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A Profile of Student Performance in Environmental Science and Geoscience

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MEASURES OF PERFORMANCE IN ENVIRONMENTAL SCIENCE AND GEOSCIENCE

A solid education in environmental science and geoscience can help students in their future academic and professional careers. Equally important, it will help them become capable citizens ready to make personal and social decisions based on scientific evidence about future environmental challenges. It is therefore worth asking: What do students know about environmental science and geoscience? What can they do with this knowledge? How competent are they in explaining scientific evidence and using scientific evidence in environmental science and geoscience?

This chapter defines and reports performance on two indices within the context of PISA 2006: an environmental science performance index and a geoscience performance index. While the environmental science performance index refers to a broad concept, the geoscience performance index focuses on the composition, structure, and other physical aspects of the earth. As such, the geoscience index is based on a subset of the questions on which the broader environmental science performance index is constructed. The chapter also explores the relationship between environmental science performance and some student characteristics such as gender, immigrant background and socio-economic background.

MAIN RESULTS OF THIS CHAPTER

Results on the environmental science and geoscience performance indices are presented in terms of the percentage of students reaching different levels of proficiency, which describe what students generally know and can do, as well as in terms of mean country scores. Education systems need both to ensure that the general population has at least some proficiency in this area, and that some students reach a high level of proficiency. The results show that:

- A minority of students do not reach the most basic level of proficiency required of them in order to understand and respond to environmental issues as future citizens. In some countries almost all students reach a basic level of proficiency: only 10% of students or fewer are unable to provide the correct answer to the easiest environment-related questions in PISA in Canada, Finland and partner countries and economies Chinese Taipei, Estonia, Hong Kong-China and Liechtenstein. On the other hand, 20% or more are unable to answer such questions in five OECD countries and in most of the partner countries.
- Fewer than one in five students across OECD countries reach the highest level of proficiency. However, between a quarter and just over a third of students reach this level in Canada, Finland, Japan, Korea and partner countries and economies Chinese Taipei, Estonia, Hong Kong-China and Slovenia. In most OECD countries there is a pool of at least 15% of students proficient at this level.
- Some countries have small but significant gender differences in proficiency in both environmental science and geosciences, with all significant differences in OECD countries favouring males.

ENVIRONMENTAL SCIENCE AND GEOSCIENCE PERFORMANCE INDICES IN PISA 2006

A definition of performance in environmental science and geoscience within the PISA 2006 science framework

Following the PISA 2006 definition of scientific literacy (OECD, 2006), this report defines environmental science performance as:

- *Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain biological and geoscience phenomena related to the environment, and to draw evidence-based conclusions about the environment.* For example, when individuals read about global warming, can they separate *environmental scientific-related* from *non-scientific* aspects of the text, and can they apply knowledge and justify personal decisions?

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- *Understanding of the characteristic features of environmental science as a form of human knowledge and inquiry.* For example, do individuals know the difference between evidence-based explanations and personal opinions about the environment?
- *Awareness of how environmental science can shape our use of earth's resources, policies about environmental sustainability, and future responsibility towards environmental quality*. For example, are individuals aware of environmental changes and the effects of those changes on economic and social stability?
- *Willingness to engage with environmental science, and with the ideas of environmental science, as a reflective citizen and consumer of geological and biological resources*. This addresses the value students place on environmental science, both in terms of topics and in terms of the scientific approach to understanding the earth's environment and solving environmental issues.

Geoscience is a discipline within environmental sciences, one that focuses on earth systems (*e.g.* their structure, changes, history, and place in the solar system). As with environmental science, geoscience encompasses general and specific scientific knowledge and its use, awareness and engagement with the issues and uses of science.

While PISA was not designed to be an assessment specifically on environmental science and geoscience, out of the 108 questions used in the PISA 2006 science assessment, 24 were related to environmental science (of these 14 focus on geoscience). This report uses student responses to these questions to assess environmental science and geoscience performance. These environmental science questions span most of the aspects identified in the PISA 2006 framework for assessing scientific literacy. Table 2.1 displays these 24 questions within the contexts, knowledge areas, and competencies in the PISA 2006 science framework.

Table 2.1

The environmental science performance index within the PISA science framework

Context: Social (11 questions, 46%) — Competency: Explaining phenomena scientifically (16 questions, 67%)

Context: Global (13 questions, 54%) — Competency: Using scientific evidence (8 questions, 33%)

Knowledge/Area of application:	Health	Natural resources	Environment	Hazard	Frontiers of science and technology	Total (quesrions)	Total (%)
Of science: "Physical systems"		1 global		1 social/global		2	8%
Of science: "Living systems"		2 social	2 social	1 global	1 global; 1 global	7	29%
Of science: "Earth and space systems"		1 social, 1 global	1 social, 2 global	1 social, 1 global	1 global	8	33%
Of science: "Technology systems"		1 global				1	4%
About science: "Scientific enquiry"			1 social			1	4%
About science: "Scientific explanations"			1 social, 3 global	1 social		5	21%
Total (questions)	**0**	**6**	**10**	**5**	**3**	**24**	
Total (%)	**0%**	**25%**	**42%**	**21%**	**13%**		

StatLink http://dx.doi.org/10.1787/562200685357

These environment related questions were set within contexts that are both positive (potential solutions to specific issues) and negative (emerging environmental hazards). They include contexts such as the use of disposal materials, biodiversity, control of pollution, costal erosion or climate change (Table 1.2 in Chapter 1).

Within these contexts, these PISA science questions included biological and geological questions (see Table 1.1 in Chapter 1 for a full description of the knowledge of science categories included in the PISA 2006 science framework). In this report, the scientific knowledge categories included in the environmental science performance index are: structure, energy and change in earth systems, the history of the earth, earth in space, and populations, ecosystems, and the biosphere. Of these, the geoscience performance index focuses on those related to earth.

Of the three competencies identified in the PISA 2006 science framework, the science questions included in the environmental science and geoscience indices cover two: *explaining phenomena scientifically* and *using scientific evidence*. This represents a limitation of the performance concept utilised in this report when compared with PISA science literacy. As a concept of performance however it still captures many of the issues covered by PISA.

Constructing the environmental science and geoscience performance indices and proficiency levels

The PISA 2006 science units were constructed under the guidance of an international expert panel using expertise from participating countries to ensure coverage of the various aspects of the science framework: contexts, competencies and knowledge. The science units were based on material submitted by participating countries. In PISA, each assessment or test unit is made up of some type of stimulus, which is followed by a number of questions (also known as test items). Each PISA test item can be characterised by its context, the competency it demands, and the knowledge it assesses.

Using the techniques of item response modelling, a description of which can be found in Appendix B, two performance indices were constructed from these questions, one for environmental science and the other for geoscience. The environmental performance science index used all 24 questions while the geoscience performance index used only the 14 questions related to geoscience. Hence geoscience is a sub-index of the broader environmental science performance index. Twenty-four is a relatively small number of questions, but other indices have used similarly small numbers of items. In comparison, in PISA 2006 the science subscale with the lowest number of items, *identifying scientific issues*, was based on 24 questions and in PISA 2003, the mathematics subscale *problem solving* was based on 19 questions. Appendix B describes in detail the limitations of these measures of environmental science and geoscience performance.

Constructing adjusted proficiency levels for the environmental science and geoscience performance indices

For the purpose of describing what students know and can do in terms of environmental science and geoscience, four proficiency levels were also developed. Whenever possible, the design of these proficiency levels followed the techniques used to develop the proficiency levels for science in PISA 2006. There are, however, two important differences between the PISA 2006 science proficiency levels and the proficiency levels described in this report.

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The environmental science and geoscience performance indices used fewer test items than the overall PISA 2006 science scale. In addition, the test items used to develop the new indices did not span the whole range of proficiency levels used in reporting science literacy in PISA 2006. For example, there were no environment-related questions in the lowest level of science proficiency (Level 1). The process resulted in four levels of proficiency for both environmental science and geoscience. To distinguish them from the proficiency levels in PISA 2006, this report refers to proficiency Levels A (the highest level) to D (the lowest).

Table 2.2

Proficiency levels on the environmental science and geoscience performance indices

General proficiencies students should have at each level	Tasks a student should be able to do	Examples from released questions
LEVEL A Item difficulty score greater than 1		
Student at this level are able to thoroughly explain environmental processes and phenomena. They demonstrate an ability to compare and differentiate among competing explanations by examining supporting evidence and drawing from their knowledge. They are able to synthesise answers from multiple sources.	▪ Read and interpret data on evolution. ▪ Given a set of data, test competing hypotheses and identify errors. ▪ Explain multi-trophic interactions and effect of biological and physical factors on organisms. ▪ Given an environmental problem, provide environmentally sound solutions.	**GREENHOUSE** Question 5 (S114 Q05t), **WIND FARMS** Question 4 (S529 Q04)
LEVEL B Item difficulty score between 0 and 1		
Students at this level are able to answer environment questions with little information provided. They are able to recognise various elements of the ecosystem and understand their interactions. They show knowledge and understanding of environmental concepts such as ecosystem balance, effect of human intervention on the environment, species distribution and survival, natural sources of energy, climate change, food chains, etc.	▪ Given a set of similar or closely related choices, determine the most adequate explanation to specific evidence. ▪ Given specific evidence, determine some causes and predictable effects. ▪ Given information on one element, identify other possibly related elements. ▪ Given different elements of the ecosystems, provide some possible interactions and consequences.	**GREENHOUSE** Question 4 (S114 Q04) **FIT FOR DRINKING** Question 1 (S409 Q01)
LEVEL C Item difficulty score between -0.7 and 0		
Students at this level show a fair understanding of environmental cycles (water, gases, energy, living organisms), energy sources and sources of pollution. They are able to link evidence to causes and explain basic biotic-abiotic interactions, when adequate information is provided.	▪ Locate relevant information in a body of text. ▪ Given specific information, choose between appropriate and inappropriate conclusions. ▪ Choose between a diverse set of approaches or phenomena based on basic knowledge in environment. ▪ Identify common sources of pollution and prevention strategies. ▪ Given adequate information, link different parts of environmental cycles.	**ACID RAIN** Question 2 (S485 Q02) **GREENHOUSE** Question 3 (S114 Q03)
LEVEL D Item difficulty score less than -0.7		
Students at this level are able to interpret a graph or figure when given appropriate cues. They show basic knowledge of common environmental processes.	▪ Given clear figures or graphs, describe differences and similarities between given environmental parameters. ▪ Given adequate and complete historical information, can extract causal relationship between environmental processes occurring at different times. ▪ Given specific evidence and a discrete set of environmental phenomena, link the causal phenomenon to the evidence using logic and basic knowledge of environmental processes.	**GRAND CANYON** Question 3 (S426 Q03) and Question 5 (S426 Q05)

StatLink http://dx.doi.org/10.1787/562200685357

Table 2.2 shows how competencies across the three criteria increase from Level D to Level A. For example, students proficient at Level D can correctly answer questions in which most of the information needed to give a correct answer is included within the question, but they generally do not have enough environmental science and geoscience knowledge to answer questions where little or not all necessary information is given. Nor can they generally answer questions that require an understanding of the interrelations of an ecosystem, or questions which require a significant synthesis of environmental or geoscience knowledge and its use in solving an unfamiliar problem. Students at Level D should be able to interpret a figure or graph representing an environmental issue or phenomenon, but are capable of understanding only the most common environmental processes.

Level D does not establish a threshold for environmental science or geoscience illiteracy. Rather, it defines a baseline level of proficiency at which students begin to demonstrate the environmental science and geoscience that will enable them to participate effectively and productively in life situations related to environmental science and geoscience.

Students scoring below Level D are unable to demonstrate science competencies in situations required by the easiest PISA tasks that relate to the environment. Students at this level are not able to interpret a graph or figure when given appropriate cues, nor are they able to show basic knowledge of common environmental processes. For example, they cannot describe differences and similarities between given environmental parameters, or give adequate and complete historical information, or extract causal relationships between environmental processes occurring at different times.

At the other end, students proficient at Level A can correctly answer more complex problem-solving questions by using considerable knowledge in environmental science and geoscience and being able to understand, explain and interpret complex environmental processes such as acid rain, population dynamics and species evolution. Levels B and C fall between Levels A and D.

Examples of tasks that students can do at each of the proficiency levels

Some of the questions used to build the environmental science and geoscience performance indices have been publicly released (see next pages). As well as illustrating the type of issues students confront in completing the PISA assessment, they show what students can do at different proficiency levels. For example, Questions 3 and 5 of the *GRAND CANYON* unit dealt with basic environmental issues, namely the degradation of rocks due to water freezing and fossil formation. Both questions tackled basic processes and were multiple-choice with a clear distinction between the choices. For all of this, they belong to Level D.

Another example of a PISA science question related to an environmental topic – in this case pertaining to geoscience – is the unit on the *GREENHOUSE EFFECT* of carbon dioxide emissions and the average temperature of the earth's atmosphere from 1860 to 1990. Question 3, classified as Level C, required students to read a graph and relate different phenomena to each other. Students had to understand that the increase in temperature and CO_2 are correlated and affect each other. Question 4, classified as Level B, challenged the capacity of students further, requiring an interpretation of scientific information. Question 5 was assigned to Level A since it required a deep understanding of the relationship between the different components of the environment, in this case the transfer of energy between the sun and the earth and the effect of pollutants and natural phenomena such as volcanic eruptions on the temperature of the earth.

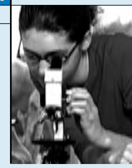


Figure A
GREENHOUSE

Read the texts and answer the questions that follow.

THE GREENHOUSE EFFECT: FACT OR FICTION?

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

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

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

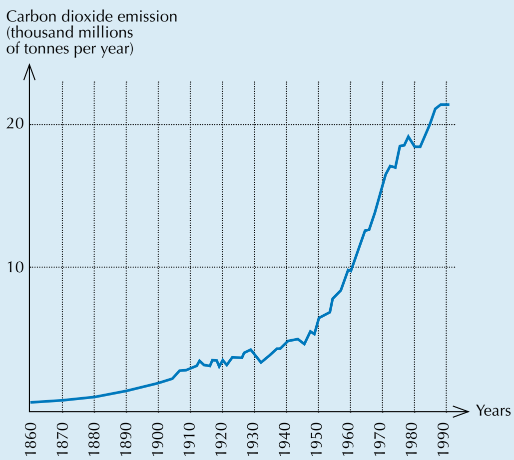
As a result of this the average temperature above the Earth's surface is higher than it would be if there were no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term greenhouse effect.

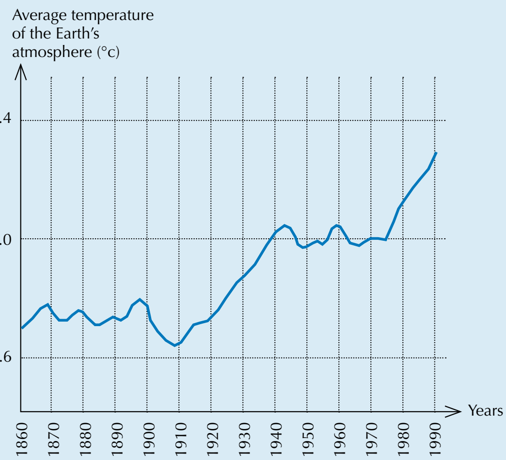
The greenhouse effect is said to have become more pronounced during the twentieth century.

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

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

In a library he comes across the following two graphs.

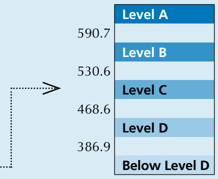




André concludes from these two graphs that it is certain that the increase in the average temperature of the Earth's atmosphere is due to the increase in the carbon dioxide emission.

GREENHOUSE – *QUESTION 3 (S114Q)*

Question type: *Open-constructed response*
Competency: *Using scientific evidence*
Knowledge category: *"Scientific explanations" (knowledge about science)*
Application area: *"Environment"*
Setting: *Global*
Difficulty (on the environmental science index): *490*
Percentage of correct answers (OECD countries): *54.0%*



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

....

....

Scoring

Full Credit:

Refers to the increase of both (average) temperature and carbon dioxide emission. For example:

- As the emissions increased the temperature increased.
- Both graphs are increasing.
- Because in 1910 both the graphs began to increase.
- Temperature is rising as CO_2 is emitted.
- The information lines on the graphs rise together.
- Everything is increasing.
- The more CO_2 emission, the higher the temperature.

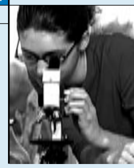
Refers (in general terms) to a positive relationship between temperature and carbon dioxide emission. *[Note: This code is intended to capture students' use of terminology such as "positive relationship", "similar shape" or "directly proportional"; although the following sample response is not strictly correct, it shows sufficient understanding to be given credit here.]* For example:

- The amount of CO2 and average temperature of the Earth is directly proportional.
- They have a similar shape indicating a relationship.

Comment

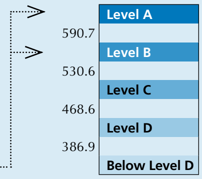
For the competency using scientific evidence, the unit GREENHOUSE (Figure A) present good examples for Level C. In GREENHOUSE, question 3, students must interpret evidence, presented in graphical form, and deduce that the combined graphs support a conclusion that both average temperature and carbon dioxide emission are increasing. The student is required to judge the validity of a conclusion correlating the Earth's atmospheric temperature and the quantity of carbon dioxide emissions by comparing evidence from two graphs having a common time scale. The student must first gain an appreciation for the context by reading a number of descriptive lines of text. Credit is given for recognising that both graphs are rising with time or that there is a positive relationship between the two graphs, thus supporting the stated conclusion. The effects of this environmental issue are global which defines the setting. The skill required by students is to interpret the graphical data supplied so the question belongs in the "Scientific explanations" category.

A student gaining credit for this Level C question is able to recognise the simple pattern in two graphical datasets and use this pattern in support of a conclusion.



GREENHOUSE – *QUESTION 4 (S114Q04)*

Question type: *Open-constructed response*
Competency: *Using scientific evidence*
Knowledge category: *"Scientific explanations" (knowledge about science)*
Application area: *"Environment"*
Setting: *Global*
Difficulty (on the environmental science index): *Full credit 662; Partial credit 556*
Percentage of correct answers (OECD countries): *34.5%*



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

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

....

....

....

Scoring

Full Credit:

Refers to one particular part of the graphs in which the curves are not both descending or both climbing and gives the corresponding explanation. For example:

- In 1900–1910 (about) CO_2 was increasing, whilst the temperature was going down.
- In 1980–1983 carbon dioxide went down and the temperature rose.
- The temperature in the 1800s is much the same but the first graph keeps climbing.
- Between 1950 and 1980 the temperature didn't increase but the CO_2 did.
- From 1940 until 1975 the temperature stays about the same but the carbon dioxide emission shows a sharp rise.
- In 1940 the temperature is a lot higher than in 1920 and they have similar carbon dioxide emissions.

Partial Credit:

Mentions a correct period, without any explanation. For example:

- 1930–1933.
- before 1910.

Mentions only one particular year (not a period of time), with an acceptable explanation. For example:

- In 1980 the emissions were down but the temperature still rose.

Gives an example that doesn't support André's conclusion but makes a mistake in mentioning the period. *[Note: There should be evidence of this mistake – e.g. an area clearly illustrating a correct answer is marked on the graph and then a mistake made in transferring this information to the text.]* For example:

- Between 1950 and 1960 the temperature decreased and the carbon dioxide emission increased.

Refers to differences between the two curves, without mentioning a specific period. For example:

- At some places the temperature rises even if the emission decreases.
- Earlier there was little emission but nevertheless high temperature.
- When there is a steady increase in graph 1, there isn't an increase in graph 2, it stays constant. *[Note: It stays constant "overall".]*
- Because at the start the temperature is still high where the carbon dioxide was very low.

Refers to an irregularity in one of the graphs. For example:

- It is about 1910 when the temperature had dropped and went on for a certain period of time.
- In the second graph there is a decrease in temperature of the Earth's atmosphere just before 1910.

Indicates difference in the graphs, but explanation is poor. For example:

- In the 1940s the heat was very high but the carbon dioxide very low. *[Note: The explanation is very poor, but the difference that is indicated is clear.]*

Comment

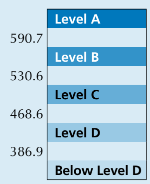
Another example from GREENHOUSE centres on the competency using scientific evidence and asks students to identify a portion of a graph that does not provide evidence supporting a conclusion. This question requires the student to look for specific differences that vary from positively correlated general trends in these two graphical datasets. Students must locate a portion where curves are not both ascending or descending and provide this finding as part of a justification for a conclusion. As a consequence it involves a greater amount of insight and analytical skill than is required for Q03. Rather than a generalisation about the relation between the graphs, the student is asked to accompany the nominated period of difference with an explanation of that difference in order to gain full credit.

The ability to effectively compare the detail of two datasets and give a critique of a given conclusion locates the full credit question at Level A of the scientific literacy scale. If the student understands what the question requires of them and correctly identifies a difference in the two graphs, but is unable to explain this difference, the student gains partial credit for the question and is identified at Level B of the environmental science and geoscience performance indices.

This environmental issue is global which defines the setting. The skill required by students is to interpret data graphically presented so the question belongs in the "Scientific explanations" category.

GREENHOUSE – *QUESTION 5 (S114Q)*

Question type: *Open-constructed response*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Earth and space systems" (knowledge of science)*
Application area: *"Environment"*
Setting: *Global*
Difficulty (on the environmental science index): *626*
Percentage of correct answers (OECD countries): *18.9%*



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.

....

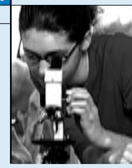
....

Scoring

Full Credit:

Gives a factor referring to the energy/radiation coming from the Sun. For example:

- The sun heating and maybe the earth changing position.
- Energy reflected back from Earth. *[Assuming that by "Earth" the student means "the ground".]*



Gives a factor referring to a natural component or a potential pollutant. For example:

- Water vapour in the air.
- Clouds.
- The things such as volcanic eruptions.
- Atmospheric pollution (gas, fuel).
- The amount of exhaust gas.
- CFC's.
- The number of cars.
- Ozone (as a component of air). *[Note: for references to depletion, use Code 03.]*

Comment

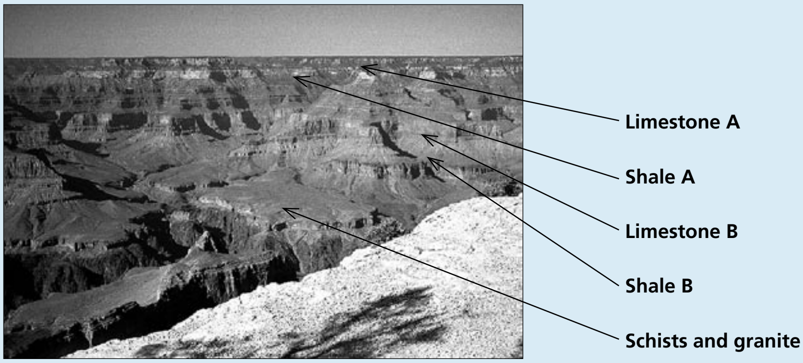
Question 5 of GREENHOUSE (Figure A) is an example of Level A and of the competency explaining phenomena scientifically. In this question, students must analyse a conclusion to account for other factors that could influence the greenhouse effect. The student needs to understand the necessity of controlling factors outside the change and measured variables and to recognise those variables. The student must possess sufficient knowledge of "Earth systems" to be able to identify at least one of the factors that should be controlled. The latter criterion is considered the critical scientific skill involved so this question is categorised as explaining phenomena scientifically. The effects of this environmental issue are global which defines the setting.

As a first step in gaining credit for this question the student must be able to identify the change and measured variables and have sufficient understanding of methods of investigation to recognise the influence of other factors. However, the student also needs to recognise the scenario in context and identify its major components. This involves a number of abstract concepts and their relationships in determining what "other" factors might affect the relationship between the Earth's temperature and the amount of carbon dioxide emissions into the atmosphere.

Figure B
GRAND CANYON

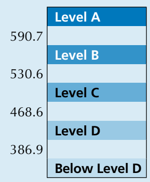
The Grand Canyon is located in a desert in the USA. It is a very large and deep canyon containing many layers of rock. Sometime in the past, movements in the Earth's crust lifted these layers up. The Grand Canyon is now 1.6 km deep in parts. The Colorado River runs through the bottom of the canyon.

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



GRAND CANYON (Figure B) is a question at Level D on the scale for the competency *Explaining phenomena scientifically*.

GRAND CANYON – *QUESTION 3 (S426Q03)*



Question type: *Multiple choice*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Earth and space systems" (knowledge of science)*
Application area: *"Environment"*
Setting: *Social*
Difficulty (on the environmental science index): *437*
Percentage of correct answers (OECD countries): *67.6%*

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

A. Freezing water dissolves warm rocks.

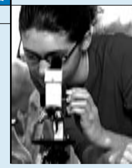
B. Water cements rocks together.

C. Ice smoothes the surface of rocks.

D. Freezing water expands in the rock cracks.

Scoring

Full Credit: D. Freezing water expands in the rock cracks.



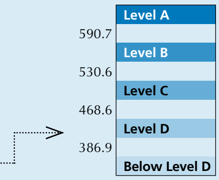
Comment

This is a multiple-choice question. Choosing the correct explanation for the weathering of rocks involves the student knowing that water freezes when the temperature falls below 0 °C and that water expands when becoming solid ice. The wording of this question does give some cues to the student as to what to eliminate, so its difficulty is lower.

The student needs to recall two tangible scientific facts and apply them in the context of the described conditions in the desert. This locates the question at Level D.

GRAND CANYON – *QUESTION 5 (S426Q05)*

Question type: *Multiple choice*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Earth and space systems" (knowledge of science)*
Application area: *"Natural resources"*
Setting: *Social*
Difficulty (on the environmental science index): *405*
Percentage of correct answers (OECD countries): *75.8%*



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

A. In ancient times, people brought seafood to the area from the ocean.

B. Oceans were once much rougher and sea life washed inland on giant waves.

C. An ocean covered this area at that time and then receded later.

D. Some sea animals once lived on land before migrating to the sea.

Scoring

Full Credit: C. An ocean covered this area at that time and then receded later.

Comment

The question requires the student to recall the fact that fossils are formed in water and that when the seas recede they may reveal fossils of organisms deposited at an earlier age and then to choose the correct explanation. Credible distractors means the recalled knowledge has to be applied in the context provided. The question is located at Level D.

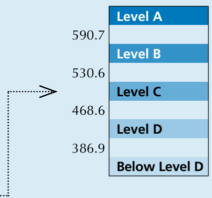
Figure C
ACID RAIN

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

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

ACID RAIN – *QUESTION 2 (S485Q02)*

Question type: *Open-constructed response*
Competency: *Explaining phenomena scientifically*
Knowledge category: *"Physical systems" (knowledge of science)*
Application area: *"Hazards"*
Setting: *Social*
Difficulty (on the environmental science index): 474
Percentage of correct answers (OECD countries): *57.7%*



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

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

....

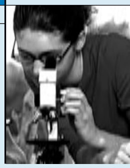
....

Scoring

Full Credit:

Any one of car exhausts, factory emissions, burning fossil fuels such as oil and coal, gases from volcanoes or other similar things.

- Burning coal and gas.
- Oxides in the air come from pollution from factories and industries.
- Volcanoes.
- Fumes from power plants. *["Power plants" is taken to include power plants that burn fossil fuels.]*
- They come from the burning of materials that contain sulphur and nitrogen.



Partial Credit:

Responses that include an incorrect as well as a correct source of the pollution. For example:

- Fossil fuel and nuclear power plants. *[Nuclear power plants are not a source of acid rain.]*
- The oxides come from the ozone, atmosphere and meteors coming toward Earth. Also the burning of fossil fuels.

Responses that refer to "pollution" but do not give a source of pollution that is a significant cause of acid rain. For example:

- Pollution.
- The environment in general, the atmosphere we live in – *e.g.* pollution.
- Gasification, pollution, fires, cigarettes. *[It is not clear what is meant by "gasification"; "fires" is not specific enough; cigarette smoke is not a significant cause of acid rain.]*
- Pollution such as from nuclear power plants.

Scoring Comment: *Just mentioning "pollution" is sufficient for Code 1.*

Comment

An example of a question in the middle of the scale is found in ACID RAIN – Question 2 (Figure C). This question requires students to explain the origin of sulphur and nitrogen oxides in the air. Correct responses require students to demonstrate an understanding of the chemicals as originating as car exhaust, factory emission, and burning fossil fuels. Students have to know that sulphur and nitrogen oxides are products of the oxidation of most fossil fuels or arise from volcanic activity.

Students gaining credit display a capacity to recall relevant facts and thus explain that the source of the gases contributing to acid rain was atmospheric pollutants. This locates the question at Level C.The awareness that oxidation results in the production of these gases places the question in the "Physical systems" content area. Since acid rain is a relatively localised hazard, its setting is social.

Attributing the gases to unspecified pollution is also an acceptable response. Analysis of student responses show little difference in the ability levels of students giving this response compared to those giving the more detailed response.

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HOW DO STUDENTS PERFORM IN THE ENVIRONMENTAL SCIENCE AND GEOSCIENCE INDICES?

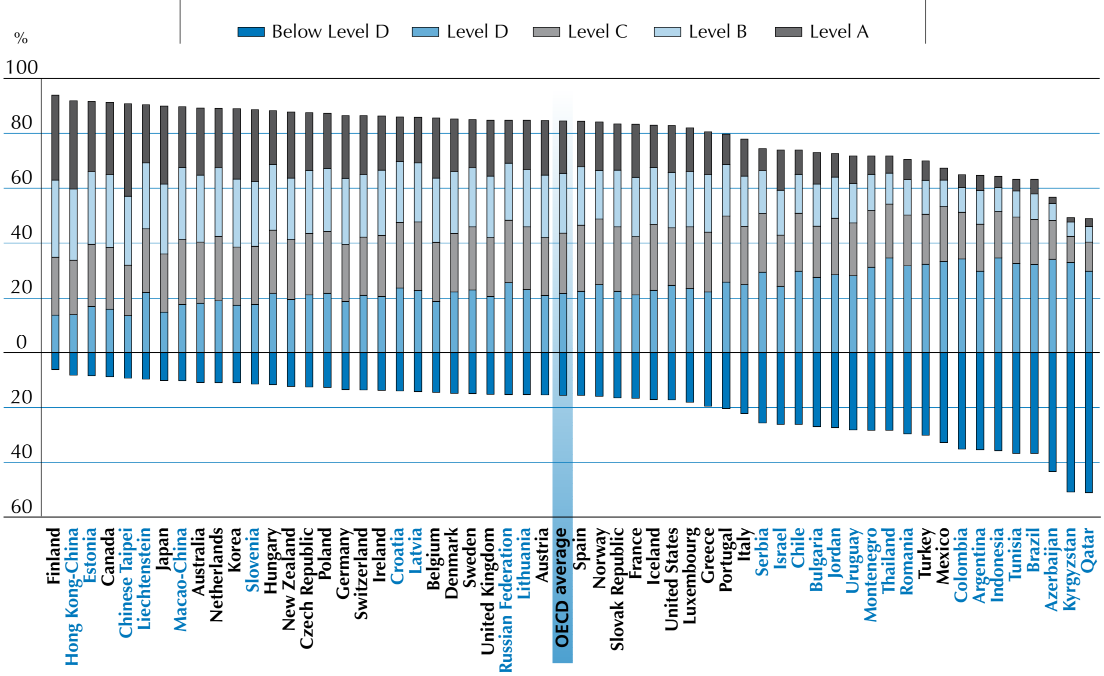
Analysing the proportion of students in each proficiency level for a particular index is a good way of summarising student performance data. Figure 2.1 displays the proportion of students in the four proficiency levels for environmental science in each country that participated in PISA 2006 (see also Table A2.1).

At the highest proficiency level are the students who may become part of the talent pool of future scientists working in a country's research centres, innovation laboratories, think-tanks and knowledge generation and accumulation centres (OECD, 2009). It is also important, however, to consider the bottom end of the distribution. A large pool of adequately educated citizens on environmental science is important for the adoption of new environmental technologies, such as new energy saving appliances, and to make personal and social decisions on environmental issues informed by scientific arguments.

Student performance at the highest level of environmental science proficiency

At the highest level of proficiency (Level A), students can consistently identify, explain and apply scientific knowledge to a variety of environmental topics. They can link different information sources and explanations and use evidence from those sources to justify decisions about environmental issues.

Figure 2.1
Percentage of students at each proficiency level on the environmental science performance index



Countries are ranked in ascending order of percentage of 15-year-olds below Level D.
Source: *OECD PISA 2006 Database*, Table A2.1.
StatLink http://dx.doi.org/10.1787/562200685357

They clearly and consistently demonstrate advanced thinking and reasoning in science relevant to the environment. They can use this understanding to develop arguments in support of recommendations and decisions in both social and global situations. Further, these highly proficient students in environmental science represent a potential pool of well informed, knowledgeable and analytically capable citizens that are ready to engage in a scientific academic and professional career (OECD, 2009b).

On average across OECD countries, 19% of 15-year-olds perform at the highest proficiency level in environmental science, Level A (Figure 2.1 and Table A2.1). The partner economy Chinese Taipei has the highest proportion of students at this level (34%) followed by Hong Kong-China, Finland, Japan, Canada, Slovenia, Korea, and Estonia, all with over 25% at Level A. With few exceptions, OECD countries have between 15% and 31% of students performing at the highest level.

Student performance at the lowest level of environmental science proficiency

The proportion of a nation's 15-year-olds with low levels of performance in environmental science, below Level D, is also an important indicator – particularly in terms of citizens' competency to meet future environmental challenges. As described earlier, students with proficiency below Level D had difficulties in answering questions containing scientific information relevant to basic environmental phenomena or issues.

While most students possess an adequate level of performance in environmental science (that is Level D or above), the proportions of students below the baseline standard remain significant. Across OECD countries, on average, 16% of students performed below Level D, and four OECD countries have one-fifth or more of their students below this level. Two partner countries have more than half of their students below Level D.

In contrast, three OECD countries have 10% or fewer students below Level D (Table A2.1): Canada (9%), Finland (6%) and Japan (10%), as well as five partner countries and economies Chinese Taipei (9%), Estonia (8%), Hong Kong-China (8%), Liechtenstein (10%) and Macao-China (10%).

Student performance in geoscience

As with environmental science, countries vary widely in their geoscience performance (see Figure 2.2 and Table A2.2). In general, countries whose students performed well in environmental science also performed well in geoscience.

Students performing at Level A in geoscience can consistently identify, explain and apply knowledge to a variety of geoscience topics. For instance, these students understand the need to control for other factors when analysing the relationship between carbon dioxide emissions and the average temperature of the earth's atmosphere and they can identify at least one of the controls that have to be taken into account. Across OECD countries, an average of 14% of 15-year-old students reached this proficiency level, with two countries having more than one fifth of their students at this level: Finland (25%), and the Netherlands (21%). Three partner countries and economies have similar proportions of students at Level A (Table A2.2): Chinese Taipei, Hong Kong-China and Slovenia (all with 22%).

Among OECD countries on average, 15% of students did not reach even the lowest level of proficiency (Level D) in geoscience. For example, these students in general had difficulties in identifying the role that freezing water in rock cracks plays in the erosion of the Grand Canyon. In three OECD countries one fifth or more of students were not proficient at Level D while two partner countries had more than 45% of students not reaching Level D (Table A2.2).

Table 2.3 [Part 1/2]
Multiple comparisons of mean performance on the environmental science performance index

			Finland	Chinese Taipei	Hong Kong-China	Japan	Canada	Estonia	Slovenia	Korea	Australia	Macao-China	New Zealand	Netherlands	Liechtenstein	Germany	Czech Republic	Hungary	Switzerland	Belgium	Poland	Ireland	United Kingdom	Austria	Denmark	France	Croatia	Sweden	Lithuania	Latvia	Spain
	Mean		543	541	540	529	528	528	523	522	519	518	516	514	514	513	509	509	508	508	507	506	504	502	502	498	498	497	497	497	495
		S.E.	(1.5)	(3.1)	(2.0)	(2.5)	(1.5)	(2.3)	(1.3)	(2.5)	(1.8)	(1.2)	(2.0)	(2.5)	(3.9)	(2.7)	(2.6)	(2.3)	(2.6)	(1.9)	(2.0)	(2.5)	(1.5)	(3.2)	(2.7)	(2.6)	(2.1)	(2.1)	(2.2)	(2.4)	(2.1)
Finland	543	(1.5)		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	541	(3.1)	○		○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	540	(2.0)	○	○		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	529	(2.5)	▼	▼	▼		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	528	(1.5)	▼	▼	▼	○		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	528	(2.3)	▼	▼	▼	○	○		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	523	(1.3)	▼	▼	▼	○	○	○		○	○	○	▲	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	522	(2.5)	▼	▼	▼	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	519	(1.8)	▼	▼	▼	▼	▼	▼	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	518	(1.2)	▼	▼	▼	▼	▼	▼	○	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	516	(2.0)	▼	▼	▼	▼	▼	▼	▼	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	514	(2.5)	▼	▼	▼	▼	▼	▼	▼	○	○	○	○		○	○	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	514	(3.9)	▼	▼	▼	▼	▼	▼		○	○	○	○	○		○	○	○	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲
Germany	513	(2.7)	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○		○	○	○	○	○	○	▲	○	▲	▲	▲	▲	▲	▲	▲
Czech Republic	509	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○		○	○	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲
Hungary	509	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲
Switzerland	508	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲
Belgium	508	(1.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲
Poland	507	(2.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲	▲
Ireland	506	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○	○		○	○	○	○	○	▲	▲	▲	▲
United Kingdom	504	(1.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	▼	○	○	○	○	○	○		○	○	○	○	○	▲	○	▲
Austria	502	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○
Denmark	502	(2.7)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	▼	○	○	○	○	○	○		○	○	○	○	○	○
France	498	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○		○	○	○	○	○
Croatia	498	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○		○	○	○	○
Sweden	497	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○		○	○	○
Lithuania	497	(2.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○		○	○
Latvia	497	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○		○
Spain	495	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○	
Slovak Republic	494	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○	○
Russian Federation	493	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○	○
Norway	491	(2.3)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○
United States	491	(3.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○	○	○	○
Iceland	490	(1.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	▼	▼	○	○	○
Greece	487	(2.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○
Luxembourg	487	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Italy	476	(1.6)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Portugal	475	(2.5)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Israel	469	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Bulgaria	461	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Chile	458	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Serbia	458	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Uruguay	456	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Jordan	455	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Montenegro	448	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Romania	446	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Turkey	444	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Thailand	444	(1.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Mexico	436	(1.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Argentina	435	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Colombia	431	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Brazil	430	(2.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Indonesia	428	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Tunisia	428	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Azerbaijan	411	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Qatar	399	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Kyrgyzstan	396	(1.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼

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

▲ Mean performance statistically significantly higher than in comparison country
○ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Source: *OECD PISA 2006 Database.*
StatLink http://dx.doi.org/10.1787/562200685357

Table 2.3 [Part 2/2]
Multiple comparisons of mean performance on the environmental science performance index

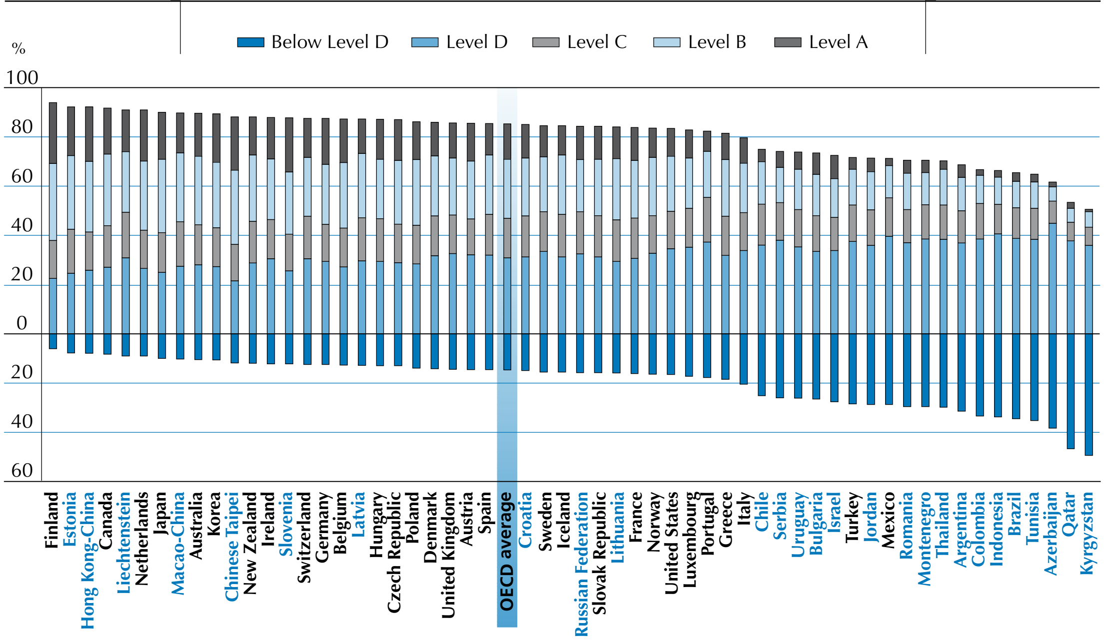
	Mean	S.E.	Slovak Republic 494 (2.6)	Russian Federation 493 (2.6)	Norway 491 (2.3)	United States 491 (3.4)	Iceland 490 (1.6)	Greece 487 (2.6)	Luxembourg 487 (1.1)	Italy 476 (1.6)	Portugal 475 (2.5)	Israel 469 (2.9)	Bulgaria 461 (4.2)	Chile 458 (3.1)	Serbia 458 (2.4)	Uruguay 456 (2.1)	Jordan 455 (2.4)	Montenegro 448 (1.2)	Romania 446 (3.2)	Turkey 444 (3.1)	Thailand 444 (1.9)	Mexico 436 (1.9)	Argentina 435 (3.8)	Colombia 431 (2.9)	Brazil 430 (2.0)	Indonesia 428 (4.1)	Tunisia 428 (2.4)	Azerbaijan 411 (2.4)	Qatar 399 (1.1)	Kyrgyzstan 396 (1.8)
Finland	543	(1.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chinese Taipei	541	(3.1)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hong Kong-China	540	(2.0)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Japan	529	(2.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Canada	528	(1.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Estonia	528	(2.3)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovenia	523	(1.3)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Korea	522	(2.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Australia	519	(1.8)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Macao-China	518	(1.2)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
New Zealand	516	(2.0)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	514	(2.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Liechtenstein	514	(3.9)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Germany	513	(2.7)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Czech Republic	509	(2.6)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Hungary	509	(2.3)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Switzerland	508	(2.6)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Belgium	508	(1.9)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Poland	507	(2.0)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Ireland	506	(2.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United Kingdom	504	(1.5)	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Austria	502	(3.2)	○	○	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Denmark	502	(2.7)	○	○	▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
France	498	(2.6)	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Croatia	498	(2.1)	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	497	(2.1)	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Lithuania	497	(2.2)	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Latvia	497	(2.4)	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Spain	495	(2.1)	○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Slovak Republic	494	(2.6)		○	○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	493	(2.6)	○		○	○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	491	(2.3)	○	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
United States	491	(3.4)	○	○	○		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Iceland	490	(1.6)	○	○	○	○		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Greece	487	(2.6)	○	○	○	○	○		○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Luxembourg	487	(1.1)	○	○	○	○	○	○		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Italy	476	(1.6)	▼	▼	▼	▼	▼	▼	▼		○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Portugal	475	(2.5)	▼	▼	▼	▼	▼	▼	▼	○		○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Israel	469	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	○		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Bulgaria	461	(4.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	○		○	○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Chile	458	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Serbia	458	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○		○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Uruguay	456	(2.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○		○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Jordan	455	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○		▲	○	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Montenegro	448	(1.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		○	○	○	▲	▲	▲	▲	▲	▲	▲	▲	▲
Romania	446	(3.2)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○		○	○	▲	○	▲	▲	▲	▲	▲	▲	▲
Turkey	444	(3.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○		○	○	○	▲	▲	▲	▲	▲	▲	▲
Thailand	444	(1.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○		▲	○	▲	▲	▲	▲	▲	▲	▲
Mexico	436	(1.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	▼		○	○	○	○	○	▲	▲	▲
Argentina	435	(3.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○		○	○	○	○	▲	▲	▲
Colombia	431	(2.9)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○		○	○	○	▲	▲	▲
Brazil	430	(2.0)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○		○	○	▲	▲	▲
Indonesia	428	(4.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○		○	▲	▲	▲
Tunisia	428	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	○	○	○	○		▲	▲	▲
Azerbaijan	411	(2.4)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲	▲
Qatar	399	(1.1)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		○
Kyrgyzstan	396	(1.8)	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	○	

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

▲ Mean performance statistically significantly higher than in comparison country
○ No statistically significant difference from comparison country
▼ Mean performance statistically significantly lower than in comparison country

Source: *OECD PISA 2006 Database.*
StatLink http://dx.doi.org/10.1787/562200685357

Figure 2.2
Percentage of students at each proficiency level on the geoscience performance index



Countries are ranked in ascending order of percentage of 15-year-olds below Level D.
Source: *OECD PISA 2006 Database,* Table A2.2.
StatLink http://dx.doi.org/10.1787/562200685357

Student average performance on the environmental science and the geoscience indices

Average performance is another useful way of summarising student performance. Both the environmental science and geoscience performance indices are on a scale with an international mean of 500 score points and a standard deviation of 100 score points. Table 2.3 gives a summary of overall performance of different countries on the environmental science index in terms of the mean scores achieved by students in each country and economy that participated in PISA 2006. It compares mean scores across countries and gives an approximation to relative performance rank of each country.

On the environmental science performance index, across OECD countries Finland has the highest average performance with 543, followed by Japan (529) and Canada (528). Six out of the 27 partner countries and economies scored over the OECD average (Table A2.3). These were Chinese Taipei (541), Hong Kong-China (540), Estonia (528), Slovenia (523), Macao-China (518), and Liechtenstein (514). These differences in mean scores are quite significant, as a score above 531 falls within proficiency Level B, whereas a score between 469 and 387 falls within proficiency Level D (see Appendix B for details about cutoff points).

On the geoscience performance index, among OECD countries Finland has the highest average score with 541, followed by the Netherlands, Japan and Canada with average scores of 524, 523, and 522 respectively (Table A2.3). Seven out of the 27 partner countries and economies have mean scores higher than the OECD average on the geoscience performance index, with Hong Kong-China again scoring second (mean geoscience score of 530). The remaining six partner countries and economies scoring over the OECD average were Estonia (528), Chinese Taipei (526), Slovenia (521), Macao-China (514), Liechtenstein (514), and Latvia (505).

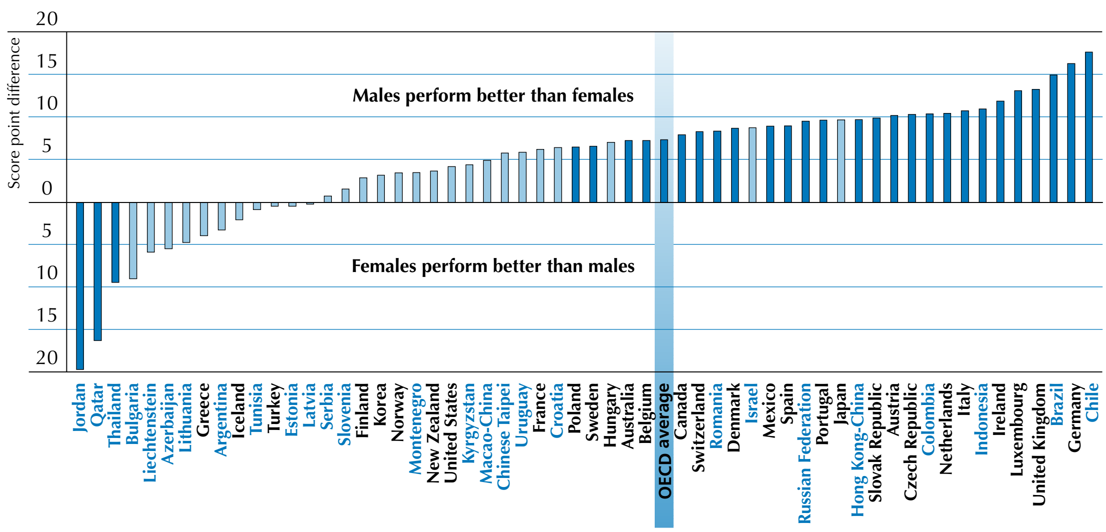
STUDENT CHARACTERISTICS AND PERFORMANCE IN ENVIRONMENTAL SCIENCE AND GEOSCIENCE

Gender

As more and more economies seek to fully capitalise on their human resources, the strife for gender equality in science, engineering and technical fields has intensified in many countries. At age 15, many students are approaching major transitions from school to work or to further education. Their performance at school and their motivation and attitudes towards science in general and environmental science specifically can have a significant influence on their future educational and occupational pathways.

Figure 2.3 ranks countries and economies by the size of the gender gap in performance on environmental science. There are 12 OECD countries where the differences were statistically significant and favoured males (see Table A2.3). Among the OECD countries, the largest significant differences in favour of males were in Germany (16 score points), the United Kingdom and Luxembourg (13 score points), Ireland (12 score points) and Italy (11 score points). Among partner countries and economies, there were significant differences in seven countries and economies, four in favour of males, and three in favour of females. The largest differences in favour of males were in Chile (18 score points), Brazil (15 score points) and Indonesia (11 score points). The largest differences in favour of females were in Jordan (20 score points), Qatar (16 score points) and Thailand (9 score points).

Figure 2.3
Gender differences in the environmental science performance index



Note: Gender differences that are statistically significant are marked in darker colour.
Source: *OECD PISA 2006 Database,* Table A2.3.
StatLink http://dx.doi.org/10.1787/562200685357

On the geoscience performance index, among the OECD countries, there were 13 countries with statistically significant differences and all favoured males (see Table A2.3). Among the OECD countries the gaps were in Luxembourg and the United Kingdom, each with a difference of 13 score points, Germany (12 score points), Austria (11 score points) and Denmark (10 score points). Among partner countries and economies, there were six significant differences in favour of males and three in favour of females. The largest differences in

favour of males were in Brazil (13 score points) and Chile (10 score points). The largest differences in favour of females were in Jordan (13 score points) and Qatar (12 score points).

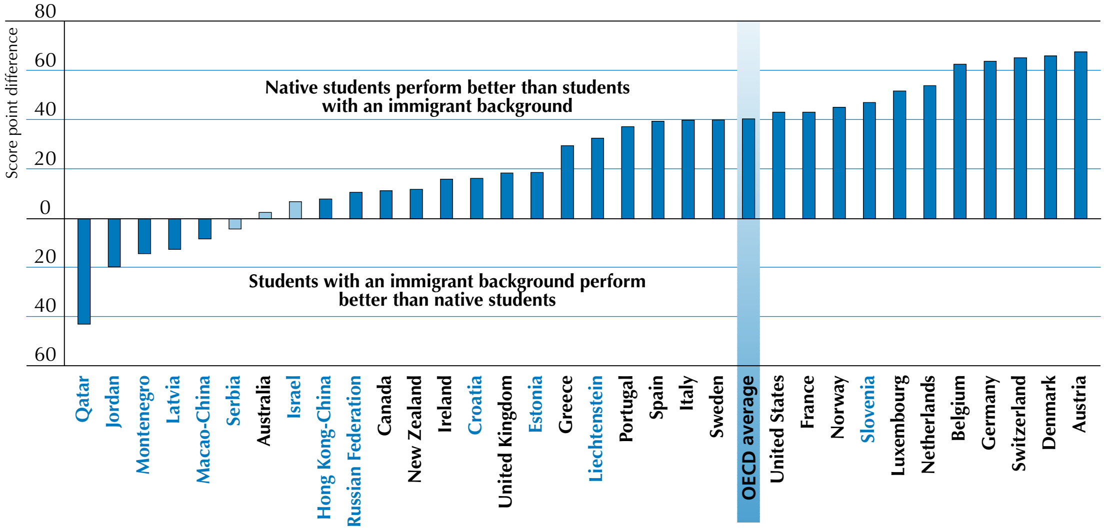
Immigrant background

Migrant students constitute a heterogeneous group with a diverse range of skills, backgrounds and motivations. The composition of immigrant populations is also shaped by immigration policies and practices and the criteria used to decide who will be admitted into a country vary considerably across countries. As a result, immigrant populations tend to have more advantaged backgrounds in some countries than in others (OECD, 2008d).

In OECD countries, native students outperform students with an immigrant background on the environmental science index in all countries with sufficient data, except Australia (Figure 2.4 and Table A2.4).[1] The differences are much larger than the gender differences described above. The average gap in OECD countries is around 41 score points. Reliable data, *i.e.* data based on more than 30 students representing at least 3% of the sample size, are only available in 20 OECD countries and 13 partner countries and economies. The gap is similar in these countries in general but it changes direction in some countries. For example, the gap in favour of native students in Slovenia is of 47 points, whereas the gap in favour of students with an immigrant background in Qatar is of 43 points.

Figure 2.4

Differences between native students and students with an immigrant background in the environmental science performance index



Note: Performance differences that are statistically significant are marked in darker colour.
Source: *OECD PISA 2006 Database,* Table A2.4.
StatLink http://dx.doi.org/10.1787/562200685357

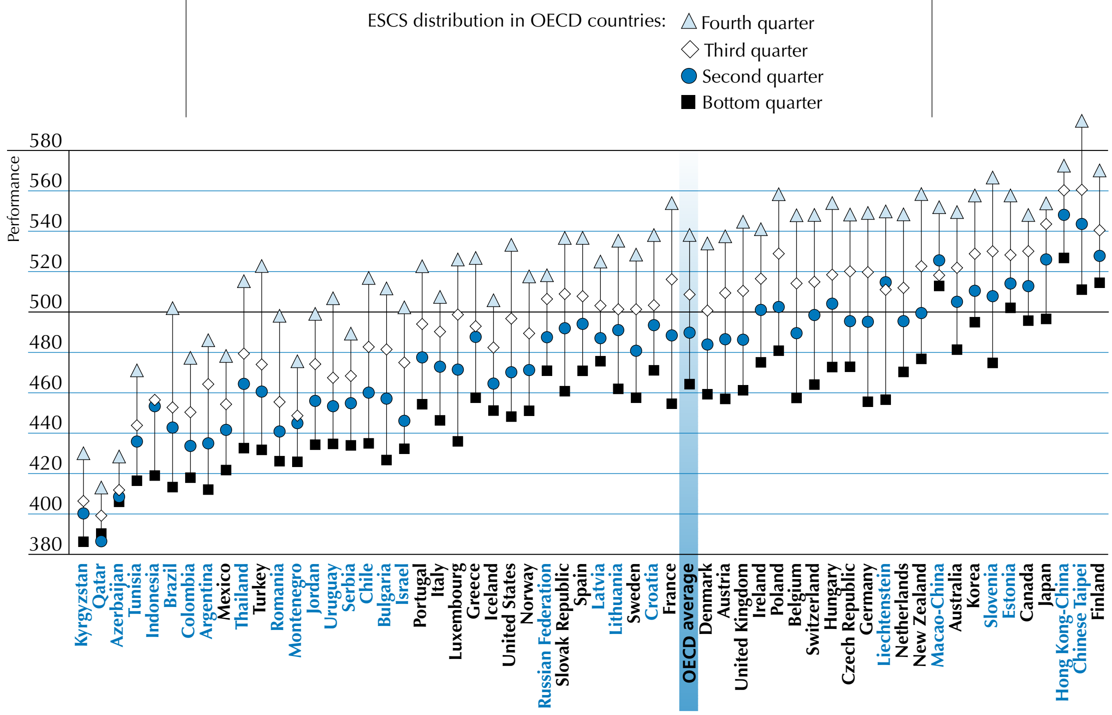
On the geoscience performance index, the average gap in scores between natives and students with an immigrant background in OECD countries is around 34 points, again with native students generally performing better than students with an immigrant background (Table A2.4). Among partner countries and economies, there gaps are again similar and sometimes in favour of students with an immigrant background.

Socio-economic background

Socio-economic background is related to student performance, but the strength of this relationship varies from country to country. Analysing the distribution of student performance by socio-economic background can reveal areas of strengths and weaknesses in education systems. For example, a wide distribution of performance across different levels of socio-economic background points to areas where more effort is needed.

Within countries, student performance on the environmental science and geoscience performance indices varies widely across groups with different socio-economic backgrounds (Figure 2.5 and Table A 2.5). For example, as shown in Figure 2.5 in Canada, the performance gap in environmental science between the top and bottom quarters of socio-economic background distribution in OECD countries is close to half a standard deviation (52 points). By contrast, in Belgium, Luxembourg, Turkey, Germany and France, the gap is close to one standard deviation (more than 90 points).

Figure 2.5
Performance on the environmental science index by quarters of the PISA index of social, economic and cultural status (ESCS)



Countries ranked in ascending order of country average performance on the environmental science index.
Source: *OECD PISA 2006 Database,* Table A2.5.
StatLink http://dx.doi.org/10.1787/562200685357

STUDENT PERFORMANCE: CONCLUSIONS AND IMPLICATIONS

If one of the goals of education systems is to produce citizens that are well prepared to understand environmental issues, it is important to ensure that students from across the ability range acquire a sufficient level of knowledge and skills in environmental science. In some countries, we can say that the vast majority of young people are able at least to some degree to relate to environmental issues, in that fewer than one in

ten failed to reach a basic level of proficiency in addressing such issues. But in other countries, a significant number of students appear not to have the requisite skills to engage with environmental questions. While these students are still a relatively small minority in most countries, students from immigrant and low socio-economic backgrounds are at significantly higher risk than average of underperforming in this area. Thus, education systems can generally feel confident that most students have learned to think about the environment at some level, they need to ensure that certain groups do not miss out on this aspect of citizenship.

Moreover, there is also a need for some students to acquire much higher levels of understanding in environmental science and in geoscience, particularly those who might pursue careers as environmental scientists or go into knowledge-based industries in which environment factors need to be taken into account. It is encouraging that in most OECD countries, a significant minority of at least 15% of students reach the top level of proficiency in environmental science performance. But the fact that some countries reach over twice this level shows that there is considerable scope for many countries to expand the pool of young people who are highly proficient in this area and thus well positioned to contribute actively to the development of an environmentally sustainable economy. There is also an indication in some countries that females are less likely to be active in this area than males, having lower levels of average performance in environmental science and thus being less likely to move towards environment-related careers. This is a potential pool of talent that could be tapped further.

Notes

1. This report follows the definition in OECD (2006b) for native students and students with an immigrant background. That is, native students are students with at least one parent born in the country of assessment. Students born in the country who have one foreign-born parent (children of "combined" families) are included in the native category, as previous research indicates that these students perform similarly to native students. Students with an immigrant background include both first-generation and second-generation students. First-generation students are those born outside of the country of assessment whose parents are also foreign-born. Second-generation students are those born in the country of assessment with foreign-born parents.

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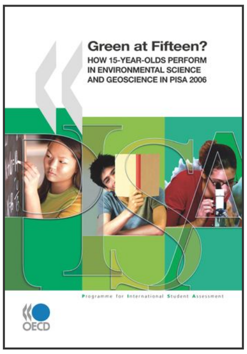

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