Thinking it through

Australian students’ skills in creative problem solving

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Executive summary

In PISA 2003, an assessment of cross-disciplinary problem solving was undertaken as a paper-based assessment. In PISA 2012, problem solving was once again assessed with 44 of the 65 participating countries and economies completing an optional computer-based assessment of problem solving. The problem-solving assessment focuses on students’ general-reasoning skills, their ability to regulate problem-solving processes and their willingness to do so, by presenting students with problems that do not require specific curricular knowledge to solve.

PISA 2012 defines problem solving as:

an individual’s capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one’s potential as a constructive and reflective citizen. (OECD, 2014, p. 30)

There are three main aspects in the problem-solving framework that guided the development of assessment items: 1) problem-solving processes—the cognitive process involved in problem solving: exploring and understanding, representing and formulating, planning and executing, and monitoring and reflecting; 2) the nature of the problem situation: interactive or static; and 3) the problem context: technological or not, personal or social.

This report presents the results of the PISA 2012 problem-solving assessment that measured how well prepared today’s 15-year-old students are in solving complex, unfamiliar problems that they may encounter outside curricular contexts.
Australian students’ performance in problem solving

Reporting student performance

Similar to the reporting of results for other assessed domains in PISA, statistics such as mean scores and measures of distribution of performance and proficiency levels are used to examine student performance.

Mean scores

Mean scores provide a summary of student performance and allow comparisons of the relative standing between different countries and different subgroups.

Proficiency levels

There are six levels in the PISA problem-solving proficiency scale, ranging from Level 6 (the highest proficiency level) to Level 1 (the lowest proficiency level).

- Students achieving a proficiency of Level 5 or 6 are considered top performers.
- Level 2 has been defined as a baseline proficiency level and is the level of achievement on the PISA scale at which students begin to demonstrate the problem-solving competencies that will enable them to actively participate in real-life situations.
- Students failing to reach Level 2 (those students placed at Level 1 or below) are considered low performers.

Results across participating countries

- Overall, Australian students performed very well in the PISA 2012 problem-solving assessment, and are well equipped to apply their skills and knowledge to solve challenging problems.
- Australia achieved a mean score of 523 points on the problem-solving assessment, which was significantly above the OECD average of 500 score points.
- Australia was one of the high-performing countries, outperformed by only seven of the 44 participating countries and economies.
- Three countries and four economic regions, all from the Asian continent, performed significantly higher than Australia. These were Singapore, Korea, Japan, Macao–China, Hong Kong–China, Shanghai–China and Chinese Taipei.
- Australia’s performance was not significantly different from three countries: Canada, Finland and England.
- Australia’s performance was significantly higher than 33 countries, including the United States and Ireland.
- Sixteen per cent of Australian students were top performers compared to 30% of students in Singapore and 12% of students across the OECD.
- Sixteen per cent of Australian students were low performers compared to 8% of students in Singapore and 21% of students across the OECD.
Results across the Australian jurisdictions

» All jurisdictions achieved statistically similar scores, except for Tasmania which performed significantly lower than all other jurisdictions.

» Six jurisdictions (Western Australia, the Australian Capital Territory, New South Wales, Victoria, Queensland and South Australia) performed at a significantly higher level than the OECD average. The Northern Territory performed at a level not significantly different to the OECD average and Tasmania performed significantly lower than the OECD average.

» The proportion of top performers in problem solving ranged from 11% in Tasmania to 19% in the Australian Capital Territory.

» The proportion of low performers in problem solving ranged from 13% in Western Australia to 27% in Tasmania.

Results for females and males

» Across OECD countries, males performed significantly higher than females (by 6 score points on average). Approximately half the countries had significant sex differences in favour of males, while 11% of the countries had significant sex differences in favour of females.

» Australian females and males performed at a level that was not significantly different in problem solving.

» In Australia, 16% of females and 18% of males were top performers compared to 10% of females and 13% of males across OECD countries.

» In Australia, 15% of females and 16% of males were low performers compared to 22% of females and 22% of males across OECD countries.

» Significant sex differences were found in only one jurisdiction, Western Australia, with males achieving 18 score points on average higher than females.

» All jurisdictions, except Tasmania, achieved a higher proportion of top-performing males compared to the OECD average (13%), while all jurisdictions achieved a higher proportion of top-performing females compared to the OECD average (10%).

» The proportion of low-performing males in Tasmania and the Northern Territory was higher than the OECD average (22%), while the proportion of low-performing females was higher in Tasmania than across the OECD (22%).

Results for geographic location of schools

The geographic location of schools was classified using the broad categories metropolitan, provincial and remote, as defined in the MCEECDYA Schools Geographic Location Classification.

» Students attending metropolitan schools performed at a significantly higher level (528 score points on average) than students in schools from provincial areas (510 score points on average) and remote areas (475 score points on average). Students attending provincial schools significantly outperformed students attending remote schools.

» Eighteen per cent of students from metropolitan schools and 12% of students from provincial schools were top performers compared to 9% of students from remote schools.

» Fifteen per cent of students from metropolitan schools and 18% of students from provincial schools were low performers compared to 30% of students from remote schools.

1 Refer to the Reader’s Guide for details about the MCEECDYA Schools Geographic Location Classification.
Results for Indigenous students

Students’ Indigenous background was derived from information provided by the school.²

» Indigenous students achieved on average 454 score points in problem solving, which was significantly lower than for non-Indigenous students (526 score points on average) and for students across the OECD.

» Four per cent of Indigenous students were top performers compared to 18% of non-Indigenous students.

» Thirty-seven per cent of Indigenous students were low performers compared to 15% of non-Indigenous students.

» Indigenous females and males performed at a level that was not significantly different in problem solving.

» A small, yet similar, proportion of Indigenous females (3%) and males (4%) were top performers in problem solving, while 35% of Indigenous females and 39% of Indigenous males were low performers.

Results for socioeconomic background

Socioeconomic background in PISA is measured by an index of Economic, Social and Cultural Status (ESCS), which captures the wider aspects of a student’s family and home background.³

» Students in the highest socioeconomic quartile achieved an average score of 560 points, which was 73 score points higher than those students in the lowest socioeconomic quartile.

» Twenty-seven per cent of students in the highest socioeconomic quartile were top performers compared to 9% of students in the lowest socioeconomic quartile.

» Eight per cent of students in the highest socioeconomic quartile were low performers compared to 25% of students in the lowest socioeconomic quartile.

Results for immigrant background

Immigrant background was measured on students’ self-report of where they and their parents were born.⁴

» Australian-born students achieved an average score of 523 points, which was not significantly different from the performance of foreign-born students (517 points), but significantly lower than the mean score achieved for first-generation students (531 points).

» Sixteen per cent of Australian-born students, 19% of first-generation students and 16% of foreign-born students were top performers.

» Fifteen per cent of Australian-born students, 14% of first-generation students and 18% of foreign-born students were low performers.

Results for language background

Language background was based on students’ responses regarding the main language spoken at home—English or another language.⁵

² The Reader’s Guide provides more information about the definition of Indigenous background.
³ Refer to the Reader’s Guide for details about the Economic, Social and Cultural Status index.
⁴ Refer to the Reader’s Guide for details about the definitions of immigrant background.
⁵ Refer to the Reader’s Guide for details about the definitions of language background.
» Students who spoke English at home performed significantly higher (average score of 526 points) than those students who spoke a language other than English at home (average score of 509 points).

» Eighteen per cent of students who spoke English at home and 16% of students who spoke a language other than English at home were top performers.

» Fifteen per cent of students who spoke English at home and 21% of students who spoke a language other than English at home were low performers.

**Variations in problem-solving performance between and within schools**

The variation in performance within countries can be divided into a measure of performance difference between students from the same school and a measure of performance difference between groups of students from different schools.

» In Australia, the amount of variation in performance within schools was 75% and was higher than the OECD average (61%), while the amount of variation in performance between Australian schools was 28% and lower than the OECD average (38%).

» On average, the variation in problem-solving performance that was observed between schools ranged from 19% in South Australia to 39% in Tasmania, while the variation in problem-solving performance that was observed within schools ranged from 72% in Victoria to 94% in the Northern Territory.

**Variation in problem-solving performance associated with performance in mathematics, science and reading**

An analysis examined the variation in problem-solving performance that was associated with skills measured in the problem-solving assessment and the variation in problem-solving performance that was also measured in one of the three regular literacy domain assessments.

» Across the OECD, 68% of the problem-solving variance reflected skills that were also measured in one of the three literacy domains regularly assessed in PISA. The remaining 32% reflected skills that were uniquely measured in the problem-solving assessment.

» In Australia, 71% of the problem-solving variance reflected skills that were also measured in one of the three literacy domains regularly assessed in PISA. The remaining 29% of the score reflected skills that were uniquely measured in the problem-solving assessment.

**Relative performance in problem solving in Australia**

» Australian students performed better than expected in problem solving, based on their performance in mathematics. The difference between observed and expected performance is particularly large among students with strong performance in mathematics.

**Students’ strengths and weaknesses in problem solving**

Focusing on the different aspects of the problem-solving framework, analyses were undertaken to identify comparative strengths and weaknesses within countries and within different social groups.
Strengths and weakness in the problem-solving processes

» Generally, the higher performing countries in problem solving performed relatively stronger on the exploring and understanding process and on the representing and formulating process, and relatively weaker on the planning and executing process and on the monitoring and reflecting process. (These comparisons take into account the countries’ overall performance.)

» Australian students are comparatively stronger on the exploring and understanding process and on the representing and formulating process, and are relatively weaker on the planning and executing process. (These comparisons take into account the countries’ overall performance.)

» Students from Western Australia performed relatively stronger on the exploring and understanding process, while in New South Wales students performed relatively weaker on this process. Students from Queensland performed relatively stronger on the representing and formulating process.

» Females’ problem-solving process skills were relatively stronger on the monitoring and reflecting process, and relatively weaker on the representing and formulating process. The opposite was found for males, where their relative strength was found on the representing and formulating process, and their relative weakness was found on the monitoring and reflecting process.

» Indigenous students were relatively weaker on the exploring and understanding process, while non-Indigenous students were found to be relatively stronger on this process.

» Students in the lowest socioeconomic quartile performed relatively stronger on the planning and executing process, and relatively weaker on the exploring and understanding process. The reverse was found for students in the highest socioeconomic quartile.

Strengths and weakness in the nature of the problem situation

» No clear pattern emerged of relative strength or weakness in static or interactive items by countries’ overall performance in problem solving.

» In Tasmania, students performed relatively stronger on the static tasks, while in Queensland students performed relatively stronger on the interactive tasks.

» No relative strengths or weaknesses in static or interactive tasks were found across the different social groups.

Strengths and weakness on the response formats

» Generally, the higher performing countries and the lower performing countries in problem solving performed relatively stronger on the selected-response format items and weaker on the constructed-response format items.

» In Australia, students performed relatively stronger on the constructed-response format items and weaker on the selected-response format items.

» Tasmanian students performed relatively stronger on the constructed-response format items and Queensland students performed relatively stronger on the selected-response format items.

» In Australia, females performed stronger than males on the constructed-response format items.

» Australian-born students performed relatively stronger on the constructed-response format items, where the effect was consistent, but weaker for students who spoke English at home. Foreign-born students were relatively stronger on the selected-response format items. This was also the case, to a lesser extent, for students who spoke a language other than English at home.
Australian students’ perseverance and openness in problem solving

The PISA definition of problem solving acknowledges that solving a problem relies on motivational and affective factors. In PISA 2012, students completed a questionnaire that collected information about their engagement with and at school, their drive and the beliefs they hold about themselves as learners. This included measures of perseverance and openness in problem solving.

Perseverance in problem solving

In PISA, perseverance relates to a student’s willingness to work on problems.

» Australian students reported a significantly higher level of perseverance than the OECD average.
» Australian males reported significantly higher levels of perseverance than Australian females.
» All jurisdictions reported higher mean scores on the perseverance index compared to the OECD average, with students from the Australian Capital Territory reporting the highest levels and students from the Northern Territory reporting the lowest levels of perseverance.
» Non-Indigenous students, students from metropolitan schools and students in the highest socioeconomic quartile reported higher levels of perseverance than their counterparts.

Students’ openness to experience in problem solving

Openness relates to a student’s willingness to engage with problems and to be open to new challenges in order to be able to solve complex problems and situations.

» Australian students reported a lower level of openness to problem solving than the OECD average.
» Australian males reported significantly higher levels of openness to problem solving than Australian females.
» The Australian Capital Territory was the only jurisdiction to have an average score that was higher than the OECD average. The Northern Territory had the same index score as the OECD average, while all other jurisdictions had a lower index score than the OECD average. The Australian Capital Territory had the highest mean score on the openness to problem-solving index, while South Australia and Queensland had the lowest mean scores on this index.
» Similar to the findings on perseverance, non-Indigenous students, students from metropolitan schools and students in the highest socioeconomic quartile reported higher levels of openness to problem solving than their counterparts.