The Programme for International Student Assessment (PISA)

PISA is a triennial survey of the knowledge and skills of 15-year-olds. It is the product of collaboration between participating countries and economies through the Organisation for Economic Co-operation and Development (OECD), and draws on leading international expertise to develop valid comparisons across countries and cultures.

More than 400 000 students from 57 countries making up close to 90% of the world economy took part in PISA 2006. The focus was on science but the assessment also included reading and mathematics and collected data on student, family and institutional factors that could help to explain differences in performance. This report summarises the main findings.

OECD

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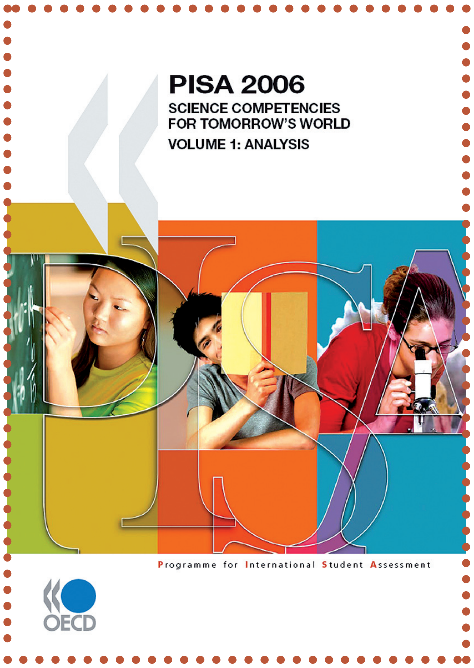
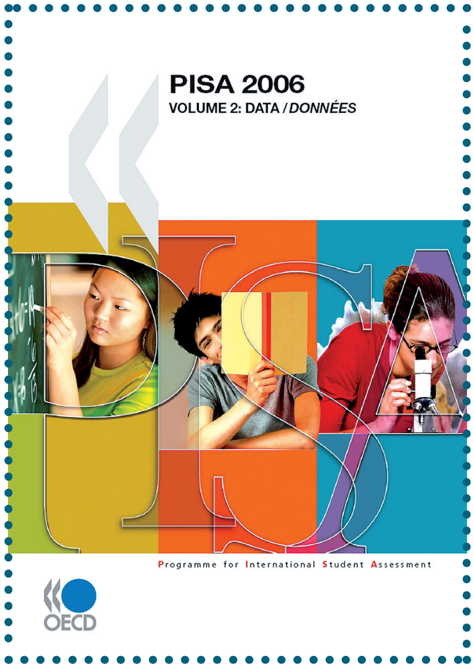

PISA 2006
SCIENCE COMPETENCIES
FOR TOMORROW'S WORLD
VOLUME 1: ANALYSIS
Programme for International Student Assessment
OECD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Key findings

SCIENCE PERFORMANCE

- Finland, with an average of 563 score points, was the highest-performing country on the PISA 2006 science scale.
- Six other high-scoring countries had mean scores of 530 to 542 points: Canada, Japan and New Zealand and the partner countries/economies Hong Kong-China, Chinese Taipei and Estonia. Australia, the Netherlands, Korea, Germany, the United Kingdom, the Czech Republic, Switzerland, Austria, Belgium and Ireland, and the partner countries/economies Liechtenstein, Slovenia and Macao-China also scored above the OECD average of 500 score points.
- On average across OECD countries, 1.3% of 15-year-olds reached Level 6 of the PISA 2006 science scale, the highest proficiency level. These students could consistently identify, explain and apply scientific knowledge, and knowledge about science, in a variety of complex life situations. In New Zealand and Finland this figure was at least 3.9%, three times the OECD average. In the United Kingdom, Australia, Japan and Canada, as well as the partner countries/economies Liechtenstein, Slovenia and Hong Kong-China, between 2 and 3% reached Level 6.
- The number of students at Level 6 cannot be reliably predicted from a country's overall performance. Korea was among the highest-performing countries on the PISA science scale, with an average of 522 score points, while the United States performed below the OECD average, with a score of 489. Nevertheless, the United States and Korea had similar percentages of students at Level 6.
- Over one in five students in Finland (21%) and over one in six in New Zealand (18%) reached at least Level 5. In Japan, Australia and Canada, and the partner economies Hong Kong-China and Chinese Taipei, this figure was between 14 and 16% (OECD average 9%). By contrast, 15 of the countries in the survey had fewer than 1% of students reaching either Level 5 or Level 6, and nearly 25 countries had 5% or fewer reaching the two highest levels.
- The number of students at very low proficiency is also an important indicator – not necessarily in relation to the development of future scientific personnel but in terms of citizens' ability to participate fully in society and in the labour market. At Level 2, students start to demonstrate the science competencies that will enable them to participate actively in life situations related to science and technology. Across the OECD, on average 19.2% were classified as below Level 2, including 5.2% below Level 1.
- Males and females showed no difference in average science performance in the majority of countries, including 22 of the 30 OECD countries. In 12 countries, females outperformed males, on average, while males outperformed females in 8 countries. Most of these differences were small. In no OECD country was the gender difference larger than 12 points on the science scale. This is different from reading and mathematics where significant gender differences were observed.
- However, similarities in average performance mask certain gender differences: In most countries, females were stronger in *identifying scientific issues,* while males were stronger

at *explaining phenomena scientifically.* Males performed substantially better than females when answering physics questions. Last but not least, in most countries more females attend higher performing, academically oriented tracks and schools than do males. As a result of this, in many countries gender differences in science were substantial within schools or programmes, even if they appeared small overall.

- On average across OECD countries, around one-third of all variation in student performance (33%) was between schools, but this varied widely from one country to another. In Germany and the partner country Bulgaria performance variation between schools was about twice the OECD average. It was over one and a half times the average in the Czech Republic, Austria, Hungary, the Netherlands, Belgium, Japan and Italy, and the partner countries Slovenia, Argentina and Chile. In most of these countries, the grouping or tracking of students affected this result.
- In other countries, school differences played only a minor part in performance variation. In Finland less than 5% of the overall performance variation among OECD countries lay between schools and in Iceland and Norway it was still less than 10%. Other countries in which performance was not very closely related to the schools in which students were enrolled included Sweden, Poland, Spain, Denmark and Ireland as well as the partner countries Latvia and Estonia. Considering that Finland also showed the highest overall performance in science suggests that Finnish parents can rely on high and consistent performance standards across schools in the entire education system.
- Students' socio-economic differences accounted for a significant part of between-school differences in some countries. This factor contributed most to between-school performance variation in the United States, the Czech Republic, Luxembourg, Belgium, the Slovak Republic, Germany, Greece and New Zealand, and the partner countries Bulgaria, Chile, Argentina and Uruguay.
- Less than 10% of the variation in student performance was explained by student background in five of the seven countries with the highest mean science scores of above 530 points (Finland, Canada and Japan, and the partner countries/economies Hong Kong-China and Estonia).
- There is no relationship between the size of countries and the average performance of 15-year-olds in PISA. There is also no cross-country relationship between the proportion of foreign-born students in countries and the average performance of countries. Last but not least, an analysis undertaken in the context of the PISA 2003 assessment showed that there were few differences among countries in students' test motivation.

READING PERFORMANCE

- Korea, with 556 score points, was the highest-performing country in reading. Finland followed second with 547 points and the partner economy Hong Kong-China third with 536 points.
- Canada and New Zealand had mean reading scores between 520 and 530, and the following countries still scored significantly above the OECD average of 492 scorepoints: Ireland, Australia, Poland, Sweden, the Netherlands, Belgium and Switzerland, and the partner countries Liechtenstein, Estonia and Slovenia.

- Reading is the area with the largest gender gaps. In all OECD countries in PISA 2006, females performed better in reading on average than males. In twelve countries, the gap was at least 50 score points. In Greece and Finland, females were 57 and 51 points ahead respectively, and the gap was 50 to 66 points in the partner countries Qatar, Bulgaria, Jordan, Thailand, Argentina, Slovenia, Lithuania, Kyrgyzstan, Latvia and Croatia.
- Across the OECD area, reading performance generally remained flat between PISA 2000 and PISA 2006. This needs to be seen in the context of significant rises in expenditure levels. Between 1995 and 2004 expenditure per primary and secondary student increased by 39% in real terms, on average across OECD countries. However, two OECD countries (Korea and Poland) and five partner countries/economies (Chile, Liechtenstein, Indonesia, Latvia and Hong Kong-China) have seen significant rises in reading performance since PISA 2000.
- Korea increased its reading performance between PISA 2000 and PISA 2006 by 31 score points, mainly by raising performance standards among the better performing students.
- Hong Kong-China has increased its reading performance by 11 score points since 2000.
- Poland increased its reading performance by 17 score points between PISA 2000 and PISA 2003 and by another 11 score points between PISA 2003 and PISA 2006 and now performs at 508 score points, for the first time clearly above the OECD average. Between the PISA 2000 and PISA 2003 assessments, Poland raised its average performance mainly through increases at the lower end of the performance distribution. As a result, in PISA 2003 fewer than 5% of students fell below performance standards that had not been reached by the bottom 10% of Polish students in PISA 2000. Since PISA 2003, performance in Poland has risen more evenly across the performance spectrum.
- The other countries that have seen significant performance increases in reading between PISA 2000 and PISA 2006 – Chile (33 score points), Liechtenstein (28 score points), Indonesia (22 score points) and Latvia (21 score points) – perform, with the exception of Liechtenstein, significantly below the OECD average.
- A number of countries saw a decline in their reading performance between PISA 2000 and PISA 2006, comprising nine OECD countries (in descending order) – Spain, Japan, Iceland, Norway, Italy, France, Australia, Greece and Mexico, and the partner countries Argentina, Romania, Bulgaria, the Russian Federation and Thailand.

MATHEMATICS PERFORMANCE

- Finland and Korea, and the partners Chinese Taipei and Hong Kong-China, outperformed all other countries/economies in PISA 2006.
- Other countries with mean performances significantly above the OECD average were the Netherlands, Switzerland, Canada, Japan, New Zealand, Belgium, Australia, Denmark, the Czech Republic, Iceland and Austria, as well as the partner countries/economies Macao-China, Liechtenstein, Estonia and Slovenia.
- In Mexico mathematics performance was 20 score points higher in PISA 2006 than in PISA 2003 but at 406 score points it is still well below the OECD average. In Greece, mathematics performance was 14 score points higher in PISA 2006 than in PISA 2003.

In Indonesia, mathematics performance was 31 score points higher in PISA 2006 than in PISA 2003 and in Brazil it was 13 score points higher in PISA 2006 than in PISA 2003.

- Mathematics performance in 2006 was significantly lower in France (15 score points), Japan (11 score points), Iceland (10 score points) and Belgium (9 score points), and in the partner country Liechtenstein (11 score points).
- Overall gender differences in mathematics were less than one-third as large as for reading, 11 points on average across OECD countries. This has not changed since PISA 2003.

STUDENT ATTITUDES TO SCIENCE

- Ninety-three per cent of students reported that science was important for understanding the natural world, 92% said that advances in science and technology usually improved people's living conditions, but only 57% said that science was very relevant to them personally. A strong acceptance by students that science is important for understanding nature and improving living conditions extends across all countries in the survey. However, this was mirrored to a much lesser extent in students' responses to the wider socio-economic benefits of science. On average across OECD countries, 25% of students (and over 40% in Iceland and Denmark) did not agree with the statement "advances in science usually bring social benefits".
- The majority of students reported that they were motivated to learn science, but only a minority reported interest in a career involving science: 72% said that it was important for them to do well in science; 67% said that they enjoyed acquiring new knowledge in science; 56% said that science was useful for further studies; but only 37% said they would like to work in a career involving science and 21% said that would like to spend their life doing advanced science. Twenty-one per cent said they regularly watched television programmes about science; 13% said they regularly visited websites about science; 8% said that they regularly borrowed books on science. Within each country, students who reported that they enjoyed learning science were more likely to have higher levels of science performance. While this does not show a causal link, the results suggest that students with greater interest and enjoyment of science are more willing to invest the effort needed to do well.
- Students with a more advantaged socio-economic background were more likely to show a general interest in science, and this relationship was strongest in Ireland, France, Belgium and Switzerland. One significant feature of a student's background was whether they had a parent in a science-related career.
- On average across OECD countries, 73% of the students said that they were aware of the consequences of clearing forests for other land use; 58% said that they were aware of the increase of greenhouse gases in the atmosphere; and 35% said that they were aware of the use of genetically modified organisms (GMOs). However, awareness of environmental issues varies by country, and within each country is stronger among students who perform better in science.
- There was some degree of pessimism among the students about the future of the natural environment: On average across OECD countries, only 21% of students reported that they believed the problems associated with energy shortages would improve over the next 20 years, 18% considered this to be the case for water shortages, 16% for air pollution, 15% for nuclear waste, 14% for the extinction of plants and animals and 13% for the clearing

of forests for other land use. Students with higher performance in science, who reported greater awareness of environmental issues, also reported being more pessimistic about the future of the environment.

- Gender differences in attitudes to science were most prominent in Germany, Iceland, Japan, Korea, the Netherlands and the United Kingdom, and in the partners Chinese Taipei, Hong Kong-China and Macao-China, where males reported more positive characteristics on at least five aspects of attitude. Of the attitudes measured in PISA, the largest gender difference was observed in students' self-concept regarding science. In 22 out of the 30 OECD countries in the survey, males thought significantly more highly of their own science abilities than did females.

SCHOOL AND SYSTEM-LEVEL FACTORS

- Institutional tracking is closely related to the impact which socio-economic background had on student performance. The earlier that students are stratified into separate institutions or programmes, the stronger the impact which the school's average socio-economic background had on performance. Also schools that divided students by ability for all subjects tended to have lower student performance, on average.
- On average across the OECD, students in private schools outperformed students in public schools in 21 countries, while public schools outperformed private ones in four countries. The picture changed, however, when the socio-economic background of students and schools was taken into account. Public schools then had an advantage of 12 score points over private schools, on average across OECD countries. That said, private schools may still pose an attractive alternative for parents looking to maximise the benefits for their children, including those benefits that are conferred to students through the socio-economic level of schools' intake.
- Across OECD countries, 60% of students were enrolled in schools whose principals reported competing with two or more other schools in the local area. Across countries, having a larger number of schools that compete for students is associated with better results, over and above the relationship with student background.
- Parents surveyed in 16 countries reported generally to be positive and well-informed about their children's schools, but this varied considerably across countries. For example, fewer than 50% of parents in Germany, but over 90% in Poland and the partner county Colombia, reported that the school provided regular and useful information on their child's progress.
- On average across OECD countries, the majority of students (54%) were enrolled in schools where school principals reported giving feedback to parents on their child's performance relative to the performance of other students at the school. In many OECD countries, the reporting of student performance information to parents is more commonly done relative to national benchmarks than relative to other students in the school. For example, in Sweden only 12% of 15-year-olds were enrolled in schools that reported performance data to parents relative to those of other students in the school, while 94% of 15-year-olds were enrolled in schools that reported data relative to national or regional standards or

benchmarks. The pattern was similar in Japan, Finland, Norway, the United Kingdom and New Zealand, as well as the partner country Estonia.

- In the United Kingdom and the United States, school principals of more than 90% of 15-year-olds enrolled in school reported that school achievement data were posted publicly; in the Netherlands, as well as the partner countries Montenegro and Azerbaijan, this was still the case for more than 80%. In contrast, in Finland, Belgium, Switzerland and Austria, as well as in the partner country Argentina, this was the case for less than 10% of the students and in Japan, Spain, Germany, Korea and Ireland, and in the partner countries/economies Macao-China, Uruguay, Indonesia and Tunisia, it held for less than 20%. There are considerable differences in the scores of students in countries where schools posted their results publicly. Some of these differences were associated with other features of schools and school systems that tended to go along with strong accountability arrangements and with the socio-economic background of students in schools that had such arrangements. However, once these factors are taken into account, there still remains a significant positive association between schools making their achievement data public and having stronger results.
- Within countries, students in schools that exercise greater autonomy do not on average get better results, once the socio-economic context is accounted for. However, students in countries where autonomy is more common tend to do better in the science assessment, regardless of whether or not they themselves are enrolled in relatively autonomous schools. This is true for the aspects of school autonomy in formulating the school budget and deciding on budget allocations within the school, even after accounting for socio-economic background factors, as well as other school and system-level factors.
- Resources such as an adequate supply of teachers and quality of educational resources at school are on average across countries associated with positive student outcomes, but many of these effects are not significant after taking account of the fact that students from a more advantaged socio-economic background tend to get access to more educational resources. After accounting for this, there remains a significant association between several aspects of learning time as well as school activities to promote students' learning of science and performance.

PISA 2006

BACKGROUND

PISA is the most comprehensive and rigorous international programme to assess student performance and to collect data on the student, family and institutional factors that can help to explain differences in performance. Decisions about the scope and nature of the assessments and the background information to be collected are made by leading experts in participating countries, and are steered jointly by governments on the basis of shared, policy-driven interests. Substantial efforts and resources are devoted to achieving cultural and linguistic breadth and balance in the assessment materials. Stringent quality assurance mechanisms are applied in translation, sampling and data collection. As a consequence, the results of PISA have a high degree of validity and reliability, and can significantly improve understanding of the outcomes of education in the world's economically most developed countries, as well as in a growing number of countries at earlier stages of economic development.

Key features of PISA include its:

- Policy orientation, with the design and reporting methods determined by the goal to inform educational policy and practice.
- Innovative approach to "literacy", which is concerned with the capacity of students to extrapolate from what they have learned and to analyse and reason as they pose, solve and interpret problems in a variety of situations. The relevance of the knowledge and skills measured by PISA is confirmed by recent studies tracking young people in the years after they have been assessed by PISA.
- Relevance to lifelong learning, which does not limit PISA to assessing students' knowledge and skills but also asks them to report on their own motivation to learn, their beliefs about themselves and their attitudes to what they are learning.
- Regularity, enabling countries to monitor improvements in educational outcomes in the light of other countries' performances.
- Consideration of student performance alongside characteristics of students and schools, in order to explore some of the main features associated with educational success.
- Breadth of geographical coverage, with the countries and economies participating in the PISA 2006 assessment representing almost nine-tenths of the world economy.

Three PISA surveys have taken place so far, in 2000, 2003 and 2006, focusing on reading, mathematics and science, respectively. This sequence will be repeated with surveys in 2009, 2012 and 2015, allowing continuous and consistent monitoring of educational outcomes.

PISA will also continue to develop new assessment instruments and tools according to the needs of participating countries. This includes collecting more detailed information on educational policies and practices. It also includes making use of computer-based

assessments, not only to measure Information and Communication Technology skills but also to allow for a wider range of dynamic and interactive tasks of student knowledge and skills.

PISA 2006 ESSENTIALS

- More than 400 000 students in 57 countries participated in PISA 2006, which involved a two-hour test with both open and multiple-choice tasks.
  - All 30 OECD member countries participated, as well as 27 partner countries and economies.
  - Nationally-representative samples were drawn, representing 20 million 15-year-olds.
- Students also answered a half-hour questionnaire about themselves, and their principals answered a questionnaire about their schools. In 16 countries parents completed a questionnaire about their investment in their children's education and their views on science-related issues and careers.

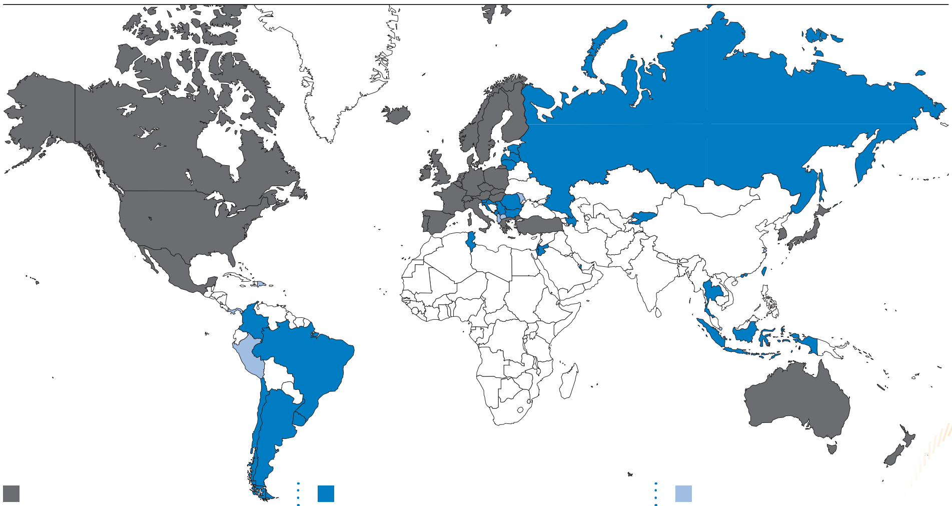
NEW IN PISA 2006

- A detailed profile of student performance in science (in PISA 2000, the focus was on reading, and in PISA 2003, on mathematics).
- Measures of students' attitudes to learning science, the extent to which they are aware of the life opportunities that possessing science competencies may open, and the science learning opportunities and environments which their schools offer.
- Measures of school contexts, instruction, student access and use of computers, and parental perceptions of students and schools.
- Performance changes in reading over three PISA assessments (six years) and changes in mathematics over two PISA assessments (three years).

The value of PISA in monitoring performance over time is growing, although it is not yet possible to assess to what extent the observed differences are indicative of longer-term trends. With science being the main assessment area for the first time, results in PISA 2006 provide the baseline for future measures of change in this subject.

PARTICIPATING COUNTRIES AND ECONOMIES

Figure 1 **A map of PISA countries and economies**



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

Partner countries and economies in PISA 2006

Argentina
Azerbaijan
Brazil
Bulgaria
Chile
Colombia
Croatia
Estonia
Hong Kong-China
Indonesia
Israel
Jordan
Kyrgyzstan
Latvia
Liechtenstein
Lithuania
Macao-China
Montenegro
Qatar
Romania
Russian Federation
Serbia
Slovenia
Chinese Taipei
Thailand
Tunisia
Uruguay

Partner countries and economies in previous PISA surveys or in PISA 2009

Albania
Shanghai-China
Dominican Republic
Macedonia
Moldova
Panama
Peru
Singapore
Trinidad and Tobago

Throughout figures and tables in this summary, OECD countries are listed in black, while partner countries and economies are listed in blue.

Assessing science

HOW PISA 2006 MEASURED STUDENT PERFORMANCE IN SCIENCE

Today, knowledge of science and about science is more important than ever. Science is relevant to everyone's life and an understanding of science is an essential tool for people in achieving their goals. This makes how science is taught and learned especially important. PISA's assessment of students' scientific knowledge and skills is rooted in the concept of *scientific literacy*, defined as the extent to which an individual:

- Possesses scientific knowledge and uses that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues.
- Understands the characteristic features of science as a form of human knowledge and enquiry.
- Shows awareness of how science and technology shape our material, intellectual and cultural environments.
- Engages in science-related issues and with the ideas of science, as a reflective citizen.

PISA 2006 assessed students' ability to perform scientific tasks in a variety of situations, ranging from those that affect their personal lives to wider issues for the community or the world. These tasks measured students' performance in relation both to their science competencies and to their scientific knowledge. PISA assessed three broad science competencies:

- *Identifying scientific issues*. This required students to recognise issues that can be explored scientifically, and to recognise the key features of a scientific investigation.
- *Explaining phenomena scientifically.* Students had to apply knowledge of science in a given situation to describe or interpret phenomena scientifically and predict changes.
- *Using scientific evidence.* This meant interpreting the evidence to draw conclusions, to explain them, to identify the assumptions, evidence and reasoning that underpin them and to reflect on their implications.

The PISA tasks required scientific knowledge of two kinds:

- *Knowledge of science*. This entailed an understanding of fundamental scientific concepts and theories, in core scientific areas. The four content areas covered in PISA 2006 were "Physical systems", "Living systems", "Earth and space systems", and "Technology systems", representing key aspects of understanding the natural world.
- *Knowledge about science*. This included understanding the purposes and nature of scientific enquiry and understanding scientific explanations, which are the results of scientific enquiry. One can think of enquiry as the means of science (how scientists obtain evidence) and of explanations as the goals of science (how scientists use data).

SCIENCE QUESTIONS, STUDENT SCORES AND PROFICIENCY LEVELS

PISA measures scientific literacy across a continuum from basic literacy skills through high levels of knowledge of scientific concepts and examines students' capacity to use their understanding of these concepts and to think scientifically about real-life problems.

In PISA 2006, students were presented a series of questions based on the kinds of scientific problems that they might encounter in their life. Examples of questions are shown on the next pages.

The PISA 2006 assessment included 108 different questions at varying levels of difficulty. Usually several questions were posed about a single scientific problem described in a text or diagram. In many cases, students were required to construct a response in their own words to questions based on the text given. Sometimes they had to explain their results or to show their thought processes.

Each student was awarded a score based on the difficulty of questions that he or she could reliably perform. Scores were reported for each of the three science competencies, and for overall performance in science. The science performance scales have been constructed so that the average student score in OECD countries is 500 points. In PISA 2006, about two-thirds of students scored between 400 and 600 points (i.e. a standard deviation equals 100 points).

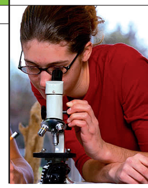
Note that a score can be used to describe both the performance of a student and the difficulty of a question. Thus, for example, a student with a score of 650 can usually be expected to complete a question with a difficulty rating of 650, as well as questions with lower difficulty ratings.

Student performance scores and the difficulty of questions were also divided into six proficiency levels. As shown in Figure 2, each of these levels can be described in terms of what kinds of science competencies students have. There is also information on students' strengths in performing questions in each of the areas of scientific knowledge described above.

Figure 2 **Student proficiency in science**

Level	Lower score limit	Percentage of students able to answer questions at each level or above (OECD average)	What students can typically do at each level on the science scale
6	707.9	1.3% of students across the OECD can answer questions at Level 6	At Level 6, students can consistently identify, explain and apply scientific knowledge and *knowledge about science* in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they demonstrate willingness to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, socio-economic, or global situations.
5	633.3	9.0% of students across the OECD can answer questions at least at Level 5	At Level 5, students can identify the scientific components of many complex life situations, apply both scientific concepts and *knowledge about science* to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to situations. They can construct explanations based on evidence and arguments based on their critical analysis.
4	558.7	29.3% of students across the OECD can answer questions at least at Level 4	At Level 4, students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence.
3	484.1	56.7% of students across the OECD can answer questions at least at Level 3	At Level 3, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.
2	409.5	80.8% of students across the OECD can answer questions at least at Level 2	At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.
1	334.9	94.8% of students across the OECD can answer questions at least at Level 1	At Level 1, students have such a limited scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence.

Source: Figure 2.8, *PISA 2006: Science Competencies for Tomorrow's World.*



A SAMPLE OF PISA SCIENCE QUESTIONS

The three science questions shown here illustrate the range of questions used in PISA 2006, in six different dimensions:

First, they show the different *competencies* that students needed. The *CLOTHES* question involves identifying which issues can be scientifically investigated and the *GREENHOUSE* question relates to scientific explanations, while *ACID RAIN* requires understanding of how to use evidence to support a conclusion.

Second, they are of different *difficulty levels,* ranging from the very difficult *GREENHOUSE* question, which requires students not only to understand scientific methods but also to deal with abstract concepts and relationships, to the much easier *ACID RAIN* question, where several obvious cues allow students to draw a simple conclusion.

Third, they require different *knowledge categories. CLOTHES* involves *knowledge about science* (the nature of scientific enquiry) and *GREENHOUSE* and *ACID RAIN knowledge of science* ("Earth and space systems" and "Physical systems", respectively).

Fourth, they represent three areas of *scientific application,* specifically "Frontiers of science and technology" (*CLOTHES*), "Environment" (*GREENHOUSE*) and "Hazards" (*ACID RAIN*).

Fifth, they are drawn from different *contexts*. The issues they raise are of *social* (*CLOTHES*), *global* (*GREENHOUSE*) and *personal* (*ACID RAIN*) relevance.

Finally, these examples show the main *question types* used in PISA: multiple-choice questions in simple and complex forms (*ACID RAIN* and *CLOTHES*, respectively) and an open-response question (*GREENHOUSE*).

Identifying scientific issues

A question of medium difficulty

CLOTHES

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

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

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

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

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

QUESTION

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

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

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

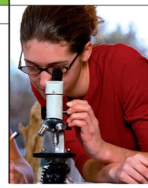
***Correct answer**: Yes, Yes, Yes, No*

***Competency:** Identifying scientific issues*

***Knowledge category**: "Scientific enquiry" (knowledge about science)*

***Difficulty:** 567*

***Percentage of correct answers (OECD countries):** 47.9%*



Explaining scientific phenomena

A difficult question

GREENHOUSE

THE GREENHOUSE EFFECT: FACT OR FICTION?

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

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

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

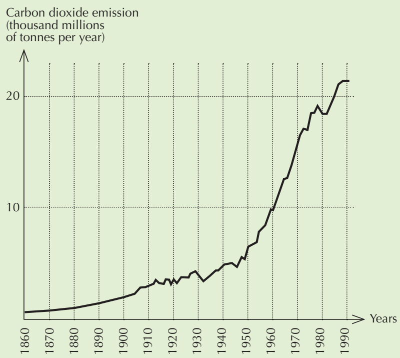
As a result of this the average temperature above the Earth's surface is higher than it would be if there were no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term greenhouse effect.

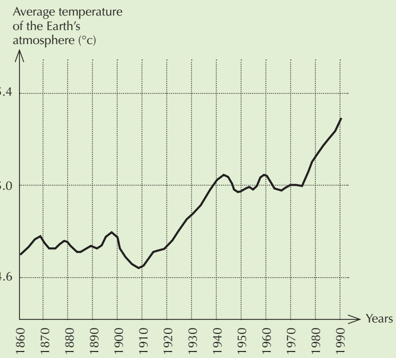
The greenhouse effect is said to have become more pronounced during the twentieth century.

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

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

In a library he comes across the following two graphs.





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

QUESTION

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

Name one of the factors that Jeanne means.

Competency: *Explaining phenomena scientifically*

Knowledge category: *"Earth and space systems" (knowledge of science)*

Difficulty: *709*

Percentage of correct answers (OECD countries): *18.9%*

Using scientific evidence

An easier question

ACID RAIN

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

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

The effect of acid rain on marble can be modelled by placing chips of marble in vinegar overnight. Vinegar and acid rain have about the same acidity level. When a marble chip is placed in vinegar, bubbles of gas form. The mass of the dry marble chip can be found before and after the experiment.

QUESTION

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

A. Less than 2.0 grams

B. Exactly 2.0 grams

C. Between 2.0 and 2.4 grams

D. More than 2.4 grams

Correct answer: *A*

Competency: *Using scientific evidence*

Knowledge category: *"Physical systems" (knowledge of science)*

Difficulty: *460*

Percentage of correct answers (OECD countries): *66.7%*

Attitude question: The following question, which follows immediately after a series of questions on acid rain (including the one above), is an example of how PISA 2006 explored students' attitudes to the scientific issues about which they were being tested.

How much interest do you have in the following information?

Tick only one box in each row.

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

Science performance

A PROFILE OF STUDENT PERFORMANCE IN SCIENCE

The following results show the:

- Distribution of student proficiency in PISA 2006
- Overall performance levels of each country
- Extent to which countries were relatively stronger or weaker in different aspects of science
- Extent of gender differences in student performance in science

STUDENT PROFICIENCY IN SCIENCE

Students in PISA 2006 were classified at one of six proficiency levels, according to the difficulty of science tasks that they could perform (see Figure 2). Those unable to perform even the easiest PISA tasks reliably were rated as "below Level 1". Table 1 shows how many reached each level in PISA 2006.

How many students show a high level of proficiency in science?

A workforce highly skilled in science is important to the economic well-being of countries. While basic science competencies are generally considered important for the absorption of new technology, high-level science competencies are critical for the creation of new technology and innovation. In particular for countries near the technology frontier, this implies that the share of highly educated workers in the labour force is an important determinant of economic growth and socio-economic development. PISA therefore devotes significant attention to the assessment of students at the high end of the skill distribution.

On average across OECD countries, 1.3% of 15-year-olds reached Level 6 of the PISA 2006 science scale, the highest level. These students could consistently identify, explain and apply scientific knowledge, and knowledge about science, in a variety of complex life situations. A total of 9% were proficient at least at Level 5, showing that they had a well-developed capacity for scientific enquiry and were able to combine knowledge and insight appropriately in scientific tasks *(Table 2.1a)*.[1]

In PISA 2006:

- More than 2% of students scored at Level 6 in nine countries. In New Zealand and Finland this figure was at least 3.9%, three times the OECD average. In the United Kingdom, Australia, Japan and Canada, as well as the partner countries/economies Liechtenstein, Slovenia and Hong Kong-China, between 2 and 3% reached this highest level of science performance.

1. All table, figure and box references in parentheses and italics refer to *PISA 2006: Science Competencies for Tomorrow's World.*

Table 1 Percentage of students at each proficiency level on the science scale

	Proficiency levels in science						
	Below Level 1	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Finland	0.5	3.6	13.6	29.1	32.2	17.0	3.9
Estonia	1.0	6.7	21.0	33.7	26.2	10.1	1.4
Hong Kong-China	1.7	7.0	16.9	28.7	29.7	13.9	2.1
Canada	2.2	7.8	19.1	28.8	27.7	12.0	2.4
Macao-China	1.4	8.9	26.0	35.7	22.8	5.0	0.3
Korea	2.5	8.7	21.2	31.8	25.5	9.2	1.1
Chinese Taipei	1.9	9.7	18.6	27.3	27.9	12.9	1.7
Japan	3.2	8.9	18.5	27.5	27.0	12.4	2.6
Australia	3.0	9.8	20.2	27.7	24.6	11.8	2.8
Liechtenstein	2.6	10.3	21.0	28.7	25.2	10.0	2.2
Netherlands	2.3	10.7	21.1	26.9	25.8	11.5	1.7
New Zealand	4.0	9.7	19.7	25.1	23.9	13.6	4.0
Slovenia	2.8	11.1	23.1	27.6	22.5	10.7	2.2
Hungary	2.7	12.3	26.0	31.1	21.0	6.2	0.6
Germany	4.1	11.3	21.4	27.9	23.6	10.0	1.8
Ireland	3.5	12.0	24.0	29.7	21.4	8.3	1.1
Czech Republic	3.5	12.1	23.4	27.8	21.7	9.8	1.8
Switzerland	4.5	11.6	21.8	28.2	23.5	9.1	1.4
Austria	4.3	12.0	21.8	28.3	23.6	8.8	1.2
Sweden	3.8	12.6	25.2	29.5	21.1	6.8	1.1
United Kingdom	4.8	11.9	21.8	25.9	21.8	10.9	2.9
Croatia	3.0	14.0	29.3	31.0	17.7	4.6	0.5
Poland	3.2	13.8	27.5	29.4	19.3	6.1	0.7
Belgium	4.8	12.2	20.8	27.6	24.5	9.1	1.0
Latvia	3.6	13.8	29.0	32.9	16.6	3.8	0.3
Denmark	4.3	14.1	26.0	29.3	19.5	6.1	0.7
Spain	4.7	14.9	27.4	30.2	17.9	4.5	0.3
Slovak Republic	5.2	15.0	28.0	28.1	17.9	5.2	0.6
Lithuania	4.3	16.0	27.4	29.8	17.5	4.5	0.4
Iceland	5.8	14.7	25.9	28.3	19.0	5.6	0.7
Norway	5.9	15.2	27.3	28.5	17.1	5.5	0.6
France	6.6	14.5	22.8	27.2	20.9	7.2	0.8
Luxembourg	6.5	15.6	25.4	28.6	18.1	5.4	0.5
Russian Federation	5.2	17.0	30.2	28.3	15.1	3.7	0.5
Greece	7.2	16.9	28.9	29.4	14.2	3.2	0.2
United States	7.6	16.8	24.2	24.0	18.3	7.5	1.5
Portugal	5.8	18.7	28.8	28.8	14.7	3.0	0.1
Italy	7.3	18.0	27.6	27.4	15.1	4.2	0.4
Israel	14.9	21.2	24.0	20.8	13.8	4.4	0.8
Serbia	11.9	26.6	32.3	21.8	6.6	0.8	0.0
Chile	13.1	26.7	29.9	20.1	8.4	1.8	0.1
Uruguay	16.7	25.4	29.8	19.7	6.9	1.3	0.1
Bulgaria	18.3	24.3	25.2	18.8	10.3	2.6	0.4
Jordan	16.2	28.2	30.8	18.7	5.6	0.6	0.0
Thailand	12.6	33.5	33.2	16.3	4.0	0.4	0.0
Turkey	12.9	33.7	31.3	15.1	6.2	0.9	0.0
Romania	16.0	30.9	31.8	16.6	4.2	0.5	0.0
Montenegro	17.3	33.0	31.0	14.9	3.6	0.3	0.0
Mexico	18.2	32.8	30.8	14.8	3.2	0.3	0.0
Argentina	28.3	27.9	25.6	13.6	4.1	0.4	0.0
Colombia	26.2	34.0	27.2	10.6	1.9	0.2	0.0
Brazil	27.9	33.1	23.8	11.3	3.4	0.5	0.0
Indonesia	20.3	41.3	27.5	9.5	1.4	0.0	a
Tunisia	27.7	35.1	25.0	10.2	1.9	0.1	0.0
Azerbaijan	19.4	53.1	22.4	4.7	0.4	0.0	a
Qatar	47.6	31.5	13.9	5.0	1.6	0.3	0.0
Kyrgyzstan	58.2	28.2	10.0	2.9	0.7	0.0	a

Source: OECD PISA 2006 database. Table 2.1a, *PISA 2006: Science Competencies for Tomorrow's World.*
Countries are ranked in descending order of percentage of students at Levels 2, 3, 4, 5 and 6.
StatLink http://dx.doi.org/10.1787/141844475532

- The number of students at Level 6 cannot be reliably predicted from a country's overall performance. Korea was among the highest-performing countries on the PISA science test, in terms of students' performance, with an average of 522 score points, while the United States performed below the OECD average, with a score of 489. Nevertheless, the United States and Korea had similar percentages of students at Level 6 *(Tables 2.1a, 2.1c)*
- Over one in five students in Finland (21%) and over one in six in New Zealand (18%) reached at least Level 5 (OECD average 9%). In Japan, Australia and Canada, and the partners Hong Kong-China and Chinese Taipei, this figure was between 14% and 16% *(Table 2.1a).*

- By contrast, 15 of the countries in the survey had fewer than 1% of students reaching either Level 5 or Level 6, and nearly 25 countries had 5% or fewer reaching the two highest levels. This highly uneven distribution underlines the gap between countries with a significant pool of potential future scientists and those without this advantage *(Table 2.1a)*.

How many students show a low level of proficiency in science?

The number of students at very low levels of proficiency is also an important indicator – not necessarily in relation to scientific personnel but in terms of citizens' ability to participate fully in society and in the labour market. At Level 2, students start to demonstrate the science competencies that will enable them to participate actively in life situations related to science and technology. Across the OECD, on average 19.2% were classified as below Level 2, including 5.2% below Level 1 *(Table 2.1a)*.

In PISA 2006:

- The majority of students did not reach Level 2 in ten countries. These included one OECD country, Mexico *(Table 2.1a)*.
- In contrast, there were five countries or economies where around 10% or fewer of students were at Level 1 or below: Finland and Canada, and the partner countries/economies Estonia, Hong Kong-China and Macao-China *(Table 2.1a)*.
- Level 2 thus represents a level of basic science competency that was held by the overwhelming majority of the population in some countries (eight in ten students on average across OECD countries), but was only achieved by a minority of students in other countries *(Table 2.1a)*.

How many students show a medium level of proficiency in science?

Some countries in PISA 2006 had few students at either high or low levels of proficiency. Whereas on average across OECD countries, 72% were at Levels 2, 3 or 4, in the partner economy Macao-China it was 84% and in the partner country Estonia, 81%. These countries have neither the advantages of a plentiful supply of highly proficient students nor a large problem of low proficiency. Similarly in Korea, the percentage at Level 6 (1.1%) and at Level 1 or below (11%) were both below average *(Table 2.1a)*.

In contrast, the United States was the one country where the proportion of students both at low and at high levels of proficiency were at or above the average. One in four students (24%) were at Level 1 or below, while 9% were at Level 5 or 6.

AVERAGE STUDENT PERFORMANCE

For each country, students' overall performance in science can be summarised in a mean score. On the basis of the samples of students assessed by PISA, it is not always possible to say with confidence which of two countries with similar performance has a higher mean score for the whole population. However, it is possible to give a range of possible rankings within which each country falls. This range is shown in Table 2 *(Table 2.1c* and *Figure 2.11c)*.

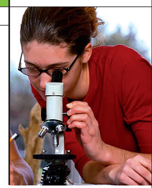
Table 2 Range of rank of countries/economies on the science scale

- Statistically significantly above the OECD average
- Not statistically significantly different from the OECD average
- Statistically significantly below the OECD average

	Science scale					
			Range of rank			
			OECD countries		All countries/economies	
	Science score	S.E.	Upper rank	Lower rank	Upper rank	Lower rank
Finland	563	(2.0)	1	1	1	1
Hong Kong-China	542	(2.5)			2	2
Canada	534	(2.0)	2	3	3	6
Chinese Taipei	532	(3.6)			3	8
Estonia	531	(2.5)			3	8
Japan	531	(3.4)	2	5	3	9
New Zealand	530	(2.7)	2	5	3	9
Australia	527	(2.3)	4	7	5	10
Netherlands	525	(2.7)	4	7	6	11
Liechtenstein	522	(4.1)			6	14
Korea	522	(3.4)	5	9	7	13
Slovenia	519	(1.1)			10	13
Germany	516	(3.8)	7	13	10	19
United Kingdom	515	(2.3)	8	12	12	18
Czech Republic	513	(3.5)	8	14	12	20
Switzerland	512	(3.2)	8	14	13	20
Macao-China	511	(1.1)			15	20
Austria	511	(3.9)	8	15	12	21
Belgium	510	(2.5)	9	14	14	20
Ireland	508	(3.2)	10	16	15	22
Hungary	504	(2.7)	13	17	19	23
Sweden	503	(2.4)	14	17	20	23
Poland	498	(2.3)	16	19	22	26
Denmark	496	(3.1)	16	21	22	28
France	495	(3.4)	16	21	22	29
Croatia	493	(2.4)			23	30
Iceland	491	(1.6)	19	23	25	31
Latvia	490	(3.0)			25	34
United States	489	(4.2)	18	25	24	35
Slovak Republic	488	(2.6)	20	25	26	34
Spain	488	(2.6)	20	25	26	34
Lithuania	488	(2.8)			26	34
Norway	487	(3.1)	20	25	27	35
Luxembourg	486	(1.1)	22	25	30	34
Russian Federation	479	(3.7)			33	38
Italy	475	(2.0)	26	28	35	38
Portugal	474	(3.0)	26	28	35	38
Greece	473	(3.2)	26	28	35	38
Israel	454	(3.7)			39	39
Chile	438	(4.3)			40	42
Serbia	436	(3.0)			40	42
Bulgaria	434	(6.1)			40	44
Uruguay	428	(2.7)			42	45
Turkey	424	(3.8)	29	29	43	47
Jordan	422	(2.8)			43	47
Thailand	421	(2.1)			44	47
Romania	418	(4.2)			44	48
Montenegro	412	(1.1)			47	49
Mexico	410	(2.7)	30	30	48	49
Indonesia	393	(5.7)			50	54
Argentina	391	(6.1)			50	55
Brazil	390	(2.8)			50	54
Colombia	388	(3.4)			50	55
Tunisia	386	(3.0)			52	55
Azerbaijan	382	(2.8)			53	55
Qatar	349	(0.9)			56	56
Kyrgyzstan	322	(2.9)			57	57

Source: OECD PISA 2006 database. Table 2.1c and Figure 2.11c, *PISA 2006: Science Competencies for Tomorrow's World.*

StatLink http://dx.doi.org/10.1787/141844475532



In PISA 2006:

- Students in Finland scored 563 points on average, compared to the OECD mean of 500. This score was an estimated 21 points above that of any other country, making Finland the highest scoring country in science *(Table 2.1c* and *Figure 2.11c)*.
- Six other high-scoring countries had mean scores of 530 to 542 points: Canada, Japan and New Zealand and the partner countries/economies Hong Kong-China, Chinese Taipei, Estonia. Other countries scoring above the OECD mean included Australia, the Netherlands, Korea, Germany, United Kingdom, Czech Republic, Switzerland, Austria, Belgium and Ireland *(Table 2.1c* and *Figure 2.11c)*.

There is no relationship between the size of countries and the average performance of 15-year-olds in PISA. There is also no cross-country relationship between the proportion of foreign-born students in countries and the average performance of countries. Last but not least, an analysis undertaken in the context of the PISA 2003 assessment showed that there were few differences among countries in students' test motivation.

IN WHICH ASPECTS OF SCIENCE ARE STUDENTS STRONGER OR WEAKER IN DIFFERENT COUNTRIES?

Three areas of science competency

Students in each country were in some cases relatively stronger and weaker in the three science competencies measured in PISA:

- Identifying scientific issues
- Explaining phenomena scientifically
- Using scientific evidence

It is important, but not sufficient, for students to understand scientific theories and facts well enough to explain phenomena scientifically. They must also be able to recognise which questions can be addressed scientifically and see how results can be used, in order to apply their scientific knowledge.

- In some countries, students were relatively stronger at *explaining phenomena scientifically* than in other science competencies. Students scored 10+ points higher in *explaining phenomena scientifically* than overall in science in the Czech Republic, Hungary and the Slovak Republic, as well as in the partner countries/economies Azerbaijan, Jordan, Chinese Taipei, Kyrgyzstan and Bulgaria. In some countries, the reverse was true – students were stronger in other science competencies than *explaining phenomena scientifically*. Students scored 10+ points higher in science overall than in *explaining phenomena scientifically*, in France and Korea and in the partner country Israel *(Figures 2.14a, 2.14b)*.
- In some countries, students showed a relative strength in *using scientific evidence*. Students scored 10+ points higher in *using scientific evidence* than in science overall in Korea, France and Japan and in the partner country Liechtenstein. In some countries, students showed a relative weakness in *using scientific evidence*. Students scored 10+ points lower in *using scientific evidence* than in science overall in Norway, the Czech Republic and the Slovak Republic, and in the partner countries Azerbaijan, Kyrgyzstan, Qatar, Jordan, Bulgaria, Brazil, Romania and Serbia *(Figures 2.14c, 2.14d)*.

In some of these cases, the differences between performance in two different competencies were substantial. For example, in France and Korea, students scored 30 and 27 points, respectively, higher in *using scientific evidence* than in *explaining phenomena scientifically (Tables 2.3c, 2.4c).*

Some countries scored substantially higher in *knowledge about science*, that is knowledge about the purposes and nature of scientific enquiry and of scientific explanations, than in *knowledge of science,* that is knowledge of the natural world as articulated in the different scientific disciplines.

- Students scored over 20 points higher on average in questions requiring *knowledge about science* in France and the partner country Israel. Students also scored 10+ points higher in such questions in Belgium, New Zealand, Australia, the Netherlands and in the partner countries Colombia, Uruguay, Argentina, Chile and Tunisia *(Figure 2.18a).*

In other countries, *knowledge of science* was stronger, suggesting that the curriculum has been relatively strong on transmitting specific scientific knowledge. This was particularly marked in East European countries, whose students tend to do less well in questions relating to the understanding of the nature of scientific work and scientific thinking.

- Students scored over 20 points higher, on average, in questions requiring *knowledge of science* in the Czech Republic, Hungary and the Slovak Republic as well as in the partner countries Azerbaijan, Jordan and Kyrgyzstan *(Figure 2.18a).*
- Students also scored 10+ points higher in such questions in Norway, Poland, Sweden and Austria and in the partner countries/economies Slovenia, Chinese Taipei, Bulgaria, Estonia, Qatar, Macao-China, Serbia, and Lithuania *(Figure 2.18a).*

Knowledge of different areas of science

Students' *knowledge of science* can be broken down further into the content areas "Physical systems", "Living systems", "Earth and space systems". Cases where a country's performance was substantially different in one content area are shown in the following table *(Figures 2.19a, 2.19b, 2.19c).*

Table 3 **Countries where students scored on average at least 15 points higher or lower in a particular science content area than in the average of the other two**

Content area	Students scored higher than average	Students scored lower than average
Earth and space systems	Korea, the United States and Iceland,	France, Austria, Denmark, Sweden, Luxembourg, and the partner countries/economies, Tunisia*, Israel*, Uruguay*, Hong Kong-China, Kyrgyzstan, Jordan, Romania, Brazil, Chinese Taipei, Macao-China and Azerbaijan.
Living systems	Luxembourg, the United Kingdom, France, Finland and the partner countries/economies Israel, Uruguay, Jordan, Brazil, Hong Kong-China, Montenegro and Tunisia.	Korea*, Iceland, the Netherlands and the partner countries Azerbaijan and Slovenia.
Physical systems	Hungary, the Netherlands and the partner countries Azerbaijan*, Kyrgyzstan and Tunisia	Spain, Portugal and the partner country Thailand

* Shows at least 30 points higher/lower.
Source: OECD PISA 2006 database. Figures 2.19a, 2.19b, 2.19c, *PISA 2006: Science Competencies for Tomorrow's World.*
StatLink http://dx.doi.org/10.1787/141844475532

Gender differences

Males and females showed no difference in average science performance in the majority of countries, including 22 of the 30 OECD countries *(Table 2.1c)*.

- In 12 countries, females outperformed males, on average, while males outperformed females in 8 countries. Most of these differences were small.
- In no OECD country was the gender difference larger than 12 points on the science scale.
- Some partner countries showed larger differences. In Qatar and Jordan, females were 32 and 29 points ahead of males, respectively.

These gender differences were smaller than those observed in mathematics and much smaller than those observed in reading. However, similarities in average performance mask continuing differences:

- Some countries showed larger gender differences in particular science competencies. In most countries, females were stronger in *identifying scientific issues,* while males were stronger at *explaining phenomena scientifically (Tables 2.2c, 2.3c)*.
- Males performed substantially better than females when answering "Physical systems" questions – 26 points better on average, rising to 45 points in Austria *(Table 2.10)*.
- In most countries more females attend higher performing, academically oriented tracks and schools than do males. As a result of this, in many countries gender differences in science were substantial within schools or programmes, even if they appeared small overall. From a policy perspective – and for teachers in classrooms – gender differences in science performance therefore warrant continued attention.

Attitudes to science

A PROFILE OF STUDENT ENGAGEMENT IN SCIENCE

In PISA, student attitudes, and an awareness of the life opportunities that possessing science competencies may open, are seen as key components of an individual's *scientific literacy*. Data were collected on students' support for scientific enquiry, their self-beliefs as science learners, their interest in science and their sense of responsibility towards resources and environments.

THE IMPORTANCE OF ATTITUDES TO SCIENCE

Issues of motivation and attitudes are particularly relevant in science, which plays a key part in today's societies and economies, but appears not always to be taken up enthusiastically by young people at school. Engagement in science is important because:

- Continued investment in scientific endeavour relies on broad public support, which is influenced by citizens' responses to science and technology.
- Scientific and technological advances are important influences on nearly everyone's life.
- A continued supply of scientific personnel requires a proportion of the population to take a close interest in science. Attitudes at age 15 have also been shown to influence whether students continue to study science and take a career path in science.

A NEW WAY OF ASSESSING ATTITUDES

PISA 2006 used a questionnaire to ask students about a variety of aspects of how they viewed science. Questions looked at students' general and personal value of science, as well as their interest and enjoyment of science, plus their self-concept of their own abilities in science and whether they are motivated to use science in the future. In some cases students were asked questions about their responses to the issues about which they were being tested. This allowed attitudes to be explored in the context of students who were, at that time, engaging with science, rather than just thinking about it in the abstract.

DO STUDENTS SUPPORT SCIENTIFIC ENQUIRY?

In general, students showed strong support for scientific enquiry. On average across OECD countries:

- 93% said that science was important for understanding the natural world *(Figure 3.2)*.
- 92% said that advances in science and technology usually improved people's living conditions *(Figure 3.2)*.

- 75% said that science helped them to understand things around them *(Figure 3.4)*.
- However, only 57% said that science was very relevant to them personally *(Figure 3.4)*.

The strong acceptance by students that science is important for understanding nature and improving living conditions extends across all countries in the survey. This acknowledgement among young people of the importance of science was mirrored to a much lesser extent in their responses to the wider socio-economic benefits of science. On average across OECD countries, 25% of students (and over 40% in Iceland and Denmark) did not report agreeing with the statement "advances in science and technology usually bring social benefits". That said, over 90% of students reported that they agreed with this statement in Korea and the partner countries/economies Thailand, Hong Kong-China, Macao-China, Chinese Taipei, Chile and Azerbaijan *(Figure 3.2)*.

DO STUDENTS BELIEVE THEY CAN SUCCEED IN SCIENCE?

Most students expressed confidence in being able to do scientific tasks, but more so for some tasks than others. For example, on average among students in OECD countries:

- 76% said they could explain why earthquakes occurred more frequently in some areas than in others *(Figure 3.5)*.
- 64% said they could predict how changes to an environment would affect the survival of certain species *(Figure 3.5)*.
- 51% said they could discuss how new evidence could lead to a change in understanding about the possibility of life on Mars *(Figure 3.5)*.

Just under one-half of students (47%) reported that they found school science topics easy *(Figure 3.7)*.

These questions addressed students' belief both in whether they can handle tasks effectively and overcome difficulties (self-efficacy in science) and in their academic abilities (self-concept in science). Both of these aspects are important because confidence in one's abilities can feed into motivation and learning behaviours.

Self-efficacy was particularly closely related to performance, even if the causal nature of this relationship cannot be established *(Figure 3.6)*. However, as shown in Figure 3, self-efficacy was not systematically strongest in countries with the highest performance:

- Self-efficacy was highest in Poland, the United States, Canada and Portugal, and the partner country Jordan.
- Self-efficacy was lowest in Japan, Korea and Italy and the partner countries Indonesia, Azerbaijan and Romania.

ARE STUDENTS INTERESTED IN SCIENCE?

The majority of students reported that they were motivated to learn science, but only a minority reported taking a close interest:

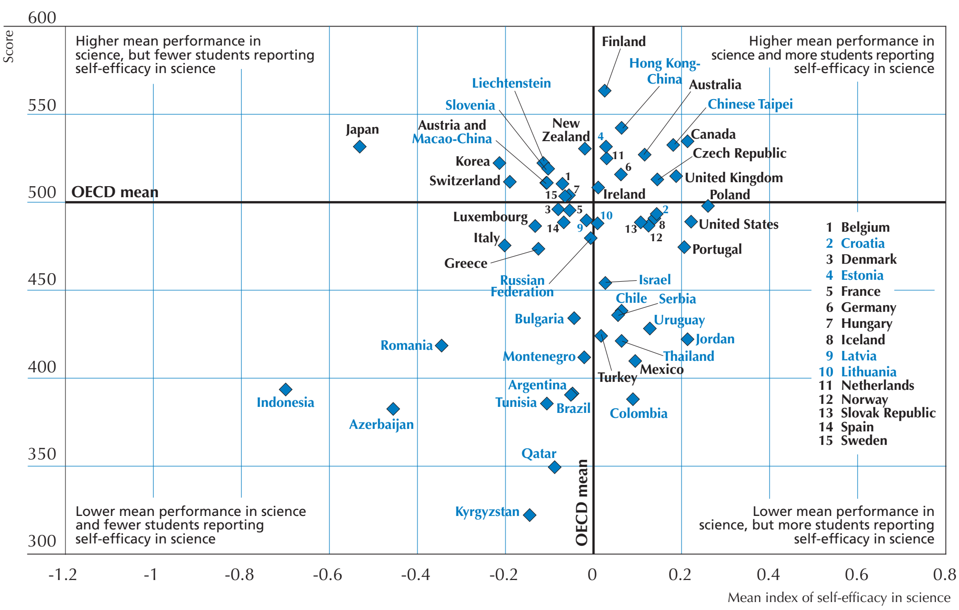
- 72% said that it was important for them to do well in science *(Figure 3.10)*.
- 67% said that they enjoyed acquiring new knowledge in science *(Figure 3.10)*.
- 67% said that science was useful to them *(Figure 3.12)*.
- 56% said that science was useful for further studies *(Figure 3.12)*.
- 37% said they would like to work in a career involving science *(Figure 3.13)*.
- 21% said that would like to spend their life doing advanced science *(Figure 3.13)*.
- 21% said they regularly watched television programmes about science *(Figure 3.16)*.
- 13% said they regularly visited websites about science *(Figure 3.16)*.
- 8% said that they regularly borrowed books on science *(Figure 3.16)*.

Within each country, students who reported that they enjoyed learning science were more likely to have higher levels of science performance. While this does not show a clear causal link, it is appears that students with greater interest and enjoyment of science are more willing to invest the effort needed to do well.

Figure 3 **Performance in science and self-efficacy in science**

Students reporting self-efficacy in science believed they could perform the following tasks either easily or with a bit of effort:

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



Source: OECD PISA2006 database. Tables 3.3 and 2.1c, Figure 3.6, *PISA 2006: Science Competencies for Tomorrow's World.*
StatLink http://dx.doi.org/10.1787/141846760512

Interest in science appears to be influenced by student background. Students from families with a more advantaged socio-economic background were more likely to show a general interest in science, and this relationship was strongest in Ireland, France, Belgium and Switzerland. Those with a more advantaged socio-economic background were also more likely to identify how science may be useful to them in the future *(Table 3.22)*.

One significant feature of a student's background was whether they have a parent in a science-related career. Among the 18% for whom this was so, one-third (6% of students) saw their own futures in such careers. A further 19% of students without a parent in a science-related career reported that they expected to be in a science-related career at age 30, making a total of 25% of students *(Table 3.14)*.

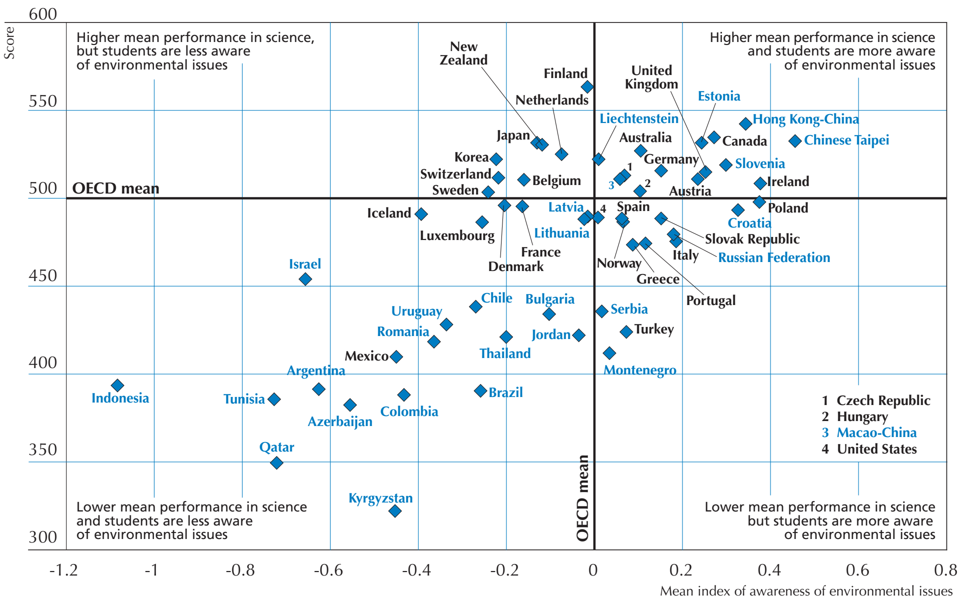
DO STUDENTS FEEL RESPONSIBLE TOWARDS RESOURCES AND THE ENVIRONMENT?

The PISA 2006 student questionnaire asked students how they felt about selected environmental issues.

Figure 4 **Performance in science and awareness of environmental issues**

Students who are aware of environmental issues reported that they were familiar with or knew something about the following:

The consequences of clearing forests for other land use; acid rain; the increase of greenhouse gases in the atmosphere; nuclear waste; use of genetically modified organisms.



Source: OECD PISA2006 database. Table 3.16 and 2.1c, Figure 3.18, *PISA 2006: Science Competencies for Tomorrow's World.*

StatLink http://dx.doi.org/10.1787/141846760512

On average across OECD countries, students' awareness of environmental issues varied considerably according to the issue:

- 73% said that they were aware of the consequences of clearing forests for other land use *(Figure 3.17)*.
- 58% said that they were aware of the increase of greenhouse gases in the atmosphere *(Figure 3.17)*.

- 35% said that they were aware of the use of genetically modified organisms (GMOs) *(Figure 3.17)*.

As shown in Figure 4, awareness of environmental issues varies by country. Within each country, awareness of environmental issues is stronger among students who perform better in science *(Figure 3.17)*.

- There was some degree of pessimism among the students about the future of the natural environment: On average across OECD countries, only 21% of students reported that they believed the problems associated with energy shortages would improve over the next 20 years, 18% considered this to be the case for water shortages, 16% for air pollution, 15% for nuclear waste, 14% for the extinction of plants and animals and 13% for the clearing of forests for other land use. Students with higher performance in science, who reported greater awareness of environmental issues, also reported being more pessimistic about the future of the environment *(Figure 3.20)*.

GENDER DIFFERENCES IN ATTITUDES TO SCIENCE

While overall gender differences in science performance were small, differing attitudes to science among males and females can potentially affect whether students go on to further studies in science and whether they choose a career in science.

PISA 2006 showed that, in some countries, males and females were similar not only in science performance but also in attitudes. In other countries, however, there were important differences. Gender differences in attitudes to science were most prominent in Germany, Iceland, Japan, Korea, the Netherlands and the United Kingdom, as well as in the partners Chinese Taipei, Hong Kong-China and Macao-China, where males reported more positive characteristics on at least five aspects of attitude *(Table 3.21)*.

Of the attitudes measured in PISA, the largest gender difference was observed in students' self-concept regarding science. In 22 out of the 30 OECD countries in the survey, males thought significantly more highly of their own science abilities than did females *(Table 3.21)*.

Quality and equity

RESULTS BY SCHOOL AND STUDENT BACKGROUND

A major focus and challenge for education policy is to foster high overall levels of student achievement (quality), while limiting the influence of socio-economic contexts on learning outcomes (equity), which can be considered an indicator of inefficiencies in education systems to fully capitalise on the cognitive potential of students.

PISA allows the twin goals of quality and equity in education to be monitored by considering not only differences in results by country, but also performance differences between students and schools from varying socio-economic contexts.

WHAT ROLE DO SCHOOL DIFFERENCES PLAY?

Within each country, there was a wide variation in the science performance of different students. In all OECD countries, the range of scores among the middle 90% of students – from the 5th to the 95th percentile – exceeded the difference between average performance in the highest-performing PISA country, Finland, and the lowest-performing, Kyrgyzstan.

To what extent were these differences associated with students attending different schools? How closely was this associated with schools' different socio-economic profiles?

Figure 5 shows the extent to which variations in student performance consist of students doing better or worse at different schools. The remainder of student variation in performance is represented as within-school differences.

In PISA 2006:

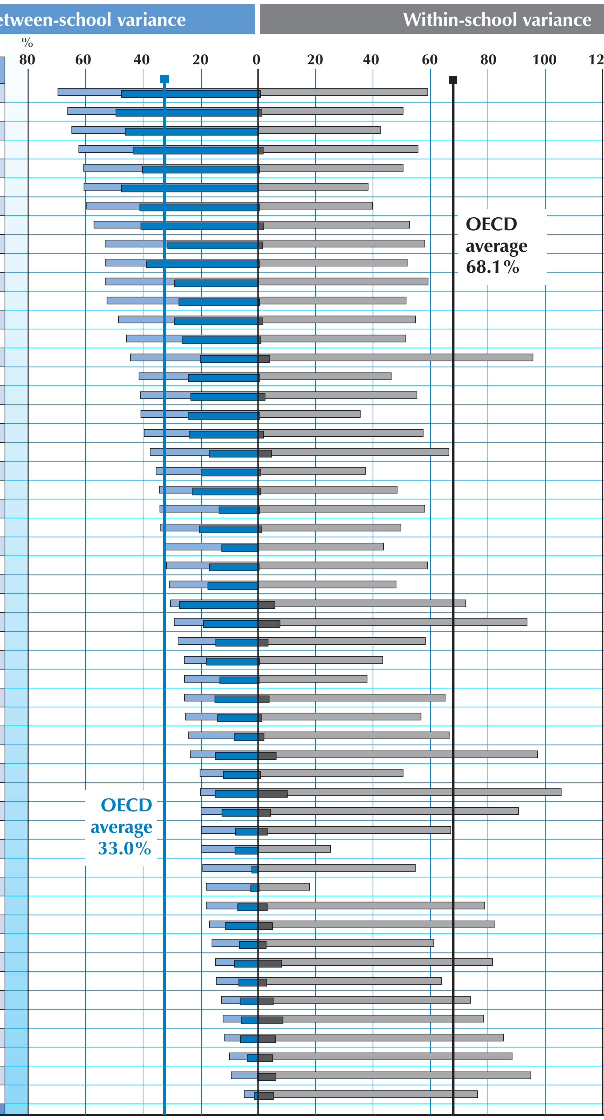
- On average, around one-third of all variation in student performance (33%) was between schools, but this varied widely from one country to another *(Table 4.1a)*.
- In Germany and the partner country Bulgaria performance variation between schools was about twice the OECD average. It was over one and a half times the average in the Czech Republic, Austria, Hungary, the Netherlands, Belgium, Japan and Italy, and the partner countries Slovenia, Argentina and Chile. In most of these countries, the grouping and tracking of students by school affected this result *(Table 4.1a)*.
- In other countries, school differences played only a minor part in performance variation. In Finland less than 5% of the overall performance variation among OECD countries lay between schools and in Iceland and Norway it was still less than 10%. Other countries in which performance was not very closely related to the schools in which students were enrolled included Sweden, Poland, Spain, Denmark and Ireland as well as the partner countries Latvia and Estonia. It is noteworthy that Finland showed also the highest overall performance in science, suggesting that parents can rely on high and consistent performance standards across schools in the entire education system *(Table 4.1a)*.

- Students' socio-economic differences accounted for a significant part of between-school differences in some countries. This factor contributed most to between-school variance in the United States, the Czech Republic, Luxembourg, Belgium, the Slovak Republic, Germany, Greece and New Zealand, and the partner countries Bulgaria, Chile, Argentina and Uruguay *(Table 4.1a)*.

Figure 5 **Variance in student performance between schools and within schools on the science scale**

Expressed as a percentage of the average variance in student performance in OECD countries

A Between-school variance explained by the PISA index of economic, social and cultural status of students and schools
B Total between-school variance
C Within-school variance explained by the PISA index of economic, social and cultural status of students and schools
D Total within-school variance



	A	B	C	D
Bulgaria	47.5	69.6	0.9	59.4
Germany	49.4	66.2	1.4	50.8
Slovenia	46.2	64.8	0.3	42.8
Czech Republic	43.5	62.4	1.8	55.9
Austria	40.1	60.7	0.6	50.7
Hungary	47.5	60.5	0.2	38.5
Netherlands	41.1	59.6	0.8	40.0
Belgium	40.7	57.0	2.0	53.0
Argentina	31.4	53.2	1.6	58.4
Chile	38.8	53.0	0.7	52.2
Japan	29.0	53.0	0.1	59.4
Italy	27.6	52.6	0.5	51.8
Greece	29.1	48.5	1.8	55.1
Chinese Taipei	26.4	45.8	1.0	51.7
Israel	20.0	44.4	4.1	96.1
Brazil	24.1	41.4	0.7	46.6
Slovak Republic	23.3	40.9	2.5	55.6
Turkey	24.3	40.8	0.7	35.8
Uruguay	23.9	39.6	2.0	57.7
Switzerland	17.0	37.5	4.8	66.7
Romania	19.8	35.5	1.0	37.7
Serbia	22.9	34.3	1.0	48.7
Hong Kong-China	13.6	34.1	0.6	58.3
Croatia	20.4	33.8	1.3	50.0
Tunisia	12.6	32.3	0.2	43.9
Korea	16.9	31.8	0.4	59.3
Kyrgyzstan	17.4	30.7	0.2	48.3
Luxembourg	27.3	30.5	6.0	72.7
United States	18.9	29.1	7.7	94.0
Portugal	14.7	27.8	3.6	58.5
Thailand	18.0	25.6	0.6	43.6
Mexico	13.3	25.5	0.4	38.2
Lithuania	15.0	25.5	3.9	65.4
Colombia	14.1	25.2	1.4	57.0
Russian Federation	8.2	24.1	2.2	66.9
United Kingdom	14.8	23.5	6.4	97.8
Montenegro	12.0	20.2	0.9	50.8
New Zealand	14.9	20.0	10.2	106.0
Australia	12.5	19.8	4.4	91.1
Jordan	7.8	19.7	3.3	67.5
Indonesia	8.0	19.4	0.0	25.4
Macao-China	2.2	19.2	0.3	55.0
Azerbaijan	2.5	17.9	0.4	18.1
Canada	7.1	17.9	3.2	79.3
Ireland	11.4	16.9	5.0	82.6
Estonia	6.5	16.0	2.9	61.5
Denmark	8.2	14.8	8.3	82.0
Latvia	6.7	14.5	3.1	64.2
Spain	6.2	12.7	5.4	74.2
Poland	5.8	12.2	8.7	78.9
Sweden	6.1	11.5	6.1	85.8
Norway	3.7	9.9	5.2	88.8
Iceland	0.2	9.3	6.3	95.4
Finland	1.3	4.7	5.5	76.7

Source: OECD PISA 2006 database. Figure 4.1 and Table 4.1a, *PISA 2006: Science Competencies for Tomorrow's World.*
StatLink http://dx.doi.org/10.1787/141848881750

CAN SOCIO-ECONOMIC EQUITY BE RECONCILED WITH SCHOOL QUALITY?

The results from PISA 2006 show that poor performance in school does not automatically follow from a disadvantaged home background. However, home background, measured on an index summarising each student's economic, social and cultural status, remains one of the most powerful factors influencing performance. On average across the OECD countries it explained 14% of the student performance variation in science.

While in every country, student performance tended to be stronger for students with more favourable home backgrounds, this relationship (or "socio-economic gradient") was much more powerful in some countries than others. Two measures used in PISA to show the influence of socio-economic background on student performance are the:

- *Strength of socio-economic gradient.* This presents how accurately one can predict a student's score from their socio-economic background, expressed as the percentage of all performance variation that socio-economic background can explain.
- *Steepness of socio-economic gradient.* This presents the width of a gap in student scores predicted for two students of differing socio-economic backgrounds.

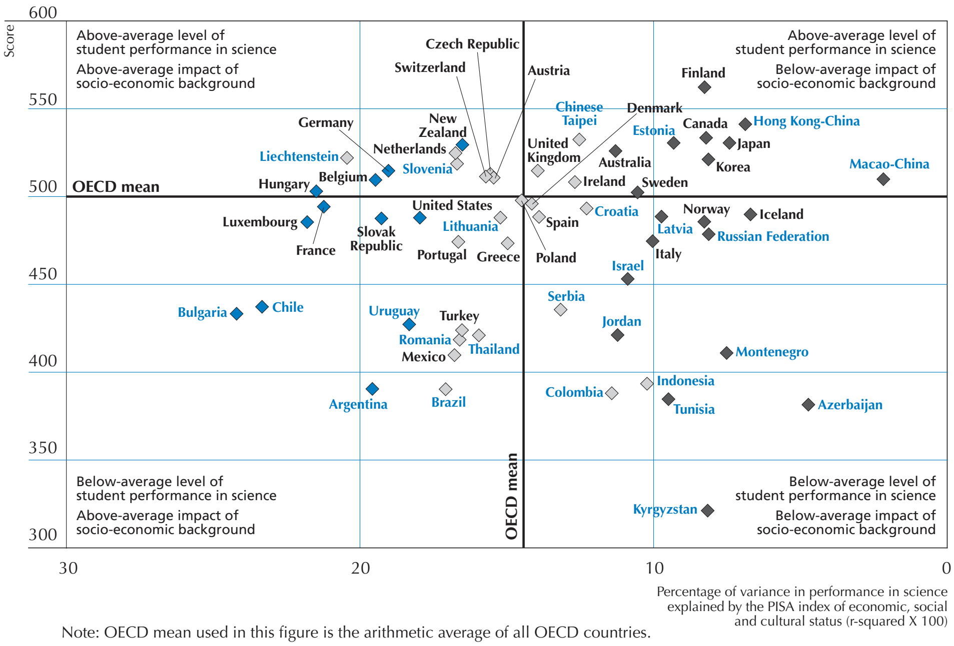
Figure 6 **Performance in science and the impact of socio-economic background**

Average performance of countries on the PISA science scale and the relationship between performance and the PISA index of economic, social and cultural status

◆ Strength of the relationship between performance and socio-economic background **above** the OECD average impact

◇ Strength of the relationship between performance and socio-economic background **not statistically significantly different from** the OECD average impact

◆ Strength of the relationship between performance and socio-economic background **below** the OECD average impact



Note: OECD mean used in this figure is the arithmetic average of all OECD countries.

Source: OECD PISA2006 database. Table 4.4a and Figure 4.10, *PISA 2006: Science Competencies for Tomorrow's World.*

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In Figure 6, countries with weaker socio-economic gradients, and thus more equitable outcomes, are shown on the right of the diagram, and those with stronger gradients on the left. The vertical scale indicates the average science score in each country. Countries are coloured according to whether the strength of the relationship is above, below or not statistically significant from the OECD mean.

Figure 6 shows that quality and equity can be reconciled in some countries.

- Less than 10% of the variation in student performance was explained by student background in five of the seven countries with the highest mean science scores of above 530 (Finland, Canada and Japan, and the partner countries/economies Hong Kong-China and Estonia). These countries demonstrate that quality and equity can be jointly achieved. This compared to an OECD average of 14.4%. In the other two high-scoring countries, New Zealand and the partner Chinese Taipei, 16 and 13% of performance variation can be explained by student background *(Table 4.4a)*.
- The countries where student background explained the largest proportion of performance variation (strongest socio-economic gradients) were Luxembourg, Hungary and France, and the partner countries Bulgaria and Chile *(Table 4.4a)*.
- The countries where two students of different socio-economic background had the largest difference in expected science scores (steepest socio-economic gradients) were France, New Zealand, the Czech Republic, the United States, the United Kingdom, Belgium and Germany, and the partner countries Bulgaria and Liechtenstein *(Table 4.4a)*.

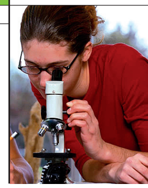
WHAT DO PATTERNS OF SCHOOL AND SOCIO-ECONOMIC DIFFERENCES IMPLY FOR POLICY IN DIFFERENT COUNTRIES?

Many of the factors of socio-economic disadvantage are not directly amenable to education policy, at least not in the short term. For example, the educational attainment of parents can only gradually improve, and average family wealth depends on the long-term economic development of a country. This gives rise to a vital question for policy makers: to what extent can schools and school policies moderate the impact of socio-economic disadvantage on student performance? The overall relationship between socio-economic background and student performance provides an important indicator of the capacity of education systems to provide equitable learning opportunities. However, from a policy perspective, the relationship between socio-economic background and school performance is even more important as it indicates how equity is interrelated with systemic aspects of education. PISA provides rich data on these patterns, whose complexity is not always easy to interpret. However, a number of different phenomena seen to a greater or lesser extent in different countries can each help to inform policy.

A concentration of low-performing students

In some countries, the key issue to address is a relatively high number of students with low proficiency in science and other competencies:

- Among the lowest-performing countries in PISA, a very high proportion of students had low levels of proficiency, indicating a need to improve standards across the board, for example through improvements in the curriculum. In Mexico and Turkey, as well as the



partner countries Kyrgyzstan, Qatar, Azerbaijan, Tunisia, Indonesia, Brazil, Colombia, Argentina, Montenegro, Romania, Thailand, Jordan, Bulgaria and Uruguay, more than 40% of 15-year-old students performed at Level 1 or below *(Table 2.1a)*.

- In another group of countries, fewer students were poor performers, but their numbers were still high relative to the overall performance of these countries.
  - In the United States, 9% of students performed at Levels 5 and 6, roughly the OECD average for these levels, but 24% were at Level 1 or below in science *(Table 2.1a)*.
  - New Zealand, one of the best-performing countries on average, still had 14% of students performing at Level 1 or below *(Table 2.1a)*.
  - Other countries with a comparatively large gap between higher and lower performing students included the United Kingdom, France, Japan and Germany *(Table 2.1a)*.
  - Most of the above countries had medium between-school differences of about 20 to 30% of average student variation. In Germany and Japan, more than one-half of student variation is between schools, in Germany largely as a result of tracking *(Table 4.1a)*.

Large differences in performance by socio-economic background

Should efforts to improve student performance be targeted mainly at those with low performance or low socio-economic background? The slope and strength of the gradient, described above, can provide useful information to answer this question.

- In countries with relatively shallow gradients, i.e. where predicted student performance tends to be similar across socio-economic groups, policies targeted just at disadvantaged students would be relatively ineffective. Canada, with a gradient of 33 score points, Korea (32), Spain (31), Finland (31), Turkey (31), Italy (31), Iceland (29), Portugal (28) and Mexico (25) had flatter gradients than the OECD average of 40 *(Table 4.4a)*.
- In countries where the relationship is relatively weak, *i.e.* student background only explains a small part of performance variation, socio-economically targeted policies may not always reach the students who need help most. This may be true even where the gradient is relatively steep – for example, where socio-economically advantaged students perform much better on average, but a substantial minority of them nevertheless perform poorly. Japan, for example, has a gradient about as steep as the OECD average, but this explains only 7% of variation in student performance *(Table 4.4a)*.
  - Less than 10% of student performance variation is accounted for by student background in: Iceland, Japan, Korea, Canada, Finland and Norway, and the partner countries/economies Macao-China, Azerbaijan, Hong Kong-China, Montenegro, the Russian Federation, Kyrgyzstan, Estonia, Tunisia and Latvia *(Table 4.4a)*.
  - In Austria, the Czech Republic and the United Kingdom, the gradient is considerably steeper than average but its strength is only about average *(Table 4.4a)*.
- In countries with relatively strong and steep socio-economic gradients, socio-economically targeted policies are likely to achieve most.
  - In Hungary, France, Belgium, the Slovak Republic, Germany, the United States and New Zealand, and the partner country Bulgaria, the gradient is both steeper and stronger than average for OECD countries *(Table 4.4a)*.

A wide variation in the socio-economic background of students

Countries need also to take account of how much difference exists in terms of the socio-economic background of their students.

- Canada and Spain have similar socio-economic gradients, flatter than the OECD average, but Spain's students are more socio-economically diverse. These two countries have equally steep socio-economic gradients, but socio-economic difference accounts for nearly twice as much performance difference in Spain, so socio-economically targeted policies are more likely to help improve performance there *(Table 4.4a)*.
- Mexico also has a relatively flat socio-economic gradient, but a highly diverse student population with a skew towards the bottom end, leading to higher than average performance variation associated with socio-economic difference. This suggests the relevance of compensatory policies to help the most disadvantaged students *(Table 4.4a)*.
- Sweden, in contrast, has a socio-economic gradient of average steepness, but a relatively equal society so that differences between students of different backgrounds have a relatively small effect *(Table 4.4a)*.

Strong socio-economic differences across schools

Socio-economic gradients also vary in important ways when comparing different schools.

- The slope of between-school gradients shows how much better students perform if they go to schools with a relatively advantaged socio-economic intake.
- The percentage of between-school performance differences accounted for by differences in school intakes – the strength of the between-school gradient.
- The degree to which students of different backgrounds are separated into different schools.

Germany, for example, has a steep socio-economic gradient, and differences in student intake account for about three-quarters of cross-school difference in performance. Spain has a very shallow socio-economic gradient across schools, but a very strong degree of separation of students from different backgrounds into different schools, and still over 40% of cross-school differences are explained by socio-economic factors. In contrast, Norway has less between-school difference associated with socio-economic difference, despite having a steeper gradient than Spain. Countries where a high level of variation is accounted for by between-school socio-economic factors particularly need to consider whether socio-economic segregation by school is harming equity and/or overall performance *(Table 4.4b)*.

Strong socio-economic differences within schools

Finally, how strong are differences in performance among students from different socio-economic backgrounds within the same school? Within-school differences tended to be smaller in countries where students have already been separated by ability, so each school had a more homogeneous intake. Despite this, within-school differences are relatively similar in magnitude from one country to another:

- Even Finland and New Zealand, which in other respects represent one of the least and one of the most unequal countries in terms of PISA results, have broadly similar within-school socio-economic gradients *(Table 4.4b)*.
- In no country did within-school socio-economic differences in performance account for more than 12% of performance variation *(Table 4.4b)*.

Thus while there may be some instances where socio-economic differences in performance within schools need to be addressed, in no country can such measures succeed on their own in creating more even student performance.

School and system-level factors

THE IMPACT OF SCHOOL AND SYSTEM PRACTICES, POLICIES AND RESOURCES

What can schools and school policies do to raise performance and to moderate the impact that socio-economic background has on student performance?

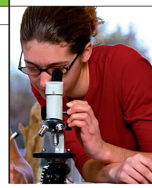
PISA 2006 looked at various school and system-level factors including the policies and practices in admitting, selecting and grouping students, school management and funding, parental pressure and choice, accountability policies, school autonomy, and school resources.

The association of these factors with student performance was estimated both before and after accounting for the demographic and socio-economic context of students, schools and countries.

ADMITTING, SELECTING AND GROUPING

How do schools in different countries confront the formidable challenge of grouping students in order to provide effective instruction for a diverse student body? They vary considerably in the extent to which they group students, both across and within schools:

- While residence was the most important single factor determining the allocation of students to schools, about one-quarter (27%) of 15-year-old students in OECD countries were in schools that select by students' academic record *(Table 5.1)*.
- The age of first selection in the education system varies from age 10 to 17 across the countries. The first selection is at the age of 11 or below in Austria, Germany, the Czech Republic, Hungary, the Slovak Republic and Turkey and in the partner countries Bulgaria and Liechtenstein, while it is at the age of 16 or above in Australia, Canada, Denmark, Finland, Iceland, New Zealand, Norway, Poland, Spain, Sweden, the United Kingdom and the United States and in the partner countries Brazil, Jordan, Latvia, Thailand and Tunisia *(Table 5.1)*.
- Fourteen percent of students in OECD countries were in schools that divided children by ability for all subjects between or within classes and 54% were in schools that practise ability grouping for some subjects, but not for all subjects *(Table 5.3)*.



PISA 2006 allows these admitting, selecting and grouping policies and practices to be compared to student performance in science, even if it cannot establish the causal nature of the relationships.

- Not surprisingly, within each country, students in schools that select by academic criteria performed, on average, better. However, school systems where there were more schools selecting students by ability, performed neither better nor worse overall.
- Institutional tracking was closely related to the impact which socio-economic background had on student performance. The earlier students were stratified into separate institutions or programmes, the stronger was the impact which the school's average socio-economic background had on performance. A long-term trend in OECD countries has been to reduce the amount of separation and tracking in secondary education. The most recent major example of this is Poland, whose reading results before and after this education reform are reported in PISA. Here, an improvement in results among lower ability students immediately after the reform was not at the expense of higher ability students, whose results also rose in the subsequent period *(Table 5.19a)*.
- Schools that divided students by ability for all subjects tended to have lower student performance, on average *(Table 5.19a)*.
- On average across the countries with a significant share of private enrolment, students in private schools outperformed students in public schools in 21 countries, while public schools outperformed private ones in four countries. The picture changed, however, when the socio-economic background of students and schools was taken into account. Public schools then had an advantage of 12 score points over private schools, on average across OECD countries. That said, private schools may still pose an attractive alternative for parents looking to maximise the benefits for their children, including those benefits that are conferred to students through the socio-economic level of schools' intake *(Tables 5.4, 5.19b)*.

PARENTAL PRESSURE AND CHOICE

In recent years, some countries have increased the extent of choice of school, particularly in secondary education. But to what extent do schools compete for students, and does this have any effect on performance?

- Across OECD countries, 60% of students were enrolled in schools whose principals reported that they must compete with two or more other schools in the local area to enrol students. Does competition improve results? PISA 2006 showed that within countries, schools facing competition for students performed better, but this can be explained by the more favourable average socio-economic background of their students. Across countries, however, having a larger number of schools that compete for students was associated with better results, over and above the relationship with student background *(Table 5.5)*.
- School choice is most prevalent in 10 countries or economies, where 80% of principals reported that students have a choice of at least two alternatives to their own school: Australia, the Slovak Republic, the United Kingdom, New Zealand and Japan, and the partner countries/economies Indonesia, Hong Kong-China, Chinese Taipei, Macao-China and Latvia. On the other hand, in Iceland, Norway, and Switzerland, and in the partner countries Qatar and Uruguay, the parents of at least one-half of the students had effectively no choice of schools, according to school principals *(Table 5.5)*.

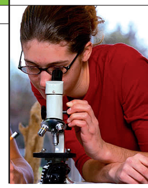
- On average, across OECD countries, 21% of students were enrolled in schools where school principals reported constant pressure from many parents who expected the school to set very high academic standards and to have the students achieve them. These reported pressures were highest in New Zealand, Sweden and Ireland *(Table 5.6)*.
- Parents surveyed in 16 countries reported generally to be positive and well-informed about their children's schools, but this varied considerably across countries. For example, fewer than 50% of parents in Germany, but over 90% in Poland and the partner county Colombia, reported that the school provided regular and useful information on their child's progress *(Table 5.7)*.

ACCOUNTABILITY POLICIES

The quest for performance standards has driven the creation of stronger and more visible systems of accountability for educational performance in many OECD countries. However, PISA 2006 shows that these vary in type and strength from country to country.

- On average across OECD countries, 65% of 15-year-olds were enrolled in schools where principals reported that performance data were tracked over time by an administrative authority. However, this ranged from over 90% in the United States, the United Kingdom, New Zealand, Mexico and Canada, as well as in the partner countries the Russian Federation and Kyrgyzstan, to over 80% in Australia, the Netherlands, Sweden, Iceland, Turkey and Luxembourg, as well as the partner countries Montenegro, Estonia, Brazil, Qatar, Croatia, Thailand, Tunisia, Jordan and Colombia, to less than 36% in Switzerland, Denmark, Italy and Japan *(Table 5.8)*.
- On average across OECD countries, 43% of 15-year-olds were enrolled in schools where principals reported that they used performance data in the evaluation of teacher performance. In the United Kingdom, Hungary and the Czech Republic, as well as the partner countries the Russian Federation, Kyrgyzstan, Azerbaijan, Romania, Indonesia, Israel, Qatar and Latvia, this was more than 90%. In Poland and Mexico, as well as the partner countries Thailand, Estonia, Lithuania, Jordan and Tunisia, it was still more than 80%. However, in Luxembourg, Switzerland and Greece this happened in less than 10% of the schools and in Finland, Belgium and Canada in less than 20% of the schools. In most countries, student performance data were used more frequently to evaluate the performance of teachers than of principals, sometimes considerably so *(Table 5.8)*.
- The use of performance data for decisions on instructional resource allocations tended to be less common. On average across OECD countries, 30% of 15-year-olds were enrolled in schools that reported such practices, but this varied from over 85% in the partner countries Chile and Indonesia to less than 10% in Greece, Iceland, Japan, Luxembourg, Finland, Hungary and the Czech Republic *(Table 5.8)*.

There remain diverging views on how results from evaluation and assessment can and should be used. Some see them primarily as tools to reveal best practices and identify shared problems in order to encourage teachers and schools to improve and develop more supportive and productive learning environments. Others extend their purpose to support contestability of public services or market-mechanisms in the allocation of resources, *e.g.* by making comparative results of schools publicly available to facilitate parental choice.



A widely debated question relates to the extent and ways in which information on student performance should be made available to parents and the public at large.

- On average across OECD countries, the majority of students (54%) were enrolled in schools, where school principals reported giving feedback to parents on their child's performance relative to the performance of other students at the school. In the Slovak Republic and the partner countries Indonesia, Azerbaijan, Romania, Serbia, Jordan, Kyrgyzstan and the Russian Federation, this held for more than 90% of students, while in Sweden, Finland and Italy this was only between 12 and 19% *(Table 5.9)*.
- In many OECD countries, the reporting of student performance information to parents is more commonly done relative to national benchmarks than relative to other students in the school. For example, in Sweden only 12% of 15-year-olds were enrolled in schools that reported performance data to parents relative to those of other students in the school, while 94% of 15-year-olds were enrolled in schools that reported data relative to national or regional standards or benchmarks. The pattern was similar in Japan, Finland, Norway, the United Kingdom and New Zealand, as well as in the partner country Estonia *(Table 5.9)*.
- It was far less common for parents to receive information on student performance in their school relative to students in other schools *(Table 5.9)*.

Providing assessment information to parents is one thing, but a more widely debated question in many countries is to what extent and how results from accountability systems should be made publicly available.

- In the United Kingdom and the United States, school principals of more than 90% of 15-year-olds enrolled in school reported that school achievement data were posted publicly; in the Netherlands, as well as the partner countries Montenegro and Azerbaijan, this was still the case for more than 80%. In contrast, in Finland, Belgium, Switzerland and Austria, as well as in the partner country Argentina, this was the case for less than 10% of the students and in Japan, Spain, Germany, Korea and Ireland, and in the partner countries/economies Macao-China, Uruguay, Indonesia and Tunisia, it held for less than 20% *(Table 5.8)*.

The PISA analysis showed considerable differences in the scores of students in countries where there were standards-based external examinations and where schools posted their results publicly. Some of these differences were associated with other features of schools and school systems that tended to go along with strong accountability arrangements and with the socio-economic background of students in schools that had such arrangements. However, once these factors are taken into account, there still remained a significant positive association between schools making their achievement data public and having stronger results.

SCHOOL AUTONOMY

Increased autonomy over many aspects of school management has become common over the past 20 years, with countries aiming to raise performance levels and responsiveness by devolving responsibilities. School principals in PISA reported varying amounts of control over the management of their schools. In most countries, for example, principals do not have much power over setting salaries.

In other aspects, the picture is more varied. Principals were asked to what extent schools decide on matters. They reported that:

- The appointment of teachers was solely a school responsibility for almost all schools in 12 countries, but for almost no schools in seven countries. At least 95% of students attend schools where principals reported that the school took sole responsibility for this in the Slovak Republic, New Zealand, the Netherlands, the Czech Republic, Iceland, Sweden, the United States and Hungary, and in the partner countries/economies Lithuania, Montenegro, Macao-China and Estonia. Fewer than 10% were enrolled in such schools in Turkey, Greece, Italy and Austria, and the partner countries Romania, Tunisia and Jordan *(Table 5.10)*.
- The setting of budgets was solely a school responsibility for schools enrolling at least 90% of students in the Netherlands and New Zealand and in the partner countries/economies Jordan, Macao-China, Indonesia and Hong Kong-China, but fewer than 10% in Poland and the partner country Azerbaijan *(Table 5.10)*.
- The determination of course content was solely a school responsibility in schools with 90% of students in Japan, Poland and Korea, as well as in the partner countries/economies Macao-China and Thailand. But in Luxembourg, Greece and Turkey and the partner countries Tunisia, Serbia, Montenegro, Uruguay, Croatia, Jordan and Bulgaria fewer than 10% of schools reported determining content solely on their own *(Table 5.10)*.

Within countries, students in schools that exercise greater autonomy do not on average get better results. However, students in countries where autonomy is more common tend to do better in the science assessment, regardless of whether or not they themselves are enrolled in relatively autonomous schools. This is true for the aspects of school autonomy in formulating the school budget and deciding on budget allocations within the school, even after accounting for socio-economic background factors as well as other school and system-level factors.

These results suggest that greater autonomy has a general impact at the system level, perhaps deriving from the greater independence of school managers in systems that authorise choice of responses to local conditions.

SCHOOL RESOURCES

PISA also considers the supply of human resources in term of teachers, as well as various kinds of material and educational resources. In PISA 2006, principals reported on:

- The impact of teacher shortages, which were most frequently reported as hindering instruction in Turkey, Luxembourg and Mexico and in the partner countries Jordan, Kyrgyzstan, Indonesia, Thailand, Azerbaijan and the Russian Federation. They were least commonly reported as hindering instruction in Poland, Portugal, Spain, Hungary, Japan and Korea, and in partner countries Slovenia, Serbia, Romania and Montenegro *(Table 5.13)*.
- The average number of students per teacher (this is not necessarily the class size average as it is taken across the whole school). This ratio was lowest (fewer than ten) in Portugal, Greece, Belgium, Italy and Luxembourg, and as well as in the partner country Azerbaijan, and highest (more than 20) in Mexico, as well as in the partner countries/economies Brazil, Chile, Colombia, Thailand and Macao-China *(Table 5.14)*.

- Shortfalls in educational resources were reported most frequently as hindering instruction in the partner countries Kyrgyzstan, Indonesia, Azerbaijan, Montenegro, the Russian Federation and Colombia, and least frequently in Switzerland, Japan and Australia, and the partner economy Chinese Taipei *(Table 5.15)*.
- Across OECD countries 29% of students reported that they had four hours or more of regular science lessons at school per week. This varied from around 11% or less in Norway and Sweden and the partner country Croatia to over 60% in New Zealand and the United Kingdom *(Table 5.17)*.

Resources such as an adequate supply of teachers and quality of educational resources at school are associated with positive student outcomes, but many of these effects are not significant after taking account of the fact that students with a more advantaged socio-economic background tend to get access to more educational resources. After accounting for this, there remains a significant association between several aspects of learning time as well as school activities to promote students' learning of science and performance. Science performance is on average higher in schools with longer instruction hours *(Table 5.19g)*.

EDUCATIONAL QUALITY AND EQUITY: FACTORS ASSOCIATED WITH STUDENT PERFORMANCE

A number of school factors measured by PISA show a relationship with performance, measured in a model that includes the most important school and system-level factors, even if PISA cannot establish the causal nature of this relationship.

School factors, based on schools principals' reports, that were associated with performance even after accounting for socio-economic background

- The practice of ability grouping for all subjects within schools (students in schools that practised ability grouping for all subjects within schools scored 4.5 points lower than students in schools that practised no ability grouping or ability grouping only for some subjects, all other things being equal) *(Table 5.19g)*.
- High academic selectivity of school admittance (students in schools in which academic records or feeder school recommendations were a prerequisite for school admittance scored 14.4 points higher than students in schools that applied a moderate selective admittance policy, all other things being equal) *(Table 5.19g)*.
- Whether the school's performance data were posted publicly (students in schools that posted performance data publicly scored 3.5 points higher compared with students in schools that did not post performance data publicly, all other things being equal) *(Table 5.19g)*.
- The school average of the time students invest in learning for science, mathematics and language at school (students in schools with one additional average hour per week scored 8.8 points higher, all other things being equal), out-of school lessons (students in schools with one additional average hour per week scored 8.6 points lower, all other things being equal), and self-study (students in schools with one additional average hour per week scored 3.1 points higher, all other things being equal) *(Table 5.19g)*.

- School activities to promote students' learning of science (one additional unit of this index was equivalent to an advantage of 2.9 score points in student performance, all other things being equal) *(Table 5.19g)*.

System factor that was associated with performance even after accounting for socio-economic background

- Education systems where schools reported a higher degree of autonomy in budgeting (students in education systems with one additional standard deviation on the index of autonomy in budgeting score 25.7 points higher, all other things being equal) *(Table 5.19g)*.

School factors that were associated with performance only before taking socio-economic background into account

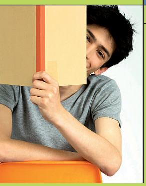
- The level of funding from government (students in schools with an additional 10% of public funding scored 2 points lower, all other things being equal) *(Table 5.19g)*.
- Whether there is one or more other schools in the area that compete for the students (students in schools competing with other schools scored 6.0 points higher compared to students in schools not competing with other schools for students, all other things being equal) *(Table 5.19g)*.
- The lack of qualified teachers hindering instruction (students in schools with one additional unit of this index scored 3.5 points lower, all other things being equal) *(Table 5.19g)*.
- The quality of educational resources at the school (students in schools with one additional unit of this index scored 3.9 points better, all other things being equal) *(Table 5.19g)*.

A larger question is whether specific policy interventions responding to these effects are likely to be overshadowed by the high number of other influences on student performance, whether in terms of the multiple aspects of school learning environment and organisation not covered by any given policy or in terms of contextual influences including the socio-economic background of the students attending each school.

An overall measure of the combined effect of these factors suggests that about a quarter of the variation in students' science performance across OECD countries can be associated with the ways in which these factors vary across countries and across schools, once the variation explained by socio-economic differences has been taken into account. However, most of this effect is not attributable to the school factors acting wholly independently of socio-economic factors, but rather a combined effect of the two. For example, schools that have longer learning hours may also enrol more socio-economically advantaged students, and while the higher predicted performance of such students can only partially account for the superior performance of such schools, the effects of longer hours and higher intake may appear to reinforce each other. At a policy level, this suggests that the potential for improving results through such school factors needs to be considered in combination with the extent to which schools with favourable characteristics are being accessed mainly by more advantaged students. The challenge is to find ways of spreading such characteristics to a wider section of the student population.

A crucial question for school systems is whether there are policies that can systematically improve equity, without threatening quality. In some cases, this requires difficult decisions about where to deploy finite educational resources. But some routes to improvement, such as accountability arrangements, are less linked to resources than to process. In such cases, there are opportunities to improve results across the board.

A more complex issue is the effects of selection and differentiation. It is clearly not possible for every school to raise its students' performance by becoming more selective about its intake. A clear-cut finding from PISA is that early differentiation of students by school is associated with wider than average socio-economic disparities and not with better results overall. There has been a trend among OECD countries to delay or reduce the separation of students early in secondary education, with Spain and Poland being the most recent examples.



Reading performance

READING PERFORMANCE IN PISA 2006 AND CHANGES SINCE PISA 2000

PISA 2000 looked in detail at reading performance, while PISA 2003 and PISA 2006 provided briefer updates. It is now possible to see changes in reading performance over six years. PISA measures *reading literacy* in terms of students' ability to use written information in situations that they encounter in their lives. This goes beyond the traditional notion of decoding information and literal interpretation. Students are shown different kinds of text, and required to retrieve information, to interpret the text and to reflect on and evaluate what they read.

READING PROFICIENCY

Reading literacy in PISA is not an all or nothing measure: rather, students are placed at different levels of proficiency according to the difficulty of task that they can complete. Easier tasks require basic handling of simple texts, with harder ones involving increasing complexity and less explicit information.

A minority of students (8.6% on average across OECD countries) were proficient at the highest reading level, Level 5. These students are capable of sophisticated, critical thinking. In PISA 2006 :

- Korea had the largest number of students at Level 5 (22%), followed by Finland and New Zealand (over 15%), Canada (14%) and Ireland, Poland and Belgium and the partner economy Hong Kong-China (over 11%) *(Table 6.1a)*.
- At the other extreme, fewer than 1% were proficient at Level 5 in Mexico and in the partner countries/economies Indonesia, Kyrgyzstan, Azerbaijan, Tunisia, Jordan, Thailand, Serbia, Romania and Montenegro it was less than one-half of a percent *(Table 6.1a)*.
- Countries with large numbers at Level 5 varied considerably in terms of how many students were at low proficiency levels, and therefore their mean performance. For example, Finland and New Zealand had 17% and 16% respectively at Level 5, but New Zealand had 15% at Level 1 or below compared to just 5% in Finland. Finland's average score of 547 was well above New Zealand's of 521 *(Tables 6.1a, 6.1c)*.

Most students (80% across OECD countries) were capable of basic reading tasks at Level 2 – locating straightforward information, making low-level inferences of various types, working out what a well-defined part of a text means and using some outside knowledge to understand it. Longitudinal follow-up studies in Australia, Canada and Denmark suggest that the minority of students not capable of these tasks, those classified either at Level 1 or below, are likely to face difficulty using reading materials to fulfil their goals and to acquire knowledge *(Box 6.1)*.

Table 4 **Range of rank of countries/economies on the reading scale**

- Statistically significantly above the OECD average
- Not statistically significantly different from the OECD average
- Statistically significantly below the OECD average

	Reading scale					
			Range of rank			
			OECD countries		All countries/economies	
	Reading score	S.E.	Upper rank	Lower rank	Upper rank	Lower rank
Korea	556	(3.8)	1	1	1	1
Finland	547	(2.1)	2	2	2	2
Hong Kong-China	536	(2.4)			3	3
Canada	527	(2.4)	3	4	4	5
New Zealand	521	(3.0)	3	5	4	6
Ireland	517	(3.5)	4	6	5	8
Australia	513	(2.1)	5	7	6	9
Liechtenstein	510	(3.9)			6	11
Poland	508	(2.8)	6	10	7	12
Sweden	507	(3.4)	6	10	7	13
Netherlands	507	(2.9)	6	10	8	13
Belgium	501	(3.0)	8	13	10	17
Estonia	501	(2.9)			10	17
Switzerland	499	(3.1)	9	14	11	19
Japan	498	(3.6)	9	16	11	21
Chinese Taipei	496	(3.4)			12	22
United Kingdom	495	(2.3)	11	16	14	22
Germany	495	(4.4)	10	17	12	23
Denmark	494	(3.2)	11	17	14	23
Slovenia	494	(1.0)			16	21
Macao-China	492	(1.1)			18	22
Austria	490	(4.1)	12	20	15	26
France	488	(4.1)	14	21	18	28
Iceland	484	(1.9)	17	21	23	28
Norway	484	(3.2)	16	22	22	29
Czech Republic	483	(4.2)	16	22	22	30
Hungary	482	(3.3)	17	22	23	30
Latvia	479	(3.7)			24	31
Luxembourg	479	(1.3)	20	22	26	30
Croatia	477	(2.8)			26	31
Portugal	472	(3.6)	22	25	29	34
Lithuania	470	(3.0)			30	34
Italy	469	(2.4)	23	25	31	34
Slovak Republic	466	(3.1)	23	26	31	35
Spain	461	(2.2)	25	27	34	36
Greece	460	(4.0)	25	27	34	36
Turkey	447	(4.2)	28	28	37	39
Chile	442	(5.0)			37	40
Russian Federation	440	(4.3)			37	40
Israel	439	(4.6)			38	40
Thailand	417	(2.6)			41	42
Uruguay	413	(3.4)			41	44
Mexico	410	(3.1)	29	29	41	44
Bulgaria	402	(6.9)			42	50
Serbia	401	(3.5)			44	48
Jordan	401	(3.3)			44	48
Romania	396	(4.7)			44	50
Indonesia	393	(5.9)			44	51
Brazil	393	(3.7)			46	51
Montenegro	392	(1.2)			47	50
Colombia	385	(5.1)			48	53
Tunisia	380	(4.0)			51	53
Argentina	374	(7.2)			51	53
Azerbaijan	353	(3.1)			54	54
Qatar	312	(1.2)			55	55
Kyrgyzstan	285	(3.5)			56	56

Source: OECD PISA 2006 database. Figure 6.8b, *PISA 2006: Science Competencies for Tomorrow's World.*
StatLink http://dx.doi.org/10.1787/142046885031

In PISA 2006:

- In every OECD country except Mexico, Turkey, the Slovak Republic and Greece, at least 73% of students were at Level 2 or above *(Table 6.1a)*.
- Countries with the fewest students below Level 2 were: Finland (5%), Korea (6%) and the partner economy Hong Kong-China (7%). Between 10 and 15% of students were below Level 2 in Canada, Ireland, Australia, New Zealand, the Netherlands and Sweden, and the partner countries/economies Macao-China, Estonia, Liechtenstein and Chinese Taipei *(Table 6.1a)*.
- On the other hand, a majority of students were at Level 1 or below in partner countries Kyrgyzstan, Qatar, Azerbaijan, Tunisia, Indonesia, Argentina, Montenegro, Colombia, Brazil, Romania, Serbia and Bulgaria *(Table 6.1a)*.

AVERAGE READING SCORES

In reading, as with science, scores for each country can be summed up in a mean score. Again, with some countries with similar mean scores, it is not possible to say with confidence which is the higher, so rankings can only be reported within a range.

In PISA 2006:

- Korea had significantly higher performance in reading than any other country, including Finland, the top performer in previous PISA reading surveys. Korea's mean score, 556 score points, was nearly one proficiency level above the OECD average of 492 score points. Finland was a clear second with 547 points and partner economy Hong Kong-China a clear third with 536 points *(Table 6.1c)*.
- Canada and New Zealand had mean reading scores between 520 and 530, and the following other countries scored significantly above the OECD average: Ireland, Australia, Poland, Sweden, the Netherlands, Belgium and Switzerland as well as the partner countries Liechtenstein, Estonia and Slovenia *(Table 6.1c)*.

CHANGES SINCE PISA 2000

It is now possible to track change in reading performance over a six-year period. The results suggest that, across the OECD area, reading performance has generally remained flat between PISA 2000 and PISA 2006. This needs to be seen in the context of significant rises in expenditure levels. Between 1995 and 2004 expenditure per primary and secondary student increased by 39% in real terms, on average across OECD countries *(Table 2.6)*. In the short period between 2000, when the first PISA assessment was undertaken and 2004, the average increase amounted to 22% and in six countries to between 30 and 61%. However, two OECD countries (Korea and Poland) and five partner countries/economies (Chile, Liechtenstein, Indonesia, Latvia and Hong Kong-China) have seen significant rises in reading performance since PISA 2000.

- Korea increased its reading performance between PISA 2000 and PISA 2006 from an already high level by 31 score points, thus reaching the highest reading performance

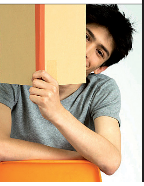
among all participating countries – even surpassing Finland, the performance of which remained stable at a high level. Korea achieved this increase mainly by significantly raising performance standards among the better performing students, while the performance at the lower end of the distribution remained essentially unchanged. Indeed, at the 95th percentile, the point above which the 5% best performing students score, reading performance rose by 59 score points, to 688 score points, at the 90th percentile still by 55 score points and at the 75th percentile by 44 score points. In contrast, there was no significant change at the 5th and 10th percentiles for Korea *(Tables 6.3a, 6.3c)*.

- Hong Kong-China is another country that has seen a significant increase, by 11 score points since PISA 2000, from an already high level of reading performance, reaching 536 score points in PISA 2006. Here the change was mainly driven by improvements among the lowest-performing students, with the 5th percentile rising by 21 score points *(Tables 6.3a, 6.3c)*.

- Poland increased its reading performance by 17 score points between PISA 2000 and PISA 2003 and another 11 score points between PISA 2003 and PISA 2006 and now performs at 508 score points, for the first time clearly above the OECD average. Between these two assessments, Poland raised its average performance mainly through increases at the lower end of the performance distribution. As a result, in PISA 2003 fewer than 5% of students fell below performance standards that had not been reached by the bottom 10% of Polish students in PISA 2000. Since PISA 2003, performance in Poland has risen more evenly across the performance spectrum *(Tables 6.3a, 6.3c)*.

- The other countries that have seen significant performance increases in reading between PISA 2000 and PISA 2006 – Chile (33 score points), Liechtenstein (28 score points), Indonesia (22 score points) and Latvia (21 score points) – perform, with the exception of Liechtenstein, significantly below the OECD average *(Tables 6.3a, 6.3c)*.

A number of countries saw a decline in their reading performance between PISA 2000 and PISA 2006, comprising nine OECD countries (in descending order) – Spain, Japan, Iceland, Norway, Italy, France, Australia, Greece, Mexico and the partner countries, Argentina, Romania, Bulgaria, the Russian Federation and Thailand. In France, Japan and Mexico, as well as the partner country Thailand, for example, performance declined slightly at the higher end of the student performance distribution, but declined markedly at the lower end. It is noteworthy that, among the countries with above-average performance levels only Australia has seen a statistically significant decline in their students reading performance, by 15 score points, which is attributable to a decline at the higher end of the performance spectrum. The other countries with a significant decline in reading performance between PISA 2000 and PISA 2006, all perform around or below the OECD average level. Of this latter group, Japan and Iceland previously performed above the OECD average. For the Czech Republic, the better performers have seen improvements, while the standards declined at the lower end of the performance distribution. In Switzerland, performance standards rose at the lower end of the distribution *(Tables 6.3a, 6.3c)*.



GENDER DIFFERENCES

In all OECD countries in PISA 2006, females perform better in reading on average than males. In PISA 2006:

- In twelve countries, the gap was at least 50 score points. In Greece and Finland, females were 57 and 51 points ahead respectively, and the gap was 50 to 66 points in the partner countries Qatar, Bulgaria, Jordan, Thailand, Argentina, Slovenia, Lithuania, Kyrgyzstan, Latvia and Croatia *(Table 6.1c)*.
- The smallest gender gaps among OECD countries were in the Netherlands and the United Kingdom (24 and 29 points, respectively) *(Table 6.1c)*.

In Korea, males increased their performance by 20 score points between 2000 and 2006, but females at twice that rate. In Finland and Korea, over 60% of females were at high levels of reading proficiency, Level 4 or 5, compared to just over one-third (36%) of boys in Finland and below one-half (47%) of boys in Korea *(Table 6.1b, 6.3a)*.

Mathematics performance

MATHEMATICS PERFORMANCE IN PISA 2006 AND CHANGES SINCE PISA 2003

PISA 2003 looked in detail at mathematics performance. PISA 2006 provides a briefer update, so it is now possible to see change in mathematics performance over three years.

PISA uses a concept of mathematical literacy that is concerned with the capacity of students to analyse, reason and communicate effectively as they pose, solve and interpret mathematical problems in a variety of situations involving quantitative, spatial, probabilistic or other mathematical concepts.

MATHEMATICS PROFICIENCY

In order to perform the hardest mathematics tasks in PISA, students must put together complex elements of a question, use reflection and creativity to solve unfamiliar problems and engage in some form of argument, often in the form of an explanation. Only 13% of students were rated at the top two proficiency levels, Levels 5 and 6 in PISA 2006.

- The highest percentage of students at Levels 5 and 6 were found in Korea (27%) and the partner Chinese Taipei (32%). Finland, Switzerland, Belgium and the Netherlands all had more than 20% of students at these top levels *(Table 6.2a)*.
- With the exception of Mexico and Turkey, at least 5% of students in each OECD country reached Level 5 or 6 *(Table 6.2a)*.

Level 2 is considered a baseline level of mathematics proficiency at which students begin to demonstrate the kind of skills that enable them to use mathematics actively. Level 2 tasks require students to recognise mathematical problems requiring only direct inferences, to extract information from a single source and to make literal interpretations of their results. Over three-quarters (78.7%) of students on average across OECD countries were proficient at least at this level.

- In Finland and Korea, and the partner Hong Kong-China, more than 90% of students performed at or above Level 2 *(Table 6.2a)*.
- In every OECD country except Mexico, Turkey, Italy, Greece and Portugal at least 70% of students were at Level 2 or above *(Table 6.2a)*.
- The proportion falling short of this level varied widely across countries, from 6% in Finland to 56% in Mexico and, among partner countries/economies, from 10% in Hong Kong-China to 89% in Kyrgyzstan *(Table 6.2a)*.

AVERAGE MATHEMATICS SCORES

In mathematics, as with reading and science, scores for each country can be summed up in a mean score. Again, with some countries with similar mean scores, it is not possible to say with confidence which is the higher, so rankings can only be reported within a range *(Figure 6.20b).*

In PISA 2006:

- Finland and Korea, and the partners Chinese Taipei and Hong Kong-China, outperformed all other countries *(Table 6.2c)*.
- Other countries with mean performances significantly above the OECD average were the Netherlands, Switzerland, Canada, Japan, New Zealand, Belgium, Australia, Denmark, the Czech Republic, Iceland and Austria, and the partner countries/economies Macao-China, Liechtenstein, Estonia, and Slovenia *(Table 6.2c)*.

CHANGES SINCE PISA 2003

It is only possible so far to compare mean scores in mathematics over a three-year period, from PISA 2003 to PISA 2006. For most countries, performance in mathematics remained broadly unchanged between PISA 2003 and PISA 2006. However, for a few countries there were notable performance differences.

Two OECD countries, Mexico and Greece, and two partner countries, Indonesia and Brazil, show higher performance in PISA 2006 than in PISA 2003 *(Tables 6.3b, 6.3d)*.

- In Mexico mathematics performance was 20 score points higher in PISA 2006 than in PISA 2003 but at 406 score points it is still well below the OECD average. In reading, Mexican females performed significantly higher in PISA 2006 than in PISA 2003, while the performance of males remained unchanged; in mathematics both males and females saw similar performance increases between the two surveys *(Tables 6.3b, 6.3d)*.
- In Greece, mathematics performance was 14 score points higher in PISA 2006 than in PISA 2003. Most of the increase was driven in the lower and middle range of the performance distribution. It is also noteworthy that the performance difference is mainly due to the significantly higher performance of females in PISA 2006 *(Tables 6.3b, 6.3d)*.
- In Indonesia, mathematics performance was 31 score points higher in PISA 2006 than in PISA 2003, which was, as in the case of reading, largely driven by the higher performance of males in PISA 2006 *(Tables 6.3b, 6.3d)*.
- In Brazil, mathematics performance was 13 score points higher in PISA 2006 than in PISA 2003, which was mainly driven by performance improvements at the lower end of the distribution *(Tables 6.3b, 6.3d)*.

Mathematics performance in PISA 2006 was significantly lower in France (15 score points – essentially because of significantly lower performance at the lower end of the performance distribution), Japan (11 score point), Iceland (10 score points) and Belgium (9 score points). Among the partner countries, Liechtenstein performed 11 score points lower in PISA 2006 than in PISA 2003 *(Tables 6.3b, 6.3d)*.

Table 5 Range of rank of countries/economies on the mathematics scale

- Statistically significantly above the OECD average
- Not statistically significantly different from the OECD average
- Statistically significantly below the OECD average

	Mathematics scale					
			Range of rank			
			OECD countries		All countries/economies	
	Mathematics score	S.E.	Upper rank	Lower rank	Upper rank	Lower rank
Chinese Taipei	549	(4.1)			1	4
Finland	548	(2.3)	1	2	1	4
Hong Kong-China	547	(2.7)			1	4
Korea	547	(3.8)	1	2	1	4
Netherlands	531	(2.6)	3	5	5	8
Switzerland	530	(3.2)	3	6	5	9
Canada	527	(2.0)	3	6	5	10
Macao-China	525	(1.3)			7	11
Liechtenstein	525	(4.2)			5	13
Japan	523	(3.3)	4	9	6	13
New Zealand	522	(2.4)	5	9	8	13
Belgium	520	(3.0)	6	10	8	14
Australia	520	(2.2)	6	9	10	14
Estonia	515	(2.7)			12	16
Denmark	513	(2.6)	9	11	13	16
Czech Republic	510	(3.6)	10	14	14	20
Iceland	506	(1.8)	11	15	16	21
Austria	505	(3.7)	10	16	15	22
Slovenia	504	(1.0)			17	21
Germany	504	(3.9)	11	17	16	23
Sweden	502	(2.4)	12	17	17	23
Ireland	501	(2.8)	12	17	17	23
France	496	(3.2)	15	22	21	28
United Kingdom	495	(2.1)	16	21	22	27
Poland	495	(2.4)	16	21	22	27
Slovak Republic	492	(2.8)	17	23	23	30
Hungary	491	(2.9)	18	23	24	31
Luxembourg	490	(1.1)	20	23	26	30
Norway	490	(2.6)	19	23	25	31
Lithuania	486	(2.9)			27	32
Latvia	486	(3.0)			27	32
Spain	480	(2.3)	24	25	31	34
Azerbaijan	476	(2.3)			32	35
Russian Federation	476	(3.9)			32	36
United States	474	(4.0)	24	26	32	36
Croatia	467	(2.4)			35	38
Portugal	466	(3.1)	25	27	35	38
Italy	462	(2.3)	26	28	37	39
Greece	459	(3.0)	27	28	38	39
Israel	442	(4.3)			40	41
Serbia	435	(3.5)			40	41
Uruguay	427	(2.6)			42	43
Turkey	424	(4.9)	29	29	41	45
Thailand	417	(2.3)			43	46
Romania	415	(4.2)			43	47
Bulgaria	413	(6.1)			43	48
Chile	411	(4.6)			44	48
Mexico	406	(2.9)	30	30	46	48
Montenegro	399	(1.4)			49	50
Indonesia	391	(5.6)			49	52
Jordan	384	(3.3)			50	52
Argentina	381	(6.2)			50	53
Colombia	370	(3.8)			52	55
Brazil	370	(2.9)			53	55
Tunisia	365	(4.0)			53	55
Qatar	318	(1.0)			56	56
Kyrgyzstan	311	(3.4)			57	57

Source: OECD PISA 2006 database. Figure 6.20b, *PISA 2006: Science Competencies for Tomorrow's World*.
StatLink http://dx.doi.org/10.1787/142046885031

GENDER DIFFERENCES

In 35 of the 57 countries participating in PISA 2006, males performed significantly ahead of females. In 21 there was no significant difference, and in the partner country Qatar, females outperformed males. In 2006:

- Overall gender differences in mathematics were less than a third as large as for reading, 11 points on average across OECD countries. This has not changed since 2003 *(Tables 6.2b, 6.2c)*.
- In 2006, males outperformed females by above 20 points only in Austria (23 points) and the partner countries Chile (28 points) and Colombia (22 points) *(Table 6.2c)*.
- Males also had an above-average advantage of 12 to 20 points in Japan, Germany, the United Kingdom, Italy, Luxembourg, Portugal, Australia, the Slovak Republic, Canada, Switzerland and the Netherlands, and the partner countries/economies Brazil, Indonesia, Hong Kong-China, Tunisia, Croatia, Chinese Taipei, Uruguay and Argentina *(Table 6.2c)*.

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