
Interest and enjoyment in mathematics	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • I enjoy reading about Mathematics. • I look forward to my Mathematics lessons. • I do Mathematics because I enjoy it. • I am interested in the things I learn in Mathematics.
Instrumental motivation	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • Making an effort in Mathematics is worth it because it will help me in the work that I want to do later on. • Learning Mathematics is important because it will help me with the subjects that I want to study further on in school. • Mathematics is an important subject for me because I need it for what I want to study later on. • I will learn many things in Mathematics that will help me get a job.
Mathematics self-efficacy	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' confidence with having to do the following calculations: • Using a train timetable, how long it would take to get from Zedville to Zedtown. • Calculating how much cheaper a TV would be after a 30 per cent discount. • Calculating how many square metres of tiles you need to cover a floor. • Understanding graphs presented in newspapers. • Solving an equation like $3x + 5 = 17$. • Finding the actual distance between two places on a map with a 1:10,000 scale. • Solving an equation like $2(x + 3) = (x + 3)(x - 3)$. • Calculating the petrol consumption rate of a car.
Mathematics anxiety	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • I often worry that it will be difficult for me in Mathematics lessons. • I get very tense when I have to do Mathematics homework. • I get very nervous doing Mathematics problems. • I feel helpless when doing a Mathematics problem. • I worry that I will get poor marks in Mathematics.
Mathematics self-concept	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • I am just not good at Mathematics. • I get good marks in Mathematics. • I learn Mathematics quickly. • I have always believed that Mathematics is one of my best subjects. • In my Mathematics class, I understand even the most difficult work.

Variable	Categories	How defined
LEARNING STRATEGIES		
Memorisation/Rehearsal	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • I go over some problems in Mathematics so often that I feel as if I could solve them in my sleep. • When I study for Mathematics, I try to learn the answers to problems off by heart. • In order to remember the method for solving a Mathematics problem, I go through examples again and again. • To learn Mathematics, I try to remember every step in a procedure.
Elaboration	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • When I am solving Mathematics problems, I often think of new ways to get the answer. • I think how the Mathematics I have learnt can be used in everyday life. • I try to understand new concepts in Mathematics by relating them to things I already know. • When I am solving a Mathematics problem, I often think about how the solution might be applied to other interesting questions. • When learning Mathematics, I try to relate the work to things I have learnt in other subjects.
Control	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • When I study for a Mathematics test, I try to work out what are the most important parts to learn. • When I study Mathematics, I make myself check to see if I remember the work I have already done. • When I study Mathematics, I try to figure out which concepts I still have not understood properly. • When I cannot understand something in Mathematics, I always search for more information to clarify the problem. • When I study Mathematics, I start by working out exactly what I need to learn.

Variable	Categories	How defined
LEARNING PREFERENCES		
Competitive Learning	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • I would like to be the best in my class in Mathematics. • I try very hard in Mathematics because I want to do better in the exams than the others. • I make a real effort in Mathematics because I want to be one of the best. • In Mathematics I always try to do better than the other students in my class. • I do my best work in Mathematics when I try to do better than others.
Cooperative Learning	Variables combined in an index with mean of 0 and standard deviation of 1.	Based on students' agreement with the following statements: • In mathematics I enjoy working with other students in groups. • When we work on a project in Mathematics, I think it is a good idea to combine the ideas of all students in a group. • I do my best work in Mathematics when I work with other students. • In Mathematics, I enjoy helping others to work well in a group. • In Mathematics I learn most when I work with other students in my class.

GLOSSARY

This glossary has two sections. The actual Glossary is preceded by a section to clarify acronyms and abbreviations.

Acronyms and abbreviations

ABS:	Australian Bureau of Statistics
ACER:	Australian Council for Educational Research
DEST:	Australian Government Department of Education, Science and Training
ESCS:	Economic, Social and Cultural Status Index
ETS:	Educational Testing Service (USA)
HISEI:	Higher of mother's and father's occupational status
HLM:	Hierarchical Linear Modeling
IALS:	International Adult Literacy Survey
IEA:	International Association for the Evaluation of Educational Achievement
IPC:	International Project Centre
ISCED:	International Standard Classification of Education
ISCO:	International Standard Classification of Occupations
IRT:	Item Response Theory
KPM:	Key Performance Measures
LSAY:	Longitudinal Surveys of Australian Youth
MCEETYA:	Ministerial Council for Education, Employment, Training and Youth Affairs
NAC:	National Advisory Committee
NCQMs:	National Centre Quality Monitors
NIER:	National Institute for Educational Research (Japan)
NPMs:	National Project Managers
OECD:	Organisation for Economic Co-operation and Development
PQMs:	PISA Quality Monitors
SMEGs:	Subject Matter Expert Groups
TAG:	PISA Technical Advisory Group
PISA:	Programme for International Student Assessment
PGB:	PISA Governing Board
SES:	socioeconomic status
SD:	standard deviation
SE:	standard error
CITO:	The Netherlands National Institute for Educational Measurement
TIMSS:	The Third International Mathematics and Science Study, now the Trends in International Mathematics and Science Study

GLOSSARY

assessment item: A question testing an aspect of students' knowledge and skills.

Five item types were used in PISA, as follows:

- ***multiple-choice items***: these items required students to circle a letter to indicate one choice among four or five alternatives. They were scored dichotomously and accounted for the largest proportion of items.
- ***complex multiple-choice items***: in these items, the student made a series of choices, usually binary. Students indicated their answer by circling a word or short phrase (for example *yes* or *no*) for each point. These items were scored dichotomously for each choice, yielding the possibility of full or partial credit for the whole item.
- ***closed constructed-response items***: these items required students to construct their own responses, there being a limited range of acceptable answers. Most of these items were scored dichotomously with a few items included in the marking process.
- ***short response items***: as in the closed constructed-response items, students were to provide a brief answer, but there was a wide range of possible answers. These items were hand-marked, thus allowing for dichotomous as well as partial credit.
- ***open constructed-response items***: in these items, students constructed a longer response, allowing for the possibility of a broad range of divergent, individual responses and differing viewpoints. Partial credit was often permitted for partially correct or less sophisticated answers, and all of these items were marked by hand.

bivariate analysis: The analysis of two variables to study the relationship between the variables. In PISA 2003, one of the variables was usually an achievement measure.

confidence interval: An interval containing the true value of a random variable, with a stated probability (confidence level).

confidence level: One minus the probability of rejecting the research (null) hypothesis, if this hypothesis is true.

correlation (linear): A statistical index (coefficient) representing the degree of linear co-variation of two variables. A common linear correlation is the Pearson product-moment correlation, whose values fall in the interval from +1 to –1. If the Pearson product-moment correlation is equal to +1, the relationship between the two variables may be represented by a straight line scatterplot with positive slope, and if the correlation is –1, by a straight line scatterplot with negative slope.

Cross-Curricular Competencies: PISA 2003 measured competencies across disciplinary boundaries, including student motivation, other aspects of students' attitudes towards learning and self-regulated learning.

Economic, social and cultural status Index (ESCS): A measure of the student's family and home background in addition to occupational status. Derived from the

HISEI; the highest level of education of the father and mother converted into years of schooling; the number of books in the home as well as access to home educational and cultural resources.

Hierarchical Linear Modeling (HLM): A statistical procedure which provides exploration of the variables that may be associated with student outcomes. Results estimate the contribution that each of the factors makes in explaining the variance within and between schools.

Higher of Mother's and Father's Socioeconomic Index (HISEI): A measure of socioeconomic status using the highest status occupation of either the mother or father.

International Adult Literacy Survey (IALS): An international study of adult literacy skills, developed by the OECD and Statistics Canada, that took place between 1994 and 1998.

International Association for the Evaluation of Educational Achievement (IEA): A non-governmental association of educational research centres, set up to study organisational and curriculum-related issues in schools.

International Standard Classification of Education (ISCED): A classification system for education level. This document was used for the coding of parents' educational backgrounds.

International Standard Classification of Occupations (ISCO): A classification system for occupations. This document was used for the coding of occupations.

Item Theory Response (IRT): Typically a class of models which hypothesise the probability of a student obtaining a correct response to an administered item, where the probability depends on parameters characterising the student and the item.

literacy: (as defined by PISA) encompasses the broad range of competencies relevant to coping with adult life in today's rapidly changing societies.

Longitudinal Surveys of Australian Youth (LSAY): A study examining the progress of young Australians as they leave school and commence tertiary education and/or enter the work force.

mathematical literacy: (as defined by PISA) The capacity to identify, understand and engage in mathematics, and to make well-founded judgements about the role that mathematics plays in an individual's current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned and reflective citizen.

MCEETYA Schools Geographic Location Classification: Based on the ARIA Plus system (Accessibility/Remoteness Index of Australia). A classification system developed to identify relative remoteness in terms of both distance and access to services and facilities.

multilevel analysis: A statistical procedure which provides exploration of the variables that may be associated with student outcomes. Results provide the contribution that each of the factors make in explaining the variance within and between schools.

multiple comparisons: A statistical technique involving comparing results of several groups simultaneously.

multivariate analyses: The analysis of many variables jointly together with another variable, usually an outcome measure. In PISA 2000, this is an achievement measure.

National Centre Quality Monitors: Associates nominated by the PISA International Consortium to ensure that procedures were being followed correctly in national centres and to offer assistance if necessary.

National Project Managers: Project directors responsible for the implementation of PISA 2003 at the national level.

OECD average: Mean based on a combined random sample of 500 students from each OECD country participating in PISA.

Organisation for Economic Co-operation and Development: An international organisation that promotes policies designed to improve economic growth and employment.

per cent correct: The overall percentage of students who correctly answered an item.

percentile rank: Another name for a cumulative percentage of a distribution of test scores. See percentile score.

percentile score: The *x*th percentile score of a group of students is a score on the relevant measurement scale. Where *x*% of the students have scores equal to or less than this score, *x*% is the percentile rank. For example, the top 10 per cent of a group are above the 90th percentile rank, and consequently have percentile scores greater than the 90th percentile score.

PISA Quality Monitors: Associates nominated by National Project Managers to observe testing sessions to ensure that the testing procedures were being implemented according to the specifications in the Test Administrator's Manual.

PISA Technical Advisory Group: A group consisting of technical experts, who oversaw the technical aspects of design for PISA 2000.

problem solving: The ability to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricular areas that might be applicable are not within a single domain of mathematics, science or reading.

proficiency level: Students' results are described in terms of skills at levels of proficiency. Each proficiency level is associated with tasks of increasing difficulty.

Programme for International Student Assessment (PISA): An international assessment producing indicators of skills in areas considered essential for full participation in twenty-first century society, on a regular basis. The study is sponsored by the OECD.

reading literacy: The ability to understand, use and reflect on written texts in order to achieve one's goals, to develop one's knowledge and potential, and to participate effectively in society.

scientific literacy: The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.

self-regulated learning: Strategies for managing and monitoring one's own learning.

social gradient: A line representing a relationship between two variables, which is not necessarily linear. The gradients are regression lines, which can be thought of as averages of the results from all the students in each of the samples.

social outcome: Any measurable trait. For the purposes of PISA, social outcome refers to the students' achievement in reading literacy, mathematical literacy or scientific literacy.

socioeconomic gradient: The relationship between a social outcome and socioeconomic status for the individuals of a specific community.

standard deviation: A measure of the spread of the scores in a distribution about the mean.

standard error: A measure of the chance fluctuations in the measurements of a variable. This gives an indication of how much the mean of a variable might fluctuate by chance with repeated measurements.

statistical significance: see below

Subject Matter Expert Groups (SMEGs): These groups consisted of subject matter and technical experts from participating countries.

table leaders: Reading, mathematics or science markers who were very experienced and managed other markers by fielding queries and addressing other issues.

The Third International Mathematics and Science Study (TIMSS): An international comparative study of mathematics and science achievement conducted under the auspices of the IEA. The study took place in 1994-95 with a repeat of the study occurring in 1998-99.

variance: A measure of variability which is the average value of the squares of the deviations from the mean of the scores in a distribution.

A note on testing the significance of differences

The statistics in this report represent *estimates* of national performance based on samples of students rather than the values that could be calculated if every student in every country had answered every question. Consequently, it is important to know the degree of uncertainty inherent in the estimates. In PISA 2003, each estimate has an associated degree of uncertainty, which is expressed through a standard error. The use of confidence intervals provides a means of making inferences about the population means and proportions in a manner that reflects the uncertainty associated with sample estimates. It can be inferred that the observed statistical result for a given population would lie within the confidence interval in 95 out of 100 replications of the measurement, using different samples drawn from the same population.

Testing whether populations differ

This report tests the statistical significance of differences between the national samples in percentages and in average performance scores in order to judge whether there are differences between the populations whom the samples represent. Each separate test follows the convention that, if in fact there is no real difference between two populations, there is no more than a five per cent probability that an observed difference between the two samples will erroneously suggest that the populations are different as the result of sampling and measurement error. In the figures and tables showing multiple comparisons of countries' mean scores, the significance tests are based on a procedure for multiple comparisons that limits to five per cent the probability that the mean of a given country will erroneously be declared to be different from that of any other country, in cases where there is in fact no difference.

Methodology of trends

The reading and science reporting scales used for PISA 2000 and PISA 2003 are directly comparable. The value of 500, for example, has the same meaning as it did in PISA 2000 – that is, the mean score in 2000 of the sampled students in the 27 OECD countries that participated in PISA 2000.

This is not the case, however, for Mathematics. Mathematics, as the major domain, was the subject of major development work for PISA 2003, and the PISA 2003 mathematics assessment was much more comprehensive than the PISA 2000 mathematics assessment – the PISA 2000 assessment covered just two (*space and shape*, and *change and relationships*) of the four areas that are covered in PISA 2003. Because of this broadening in the assessment it was deemed inappropriate to report the PISA 2003 mathematics scores on the same scale as the PISA 2000 mathematics scores.

The PISA 2000 and PISA 2003 assessments of mathematics, reading and science are linked assessments. That is, the sets of items used to assess each of mathematics, reading and science in PISA 2000 and the sets of items used to assess each of mathematics, reading and science in PISA 2003 include a subset of items common to both sets. For mathematics there were 20 items that were used in both assessments, in reading there were 28 items used in both assessments and for science 25 items were used in both assessments. These common items are referred to as link items.

To establish common reporting metrics for PISA 2000 and PISA 2003 the difficulty of these link items, on the two assessment occasions, was compared. Using procedures that are detailed in the PISA Technical Report the comparison of the item difficulties on the two occasions was used to determine a score transformation that allows the reporting of the data from the two assessments on a common scale. The change in the difficulty of each of the individual link items is used in determining the transformation.

Linking error

As each item provides slightly different information about the link transformation it follows that the chosen sample of link items will influence the estimated transformation. This means that if an alternative set of link items had been chosen the resulting transformation would be slightly different. The consequence is an uncertainty in the transformation due to the sampling of the link items, just as there is an uncertainty in values such as country means due to the use of a sample of students.

The uncertainty that results from the link-item sampling is referred to as linking error and this error must be taken into account when making certain comparisons between PISA 2000 and PISA 2003 results. Just as with the error that is introduced through the process of sampling students, the exact magnitude of this linking error cannot be determined. We can, however, estimate the likely range of magnitudes for this error and take this error into account when interpreting PISA results. As with sampling errors, the likely range of magnitude for the errors is represented as a standard error. The standard error of linking for reading is 3.744, for science is 3.02, for mathematics/space and shape is 6.01 and for mathematics/change and relationships is 4.84.

In PISA a common transformation has been estimated, from the link items, and this transformation is applied to all participating countries. It follows that any uncertainty that is introduced through the linking is common to all students and all countries. Thus, for example, suppose the *unknown* linking error (between PISA 2000 and PISA 2003) in reading resulted in an over-estimation of student scores by two points on the PISA 2000 scale. It follows that every student's score will be over-estimated by two score points. This over-estimation will have effects on certain, but not all, summary statistics computed from the PISA 2003 data. For example, consider the following:

- each country's mean will be over-estimated by an amount equal to the link error, in our example this is two score points;
- the mean performance of any subgroup will be over-estimated by an amount equal to the link error, in our example this is two score points;
- the standard deviation of student scores will not be effected because the over-estimation of each student by a common error does not change the standard deviation;
- the difference between the mean scores of two countries in PISA 2003 will not be influenced because the over-estimation of each student by a common error will have distorted each country's mean by the same amount;
- the difference between the mean scores of two groups (*e.g.*, males and females) in PISA 2003 will not be influenced, because the over-estimation of each student by a common error will have distorted each group's mean by the same amount;
- the difference between the performance of a group of students (*e.g.*, a country) between PISA 2000 and PISA 2003 will be influenced because each student's score in PISA 2003 will be influenced by the error; and finally,
- a change in the difference in performance between two groups from PISA 2000 to PISA 2003 will not be influenced. This is because neither of the components of this comparison, which are differences in scores in 2000 and 2003 respectively, is influenced by a common error that is added to all student scores in PISA 2003.

In general terms, the linking error need only be considered when comparisons are being made between PISA 2000 and PISA 2003 results, and then usually only when group means are being compared. However, where a result is discussed that does use linking error then the need to use linking error is explicitly mentioned.

The most obvious example of a situation where there is a need to use linking error is in the comparison of the mean performance for a country between PISA 2000 and PISA 2003. For example, let us consider a comparison between 2000 and 2003 of the performance of New Zealand in reading. The mean performance of New Zealand in 2000 was 529 with a standard error of 2.78, while in 2003 the mean was 522 with a standard error of 2.46. The standardised difference in the mean for New Zealand is 1.33, which is computed as follows:

$$1.33 = (529 - 522) / \sqrt{2.78^2 + 2.46^2 + 3.744},$$

and is not statistically significant.