



PISA 2012 Results: Creative Problem Solving

STUDENTS' SKILLS IN TACKLING
REAL-LIFE PROBLEMS

VOLUME V



Programme for International Student Assessment



Source: Extracts from <http://www.oecd.org/pisa/keyfindings/PISA-2012-results-volume-V.pdf>



Foreword

Equipping citizens with the skills necessary to achieve their full potential, participate in an increasingly interconnected global economy, and ultimately convert better jobs into better lives is a central preoccupation of policy makers around the world. Results from the OECD's recent Survey of Adult Skills show that highly skilled adults are twice as likely to be employed and almost three times more likely to earn an above-median salary than poorly skilled adults. In other words, poor skills severely limit people's access to better-paying and more rewarding jobs. Highly skilled people are also more likely to volunteer, see themselves as actors rather than as objects of political processes, and are more likely to trust others. Fairness, integrity and inclusiveness in public policy thus all hinge on the skills of citizens.

The ongoing economic crisis has only increased the urgency of investing in the acquisition and development of citizens' skills – both through the education system and in the workplace. At a time when public budgets are tight and there is little room for further monetary and fiscal stimulus, investing in structural reforms to boost productivity, such as education and skills development, is key to future growth. Indeed, investment in these areas is essential to support the recovery, as well as to address long-standing issues such as youth unemployment and gender inequality.

In this context, more and more countries are looking beyond their own borders for evidence of the most successful and efficient policies and practices. Indeed, in a global economy, success is no longer measured against national standards alone, but against the best-performing and most rapidly improving education systems. Over the past decade, the OECD Programme for International Student Assessment, PISA, has become the world's premier yardstick for evaluating the quality, equity and efficiency of school systems. But the evidence base that PISA has produced goes well beyond statistical benchmarking. By identifying the characteristics of high-performing education systems PISA allows governments and educators to identify effective policies that they can then adapt to their local contexts.

The results from the PISA 2012 assessment, which was conducted at a time when many of the 65 participating countries and economies were grappling with the effects of the crisis, reveal wide differences in education outcomes, both within and across countries. Using the data collected in previous PISA rounds, we have been able to track the evolution of student performance over time and across subjects. Of the 64 countries and economies with comparable data, 40 improved their average performance in at least one subject. Top performers such as Shanghai in China or Singapore were able to further extend their lead, while countries like Brazil, Mexico, Tunisia and Turkey achieved major improvements from previously low levels of performance.

Some education systems have demonstrated that it is possible to secure strong and equitable learning outcomes at the same time as achieving rapid improvements. Of the 13 countries and economies that significantly improved their mathematics performance between 2003 and 2012, three also show improvements in equity in education during the same period, and another nine improved their performance while maintaining an already high level of equity – proving that countries do not have to sacrifice high performance to achieve equity in education opportunities.

Nonetheless, PISA 2012 results show wide differences between countries in mathematics performance. The equivalent of almost six years of schooling, 245 score points, separates the highest and lowest average performances



of the countries that took part in the PISA 2012 mathematics assessment. The difference in mathematics performances within countries is even greater, with over 300 points – the equivalent of more than seven years of schooling – often separating the highest- and the lowest-achieving students in a country. Clearly, all countries and economies have excellent students, but few have enabled all students to excel.

The report also reveals worrying gender differences in students' attitudes towards mathematics: even when girls perform as well as boys in mathematics, they report less perseverance, less motivation to learn mathematics, less belief in their own mathematics skills, and higher levels of anxiety about mathematics. While the average girl underperforms in mathematics compared with the average boy, the gender gap in favour of boys is even wider among the highest-achieving students. These findings have serious implications not only for higher education, where young women are already under-represented in the science, technology, engineering and mathematics fields of study, but also later on, when these young women enter the labour market. This confirms the findings of the OECD Gender Strategy, which identifies some of the factors that create – and widen – the gender gap in education, labour and entrepreneurship. Supporting girls' positive attitudes towards and investment in learning mathematics will go a long way towards narrowing this gap.

PISA 2012 also finds that the highest-performing school systems are those that allocate educational resources more equitably among advantaged and disadvantaged schools and that grant more autonomy over curricula and assessments to individual schools. A belief that all students can achieve at a high level and a willingness to engage all stakeholders in education – including students, through such channels as seeking student feedback on teaching practices – are hallmarks of successful school systems.

PISA is not only an accurate indicator of students' abilities to participate fully in society after compulsory school, but also a powerful tool that countries and economies can use to fine-tune their education policies. There is no single combination of policies and practices that will work for everyone, everywhere. Every country has room for improvement, even the top performers. That's why the OECD produces this triennial report on the state of education across the globe: to share evidence of the best policies and practices and to offer our timely and targeted support to help countries provide the best education possible for all of their students. With high levels of youth unemployment, rising inequality, a significant gender gap, and an urgent need to boost growth in many countries, we have no time to lose. The OECD stands ready to support policy makers in this challenging and crucial endeavour.

Angel Gurría
OECD Secretary-General



Executive Summary

In modern societies, all of life is problem solving. Changes in society, the environment, and in technology mean that the content of applicable knowledge evolves rapidly. Adapting, learning, daring to try out new things and always being ready to learn from mistakes are among the keys to resilience and success in an unpredictable world.

Few workers today, whether in manual or knowledge-based occupations, use repetitive actions to perform their job tasks. What's more, as the new Survey of Adult Skills (PIAAC) finds, one in ten workers is confronted every day with more complex problems that require at least 30 minutes to solve. Complex problem-solving skills are particularly in demand in fast-growing, highly skilled managerial, professional and technical occupations.

Are today's 15-year-olds acquiring the problem-solving skills needed in the 21st century? This volume reports the results from the PISA 2012 assessment of problem solving, which was administered, on computer, to about 85 000 students in 44 countries and economies.

Students in Singapore and Korea, followed by students in Japan, score higher in problem solving than students in all other participating countries and economies.

Four more East Asian partner economies score between 530 and 540 points on the PISA problem-solving scale: Macao-China (with a mean score of 540 points), Hong Kong-China (540 points), Shanghai-China (536 points) and Chinese Taipei (534 points); and Canada, Australia, Finland, England (United Kingdom), Estonia, France, the Netherlands, Italy, the Czech Republic, Germany, the United States and Belgium all score above the OECD average, but below the former group of countries.

Across OECD countries, 11.4% of 15-year-old students are top performers in problem solving.

Top performers attain proficiency Level 5 or 6 in problem solving, meaning that they can systematically explore a complex problem scenario, devise multi-step solutions that take into account all constraints, and adjust their plans in light of the feedback received. In Singapore, Korea and Japan, more than one in five students achieve this level, while more than one in six students perform at Level 5 or above in Hong Kong-China (19.3%), Chinese Taipei and Shanghai-China (18.3%), Canada (17.5%) and Australia (16.7%). By contrast, in Montenegro, Malaysia, Colombia, Uruguay, Bulgaria and Brazil, fewer than 2% of students perform at Level 5 or 6; and all of these countries perform well below the OECD average.

On average across OECD countries, about one in five students is able to solve only straightforward problems – if any – provided that they refer to familiar situations.

By contrast, fewer than one in ten students in Japan, Korea, Macao-China and Singapore are low-achievers in problem solving.

In Australia, Brazil, Italy, Japan, Korea, Macao-China, Serbia, England (United Kingdom) and the United States, students perform significantly better in problem solving, on average, than students in other countries who show similar performance in mathematics, reading and science.

In Australia, England (United Kingdom) and the United States, this is particularly true among strong and top performers in mathematics; in Italy, Japan and Korea, this is particularly true among moderate and low performers in mathematics.



Students in Hong Kong-China, Korea, Macao-China, Shanghai-China, Singapore and Chinese Taipei perform strongest on problems that require understanding, formulating or representing new knowledge, compared to other types of problems.

Many of the best-performing countries and economies in problem solving are those with better-than-expected performance on tasks related to acquiring knowledge, such as “exploring and understanding” and “representing and formulating” tasks, and relatively weaker performance on tasks involving only the use of knowledge, such as “planning and executing” tasks that do not require substantial understanding or representation of the problem situation. Meanwhile, students in Brazil, Ireland, Korea and the United States perform strongest on interactive problems (those that require the student to uncover some of the information needed to solve the problem) compared to static problems (those that have all information disclosed at the outset).

In Malaysia, Shanghai-China and Turkey, more than one in eight students attend a vocational study programme, and these students show significantly better performance in problem solving, on average, than students with comparable performance in mathematics, reading and science but who are in general study programmes.

This finding can be interpreted in two ways. On the one hand, the curriculum and teaching practices in these vocational programmes may equip students better for tackling complex, real-life problems in contexts that they do not usually encounter at school. On the other hand, better-than-expected performance in problem solving may be an indication that in these programmes, students’ ability to solve problems is not nurtured within the core academic subjects.

Boys outperform girls in problem solving in 23 countries/economies, girls outperform boys in five countries/economies, and in 16 countries/economies, there is no significant difference in average performance between boys and girls.

Gender differences are often larger among top performers. On average across OECD countries, there are three top-performing boys for every two top-performing girls in problem solving. In Croatia, Italy and the Slovak Republic, boys are as likely as girls to be low-achievers, but are more than twice as likely to be top performers as girls. In no country or economy are there more girls than boys among the top performers in problem solving. Girls appear to be stronger in performing the “planning and executing” tasks that measure how students use knowledge, compared to other tasks; and weaker in performing the more abstract “representing and formulating” tasks, which relate to how students acquire knowledge.

The impact of socio-economic status on problem-solving performance is weaker than it is on performance in mathematics, reading or science.

Students from disadvantaged backgrounds are more likely to score higher than expected in problem solving than in mathematics, perhaps because after-school opportunities to exercise their skills in problem solving arise in diverse social and cultural contexts. Still, the quality of schools matters: unequal access to high-quality schools means that, on average, disadvantaged students score below advantaged students in all subjects assessed, including problem solving.




■ Table V.A ■
SNAPSHOT OF PERFORMANCE IN PROBLEM SOLVING

Countries/economies with mean score/share of top performers/relative performance/solution rate above the OECD average Countries/economies with share of low achievers below the OECD average									
Countries/economies with mean score/share of top performers/relative performance/solution rate not statistically different from the OECD average									
Countries/economies with mean score/share of top performers/relative performance/solution rate below the OECD average Countries/economies with a share of low achievers above the OECD average									
	Performance in problem solving				Relative performance in problem solving, compared with students around the world with similar performance in mathematics, reading and science	Performance in problem solving, by process		Performance in problem solving, by nature of the problem situation	
	Mean score in PISA 2012	Share of low achievers (below Level 2)	Share of top performers (Level 5 or 6)	Gender difference (boys - girls)		Solution rate on tasks measuring acquisition of knowledge	Solution rate on tasks measuring utilisation of knowledge	Solution rate on items referring to a static problem situation	Solution rate on items referring to an interactive problem situation
	Mean score	%	%	Score dif.	Score dif.	Percent correct	Percent correct	Percent correct	Percent correct
OECD average	500	21.4	11.4	7	-7	45.5	46.4	47.1	43.8
Singapore	562	8.0	29.3	9	2	62.0	55.4	59.8	57.5
Korea	561	6.9	27.6	13	14	62.8	54.5	58.9	57.7
Japan	552	7.1	22.3	19	11	59.1	56.3	58.7	55.9
Macao-China	540	7.5	16.6	10	8	58.3	51.3	57.0	51.7
Hong Kong-China	540	10.4	19.3	13	-16	57.7	51.1	56.1	52.2
Shanghai-China	536	10.6	18.3	25	-51	56.9	49.8	56.7	50.3
Chinese Taipei	534	11.6	18.3	12	-9	56.9	50.1	56.3	50.1
Canada	526	14.7	17.5	5	0	52.6	52.1	52.7	50.5
Australia	523	15.5	16.7	2	7	52.3	51.5	52.8	49.9
Finland	523	14.3	15.0	-6	-8	50.2	51.0	52.1	47.7
England (United Kingdom)	517	16.4	14.3	6	8	49.6	49.1	49.5	47.9
Estonia	515	15.1	11.8	5	-15	46.8	49.5	49.7	45.6
France	511	16.5	12.0	5	5	49.6	49.4	50.3	47.6
Netherlands	511	18.5	13.6	5	-16	48.2	49.7	50.4	46.5
Italy	510	16.4	10.8	18	10	49.5	48.0	49.5	46.8
Czech Republic	509	18.4	11.9	8	1	45.0	46.9	46.2	44.4
Germany	509	19.2	12.8	7	-12	47.5	49.5	49.4	46.3
United States	508	18.2	11.6	3	10	46.5	47.1	46.6	45.9
Belgium	508	20.8	14.4	8	-10	47.0	47.5	48.3	45.4
Austria	506	18.4	10.9	12	-5	45.7	47.4	48.3	43.0
Norway	503	21.3	13.1	-3	1	47.7	48.1	49.4	44.5
Ireland	498	20.3	9.4	5	-18	44.6	45.5	44.4	44.6
Denmark	497	20.4	8.7	10	-11	44.2	48.1	47.9	42.3
Portugal	494	20.6	7.4	16	-3	41.6	45.7	44.0	42.0
Sweden	491	23.5	8.8	-4	-1	45.2	44.6	47.7	41.6
Russian Federation	489	22.1	7.3	8	-4	40.4	43.8	43.8	39.7
Slovak Republic	483	26.1	7.8	22	-5	40.5	43.2	44.2	38.8
Poland	481	25.7	6.9	0	-44	41.3	43.7	44.1	39.7
Spain	477	28.5	7.8	2	-20	40.0	42.3	42.3	39.8
Slovenia	476	28.5	6.6	-4	-34	37.8	42.3	42.9	36.7
Serbia	473	28.5	4.7	15	11	37.7	40.7	40.3	36.8
Croatia	466	32.3	4.7	15	-22	35.2	40.5	39.3	35.6
Hungary	459	35.0	5.6	3	-34	35.2	37.6	38.2	33.9
Turkey	454	35.8	2.2	15	-14	32.8	36.0	35.8	32.7
Israel	454	38.9	8.8	6	-28	38.7	37.0	39.7	35.6
Chile	448	38.3	2.1	13	1	30.9	35.2	34.9	31.8
Cyprus*	445	40.4	3.6	-9	-12	33.6	34.8	37.0	31.4
Brazil	428	47.3	1.8	22	7	28.0	32.0	29.8	29.1
Malaysia	422	50.5	0.9	8	-14	29.1	29.3	30.1	27.4
United Arab Emirates	411	54.8	2.5	-26	-43	28.4	29.0	29.9	27.1
Montenegro	407	56.8	0.8	-6	-24	25.6	30.0	30.3	25.1
Uruguay	403	57.9	1.2	11	-27	24.8	27.9	27.5	24.8
Bulgaria	402	56.7	1.6	-17	-54	23.7	26.7	28.4	22.3
Colombia	399	61.5	1.2	31	-7	21.8	27.7	26.3	23.7

Note: Countries/economies in which the performance difference between boys and girls is statistically significant are marked in bold. Countries and economies are ranked in descending order of the mean score in problem solving in PISA 2012.

* See notes in the Reader's Guide.

Source: OECD, PISA 2012 Database, Tables V.2.1, V.2.2, V.2.6, V.3.1, V.3.6 and V.4.7.

StatLink  <http://dx.doi.org/10.1787/888933003649>



What is PISA?

“What is important for citizens to know and be able to do?” That is the question that underlies the triennial survey of 15-year-old students around the world known as the Programme for International Student Assessment (PISA). PISA assesses the extent to which students near the end of compulsory education have acquired key knowledge and skills that are essential for full participation in modern societies. The assessment, which focuses on mathematics, reading, science and problem solving, does not just ascertain whether students can reproduce knowledge; it also examines how well students can extrapolate from what they have learned and apply that knowledge in unfamiliar settings, both in and outside of school. This approach reflects the fact that modern economies reward individuals not for what they know, but for what they can do with what they know.

PISA is an ongoing programme that offers insights for education policy and practice, and that helps monitor trends in students’ acquisition of knowledge and skills across countries and economies and in different demographic subgroups within each country. PISA results reveal what is possible in education by showing what students in the highest-performing and most rapidly improving school systems can do. The findings allow policy makers around the world to gauge the knowledge and skills of students in their own countries in comparison with those in other countries, set policy targets against measurable goals achieved by other school systems, and learn from policies and practices applied elsewhere. While PISA cannot identify cause-and-effect relationships between policies/practices and student outcomes, it can show educators, policy makers and the interested public how education systems are similar and different – and what that means for students.

A test the whole world can take

PISA is now used as an assessment tool in many regions around the world. It was implemented in 43 countries and economies in the first assessment (32 in 2000 and 11 in 2002), 41 in the second assessment (2003), 57 in the third assessment (2006) and 75 in the fourth assessment (65 in 2009 and 10 in 2010). So far, 65 countries and economies have participated in PISA 2012.

In addition to OECD member countries, the survey has been or is being conducted in:

East, South and Southeast Asia: Himachal Pradesh-India, Hong Kong-China, Indonesia, Macao-China, Malaysia, Shanghai-China, Singapore, Chinese Taipei, Tamil Nadu-India, Thailand and Viet Nam.

Central, Mediterranean and Eastern Europe, and Central Asia: Albania, Azerbaijan, Bulgaria, Croatia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, the former Yugoslav Republic of Macedonia, Malta, Moldova, Montenegro, Romania, the Russian Federation and Serbia.

The Middle East: Jordan, Qatar and the United Arab Emirates.

Central and South America: Argentina, Brazil, Colombia, Costa Rica, Netherlands-Antilles, Panama, Peru, Trinidad and Tobago, Uruguay and Miranda-Venezuela.

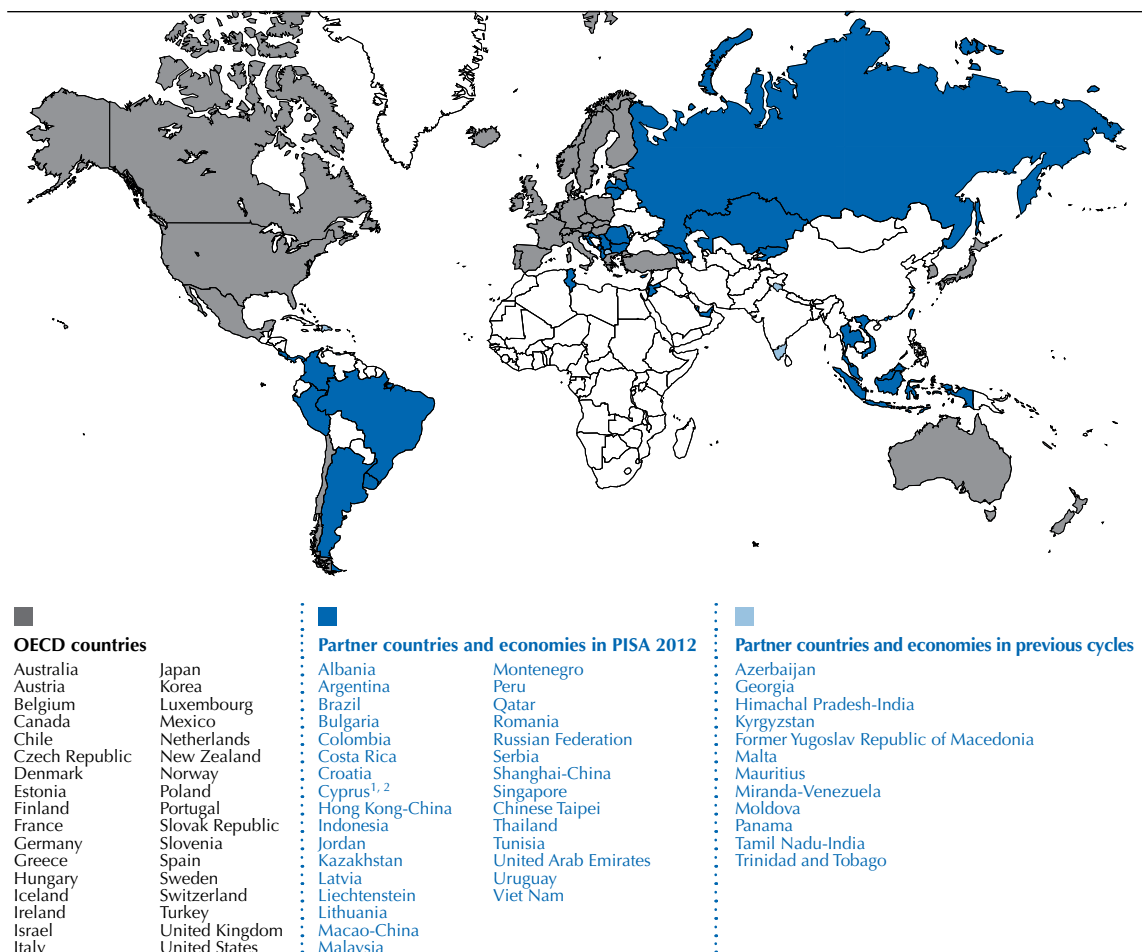
Africa: Mauritius and Tunisia.

Decisions about the scope and nature of the PISA assessments and the background information to be collected are made by participating countries based on recommendations from leading experts. Considerable efforts and resources are devoted to achieving cultural and linguistic breadth and balance in assessment materials. Since the design and translation of the test, as well as sampling and data collection, are subject to strict quality controls, PISA findings are considered to be highly valid and reliable.

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Map of PISA countries and economies



1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

PISA's unique features include its:

- policy orientation, which links data on student learning outcomes with data on students' backgrounds and attitudes towards learning and on key factors that shape their learning, in and outside of school, in order to highlight differences in performance and identify the characteristics of students, schools and school systems that perform well;
- innovative concept of "literacy", which refers to students' capacity to apply knowledge and skills in key subjects, and to analyse, reason and communicate effectively as they identify, interpret and solve problems in a variety of situations;
- relevance to lifelong learning, as PISA asks students to report on their motivation to learn, their beliefs about themselves, and their learning strategies;
- regularity, which enables countries and economies to monitor their progress in meeting key learning objectives; and
- breadth of coverage, which, in PISA 2012, encompasses the 34 OECD member countries and 31 partner countries and economies.



Key features of PISA 2012

The content

- The PISA 2012 survey focused on mathematics, with reading, science and problem solving as minor areas of assessment. For the first time, PISA 2012 also included an assessment of the financial literacy of young people, which was optional for countries and economies.
- PISA assesses not only whether students can reproduce knowledge, but also whether they can extrapolate from what they have learned and apply their knowledge in new situations. It emphasises the mastery of processes, the understanding of concepts, and the ability to function in various types of situations.

The students

- Around 510 000 students completed the assessment in 2012, representing about 28 million 15-year-olds in the schools of the 65 participating countries and economies.

The assessment

- Paper-based tests were used, with assessments lasting a total of two hours for each student. In a range of countries and economies, an additional 40 minutes were devoted to the computer-based assessment of mathematics, reading and problem solving.
- Test items were a mixture of multiple-choice items and questions requiring students to construct their own responses. The items were organised in groups based on a passage setting out a real-life situation. A total of about 390 minutes of test items were covered, with different students taking different combinations of test items.
- Students answered a background questionnaire, which took 30 minutes to complete, that sought information about themselves, their homes and their school and learning experiences. School principals were given a questionnaire, to complete in 30 minutes, that covered the school system and the learning environment. In some countries and economies, optional questionnaires were distributed to parents, who were asked to provide information on their perceptions of and involvement in their child's school, their support for learning in the home, and their child's career expectations, particularly in mathematics. Countries and economies could choose two other optional questionnaires for students: one asked students about their familiarity with and use of information and communication technologies, and the second sought information about their education to date, including any interruptions in their schooling and whether and how they are preparing for a future career.

WHO ARE THE PISA STUDENTS?

Differences between countries in the nature and extent of pre-primary education and care, in the age of entry into formal schooling, in the structure of the school system, and in the prevalence of grade repetition mean that school grade levels are often not good indicators of where students are in their cognitive development. To better compare student performance internationally, PISA targets a specific age of students. PISA students are aged between 15 years 3 months and 16 years 2 months at the time of the assessment, and have completed at least 6 years of formal schooling. They can be enrolled in any type of institution, participate in full-time or part-time education, in academic or vocational programmes, and attend public or private schools or foreign schools within the country or economy. (For an operational definition of this target population, see Annex A2.) Using this age across countries and over time allows PISA to compare consistently the knowledge and skills of individuals born in the same year who are still in school at age 15, despite the diversity of their education histories in and outside of school.

The population of participating students is defined by strict technical standards, as are the students who are excluded from participating (see Annex A2). The overall exclusion rate within a country was required to be below 5% to ensure that, under reasonable assumptions, any distortions in national mean scores would remain within plus or minus 5 score points, i.e. typically within the order of magnitude of 2 standard errors of sampling. Exclusion could take place either through the schools that participated or the students who participated within schools (see Annex A2, Tables A2.1 and A2.2).

There are several reasons why a school or a student could be excluded from PISA. Schools might be excluded because they are situated in remote regions and are inaccessible, because they are very small, or because of organisational or operational factors that precluded participation. Students might be excluded because of intellectual disability or limited proficiency in the language of the assessment.



In 28 out of the 65 countries and economies participating in PISA 2012, the percentage of school-level exclusions amounted to less than 1%; it was less than 4% in all countries and economies. When the exclusion of students who met the internationally established exclusion criteria is also taken into account, the exclusion rates increase slightly. However, the overall exclusion rate remains below 2% in 30 participating countries and economies, below 5% in 57 participating countries and economies, and below 7% in all countries except Luxembourg (8.4%). In 11 out of the 34 OECD countries, the percentage of school-level exclusions amounted to less than 1% and was less than 3% in 31 OECD countries. When student exclusions within schools were also taken into account, there were 11 OECD countries below 2% and 26 OECD countries below 5%.

(For more detailed information about the restrictions on the level of exclusions in PISA 2012, see Annex A2.)

WHAT KINDS OF RESULTS DOES THE TEST PROVIDE?

The PISA assessment provides three main types of outcomes:

- basic indicators that provide a baseline profile of students' knowledge and skills;
- indicators that show how skills relate to important demographic, social, economic and educational variables; and
- indicators on trends that show changes in student performance and in the relationships between student-level and school-level variables and outcomes.

Although indicators can highlight important issues, they do not provide direct answers to policy questions. To respond to this, PISA also developed a policy-oriented analysis plan that uses the indicators as a basis for policy discussion.

WHERE CAN YOU FIND THE RESULTS?

This is the fifth of six volumes that presents the results from PISA 2012. It begins by providing the rationale for assessing problem-solving competence in PISA, and introduces the innovative features of the 2012 assessment. Chapter 2 introduces the problem-solving performance scale and proficiency levels, examines student performance in problem solving, and discusses the relationship between problem-solving performance and performance in mathematics, reading and science. Chapter 3 provides a nuanced look at student performance in problem solving by focusing on students' strengths and weaknesses in performing certain types of tasks. Chapter 4 looks at differences in problem-solving performance related to education tracks and to students' gender, socio-economic status and immigrant background. It also examines students' behaviours and attitudes related to problem solving, and students' familiarity with information and communication technology. The volume concludes with a chapter that discusses the implications of the PISA problem-solving assessment for education policy and practice.

The other five volumes cover the following issues:

Volume I, *What Students Know and Can Do: Student Performance in Mathematics, Reading and Science*, summarises the performance of students in PISA 2012. It describes how performance is defined, measured and reported, and then provides results from the assessment, showing what students are able to do in mathematics. After a summary of mathematics performance, it examines the ways in which this performance varies on subscales representing different aspects of mathematics literacy. Given that any comparison of the outcomes of education systems needs to take into consideration countries' social and economic circumstances, and the resources they devote to education, the volume also presents the results within countries' economic and social contexts. In addition, the volume examines the relationship between the frequency and intensity of students' exposure to subject content in school, what is known as "opportunity to learn", and student performance. The volume concludes with a description of student results in reading and science. Trends in student performance in mathematics between 2003 and 2012, in reading between 2000 and 2012, and in science between 2006 and 2012 are examined when comparable data are available. Throughout the volume, case studies examine in greater detail the policy reforms adopted by countries that have improved in PISA.

Volume II, *Excellence through Equity: Giving Every Student the Chance to Succeed*, defines and measures equity in education and analyses how equity in education has evolved across countries and economies between PISA 2003 and PISA 2012. The volume examines the relationship between student performance and socio-economic status, and describes how other individual student characteristics, such as immigrant background and family structure, and school characteristics, such as school location, are associated with socio-economic status and performance. The volume also reveals differences in how equitably countries allocate resources and opportunities to learn to schools with different



socio-economic profiles. Case studies, examining the policy reforms adopted by countries that have improved in PISA, are highlighted throughout the volume.

Volume III, *Ready to Learn: Students' Engagement, Drive and Self-Beliefs*, explores students' engagement with and at school, their drive and motivation to succeed, and the beliefs they hold about themselves as mathematics learners. The volume identifies the students who are at particular risk of having low levels of engagement in, and holding negative dispositions towards, school in general and mathematics in particular, and how engagement, drive, motivation and self-beliefs are related to mathematics performance. The volume identifies the roles schools can play in shaping the well-being of students and the role parents can play in promoting their children's engagement with and dispositions towards learning. Changes in students' engagement, drive, motivation and self-beliefs between 2003 and 2012, and how those dispositions have changed during the period among particular subgroups of students, notably socio-economically advantaged and disadvantaged students, boys and girls, and students at different levels of mathematics proficiency, are examined when comparable data are available. Throughout the volume, case studies examine in greater detail the policy reforms adopted by countries that have improved in PISA.

Volume IV, *What Makes Schools Successful? Resources, Policies and Practices*, examines how student performance is associated with various characteristics of individual schools and of concerned school systems. It discusses how 15-year-old students are selected and grouped into different schools, programmes, and education levels, and how human, financial, educational and time resources are allocated to different schools. The volume also examines how school systems balance autonomy with collaboration, and how the learning environment in school shapes student performance. Trends in these variables between 2003 and 2012 are examined when comparable data are available, and case studies, examining the policy reforms adopted by countries that have improved in PISA, are presented throughout the volume.

Volume VI, *Students and Money: Financial Literacy Skills for the 21st Century*, examines 15-year-old students' performance in financial literacy in the 18 countries and economies that participated in this optional assessment. It also discusses the relationship of financial literacy to students' and their families' background and to students' mathematics and reading skills. The volume also explores students' access to money and their experience with financial matters. In addition, it provides an overview of the current status of financial education in schools and highlights relevant case studies.

The frameworks for assessing mathematics, reading and science in 2012 are described in *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy* (OECD, 2013). They are also summarised in this volume.

Technical annexes at the end of this report describe how questionnaire indices were constructed and discuss sampling issues, quality-assurance procedures, the reliability of coding, and the process followed for developing the assessment instruments. Many of the issues covered in the technical annexes are elaborated in greater detail in the *PISA 2012 Technical Report* (OECD, forthcoming).

All data tables referred to in the analysis are included at the end of the respective volume in Annex B1, and a set of additional data tables is available on line (www.pisa.oecd.org). A Reader's Guide is also provided in each volume to aid in interpreting the tables and figures that accompany the report. Data from regions within the participating countries are included in Annex B2.

References

OECD (forthcoming), *PISA 2012 Technical Report*, PISA, OECD Publishing.

OECD (2013), *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*, PISA, OECD Publishing.

<http://dx.doi.org/10.1787/9789264190511-en>



PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT (PISA) RESULTS FROM PISA 2012 PROBLEM SOLVING

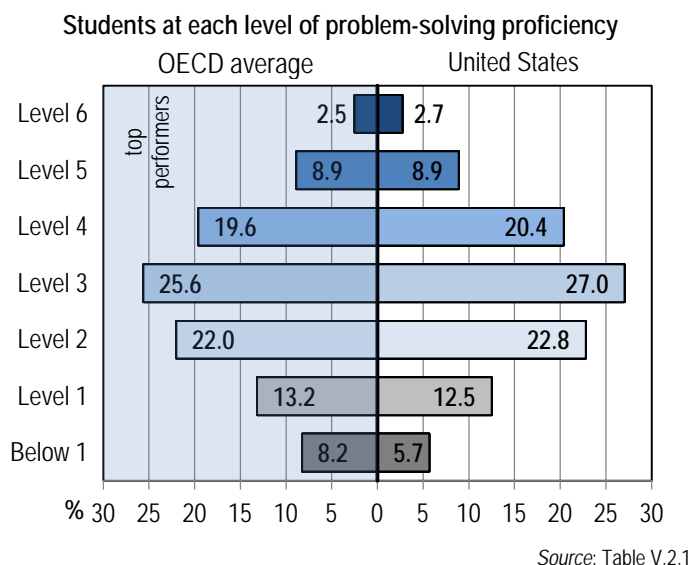
United States

In recent decades, there has been a marked increase in the share of jobs that require creative problem-solving skills. Fifteen-year-olds who lack these skills today thus face a high risk of economic disadvantage as adults. They will compete for jobs that are becoming rare; and if they are unable to adapt to new circumstances and learn in unfamiliar contexts, they may find it particularly difficult to move to better jobs as economic and technological conditions evolve. PISA's first assessment of creative problem-solving skills shows how well-prepared students are to confront – and solve – the kinds of problems that are encountered almost daily in 21st century life.

- With a mean score of 508 points in problem solving, students in the United States perform slightly above the average (500 points) of the 28 OECD countries that took part in the assessment.
- In the United States, students perform significantly better in problem solving, on average, than students in other countries who show similar performance in mathematics, reading and science. This is particularly true among strong performers in mathematics, which suggests that these students, in particular, have access to learning opportunities that prepare them well for handling complex, real-life problems in contexts that they do not usually encounter at school.
- Fifteen-year-olds in the United States perform strongest on interactive tasks, compared to students of similar overall performance in other countries. Interactive tasks require students to uncover some of the information needed to solve the problem themselves. This suggests that students in the United States are open to novelty, tolerate doubt and uncertainty, and dare to use intuition to initiate a solution.
- Still, more than one in six students (18.2%) in the United States do not reach the baseline level of proficiency in problem solving – meaning that, at best, they are only able to solve very simple problems that do not require thinking ahead and that are cast in familiar settings, such as selecting the least-expensive models of furniture from a catalogue showing different brands and prices (Level 1 tasks). While this proportion is smaller than the OECD average (21.4%), in Japan and Korea only 7% of students perform below Level 2.
- The largest achievement gap in problem solving between the United States and the highest-performing Asian countries is found on tasks where students must select, organise and integrate the information and feedback received in order to represent and formulate their understanding of the problem.

PISA 2012 defines problem-solving competence 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”. The problem-solving assessment focuses on students' general reasoning skills, their ability to regulate problem-solving processes, and their willingness to do so, by confronting students with problems that do not require expert knowledge to solve – such as buying the best ticket that satisfies all constraints at an unfamiliar vending machine. In contrast, when the regular assessments of mathematics, reading and science in PISA include problem-solving tasks, solving these problems requires curricular knowledge in addition to problem-solving skills.

Performance in problem solving in the United States



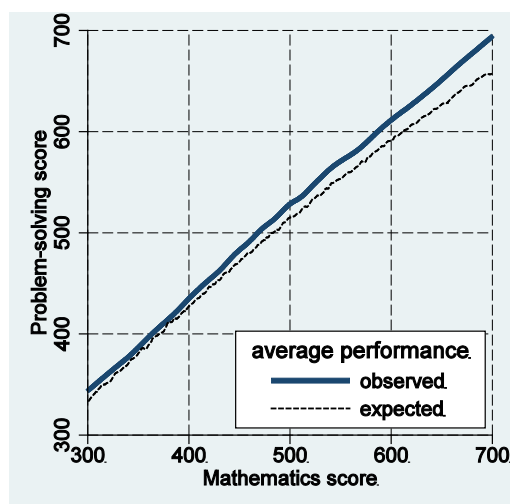
Mean performance in problem solving	Range of	
	Mean score	range of ranks
Singapore	562	1 – 2
Korea	561	1 – 2
Japan	552	3
...		
Shanghai-China	536	4 – 7
Canada	526	8 – 10
Australia	523	8 – 11
Finland	523	8 – 11
England (United Kingdom)	517	9 – 16
France	511	11 – 19
Netherlands	511	11 – 21
Italy	510	12 – 21
Germany	509	12 – 21
United States	508	12 – 21
OECD average	500	

This table includes only a selection of participating countries and economies. For the complete ranking, see Figure V.2.4.

- Students in the United States perform above the average of the 28 OECD countries that assessed students' problem-solving skills in 2012. With an average score of 508 points, the rank of the United States among all 44 participating countries and economies is estimated to lie between ranks 12 and 21.
- Average performance in the United States is not significantly different from that in Austria, Belgium, the Czech Republic, Estonia, France, Germany, Ireland, Italy, the Netherlands, Norway and England (United Kingdom).

Relative performance in problem solving in the United States

Relative performance at different levels of the mathematics scale



Relative performance is defined as the difference between the observed score in problem solving and the expected score, based on performance in core subjects. Stronger-than-expected performance in problem solving may indicate that the learning opportunities available to students prepare them well for handling complex, real-life problems in contexts that they do not usually encounter at school. However, if it coincides with low performance overall, it may also indicate that students' potential is not realised in the core subjects.

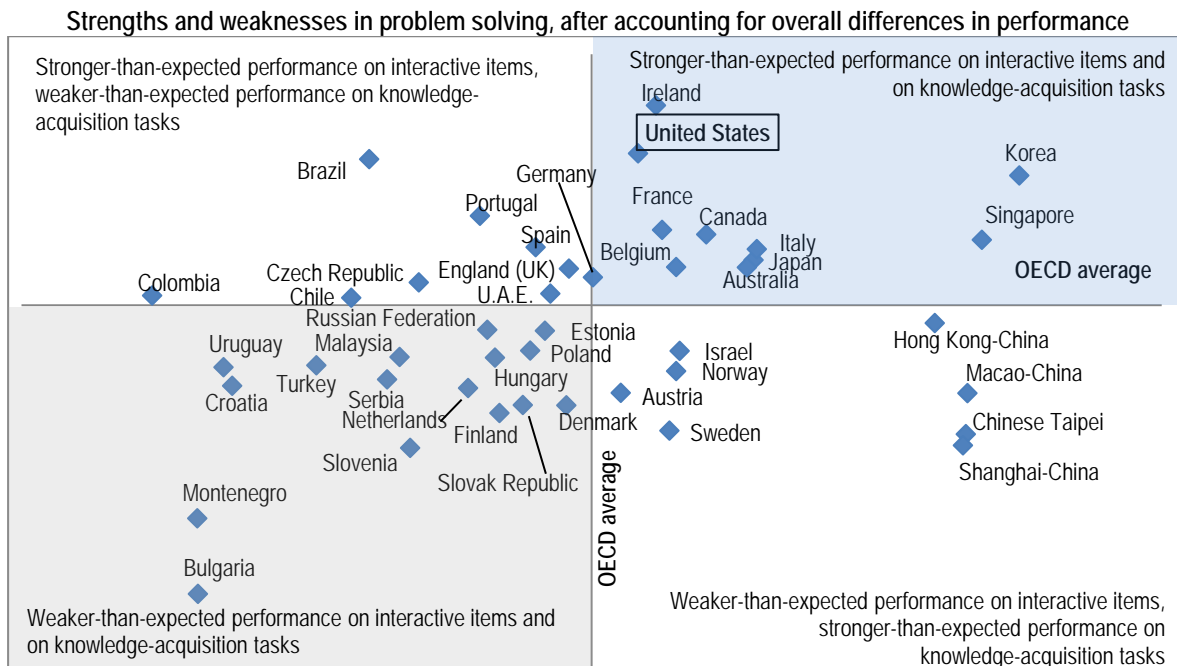
Relative performance in problem solving	
	Score dif.
Accounting for performance in all core subjects	
...among all students	10
Accounting for performance in mathematics only	
...among all students	13
...among strong and top performers in mathematics	20
...among moderate and low performers in mathematics	11

Note: Statistically significant differences are marked in bold. Source: Table V.2.6

- Students in the United States perform better than expected in problem solving, based on their performance in mathematics, reading and science. The difference between observed and expected performance is particularly large among students who perform at Level 4 and above.

Strengths and weaknesses in problem solving

- Students in the United States perform better than expected on interactive items, based on their success on static (non-interactive) tasks. Interactive items require students to uncover useful information by exploring the problem situation and gathering feedback on the effect of their actions. To do so, students need to be open to novelty, tolerate doubt and uncertainty, and dare to use intuitions to initiate a solution.
- Success rates on knowledge-acquisition and knowledge-utilisation tasks are in line with the OECD average, after accounting for overall success on the test. However, these rates are lower than those found in the best-performing countries in problem solving, which often do particularly well on knowledge-acquisition tasks that require advanced reasoning skills and self-directed learning.



Source: Figure V.3.10.

How performance in problem solving varies within the United States

Performance in problem solving by subgroup	
	Mean score/score dif.
Boys	509
Girls	506
Difference (Boys-Girls)	3
Immigrant students	498
Non-immigrant students	512
Difference (imm. – non-imm.)	-14
Strength of the relationship between socio-economic status and performance	
Performance variation accounted for by socio-economic status (%)	
Problem solving	10.1
Mathematics	14.8
Difference (PS - M)	-4.7

Statistically significant differences are marked in bold.

Source: Tables V.4.7, V.4.13, V.4.19

- In the United States, boys score at the same level as girls in problem solving, on average (the OECD average difference in favour of boys is 7 score points), but there are more boys than girls among the students performing at Level 5 or 6.
- Students with an immigrant background score significantly below non-immigrant students in the United States. However, they perform as expected based on their scores in mathematics, reading and science.
- The impact of socio-economic status on performance is significantly weaker in problem solving than in mathematics, both in the United States and across OECD countries, on average.

What is PISA?

The Programme for International Student Assessment (PISA) is a triennial survey that assesses the extent to which 15-year-old students near the end of compulsory education have acquired the knowledge and skills that are essential for full participation in modern societies. The assessment does not just ascertain whether students can reproduce knowledge; it also examines how well students can extrapolate from what they have learned and apply that knowledge in unfamiliar settings, both in and outside of school.

PISA offers insights for education policy and practice, and helps monitor trends in students' acquisition of knowledge and skills across countries and in different demographic subgroups within each country. The findings allow policy makers to gauge the knowledge and skills of students in their own countries in comparison with those in other countries, set policy targets against measurable goals achieved by other education systems, and learn from policies and practices applied elsewhere.

Key features of the PISA 2012 assessment of problem solving

In 2012, more than 40 countries and economies participated in the assessment of problem solving. **OECD countries:** Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Israel, Italy, Japan, Korea, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Turkey, England (United Kingdom) and the United States. **Partner countries and economies:** Brazil, Bulgaria, Colombia, Croatia, Hong Kong-China, Macao-China, Malaysia, Montenegro, the Russian Federation, Serbia, Shanghai-China, Singapore, Chinese Taipei, the United Arab Emirates and Uruguay.

The assessment

- Problem solving was assessed on computers. The computer-based assessments lasted a total of 40 minutes, with different students taking different combinations of test items. A total of 80 minutes of problem-solving items were covered. Only basic computer familiarity and skills were required to complete the assessment.
- The use of computers made it possible to include interactive problems, in which students need to explore the (simulated) environment and gather feedback on the effect of their interventions in order to obtain all the information needed to solve a problem. Test questions were a mixture of multiple-choice questions and those requiring students to construct their own responses. Sample items can be explored online at www.oecd.org/pisa/test.
- Students assessed in problem solving also completed a two-hour assessment of mathematics, reading and science. They also answered a background questionnaire, which took 30 minutes to complete, that sought information about themselves, their homes and their school and learning experiences. In addition, countries could choose an optional questionnaire for students, asking about their familiarity with and use of information and communication technologies.

The students

- Only a subsample of all students assessed in mathematics, reading and science in 2012 also participated in the computer-based assessment of problem solving. Around 85 000 students were assessed in problem solving, representing about 19 million 15-year-olds in the schools of the 44 participating countries and economies.

In the United States, 1 273 students in 162 schools completed the assessment of problem solving.

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For more information on the Programme for International Student Assessment and to access the full set of PISA 2012 results, visit: www.oecd.org/pisa

Source: <http://www.oecd.org/pisa/keyfindings/PISA-2012-PS-results-eng-USA.pdf>