FIRST RESULTS FROM PISA 2003

Executive Summary

Are students well prepared to meet the challenges of the future? Are they able to analyse, reason and communicate their ideas effectively? Do they have the capacity to continue learning throughout life? These are questions that parents, students, the public and those who run education systems continually ask.

The **OECD Programme for International Student Assessment (PISA)** provides some of the answers to these questions. It assesses to what extent students near the end of compulsory schooling have acquired some of the knowledge and skills that are essential for full participation in society. The first PISA survey, with a focus on reading, was conducted in 2000, while the second PISA survey, with a focus on mathematics, was conducted in 2003 and also examined for the first time student performance in problem solving.

This Executive Summary reports on the initial results of PISA 2003 as presented in *Learning for Tomorrow's World – First Results from PISA 2003* and *Problem Solving for Tomorrow's World – First Measures of Cross-Curricular Competencies from PISA 2003*. These reports go well beyond an examination of the relative standing of countries in mathematics, science, reading, and problem solving, looking at a wider range of educational outcomes that includes students' motivation to learn, their beliefs about themselves and their learning strategies. The reports also consider how performance varies between the genders and between socio-economic groups, and provide insights into some of the factors that influence the development of knowledge and skills at home and at school, how these factors interact and what the implications are for policy development. Most importantly, the reports shed light on countries that succeed in achieving high performance standards while, at the same time, providing an equitable distribution of learning opportunities. These are noteworthy achievements. Will other countries take up the challenge?

The OECD Programme for International Student Assessment (PISA)

PISA is a collaborative process among the 30 member countries of the OECD and nearly 30 partner countries. It brings together scientific expertise from the participating countries and is steered by their governments on the basis of shared, policy-driven interests. PISA is an unprecedented attempt to measure student achievement, as is evident from some of its features:

– *The literacy approach:* PISA aims to define each assessment area (mathematics, science, reading and problem solving) not mainly in terms of mastery of the school curriculum, but in terms of the knowledge and skills needed for full participation in society.

– *A long-term commitment:* It will enable countries to monitor regularly and predictably their progress in meeting key learning objectives.

– *The age-group covered:* By assessing 15-year-olds, *i.e.* young people near the end of their compulsory education, PISA provides a significant indication of the overall performance of school systems.

– *The relevance to lifelong learning:* PISA does not limit itself to assessing students' knowledge and skills but also asks them to report on their own motivation to learn, their beliefs about themselves and their learning strategies.

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OECD Programme for International Student Assessment

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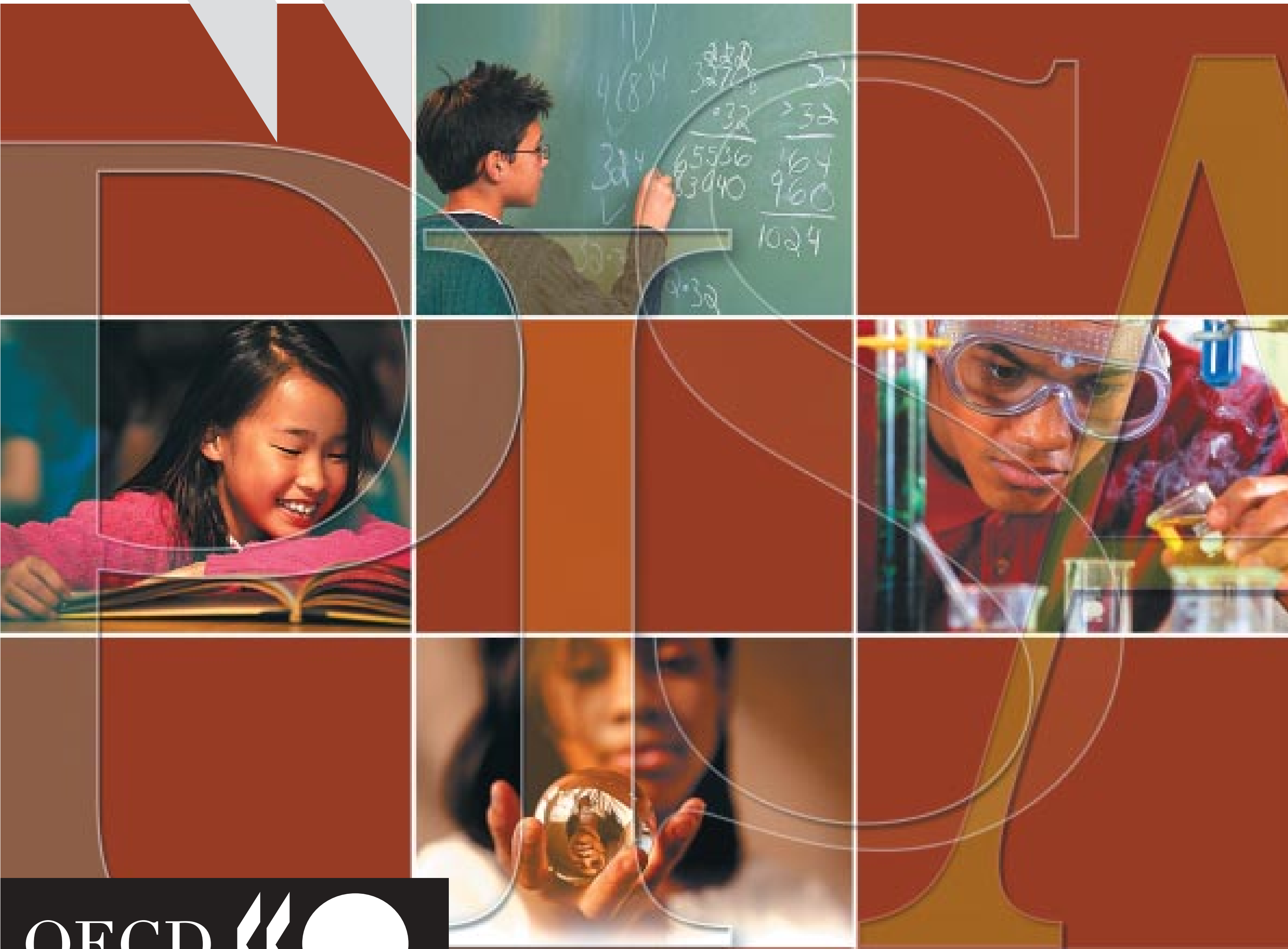
Executive Summary



OECD

Programme for International Student Assessment

What is PISA?

The Programme for International Student Assessment (PISA) is a three-yearly survey of the knowledge and skills of 15-year-olds in the principal industrialised countries. The product of a collaboration between participating governments through the Organisation for Economic Co-operation and Development (OECD), it draws on leading international expertise to develop valid comparisons across countries and cultures.

Key features of the PISA approach are:

- Its policy orientation, with design and reporting methods determined by the need of governments to draw policy lessons.
- Its innovative approach to "literacy", which is concerned with the capacity of students to apply knowledge and skills in key subject areas and to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations.
- Its relevance to lifelong learning, which does not limit PISA to assessing students' curricular and cross-curricular competencies but also asks them to report on their own motivation to learn, their beliefs about themselves and their learning strategies.
- Its regularity, which will enable countries to monitor their progress in meeting key learning objectives.
- Its consideration of student performance alongside the characteristics of students' backgrounds and schools, in order to explore some of the main features associated with educational success.
- Its breadth of geographical coverage, with the 49 countries that have participated in a PISA assessment so far and the 11 additional countries that will join the PISA 2006 assessment representing a total of one-third of the world population and almost nine-tenths of the world's gross domestic product (GDP).

First Results from PISA 2003

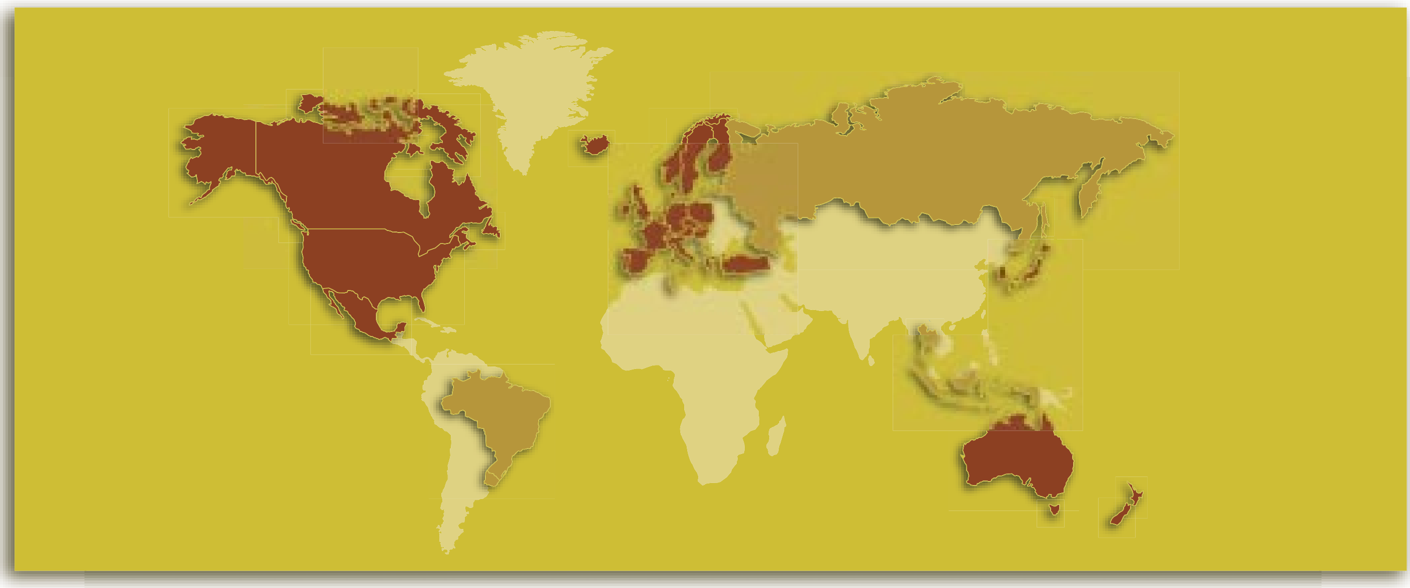
Executive Summary

PISA 2003 is the second assessment in the Programme: the first survey was in 2000. Well over a quarter of a million students in 41 countries took part in a two-hour test in their schools, assessing their skills in mathematics, reading, science and problem solving. All 30 OECD member countries participated, as well as 11 partner countries.

New in PISA 2003:

- The survey establishes a detailed profile of student performance in mathematics (in PISA 2000, the focus was on reading).
- A new part of the survey assesses students' problem-solving skills, providing for the first time a direct assessment of life competencies that apply across different areas of the school curriculum.
- The second survey makes comparisons over time possible. This must be approached with caution, however, since two results do not make a trend and since education systems develop relatively slowly.

Countries participating in PISA 2003:



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[1], United States

PISA partner countries

Brazil, Hong Kong-China, Indonesia, Latvia, Liechtenstein, Macao-China, Russian Federation, Serbia and Montenegro[2], Thailand, Tunisia, Uruguay

1. Response rate too low to ensure comparability. See Annex A3 in the main report.
2. For the country Serbia and Montenegro, data for Montenegro are not available. The latter accounts for 7.9 per cent of the national population. Throughout this summary, the name "Serbia" is used as a shorthand for the Serbian part of Serbia and Montenegro.

Reporting PISA results and findings

The results of PISA 2003 are reported and analysed in ***Learning for Tomorrow's World*** ***First Results from PISA 2003*** and ***Problem Solving for Tomorrow's World*** ***First Measures of Cross-Curricular Competencies from PISA 2003***

(The full reports are available at www.pisa.oecd.org)

The focus of the PISA 2003 assessment was on mathematics.

This was not a test of students' ability simply to perform mathematical operations, but rather an assessment of how well they can recognise, formulate and tackle mathematical problems in the context of real life.

PISA reports students' knowledge and skills separately in four areas of mathematics but also provides an overall summary of results.

This measure of overall student performance in mathematics is the basis for the analysis in this summary, which looks at factors associated with performance.

Contents

In this Executive Summary:

How PISA 2003 measured student performance in mathematics

Today, everyone is required to use mathematics as a tool in daily life. PISA's assessment of students' mathematical knowledge and skills is rooted in the concept of "mathematical literacy". This is defined in terms of the capacity to see how mathematics can be used in the real world and thus to engage in mathematics to meet one's needs. There is not a single cut-off point at which students are deemed mathematically literate, but rather various levels of mathematical proficiency related to students' capacity to analyse, reason and communicate effectively when using mathematics.

PISA 2003 measured student performance in four areas of mathematics:

- **Space and shape,** involving spatial and geometric phenomena and the properties of objects;
- **Change and relationships,** involving relationships between variables, and an understanding of the ways in which they are represented, including equations;
- **Quantity,** involving numeric phenomena as well as quantitative relationships and patterns; and
- **Uncertainty,** involving probabilistic and statistical phenomena.

The PISA mathematics assessment required students to confront mathematical problems that are based in real-world contexts, where students are required to identify features of a problem situation that might be amenable to mathematical investigation, and to activate the relevant mathematical competencies to solve the problem. This requires various skills, including: thinking and reasoning; argumentation; communication; modelling; problem posing and solving; representation; and using symbolic, formal and technical language and operations. While it is generally true that these skills operate together, and there is some overlap in their definitions, three clusters of cognitive activity encompassed by these skills can be distinguished:

- **Reproduction skills** refer to the reproduction of knowledge, such as recognition of familiar mathematical processes and problem types and carrying out routine operations. These are needed for the simplest of the tasks set for students in PISA.
- **Connection skills** require students to move beyond routine problems to make interpretations and links in different situations, but still in relatively familiar contexts. These tend to be used in problems of medium difficulty.
- **Reflection skills** require insight and reflection on the part of students, as well as creativity in identifying mathematical elements in a problem and in making connections. These problems are often complex, and tend to be the most difficult in PISA.

Mathematics tasks, student scores and proficiency levels

Students were presented with a series of tasks based on the kinds of problems that they might encounter in real life – related to their personal lives, to learning, to work or to issues of wider public relevance such as community-related or scientific phenomena. Examples of tasks are shown overleaf.

The 2003 assessment included 85 different mathematical questions at varying levels of difficulty. Usually several tasks were posed about a single mathematical situation 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 write down their calculations or explain their results, to show their methods and thought processes. These open tasks required the professional judgement of trained markers to assign the observed responses to defined response categories. For answers that were not fully correct, partial credit was often given.

Each student was awarded a score based on the difficulty of tasks that he or she could reliably perform. Scores were reported for each of the four areas of mathematics, and for overall performance in mathematics. The scale was constructed so that in 2003, the average student score in OECD countries is 500 points, and about two-thirds of students score between 400 and 600 points (i.e., 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 task. Thus, for example, a student with a score of 650 can usually be expected to complete a task with a difficulty rating of about 650, as well as easier tasks with lower ratings.

Student performance scores and the difficulty of tasks were also divided into six proficiency levels. As shown on the facing page, each of these levels can be described in terms of what kinds of mathematical processes students can do.

Figure 1

Student proficiency in mathematics

Summary descriptions for the six levels of proficiency in mathematics

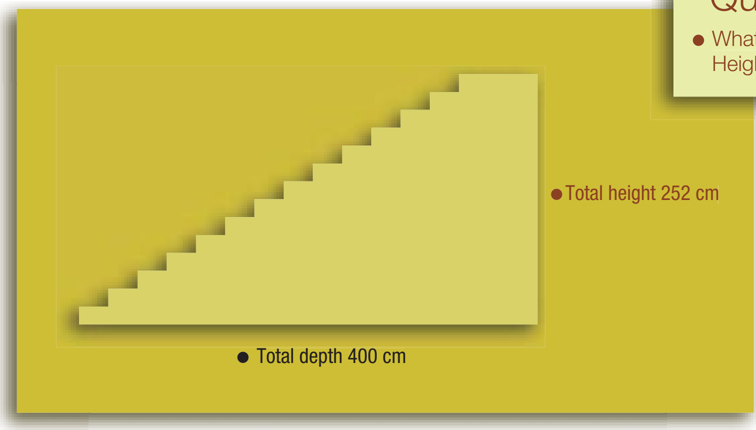
Score points	Level	What students can typically do
668	Level 6	At Level 6 students can conceptualise, generalise, and utilise information based on their investigations and modelling of complex problem situations. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply insight and understanding along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for dealing with novel situations. Students at this level can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments and the appropriateness of these to the original situations.
606	Level 5	At Level 5 students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriately linked representations, symbolic and formal characterisations, and insight pertaining to these situations. They can reflect on their actions and formulate and communicate their interpretations and reasoning.
544	Level 4	At Level 4 students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic ones, linking them directly to aspects of real-world situations. Students at this level can utilise well-developed skills and reason flexibly, with some insight, in these contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
482	Level 3	At Level 3 students can execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They can develop short communications reporting their interpretations, results and reasoning.
420	Level 2	At Level 2 students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures, or conventions. They are capable of direct reasoning and making literal interpretations of the results.
358	Level 1	At Level 1 students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are obvious and follow immediately from the given stimuli.

A sample of PISA mathematics tasks

Space and shape scale

STAIRCASE

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



Question

- What is the height of each of the 14 steps?
  Height: .... cm

This short response question is situated in a daily life context. The student has to interpret and solve the problem which uses two different representation modes: language, including numbers, and graphical. This question also has redundant information (i.e., the depth is 400 cm) which can be confusing for students, but this is not unusual in real-world problem solving. The actual procedure needed is a simple division. As this is a basic operation with numbers (252 divided by 14) the question belongs to the reproduction competency cluster. All the required information is presented in a recognisable situation and the students can extract the relevant information from this. The question has a difficulty of 421 score points (Level 2).

Change and relationships scale

WALKING

The picture shows the footprints of a man walking.
The pacelength P is the distance between the rear of two consecutive footprints.

For men, the formula, $\frac{n}{P} = 140$, gives an approximate relationship between n and P where:

n = number of steps per minute, and
P = pacelength in metres.

Question

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

This open-constructed response question is situated in a personal context. The question is about the relationship between the number of steps per minute and pacelength, which means that it is in the change and relationships content area. Students need to solve the problem by substitution into a simple formula and carrying out a routine calculation: if n/p = 140, and n = 70, what is the value of p? The competencies needed involve reproducing practised knowledge, performing routine procedures, the application of standard technical skills, manipulating expressions containing symbols and formulae, and carrying out computations. With this combination of competencies, and the real-world setting that students must handle, the question has a difficulty of 611 score points (Level 5).

Quantity scale

EXCHANGE RATE

Mei-Ling from Singapore was preparing to go to South Africa for 3 months as an exchange student.
She needed to change some Singapore dollars (SGD) into South African rand (ZAR).

Question

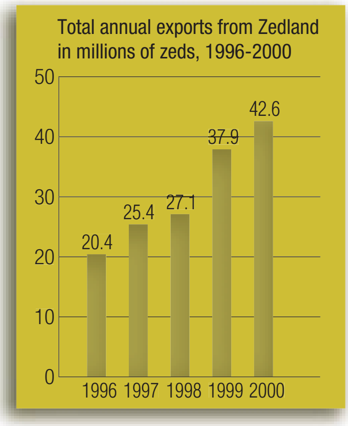
- During these 3 months the exchange rate had changed from 4.2 to 4.0 ZAR per SGD.
Was it in Mei-Ling's favour that the exchange rate now was 4.0 ZAR instead of 4.2 ZAR, when she changed her South African rand back to Singapore dollars?
Give an explanation to support your answer.

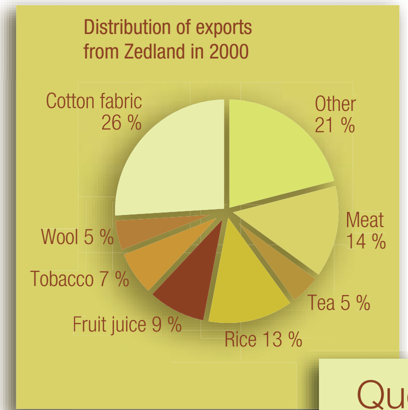
This open-constructed response question is situated in a public context. The students need to apply procedural knowledge involving the number operations of multiplication and division – this places the question in the quantity content area. The students are required to interpret a non-trivial mathematical relationship (a specified change in the exchange rate for 1 Singapore Dollar/1 South African Rand), reflect on this change, use flexible reasoning to solve the problem and apply basic computational and quantitative comparison skills. Students also need to construct an explanation of their conclusion. The combination of familiar context, complex situation, non-routine problem, the need for reasoning and insight and communication means this question has a difficulty of 586 score points (Level 4).

Uncertainty scale

EXPORTS

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





This multiple-choice question is situated in a public context and is in the uncertainty content area. It consists of reading data from a bar chart and a pie chart, and combining that data to carry out a basic number operation. Specifically, it involves decoding the charts by looking at the total of annual exports of the year 2000 (42.6 million zeds) and at the percentage coming from Fruit Juice exports (9%). It is this activity and the process of connecting these numbers by an appropriate numerical operation (9% of 42.6) that places this question in the connections competency cluster. The question has a difficulty of 565 score points (Level 4).

Question

- What was the value of fruit juice exported from Zedland in 2000?
A. 1.8 million zeds.
B. 2.3 million zeds.
C. 2.4 million zeds.
D. 3.4 million zeds.
E. 3.8 million zeds.

Further examples of PISA mathematics tasks can be found in the full report.

A profile of student performance in mathematics

A profile of student performance in mathematics in each country participating in PISA 2003 can be described in terms of three main measures:

1) **Student proficiency in mathematics,** showing the percentage who reach international benchmarks, according to their mastery of problems at different levels of difficulty

2) **Overall student performance,** in terms of the average mathematics score

3) **The spread of performance in each country,** showing the gap between better and poorer performing students

Student proficiency in mathematics

PISA 2003 divides students according to the highest of the six proficiency levels at which they can usually perform tasks correctly. The knowledge and skills that they need to do so are described on page 5. The small minority who can perform the most complex and demanding tasks are ranked at Level 6; those who can only perform very simple tasks are at Level 1. Students unable even to complete these tasks are said to be "below Level 1".

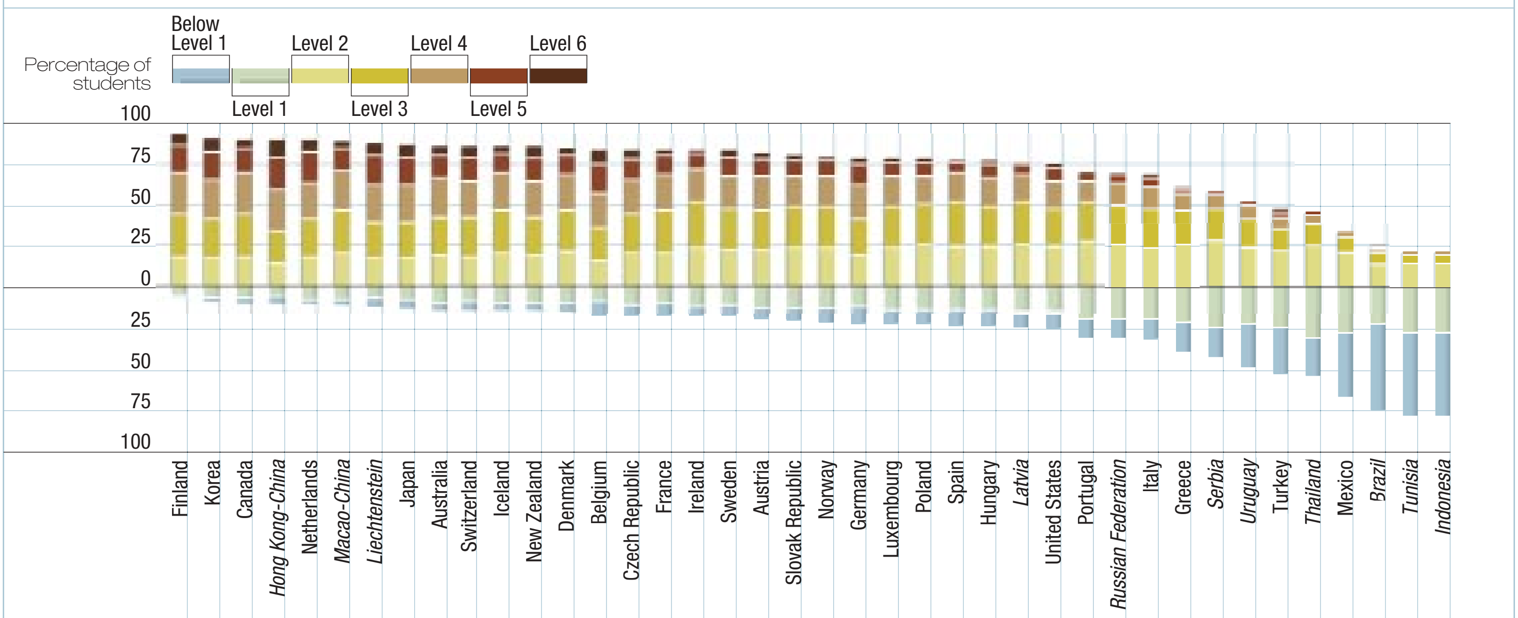
Figure 2 classifies 15-year-olds in each country according to the highest level of mathematical proficiency that they demonstrated in the PISA assessments:

- Only 4 per cent of students in the combined OECD area, but more than 8 per cent in Belgium, Japan, Korea and the partner country *Hong Kong-China* – can perform the highly complex tasks required to reach Level 6.
- About a third of OECD students can perform relatively difficult tasks at Levels 4, 5 or 6, but over 49 per cent of students in Finland, Korea and the partner country *Hong Kong-China* can perform at least at Level 4.
- About three-quarters of OECD students can perform at least mathematical tasks at Level 2 (shown above the central line in the graph). However, over a quarter of students are not proficient beyond Level 1 in Italy and Portugal, over a third in Greece and over half in Mexico and Turkey. A number of partner countries also have high numbers at Level 1 or below.
- Eleven per cent of students in OECD countries are not capable even of Level 1 tasks. These students may still be able to perform basic mathematical operations, but were unable to utilise mathematical skills in a given situation, as required by the easiest PISA tasks. In some countries, over 20 per cent are in this category.

While the number of students with strong mathematical knowledge and skills has relevance for the future competitiveness of knowledge-oriented economies, a particularly important aspect of each country's skill profile is the proportion of students who lack baseline mathematical skills, as economies will also need a broadly educated workforce, and individuals who are without these skills are likely to face difficulties in their adult lives. Figure 2 thus distinguishes those who are at least at Level 2, a baseline at which students begin to demonstrate skills allowing them to use mathematics actively – such as using direct inference to recognise the mathematical elements of a situation (see page 5).

Figure 2

Percentage of students at each level of proficiency on the mathematics scale



Countries are ranked in descending order of the percentage of 15-year-olds in levels 2, 3, 4, 5 and 6.
Source: *OECD PISA 2003 database, Table 2.5a.*

Overall student performance

For each country, students' overall performance in mathematics 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 1.

In PISA 2003, Finland, Korea and the partner country *Hong Kong-China* score particularly well and rank between first and third, first and fourth, and first and fifth, respectively, on the mathematics scale.

Most OECD countries have estimated mean performance in mathematics at proficiency Level 3. The exceptions are Finland, whose students score on average at the boundary between Level 3 and Level 4; Greece, Italy, Portugal, and Turkey with averages at Level 2; and Mexico at Level 1. Among the partner countries in PISA, *Hong Kong-China* had an average in Level 4, *Latvia, Liechtenstein* and *Macao-China* in Level 3 and the remainder in Level 1 or Level 2.

This represents wide differences in the mathematical skill profiles of different countries, with some having students who can typically identify and solve real-life mathematical problems of medium difficulty and others where they are only capable of very simple and explicit tasks. These differences may have serious implications for international competitiveness. Note, however, that diverse results occur in different countries whose students have widely differing average socio-economic backgrounds, even among OECD countries, and which spend different amounts per student on their schooling.

Mean scores in mathematics can also be compared across different areas of mathematics; between 2000 and 2003; and between males and females. These comparisons are shown overleaf.

Table 1

Mean performance on the mathematics scale

		Range of ranks*			
		OECD countries		All countries	
		Upper rank	Lower rank	Upper rank	Lower rank
Statistically significantly above the OECD average	*Hong Kong-China*	-	-	1	3
	Finland	1	3	1	4
	Korea	1	4	1	5
	Netherlands	1	5	2	7
	Liechtenstein	-	-	2	9
	Japan	2	7	3	10
	Canada	4	7	5	9
	Belgium	4	8	5	10
	Macao-China	-	-	6	12
	Switzerland	4	9	6	12
	Australia	7	9	9	12
	New Zealand	7	10	9	13
	Czech Republic	9	14	12	17
	Iceland	10	13	13	16
	Denmark	10	14	13	17
	France	11	15	14	18
	Sweden	12	16	15	19
Not statistically significantly different from the OECD average	Austria	13	18	16	20
	Germany	14	18	17	21
	Ireland	15	18	17	21
	Slovak Republic	16	21	19	24
Statistically significantly below the OECD average	Norway	18	21	21	24
	Luxembourg	19	21	22	24
	Poland	19	23	22	26
	Hungary	19	23	22	27
	Spain	22	24	25	28
	Latvia	-	-	25	28
	United States	22	24	25	28
	Russian Federation	-	-	29	31
	Portugal	25	26	29	31
	Italy	25	26	29	31
	Greece	27	27	32	33
	Serbia	-	-	32	34
	Turkey	28	28	33	36
	Uruguay	-	-	34	36
	Thailand	-	-	34	36
	Mexico	29	29	37	37
	Indonesia	-	-	38	40
	Tunisia	-	-	38	40
	Brazil	-	-	38	40

*Note: Because data are based on samples, it is not possible to report exact rank order positions for countries. However, it is possible to report the range of rank order positions within which the country mean lies with 95 per cent likelihood.

Source: *OECD PISA 2003 database.*

Four areas of performance in mathematics

PISA reported on four areas of mathematics (see page 4), showing student performance on separate scales for "space and shape", "change and relationships", "quantity" and "uncertainty". In some countries, students' relative performance is not equally strong across these scales, which could indicate where mathematics teaching is stronger or where it puts greater emphasis. Some of the most substantial differences among OECD countries are in:

- The Czech Republic and the Slovak Republic – both above the OECD average on the space and shape scale, but around average and below average respectively on the uncertainty scale;
- New Zealand – only just above average on the quantity scale, but well above average on the other three scales.
- Switzerland – one of the highest scoring countries on three of the scales, but further down the distribution on the uncertainty scale.
- Germany – above the OECD average on the quantity scale, but below average on the uncertainty scale.

See Figs. 2.6b, 2.9b, 2.12b and 2.15b, main report

Change since 2000

PISA allows comparison of performance over time in those areas of mathematics that were also assessed in 2000. These are space and shape, where overall OECD performance was similar in the two surveys, and change and relationships, where it increased by around ten score points between 2000 and 2003.

Some countries, however, have seen substantial change, with average scores increasing by at least half a proficiency level (32 score points) in Poland and in the partner country *Liechtenstein* on the change and relationships scale, and in the partner countries *Latvia* and *Brazil* on both of the comparable mathematics scales. Table 2 shows the countries where mean scores showed statistically significant change:

Table 2

Countries showing a statistically significant change in areas of mathematics performance

PISA 2000 to PISA 2003

	Space and shape scale	Change and relationships scale
Increase	Belgium, Czech Republic, Italy, Poland	Belgium, Canada, Czech Republic, Finland, Germany, Hungary, Korea, Poland, Portugal, Spain
	Brazil, Indonesia, Latvia, Thailand	*Brazil, Latvia, Liechtenstein*
Decrease	Iceland, Mexico	*Thailand*

Gender differences

Disadvantages faced by females in education have diminished in recent years in many educational domains, but males continue to do better in certain disciplines, particularly in terms of their likelihood of gaining tertiary qualifications in mathematics-related fields of study.

PISA found that in most countries males outperform females, but the overall difference is usually not large. Despite the absence of a large overall gender difference in mathematics as there is in favour of females in reading (see page 32), gender differences in mathematics warrant continued attention for several reasons:

See Table 2.5c, Fig. 2.18, main report

- The contrast between countries where such differences persist and those where they are not visible suggests that unequal performance by gender in mathematics is not an inevitable result, and that some countries do provide a learning environment that benefits both genders equally.

OECD countries with no statistically significant gender difference in mathematics overall:
Australia, Austria, Belgium, Japan, the Netherlands, Norway, Poland

In other countries there remains a male advantage, except Iceland where there is a female advantage.

- Differences in the picture among different areas of mathematics show that some areas require particular attention. Males are ahead in performing space and shape tasks in all but five OECD countries: Finland, Iceland, Japan, the Netherlands and Norway. Gender difference is much less widespread for tasks involving quantity: they are measurable in only 12 out of 29 OECD countries.

OECD countries where males perform better than females in all four areas of mathematics:
Canada, Denmark, Greece, Ireland, Italy, Korea, Luxembourg, New Zealand, Portugal, the Slovak Republic

- In most countries, the gender differences are larger within schools than they are overall, since females tend to attend the higher performing, academically oriented tracks and schools at a higher rate than males but, within these, often perform well below males in mathematics. This raises issues for teachers and teaching.

Spread of performance within each country

How widely are mathematics scores spread around the mean for each country? The within-country distribution measures how close students score around the local average. This is relevant over and above how many are proficient at particular levels on the international scale, as the advantage or disadvantage felt by someone with a given set of mathematical skills will be influenced by the extent to which their skills are above or below those of most other people in the school they attend and the country where they live.

Figure 3 shows countries ranked by the average mathematics scores. The total length of the bar represents the range at which the middle 90 per cent perform – that is, the difference between a student with a score higher than just 5 per cent of the student population, and one with a score higher than 95 per cent. The central box shows the range within which the mean score can be said with confidence to lie.

The results show that the amount of within-country variation in student performance in mathematics differs widely among OECD countries. The range of scores of the middle 90 percent varies from the equivalent of around 4.4 proficiency levels in Canada, Finland, Ireland and Mexico, to between 5.3 and 5.8 proficiency levels in Belgium, Germany, Japan and Turkey.

Looking at the performance of the middle half of students, two particular features are of interest for policy. First, countries with very similar average results can see a wider or narrower range of achievement. For example, among the highest performers, Finland shows much less performance variation than the Netherlands. Second, the results show that wide disparities in performance are not necessarily associated with a country's students doing well overall. Canada, Denmark, Finland, Iceland and Korea all have above-average performance, but the middle half of students score within a relatively narrow range.

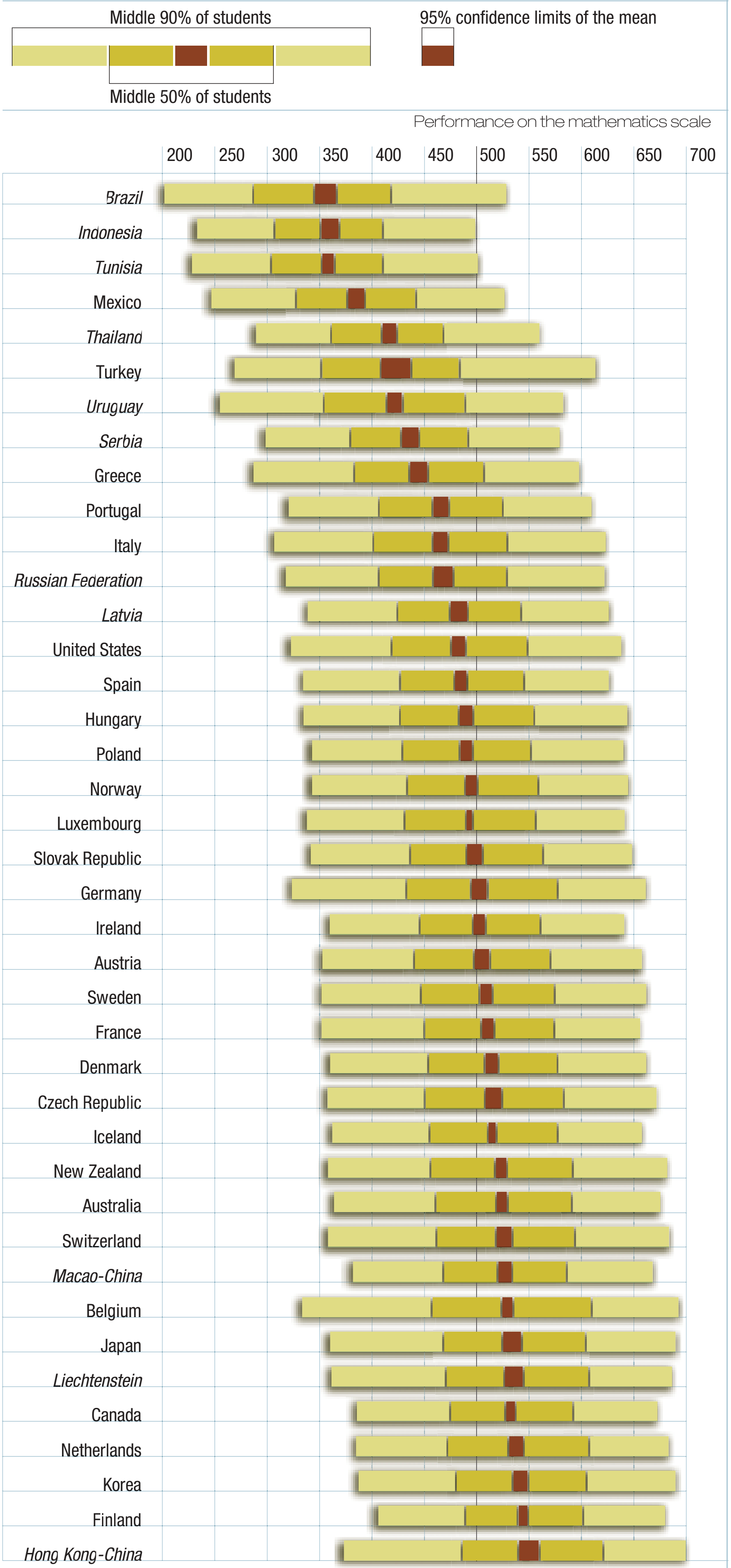
Changes in distribution

In the two areas of mathematics assessed in 2000 as well as 2003, it is possible to see not just where average scores have changed, but also where there have been changes in the distribution of performance. In most cases, patterns remain similar. However, in some countries, performance differences have widened or narrowed over a three-year period, as changes in one part of the performance range are not matched by changes in others. An example of this is Poland, where a substantial rise in mean performance is associated with rises in scores of lower-performing students which may have followed the reform of the schooling system in 1999 to provide more integrated secondary education. Overall improvement has also been driven from the bottom in the Czech Republic on both scales and in Hungary on the change and relationships scale. In contrast, improvement has been seen mainly among higher-achievers, potentially widening performance differences, in Belgium and Italy on the space and shape scale and in Canada, Finland, Germany, Italy, Korea, Portugal and Sweden on the change and relationships scale.

See Figs. 2.6c and 2.9c, main report

Figure 3

Distribution of student performance on the mathematics scale



Source: *OECD PISA 2003 database, Table 2.5c.*

Characteristics of effective learners

What are students like as learners at age 15? Those who are well motivated, confident in their own abilities and who regularly adopt effective learning strategies tend to do better at school. However, positive approaches not only help to explain student performance but are themselves important outcomes of education. Students who have become effective learners by the time they leave school, and particularly those who have learned to regulate their own learning, are often considered more likely to continue to learn throughout life.

PISA 2003 asked students about four aspects of their approaches to learning mathematics:

- **Their motivation:**
  whether they are interested in and enjoy mathematics, whether they believe it will help them fulfil their goals, whether they feel positive about their school and whether they feel that they belong there;
- **Their self-related beliefs:**
  how confident they are in their ability in mathematics ("self-concept") and their capacity to overcome learning challenges that they find difficult ("self-efficacy");
- **Emotional factors:**
  specifically, how anxious students feel when learning mathematics; and
- **Learning strategies:**
  the extent to which students "memorise" new information, "elaborate" it by thinking about how it relates to what they have already learned and "control" their own learning by checking that learning goals are being reached.

Analysing student responses, PISA shows three useful things about student approaches to learning. The first is the extent to which students in different countries have certain self-identified characteristics that may help them to learn. Secondly, the PISA results show to what degree particular characteristics are associated with performance. Third, they show how motivation, self-related beliefs and emotional factors are linked to the adoption of effective learning strategies, and thus can help students become lifelong learners.

Profile of learner characteristics

Students' approaches to learning mathematics show both negative and positive characteristics, with some countries facing some worrying concerns. In particular:

Intrinsic interest in mathematics is far lower, across countries, than in reading (as reported in PISA 2000)

Among OECD countries, about half of the students report being interested in the things they learn in mathematics but only 38 per cent agree or strongly agree that they do mathematics because they enjoy it. While many students are still interested in the things they learn in mathematics, less than one-third report looking forward to their mathematics lessons.

See Table 3.1, Fig. 3.2, main report

On the other hand, the great majority of students believe that studying mathematics will help them in the future

Among OECD countries 75 per cent of 15-year-olds (though only around half of students in Japan or Luxembourg) agree or strongly agree that making an effort in mathematics is worth it because it will help them in the work that they want to do later on. Seventy-eight per cent of 15-year-olds agree or strongly agree that learning mathematics is important because it will help them with the subjects that they want to study further on in school. And 70 per cent (though less than half in Japan and Korea) agree or strongly agree that they will learn many things in mathematics that will help them get a job. Such "instrumental motivation" may have some relationship to students' futures, or at least to how students envision them aged 15. PISA asked students what education level they expect to attain. In most countries, levels of instrumental motivation are higher among students aspiring at least to complete educational programmes that provide access to tertiary education and the relationship tends to be stronger still if the students expect to complete a tertiary programme.

See Tables 3.2a-c, Fig. 3.3a, main report

All education systems aspire not just to transmit subject knowledge but also to prepare students well for life in general. The views of the majority of 15-year-olds suggest that education systems are quite successful in this respect

Typical students in the OECD agree that school helped give them confidence to make decisions and has taught them things which could be useful in a job. Nevertheless, a significant minority of students, 8 per cent on average across OECD countries consider school a waste of time. An average of 32 per cent, and above 40 per cent in Germany, Hungary, Luxembourg, Mexico and Turkey, report that school has done little to prepare them for life. This suggests that there is room for improvement in general attitudes towards schooling for 15-year-olds. In many countries students' attitudes towards school vary greatly from one school to another, suggesting that school policy and practice can address this problem.

See Table 3.4, Fig. 3.4, main report

Overall, students report a positive sense of belonging at school

On average across OECD countries, 81 per cent of the students agree that their school is a place where they feel like they belong. Eighty-nine per cent agree that their school is a place where they make friends easily. Nevertheless, there is considerable variation across countries. Students in Austria, Germany, Iceland, Luxembourg, Norway, Spain, Sweden and Switzerland report the highest sense of belonging at school. In contrast, the lowest sense of belonging at school is reported by students in Belgium, the Czech Republic, France, Japan, Korea, Poland, the Slovak Republic and Turkey. For example, while in Sweden 5 per cent of students report that school is a place where they feel awkward and out of place, more than three times this proportion report that feeling in Belgium and Japan.

See Table 3.5a, Fig. 3.5, main report

Students' concept of their mathematics abilities is both an important outcome of education and a powerful predictor of student success. A large proportion of 15–year-olds are not confident of their own abilities in mathematics

On average across OECD countries, 67 per cent of students disagree that in their mathematics class, they understand even the most difficult work. Response patterns vary by country. For example, for the aforementioned item, percentages disagreeing range from around 84 per cent or more in Japan and Korea to 57 per cent or less in Canada, Mexico, Sweden and the United States. Similarly, on average across OECD countries, roughly half of the students disagree that they learn mathematics quickly. But while in Japan and Korea more than 62 per cent of students disagree, the proportion is only around 40 per cent of students in Denmark and Sweden. For most of these questions, comparatively large gender differences are apparent. For example, while on average across OECD countries, 36 per cent of males agree or strongly agree with the statement that they are "simply not good at mathematics", the average for females is 47 per cent.

See Table 3.6, Fig. 3.6, main report

Anxiety in relation to mathematics is widespread

On average among OECD countries, half of 15-year-old males and more than 60 per cent of females report that they often worry that they will find mathematics classes difficult and that they will get poor marks. Almost 30 per cent of students across the OECD agree that they get very nervous doing mathematics problems, get very tense when they have to do mathematics homework or feel helpless when doing a mathematics problem. There is considerable cross-country variation in the degree to which students feel anxiety when dealing with mathematics, with students in France, Italy, Japan, Korea, Mexico, Spain, and Turkey reporting feeling most concerned and students in Denmark, Finland, the Netherlands and Sweden least concerned. For example, more than half of the students in France and Japan report that they get very tense when they have to do mathematics homework, but only 7 per cent of students in Finland and the Netherlands report this. It is noteworthy that Finland and the Netherlands are also two of the top performing countries. More than two-thirds of the students in Greece, Italy, Japan, Korea, Mexico and Portugal report that they often worry that it will be difficult for them in mathematics classes, whereas only about one-third of students in Denmark or Sweden fall into this category.

See Table 3.8, Fig. 3.8, main report

Some caution is needed when comparing these self-reported characteristics across countries. Analysis of responses shows that comparisons across cultures are sometimes difficult to make on such measures. Nevertheless, some of the wider reported differences show interesting contrasts about how students in different countries see themselves as learners. On the three characteristics that can most easily be compared across countries and that are clearly associated with performance (see below), students have the strongest and weakest* approaches to learning in the following countries:

"Self-concept" in mathematics:

Strongest in:
the United States

Weakest in:
Japan, Korea, *Hong Kong-China*

See Table 3.6, main report

"Self-efficacy" in mathematics:

Strongest in:
Canada, Hungary, the Slovak Republic, Switzerland, the United States, *Liechtenstein*

Weakest in:
Greece, Japan, Korea, *Brazil, Indonesia, Thailand, Tunisia*

See Table 3.7, main report

Anxiety in mathematics:

Lowest in:
Austria, Denmark, Finland, Germany, the Netherlands, Sweden, Switzerland, *Liechtenstein*

Highest in:
France, Italy, Japan, Korea, Mexico, Spain, Turkey, *Brazil, Indonesia, Thailand, Serbia, Tunisia, Uruguay*

See Table 3.8, main report

*Each characteristic is scored on an index.
The strongest countries shown are those where the average student score is at least a quarter of a standard deviation above the OECD average, the weakest where it is at least a quarter of a standard deviation below.

The widest differences between countries on these three indicators are seen for anxiety.

Strength of association with mathematics performance

To what extent do students with positive attitudes towards mathematics and who adopt effective learning strategies perform better in mathematics? While PISA cannot demonstrate cause and effect, the results show a number of important associations:

Interest in and enjoyment of mathematics is closely associated with performance in all OECD countries

This association is particularly strong in some countries, notably in Finland, Japan and Korea, three high-performing countries where the average interest expressed in mathematics is low, but those with an interest higher than the norm for their country are likely to perform better.

See Table 3.1, main report

Students who believe in their abilities and efficacy, and who are not anxious about mathematics, are particularly likely to do well in it

Here, the link is considerably stronger than for interest and enjoyment. While it is likely that success in mathematics feeds confidence as well as the other way around, the evidence suggests that this is a mutually reinforcing process. Moreover, the fact that gender differences in mathematics performance are relatively minor, but females have considerably less confidence in mathematics than males underlines the fact that sometimes low self-related beliefs and anxiety do not simply mirror weak performance.

See Table 3.7, main report

Some student characteristics that might well affect mathematics performance are not clearly associated with it in PISA

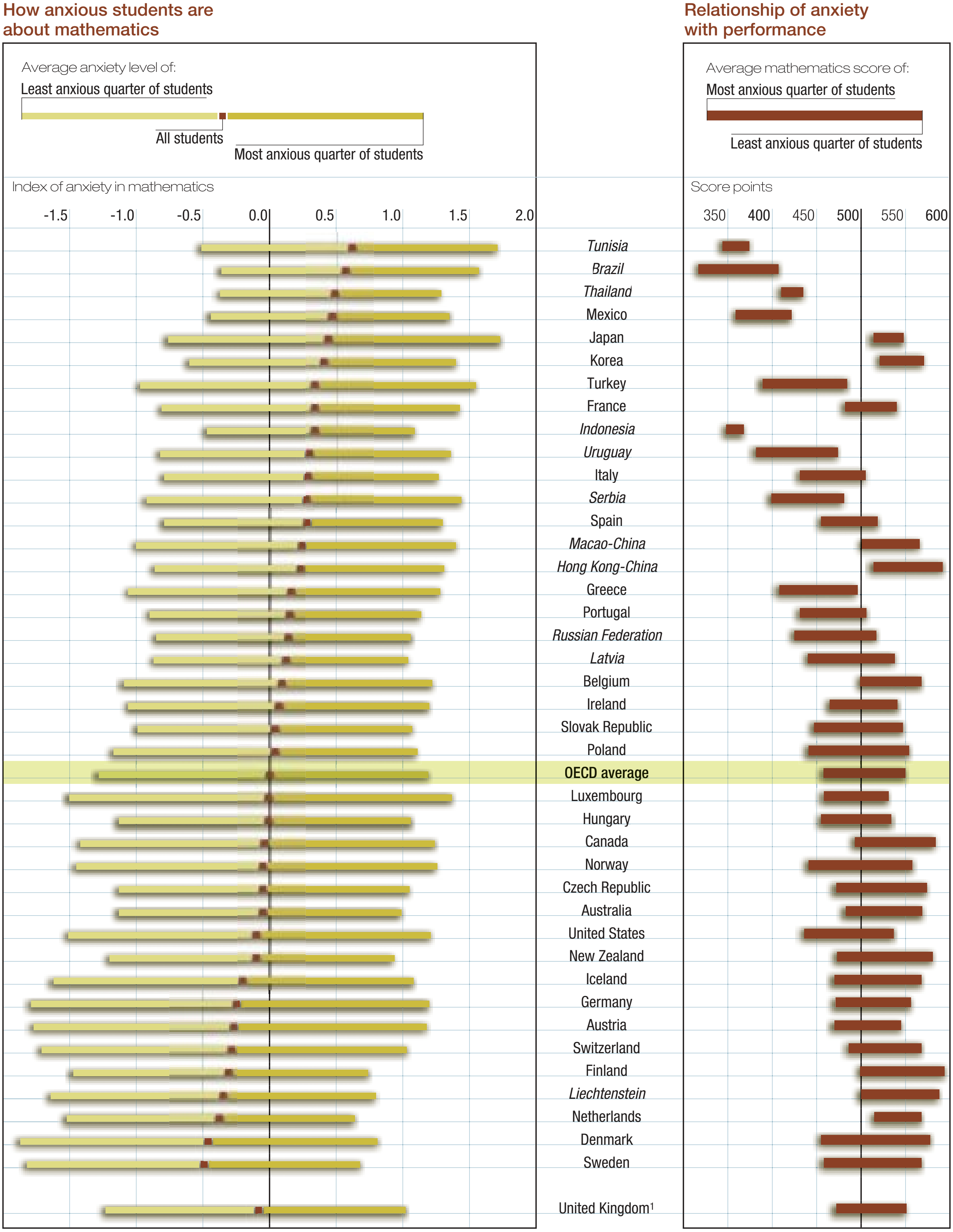
For example, students who make a conscious effort to control their own learning more do not on average perform significantly better. This may be because some students with lower performance use such strategies to try to remedy deficiencies in performance, thus affecting the profile of students using control strategies.

The association of each of these characteristics with performance is complicated by the fact that different positive approaches to learning tend to go together. For example, a student who enjoys mathematics is also likely to be less anxious and more confident about it – and that student's greater chance of performing well may be linked more to low anxiety and high self-related beliefs than directly to interest and enjoyment.

Figure 4 gives a profile of one such factor, anxiety, in different countries, by showing first the level of anxiety expressed by students in different countries and second the strength of the relationship with performance. In Japan, for example, a quarter of students express a particularly high level of anxiety about mathematics, yet still manage to score above average in the assessment. On the other hand, students in Denmark show much lower levels of anxiety, yet the most anxious quarter among them score 124 points, or two proficiency levels lower in mathematics than the quarter with least anxiety.

Figure 4

Anxiety in mathematics and its relationship to mathematics performance



1. Response rate too low to ensure comparability.
Source: *OECD PISA 2003 database, Table 2.5c.*

Student attitudes and learning strategies

Although PISA 2003 does not show strong links between students' self-reports on the learning strategies they use and performance, the results do suggest that students are most likely to initiate high quality learning, using various strategies, if they are well motivated, not anxious about their learning and believe in their own capacities.

There are good grounds for this: high quality learning is time and effort-intensive. It involves control of the learning process as well as the explicit checking of relations between previously acquired knowledge and new information, the formulation of hypotheses about possible connections and the testing of these hypotheses against the background of the new material. Learners are only willing to invest such effort if they have a strong interest in a subject or if there is a considerable benefit, in terms of high performance, with learners motivated by the external reward of performing well. Thus, students need to be willing to learn how to learn. From the perspective of teaching this implies that effective ways of learning – including goal setting, strategy selection and the control and evaluation of the learning process – can and should be fostered by the educational setting and by teachers.

School differences

Are negative attitudes to learning mathematics concentrated in underperforming schools? This is difficult to examine through PISA, as students often report their attitudes and learning strategies within the frame of reference provided by their own classroom and school. Thus, although PISA finds that the profile of students' self-reported approaches to learning varies much more within schools than across schools, this may underestimate the true cross-school variation in students' characteristics as learners. Nevertheless the PISA findings do highlight considerable variation of such characteristics among students within each school. This underlines the importance for schools and teachers of being able to engage constructively with heterogeneity not only in student abilities but also in their characteristics as learners and their approaches to learning. It will not be sufficient to operate on the principle that "a rising tide raises all ships", since even in well-performing schools there are students who lack confidence and motivation and who are not inclined to set and monitor their own learning goals.

See Table 3.15, main report

Gender differences

PISA 2003 shows that, while females generally do not perform much below males in mathematics, they consistently report much lower interest in and enjoyment of mathematics, lower self-related beliefs and much higher levels of helplessness and stress in mathematics classes. This finding is highly relevant for policy makers, as it reveals inequalities between the genders in the effectiveness with which schools and societies promote motivation and interest and – to an even greater extent – help students overcome anxiety towards different subject areas. These patterns may well be predictive of differences between males and females appearing later in their educational and occupational careers, raising further questions about how the gender gap can be reduced. Related data show, for example, that, despite improvements in female mathematics performance, males remain far more likely to pursue studies in mathematics-related disciplines at tertiary level.

See Table 3.16, Fig. 3.14, main report

Approaches to learning: overall policy implications

These results suggest that education systems have to design ways to work with students to address aspects of attitudes and learning behaviours and perhaps even make these goals just as central to their mission as cognitive instruction. This may have implications for teacher training, as well as continuous professional development.

In designing solutions, policy makers will need to bear in mind that weaknesses in approaches to learning mathematics do not only affect strongly underperforming groups of students or schools. The PISA evidence suggests that even in schools where students tend to perform relatively well, some may be held back by negative attitudes towards mathematics, as are females to a greater extent than might be expected from their average performance. The implication is that measures to improve attitudes could not be effectively targeted on the basis of low mathematics performance alone.

Mathematics performance, school differences and student background

Which schools students attend can influence educational outcomes, as can the characteristics of their home background.

These two factors can interact, since school differences may result not only from school factors such as teaching methods and resource inputs, but also from the combined socio-economic background of the students who attend the school.

This section looks at the amount of performance differences attributable to between-school variation, at the influence of home background and at the interaction between the two.

Differences in performance across schools

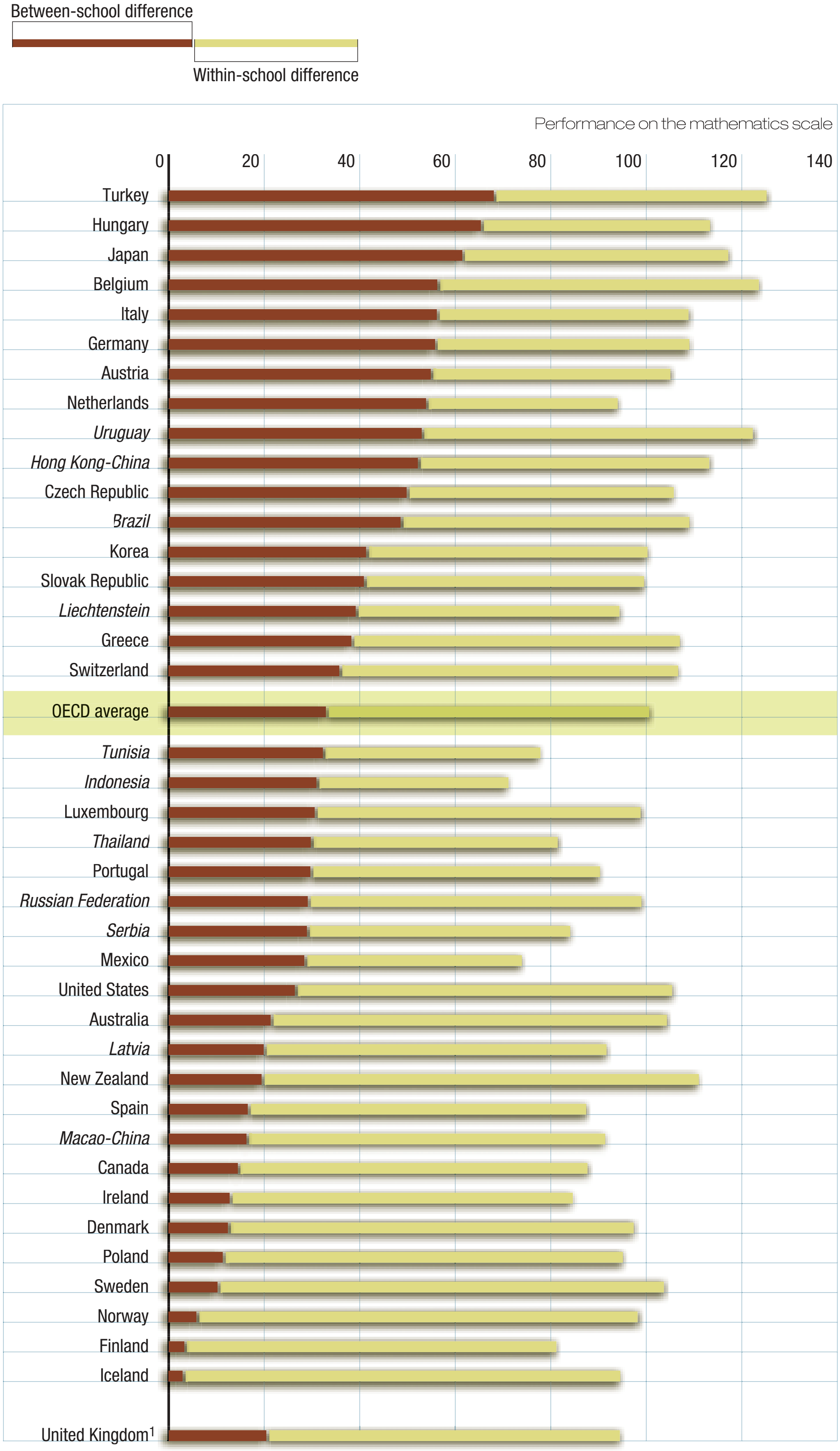
Secondary schools may vary in performance for a variety of reasons, including policies for dividing students into different ability groups, geographical differences in student profiles and differences in school quality. As a result of a combination of such factors, countries differ greatly in the extent to which variation occurs across schools. Figure 5 looks at the total between-school variation, as part of the overall variation in student performance that is found in each country. The rest of this variation is contained within schools. The graph shows that between-school variation is many times as great in some countries as in others, and also comprises very different proportions of the overall student variation seen within a country.

In the 11 countries at the top of the graph, variation between schools is much greater than the OECD area on average. In Hungary and Turkey, variation in performance between schools is particularly large and is more than twice the OECD average between-school variation. In Austria, Belgium, the Czech Republic, Germany, Italy, Japan and the Netherlands, as well as in the partner countries *Hong Kong-China* and *Uruguay,* the proportion of variation that lies between schools and school types is still over one-and-a-half times that of the OECD average level. In contrast, the proportion of performance variation that lies between schools and school types is around one-tenth of the OECD average level in Finland and Iceland, and half or less in Canada, Denmark, Ireland, Norway, Poland, Sweden and in the partner country *Macao-China*. In these countries performance is largely unrelated to the schools in which students are enrolled. It is noteworthy that Canada, Denmark, Finland, Iceland, Ireland, Sweden and the partner country *Macao-China* also perform well or at least above the OECD average level. Parents in these countries can be less concerned about school choice in order to enhance their children's performance, and can be confident of high and consistent performance standards across schools in the entire education system.

In one country, Poland, there has been a marked reduction in between-school differences since PISA 2000, possibly linked to the development of a more integrated school system. Here, the result appears to have been a "levelling up", with the improvements among lower-performing students noted on page 11.

Figure 5

Between-school and within-school differences in mathematics performance



1. Response rate too low to ensure comparability.
Source: *OECD PISA 2003 database, Table 4.1a.*

Differences in performance by socio-economic background

It is well known that students from less advantaged home backgrounds tend to do less well on average at school than their more advantaged peers. However, the extent to which different countries manage to contain this disadvantage is an indicator of how far school systems manage to spread equal opportunities to students regardless of background.

PISA 2003 looked at the relationship of a number of different aspects of student background with mathematics performance (see Box A). It also constructed an overall index of student socio-economic background, taking account of economic, social and cultural status.

Different countries show different relationships between socio-economic background and performance in mathematics. This can be measured in two main ways.
See Table 4.3b, main report

First, it is possible to look at the strength of the relationship, in terms of how much variation in student performance can be accounted for by students' differing socio-economic backgrounds. In other words, if one were to predict each student's score on the basis of their economic, social and cultural characteristics, how much of existing variation could one account for? Overall in OECD countries, one-fifth of all student variation can be accounted for in this way, but this ranges widely:

Countries with the highest and lowest proportion of mathematics performance variation associated with socio-economic background:

Highest (22-27 per cent):
Belgium, Germany, Hungary, the Slovak Republic, Turkey

Lowest (2-7 per cent):
Iceland, *Hong Kong-China, Indonesia, Macao-China*

See Table 4.4, main report

BOX A

Aspects of student background related to student performance

Several features of students' socio-economic backgrounds are predictive of how well they perform at school. PISA classifies students by:

The occupational status of their parents

On average, the quarter of students whose parents have the highest-status jobs score 93 points higher than the quarter with the lowest-status jobs.

Countries with the greatest and smallest performance gaps between the top and bottom quarter of students by parents' occupational status:

Greatest (difference of at least 100 points)**:**
Belgium, Germany, *Liechtenstein*

Smallest (difference of below 60 points)**:**
Iceland, Korea, *Hong Kong-China, Latvia, Macao-China, the Russian Federation*

See Table 4.2a, main report

The highest educational level of their parents

In particular, those with mothers who completed upper secondary school score on average 50 points higher than those whose mothers have lower qualifications, and having a mother with tertiary education adds a further 24 points

Countries with the greatest and smallest performance gaps between students whose mothers' highest qualification is upper secondary education and those with lower qualifications:

Greatest (difference of at least 60 points)**:**
Germany, the Slovak Republic, Turkey, *Brazil*

Smallest (difference of below 20 points)**:**
Australia, Finland, Iceland, the Netherlands, Spain, *Macao-China*

See Table 4.2b, main report

Families' cultural possessions

PISA considered the extent to which students have home possessions related to "classical" culture, such as literature, art and poetry. This has a substantial relationship to performance, with the quarter of students with most cultural possessions scoring on average 66 points higher than the quarter with least. Even though part of this is linked to the higher average occupational and educational status of the families of culturally advantaged students, an effect remains after controlling for these factors, which is nearly as high as the separate effect of occupational status.

Countries with the greatest and smallest performance gaps between the top and bottom quarter of students by cultural possessions in the home:

Greatest (difference of at least 75 points)**:**
Belgium, Denmark, France, Hungary, Sweden

Smallest (difference of below 40 points)**:**
Iceland, Switzerland, *Indonesia, Macao-China, Thailand*

See Table 4.2d, main report

Students' immigrant status and the language they speak at home

Students whose parents are immigrants show weaker performance than native students in some but not all countries. The greatest gap, of 93 points in mathematics scores, is in Germany. Students themselves born outside the country tend to lag even further behind, in Belgium by 109 points. While circumstances of different immigrant groups vary greatly, and some are disadvantaged by linguistic or socio-economic disadvantage as well as their migrant status itself, two particular findings are worrying for some countries. One is the relatively poor performance even among students who have grown up in the country and gone to school there. The other is that after controlling for the socio-economic background and language spoken at home, a substantial performance gap between immigrant students and others remains in many countries – it is above half a proficiency level in Belgium, Germany, the Netherlands, Sweden and Switzerland.

See Table 4.2h, main report

A second measure looks at the extent of the predicted performance gap between students with higher and lower socio-economic background – or the steepness of the "social gradient". On average in OECD countries, two students whose socio-economic background is separated by one internationally standardised "unit" of difference (one standard deviation) can be predicted to be 45 points apart in mathematics scores. This means, roughly, that among the middle two-thirds of students ranked by socio-economic background, predicted scores vary by 90 score points, or roughly one-and-a-half proficiency levels.

See Table 4.3a, main report

For example, in Poland, with a close-to-average performance gap, a relatively disadvantaged student, with a socio-economic background profile lower than all but one-sixth of Polish students, is predicted to have mathematics proficiency around the middle of Level 2, with 445 points, similar to the average score in Greece. A relatively advantaged Polish student, with a socio-economic background higher than all but one-sixth of Polish students, is predicted to have a proficiency of Level 3, at 535 points, the average performance of a Japanese student.

Note that while each of these two measures shows something about how much difference socio-economic background makes, they do not produce identical results. For example, in both Germany and Japan, the predicted gap between students is about average. However, in Germany, students have a relatively high likelihood of performing as predicted by their socio-economic backgrounds, and this accounts for 23 per cent of performance variation. On the other hand in Japan, the predicted relationship makes less difference because fewer students perform as predicted: socio-economic background only accounts for 12 per cent of variation.

See Table 4.4, main report

A further significant factor is the range of socio-economic backgrounds among the student population in each country. For example, Japan and Norway have a relatively low spread of social differences among the middle 90 per cent of the population; it is at least 50 per cent higher in Mexico and Portugal. School systems face greater challenges in reducing social differences in countries where students come from a wider spread of backgrounds.

Figure 6 shows the strength of the relationship between students' socio-economic background and their mathematics performance, in the context of how well students perform on average in mathematics. This shows that five countries in particular, Canada, Finland, Japan and the partner countries *Hong Kong-China* and *Macao-China,* manage to combine high average performance with a relatively weak effect of socio-economic background. In these countries, not only are high average standards maintained, but differences in the extent to which students reach these standards are determined relatively little by their home background.

Figure 6

Performance in mathematics and the impact of socio-economic background

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

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

Source: *OECD PISA 2003 database, Table 4.3a.*

The interaction between school and socio-economic background differences

To what extent are the differences between the performance of students at different schools associated with differences in socio-economic background? The answer again varies greatly across countries. In some, each school tends to educate a socially relatively homogeneous group of students. In these countries, the average socio-economic background of the students at the school is usually a much strong predictor of student performance than a student's individual socio-economic background.

The combined effect of individual socio-economic background and the social intake of schools accounts for 74-80 per cent of between-school differences in three of the countries where these differences are among the greatest: Belgium, Germany and Hungary. In these countries, the total amount of variation associated with differences in the socio-economic background of students at different schools exceeds 40 per cent of average performance variation among students in OECD countries.
See Tables 4.1a and 4.5, main report

In contrast, in Canada, Finland, Iceland, Mexico, Norway and Sweden, differences in the social composition of schools do little to explain between-school differences. In Japan, the direct effect of individuals' backgrounds appears to have little effect, but taking account of the effect of the school's social intake raises the amount of between-school variation attributable to socio-economic background to one of the highest levels in the OECD.

A measure of the social intake effect can be shown by considering the difference in predicted performance of two students who are identical in characteristics except that they attend different schools, one more and one less advantaged in social intake. These schools' average socio-economic backgrounds differ by about as much as the middle half of schools in OECD countries – thus, not exceptionally privileged or disadvantaged institutions. The magnitude of the different performance of the two students is striking in some countries:
See Table 4.5, main report

Mathematics scores of students attending a more and a less advantaged school differ particularly widely in:

Austria, Belgium, the Czech Republic, Germany, Hungary, Japan, Korea, the Netherlands, the Slovak Republic, Turkey, *Hong Kong-China* and *Liechtenstein*.

These differences among schools according to social intake may arise from a range of factors, including peer interactions, disciplinary climate and a faster-paced curriculum. Any attempt to develop education policies to reduce or to mitigate the effects of segregation would need to take into account its underlying causes, which may be different in different contexts.

School and social differences: policy implications

PISA shows that experiences at school can too often reinforce rather than mitigate the effects of home background. This may be because privileged families are better able to take advantage of the education system, or because schools find it easier to educate them, or for other reasons. Yet some countries manage to combine greater equity with high performance, and all systems face a challenge to move in this direction.

The findings from PISA can help each country to design strategies to increase quality and equity, by describing the ways in which performance and socio-economic advantage are distributed across and within schools. Different patterns in different countries suggest different solutions. Among the approaches that policy might take are to:

- **Target assistance to low-performing students,** regardless of socio-economic background, for example through early intervention or remedial assistance aimed underperforming students. Individualising learning in order to provide students with appropriate forms of instruction is one approach.
- **Target assistance to students from less advantaged backgrounds,** for example through preschool help for disadvantaged students or extra resources for schools in deprived areas.
- **Aim to raise the performance of all students,** for example by improving instructional techniques or curricula. A wide range of approaches can be adopted here, including improving learning environments, involving parents and making schools more accountable for outcomes.
- **Aim to create more inclusive school structures that reduce segregation among students,** for example through changes in catchment areas or magnet programmes.

Targeting performance or background

One underlying issue confronting school administrators is whether to target low performance or low socio-economic background. Useful indicators here are the slope of the socio-economic gradient (the predicted performance difference between students of different backgrounds) and the strength of the gradient (the amount of variation accounted for by this link). Countries with relatively flat gradients are likely to find performance-based policies more effective in raising performance among students. Conversely, countries with steep socio-economic gradients might find some combination of performance-targeted and socio-economically-targeted policies more effective. For example, in Canada, Finland, Iceland, Italy, Luxembourg, Portugal and Spain, with flatter than average gradients, a relatively smaller proportion of low-performing students come from disadvantaged backgrounds. Here, policies that specifically target students from disadvantaged backgrounds would not address the needs of many low performers. Moreover, socio-economically targeted policies in these countries would be providing services to a sizeable proportion of students who already have high performance levels.

By contrast, in countries where the impact of socio-economic background on student performance is strong, socio-economically targeted policies would direct more of the resources towards students who are likely to require these services. However, the case for socio-economically-targeted policies can still be overstated for some countries with steep socio-economic gradients. In some such countries, the amount of performance variation accounted for by socio-economic background is only moderate, implying that a sizeable group of poorly performing students have higher socio-economic backgrounds.

Targeting schools or students

Another key issue is whether to target low-performing schools or students. The proportion of performance variation between schools, shown in Figure 5, can provide a useful indicator in judging the appropriateness of particular policy approaches. If there is little performance variation between schools, as in Canada, Denmark, Finland, Iceland, Ireland, Norway, Poland or Sweden, then within-school policies aimed at improving the performance of low-performing students are likely to be more effective. By contrast, in countries such as Austria, Belgium, the Czech Republic, Germany, Hungary, Italy, Japan, the Netherlands and Turkey, large performance differences between schools would suggest that policies should target low-performing schools, at least within each type of school where the education system is stratified.

Systems where school and socio-economic differences go together

Finally, the analyses reveal that countries with greater socio-economic inclusion tend to have higher overall performance. In some countries, socio-economic segregation can be deeply entrenched due to economic divides between urban and rural areas, as well as residential segregation in cities. However, segregation can also stem from educational policies that stream children into certain kinds of programmes early in their school careers. To increase quality and equity in such countries would require specific attention to between-school differences. Reducing the socio-economic segregation of schools would be one strategy, while allocating resources differentially to schools and programmes and seeking to provide students with differentiated and appropriate educational opportunities are others. In countries that separate students more into different types of schools or programmes, it is important to understand how the allocation of school resources is related to the socio-economic intake of its schools. In some countries, there is relatively little socio-economic segregation between schools i.e., schools tend to be similar in their average socio-economic intake. In these countries, overall performance and social differences are mainly affected by the relationship between student performance and the socio-economic background of individual students within each school. To increase quality and equality in these countries will require actions that predominantly focus within schools. Reducing the segregation within schools of students of differing economic, social and cultural status would be one strategy, and might require a review of classroom streaming practices. More direct assistance for poorly performing students may also be needed.

How schools make a difference

What can schools and school policies do to raise performance and promote equity? As shown above, variations in the performance of both students and schools are strongly associated with home background, which is largely beyond the control of policy makers. Yet research shows clearly that there are many things that schools can do to enhance learning effectiveness.

PISA is able to probe further the influence on student performance of the school environment, school policies and practices, the resources invested in schools and the organisational structure of schooling. In each case, the analysis looks at:

- First, the incidence in different countries of various characteristics that may be associated with performance.
- Second, the actual strength of this association for individual factors within each country.
- Third, the combined effect of these factors on performance in the context of student background effects. The analysis finds that the association of various school factors with enhanced performance is in large part related to the socio-economic advantages of schools, implying that those school factors often work in combination with the influence of student background.

The school environment

PISA asked students and principals about their perceptions of the learning environment and school climate. There is considerable variation across countries in some crucial factors affecting the environment in which students learn, most notably the extent to which they feel supported by their teachers and the disciplinary climate.

For example, while most students overall feel that their mathematics teacher gives extra help when students need it, this ranges from less than 60 per cent in Austria, Germany, Italy, Korea, the Slovak Republic, Spain, *Macao-China, Serbia* and *Uruguay* to 75 per cent or more in Australia, Canada, the Czech Republic, Finland, New Zealand, the United States and *Thailand*.

See Fig. 5.1, main report

In terms of disciplinary climate, in most OECD countries, principals identify student absenteeism as the most frequent student-related obstacle to learning: on average, 48 per cent of 15-year-olds are enrolled in schools whose principals identify this as hindering learning by 15-year-olds either to some extent or a lot. Disruptive behaviour is the next most frequently indicated obstacle to learning (40 per cent). This is followed by students skipping classes (30 per cent). From the students' perspective, having noise and disorder is the most frequently reported disciplinary problem in their mathematics lessons, with 36 per cent of students reporting that this happens in every lesson or at least in most lessons. On average across OECD countries, more than a quarter of students report that in every lesson or at least in most lessons, students do not start working for a long time after lessons begin and a third of students report that the teacher must wait a long time for students to quieten down or that students don't listen to what the teacher says.

See Figs. 5.2 and 5.3, main report

Reports of features of the school environment*:

Students report the greatest teacher support in mathematics lessons in:
Australia, Canada, Mexico, Portugal, Turkey, the United States, *Brazil, Indonesia, the Russian Federation, Thailand* and *Uruguay*

See Table 5.1a, main report

Students report the least teacher support in mathematics lessons in:
Austria, Germany, Japan, Luxembourg and the Netherlands

See Table 5.1a, main report

Students report the strongest disciplinary climate in mathematics lessons in:
Germany, Ireland, Japan, *Latvia* and *the Russian Federation*

See Table 5.3a, main report

Principals report the strongest student-related factors affecting school climate in:
Belgium, Denmark, Hungary, Japan, Korea, the Slovak Republic, *Hong Kong-China, Thailand* and *Uruguay*

See Table 5.2a, main report

Students report the weakest disciplinary climate in mathematics lessons in:
Brazil

See Table 5.3a, main report

Principals report the weakest student-related factors affecting school climate in:
Canada, Greece, Ireland, New Zealand, Turkey, the United States, *Indonesia, Macao-China, the Russian Federation, Serbia* and *Tunisia*

See Table 5.2a, main report

*Each characteristic is measured on an index.
The strongest countries shown are those where the average student score is at least a quarter of a standard deviation above the OECD average, the weakest where it is at least a quarter of a standard deviation below.

Three school environment factors are most clearly associated with performance: student-related factors affecting school climate as reported by principals, disciplinary climate as reported by students, and students' morale and commitment as reported by principals. The effects are statistically significant in most countries, but the first of these is most variable across countries: students do particularly well in schools whose principals say that they behave well in Belgium, Germany, Japan and the Netherlands, but this effect is negligible in Norway.

When climate factors are considered alongside socio-economic differences their separate effects are relatively small. However, it appears that there is a powerful effect of school climate in combination with students' socio-economic background. Thus, it is not just that students happen to do well in schools with good discipline because these are also the schools containing advantaged students who would do well anyway.
See Table 5.7, Fig. 5.7, main report

It is apparent from the analysis that socio-economic factors seem to reinforce the impact school climate has on school performance in important ways, perhaps because students from more advantaged socio-economic backgrounds bring with them a higher level of discipline and more positive perceptions of school values, or perhaps because parental expectations of good classroom discipline and strong teacher commitment are higher in schools with advantaged socio-economic intake. Conversely, disadvantaged schools may experience less parental pressure towards enforcing effective disciplinary practices or making sure that absent or unmotivated teachers are replaced. Thus, a large joint influence of socio-economic background and school climate should be of concern for policy makers seeking to ensure that all schools have committed teachers and an orderly climate, irrespective of their socio-economic intake.

In this regard, it is noteworthy that in some countries the joint influence of socio-economic background and school climate is much larger than at the OECD average level. For example, the "net" effect of school climate on student performance accounts for only between 1.4 and 7.5 per cent of the performance variation among schools in Australia, Belgium, Germany, Japan, Korea, the Netherlands and Spain, but when the socio-economic context of students and schools is considered as well, the resulting gross effect increases to between 29 per cent in Spain and 49 per cent in Belgium, with these seven countries having the highest values among OECD countries.

School policies and practices

A large-scale international survey cannot measure all of the aspects of school policies and practices relevant to successful learning, but PISA asked principals about a selection of such factors. It was thus able to compare the extent to which these are applied across countries and in some cases to note relationships with student performance. In particular:

Student assessment within schools is used to widely varying degrees within and across countries

For example, among OECD countries on average a quarter of 15-year-olds and over half in Korea and New Zealand are in schools using standardised tests at least three times a year (according to school principals). In contrast, on average a quarter (and over half of students in Austria, Belgium, Germany and Switzerland) are in schools that never use such tests. Other forms of assessment such as portfolio assessment and teacher-set tests are more frequently used and the use by teachers of their own tests appears to be most positively related to performance. Countries also vary in the extent to which testing is used for accountability purposes, and in some countries, but not in others, students in schools that use their results to compare themselves with others tend to perform better.

See Tables 5.9-5.10, main report

School management autonomy is highly variable, with for example control over budgets varying greatly across countries

Since within each education systems the extent of school autonomy does not always vary much, it is hard to identify a link between autonomy and performance within countries, but the results across countries suggest that education systems devolving more responsibility to schools in areas concerning budget allocations within schools, the appointment of teachers, course offerings and disciplinary matters get better results, even if this does not imply causal links. Important differences among countries emerge in the ways in which stakeholders outside and inside the school are involved in decision-making. Across the four decision-making areas of staffing, budgeting, instructional content and assessment practices, and among the seven stakeholder groups that were considered, school principals report the strongest influence by regional or national education authorities, followed by school governing boards, teacher groups, external examination boards, and then employers in the enterprise sector, parent groups and student groups.

See Tables 5.11 to 5.11b, main report

For school policies and practices, as for school climate, there is little discernible link with performance once associations with student background have been separated out, but a substantial combined effect of socio-economic background in combination with what schools do. This is particularly marked in Austria, Belgium, Germany, Korea, the Netherlands, Portugal and Uruguay. This suggests that, in these countries in particular, certain positive features of policies and practices in schools attended by more advantaged students reinforce the effects of home advantage.

See Table 5.13, Fig. 5.13, main report

Resources invested in schools

Various aspects of the physical and human resources invested in schools are often associated with student performance in the public debate. PISA asked principals questions about the adequacy of such resources in their schools, and also was able to compare public and private schools, and to consider the time invested in learning:

Teacher shortages appear to be of concern in a number of countries, although not in others

On average in OECD countries, principals report that teacher shortages hinder instructional capacity in schools enrolling a quarter of students. Note however that this measure relies on principal perception of the effect of teacher supply, rather than being a measure of teacher supply itself: some countries where schools report more acute teacher shortages in fact have relatively low overall ratios of students to teachers.

See Table 5.15, Fig. 5.16, main report

Percentage of students in schools where principals report that shortage of mathematics teachers hinders instruction capacity at least to some extent:

Highest (41-84 per cent**) in:**
Luxembourg, New Zealand, Turkey, *Indonesia, Uruguay*

Lowest (below 10 per cent**) in:**
Austria, Denmark, Finland, Hungary, Korea, Portugal, the Slovak Republic, Switzerland

The quality of the physical infrastructure and educational resources cannot guarantee educational success, but having adequate material resources is a necessary condition for effective learning

In some countries difficulties with physical infrastructure does little to hinder schools' instructional capacity according to principals; in others, notably Greece, Norway and Turkey, principals raise such concerns more frequently. Only in a few countries is any link between physical resources and student performance evident; the link is slightly stronger in some countries in the case of educational resources such as instructional materials and computers. Principals were most likely to report that shortage or low quality of educational resources hinders instruction in Greece, Mexico, Poland, the Slovak Republic, Turkey, *Brazil, Indonesia, Latvia, the Russian Federation*, *Serbia, Thailand, Tunisia* and *Uruguay*. Among these, the link with performance is strongest in *Brazil*.

See Table 5.17, main report

Students in private schools, often funded partly or wholly by the public purse, tend to perform well, but also to have home advantages

Only in Japan, Korea, Mexico, *Brazil, Indonesia, Macao-China* and *Uruguay* are more than 10 per cent of 15–year-olds enrolled in independent schools resourced mainly by private means. Students in private schools perform much better on average, but the difference reduces if the socio-economic characteristics of individual students attending these schools are controlled for, and disappears entirely after also controlling for the fact that a student of a given socio-economic background tends to do better in a school with a more advantaged social intake.

There might still be some benefit associated with the school being private and not just its intake: the advantage of having more advantaged peers may be more likely to show through with certain kinds of school policies and approaches experienced in private schools. However, these comparisons show that the association between a school being private and its students doing well is at best tenuous. Thus, any policy to enhance overall performance only by moving funding from public to private institutions is subject to considerable uncertainty.

See Table 5.19, main report

PISA looked at how much time students invested in learning, and found that those who had invested more in early childhood do better

It is hard to find clear links with performance, especially for example among students who do more homework, partly because slower learners may need more time to complete homework. However, PISA identified one particularly interesting link between performance and time invested in learning: students who attended pre-school programmes often perform significantly better at age 15. In nine OECD countries this effect was particularly great – ranging between half a proficiency level and just over one proficiency level in mathematics (30-73 points). This suggests that preschool investments may have effects that are still marked and widespread across the student population (and in some cases greater among the least advantaged students) eight to ten years into a child's school education.

See Figs. 5.15 and 5.16, main report

Looking at school resources as a whole reveals a substantial combined effect of socio-economic background in combination with the resources available to schools. This is particularly marked in Austria, Belgium, the Czech Republic, Germany, the Netherlands and New Zealand. In these countries policy makers need to address the fact that school resources appear to reinforce, rather than moderate, socio-economic differences.

See Table 5.20, Fig. 5.19, main report

The organisational structure of schooling

As noted above, catering for an increasingly diverse student body and narrowing the gaps in student performance represent formidable challenges for all countries, and the approaches that countries have chosen to address these demands vary. Some countries have non-selective school systems that seek to provide all students with similar opportunities for learning by requiring that each school caters for the full range of student performance.

Other countries respond to diversity explicitly by forming groups of students through selection either between schools or between classes within schools, with the aim of serving students according to their academic potential and/or interests in specific programmes. Education systems can be located on a continuum ranging from systems with low stratification at system, school and classroom levels to systems that are highly differentiated.

Aspects of differentiation

One device to differentiate among students is the use of different institutions or programmes that seek to group students, in accordance with their performance or other characteristics. Where students are sorted based on their performance, this is often done on the assumption that their talents will develop best in a learning environment in which they can stimulate each other equally well, and that an intellectually homogeneous student body will be conducive to the efficiency of teaching. Countries range from essentially undivided secondary education until the age of 15 years to systems with four or more school types or distinct educational programmes (Austria, Belgium, the Czech Republic, Germany, Ireland, the Netherlands the Slovak Republic and Switzerland). Simple cross-country comparisons show that the number of school types or distinct educational programmes available to 15-year-olds accounts for 39 per cent of the share of the OECD average variation that lies between schools. No less important, it accounts for 26 per cent of the cross-country variation among countries in the strength of the relationship between socio-economic background and student performance. In other words, in countries with a larger number of distinct programme types, socio-economic background tends to have a significantly larger impact on student performance such that equity is much harder to realise. The percentage of 15-year-olds in vocational programmes and the extent of grade repetition show similar associations.

See Figs. 5.20a-b, main report

An important dimension of tracking and streaming is the age at which decisions between different school types are generally made, and therefore students and their parents are faced with choices. Such decisions occur very early in Austria and Germany, at around age 10. By contrast, in countries such as New Zealand, Spain and the United States no formal differentiation takes place at least between schools until the completion of secondary education. Across the OECD, the age of selection accounts for half of the between-school differences. While this, in itself, is not surprising because variation in school performance is an intended outcome of stratification, the findings also show that education systems with lower ages of selection tend to show much larger social disparities, with the age of selection accounting for 28 per cent of the country average of the strength of the relationship between the PISA index of economic, social and cultural status and student performance.

Overall, these results show that institutional differentiation of students is associated with performance differences across schools and across social groups. It is difficult to define these measures of differentiation in ways that are cross-nationally comparable and interpretable. However, the various indicators of stratification that have been employed in the report are highly interrelated so that the results do not depend in significant ways on how stratification is measured. Moreover, the association with performance differences across social groups applies for the various aspects of family background that were measured by PISA, and this remains true even when controlling for variables such as national income.

Possible explanations

An explanation for these results is not straightforward. There is no intrinsic reason why institutional differentiation should necessarily lead to greater variation in student performance, or even to greater social selectivity. If teaching homogeneous groups of students is more efficient than teaching heterogeneous groups, this should increase the overall level of student performance rather than the dispersion of scores. However, in homogeneous environments, while the high performing students may profit from the wider opportunities to learn from one another, and stimulate each other's performance, the low performers may not be able to access effective models and support.

It may also be that in highly differentiated systems it is easier to move students not meeting certain performance standards to other schools, tracks or streams with lower performance expectations, rather than investing the effort to raise their performance. Finally, it could be that a learning environment that has a greater variety of student performance and backgrounds may stimulate teachers to use approaches that involve a higher degree of individual attention for students.

The reason why the age at which differentiation begins is closely associated with social selectivity may be explained by the fact that students are more dependent upon their parents and their parental resources when they are younger. In systems with a high degree of educational differentiation, parents from higher socio-economic backgrounds are in a better position to promote their children's chances than in a system in which such decisions are taken at a later age, and students themselves play a bigger role.

Measuring problem solving in PISA 2003

In addition to skills related to specific parts of the school curriculum, students need to be equipped with some general competencies to solve life's challenges. As they progress to adulthood, they need to learn to be able to complete not just pre-rehearsed exercises, but must also be able to solve problems set in unfamiliar situations by thinking flexibly and pragmatically.

PISA 2003 therefore makes a first-time assessment of students' problem-solving skills. Even though such skills contribute to performance at school, the tasks set were general ones, rather than attached to specific curriculum areas. They were rooted in a number of processes that students need to go through when confronted with a problem:

- **Understanding a situation;**
- **Identifying relevant information or constraints;**
- **Representing possible alternatives or solution paths;**
- **Selecting a solution strategy;**
- **Solving the problem;**
- **Checking or reflecting on the solution; and**
- **Communicating the result.**

Students were given a series of situations, and required to solve problems that required one of three types of processes:

- **Making a decision under constraints**
  For example, *Holiday* is a difficult task requiring students to plan a complex holiday itinerary.
- **Analysing and designing systems for a particular situation**
  For example, *Library System* shows one easy and one difficult task requiring students to interpret and represent sets of rules for borrowing school library books.
- **Trouble shooting a malfunctioning device or system based on a set of symptoms**
  For example, *Freezer* shows a task of medium to high difficulty requiring students to analyse what is wrong with a freezer.

As with the other PISA areas of assessment, the tasks were of varying difficulty and students were given scores according to the difficulty of task that they would usually be able to complete. The average score for OECD countries was set at 500 points, with about two-thirds of students scoring between 400 and 600. In this case, students were assigned to three proficiency levels, with Level 3 the highest and some students failing to reach Level 1.

Making a decision under constraints

HOLIDAY

This problem is about planning the best route for a holiday.
Figures 1 and 2 show a map of the area and the distances between towns.

Fig. 1 Map of roads between towns.

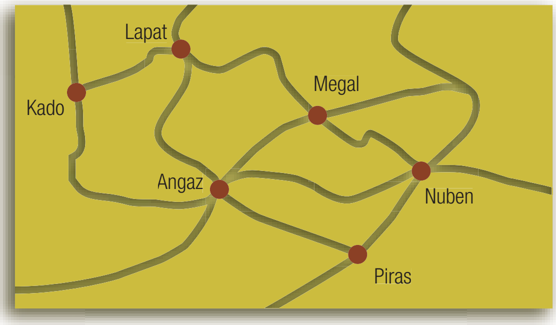


Fig. 2 Shortest road distance of towns from each other in kilometres.

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

Question (Difficulty: 603 score points – Level 3)

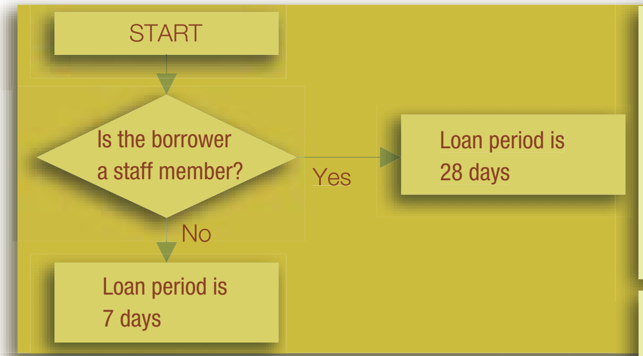
- Zoe lives in Angaz. She wants to visit Kado and Lapat. She can only travel up to 300 kilometres in any one day, but can break her journey by camping overnight anywhere between towns. Zoe will stay for two nights in each town, so that she can spend one whole day sightseeing in each town. Show Zoe's itinerary by completing the following table to indicate where she stays each night.

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

Analysing and designing systems

LIBRARY SYSTEM

The John Hobson High School library has a simple system for lending books:
for staff members the loan period is 28 days, and for students the loan period is 7 days.
The following is a decision tree diagram showing this simple system:



The Greenwood High School library has a similar, but more complicated, lending system:

- All publications classified as "Reserved" have a loan period of 2 days.
- For books (not including magazines) that are not on the reserved list, the loan period is 28 days for staff, and 14 days for students.
- For magazines that are not on the reserved list, the loan period is 7 days for everyone.
- Persons with any overdue items are not allowed to borrow anything.

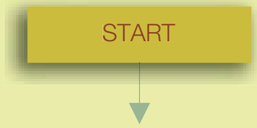
Question 1 (Difficulty: 437 score points – Level 1)

- You are a student at Greenwood High School, and you do not have any overdue items from the library. You want to borrow a book that is not on the reserved list. How long can you borrow the book for?

Answer: .... days

Question 2 (Difficulty: 692 score points – Level 3)

- Develop a decision tree diagram for the Greenwood High School Library system so that an automated checking system can be designed to deal with book and magazine loans at the library. Your checking system should be as efficient as possible (i.e. it should have the least number of checking steps). Note that each checking step should have only two outcomes and the outcomes should be labelled appropriately (e.g. "Yes" and "No").



Trouble shooting a malfunctioning device

FREEZER

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

- Connect the appliance to the power and switch the appliance on.
- You will hear the motor running now.
- A red warning light (LED) on the display will light up.
- Turn the temperature control to the desired position. Position 2 is normal.

Position	Temperature
1	-15 °C
2	-18°C
3	-21 °C
4	-25 °C
5	-32 °C

- The red warning light will stay on until the freezer temperature is low enough. This will take 1-3 hours, depending on the temperature you set.
- Load the freezer with food after four hours.

Jane followed these instructions,
but she set the temperature control to position 4.
After 4 hours, she loaded the freezer with food.
After 8 hours, the red warning light was still on,
although the motor was running
and it felt cold in the freezer.

Question (Difficulty: 551 score points – Level 2)

- Jane read the manual again to see if she had done something wrong. She found the following six warnings:

1- Do not connect the appliance to an unearthed power point.
2- Do not set the freezer temperatures lower than necessary (-18 °C is normal)
3- The ventilation grills should not be obstructed. This could decrease the freezing capability of the appliance.
4- Do not freeze lettuce, radishes, grapes, whole apples and pears, or fatty meat.
5- Do not salt or season fresh food before freezing.
6- Do not open the door too often.

Ignoring which of these six warnings could have caused the delay in the warning light going out?
Circle "Yes" or "No" for each of the six warnings.

Warning	Could ignoring the warning have caused a delay in the warning light going out?
Warning 1	Yes / No
Warning 2	Yes / No
Warning 3	Yes / No
Warning 4	Yes / No
Warning 5	Yes / No
Warning 6	Yes / No

Problem-solving performance in PISA 2003

Just under one in five 15-year-olds in OECD countries are "reflective, communicative problem solvers" able to tackle difficult tasks. These students, scoring at Level 3 in the PISA 2003 problem-solving assessment, are able to not only analyse a situation and make decisions, they are also capable of managing multiple conditions simultaneously. They can think about the underlying relationships in a problem, solve it systematically, check their work and communicate the results. In two countries over a third of students and in seven other countries a quarter or more have these skills:

Countries with over a quarter of students reaching problem-solving Level 3:

Over one-third: Japan, *Hong Kong-China*

Between a quarter and a third: Australia, Belgium, Canada, Finland, Korea, New Zealand, *Liechtenstein*

Around half of students in OECD countries are "reasoning, decision-making problem solvers", able at least to answer Level 2 problems correctly. These students, like those at Level 3, need to be good at reasoning, able to confront unfamiliar problems and capable of coping with a degree of complexity. In Finland, Japan, Korea and *Hong Kong-China,* 70 to 73 per cent of students are at least at Level 2, but only 3 to 4 per cent are at this level in *Indonesia* and *Tunisia*.

This shows that there are widely different norms across countries in what kind of problem most students can be expected to solve. Indeed, in some countries, the majority cannot even be classified as "basic problem solvers" at Level 1, which requires students to undertake less complex problem-solving processes. Just under one in five students in OECD countries have problem-solving skills that are below Level 1.

Countries with the fewest and the most students below problem-solving Level 1:

10 per cent or less:	Between 30 and 50 per cent:	More than 50 per cent:
Australia, Canada, Denmark, Finland, Japan, Korea, New Zealand, *Hong Kong-China, Liechtenstein, Macao-China*	Greece, *Serbia, Thailand, Uruguay*	Mexico, Turkey, *Brazil, Indonesia, Tunisia*

Average problem-solving scores and distribution

As with other areas of the PISA assessment, scores for each country can be summed up in a mean score. However, 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 four countries – Finland, Japan, Korea and the partner country *Hong Kong-China* – students perform higher than in any other country participating in the study. Their mean performances are about 50 points, or about one-half of a proficiency level, above the OECD average (see Table 3).

As in the other areas of PISA, the ranking of country averages disguises a wide range of performance within each country. In most OECD countries, for example, the highest-performing 10 per cent of students are all proficient at Level 3, but the lowest-performing 10 per cent fall below Level 1.

The total amount of variation in student scores varies across countries; Finland, Korea and the partner country *Macao-China* stand out as countries that have high performance overall, and at the same time manage to contain the amount of variation. A striking contrast is between Belgium and Korea. In these two countries, students at the 95th percentile show similar knowledge and skills in problem solving, but students at the 5th percentile score 64 points lower in Belgium than Korea, equivalent to two-thirds of a proficiency level.

Comparison with mathematics performance

Comparing problem-solving performance with that of other areas of the PISA assessment helps shed light on the skills assessed in PISA, as well as on some country strengths and weaknesses. Overall, there is a high correlation between problem solving and other areas of performance, especially in the case of mathematics. There appears to be a substantial overlap in the skills being tested: for example, both problem solving and mathematics require analytical reasoning skills. However, in each assessment area there are also distinctive things being tested; for example, performance in the mathematical problems involving mainly simple computations rather than wider inference is relatively weakly associated with problem-solving performance. This suggests that successful functioning in mathematics requires a combination of knowledge processing and application skills, which do not inevitably go together. It also confirms the value of PISA as an assessment that goes beyond the performance of standard curricular tasks in familiar contexts.

Even though individual countries show similar performance, on average, on the mathematics and the problem-solving scale, in most there is a small but statistically significant difference in the mean score, although usually by less than ten points.

Countries where average scores in mathematics and problem solving differ by at least ten points:

Mathematics performance higher:
Iceland, the Netherlands, Turkey, *Serbia, Tunisia, Uruguay*

Problem solving performance higher:
Germany, Hungary, Japan, *Brazil, the Russian Federation*

While these differences do not generally alter countries' relative standing greatly, the Netherlands is among the top-scoring group of seven countries in mathematics but between tenth and fifteenth overall in problem solving, while students in Hungary are below average in mathematics but average for the OECD in problem solving.

Gender differences

The relative performance of males and females in problem solving is useful for analysing performance differences among the genders more generally. Males do better on average in mathematics. If this is due to an advantage in analytical reasoning skills, it might feed through into better performance in problem solving; if this is linked to greater confidence with the mathematical curriculum, however, it might not. Females do better in reading and show more positive attitudes towards school overall. If this makes them more generally successful as learners, they might have an advantage in solving problems that demand a range of cognitive abilities.

In PISA 2003, gender differences in problem solving are mainly minor, and in most cases not statistically significant:

Females outperform males in problem solving in:
Iceland, Norway, Sweden, *Indonesia, Thailand*

Males outperform females in:
Macao-China

However, males notably show a greater range of performance in problem solving than females: more males are among both the higher and the lower performers. In fact, males have a greater range of performance in every participating country apart from the partner country *Indonesia*.

These results imply that both males and females bring particular strengths to problem solving. Problem solving may serve as an indicator of the extent to which gender differences exist beyond the context of a curriculum subject. In countries with a relatively strong gender advantage either for males in mathematics or females in reading, there sometimes remains a smaller but statistically significant gender difference in a similar direction in problem solving. On the other hand, in Italy and Greece, for example, both the male advantage in mathematics and the female advantage in reading are relatively large, but problem-solving performance is the same, suggesting that the gap is due to gender-typical characteristics of particular curriculum areas.

Table 3

Mean performance on the problem-solving scale

		Range of ranks*			
		OECD countries		All countries	
		Upper rank	Lower rank	Upper rank	Lower rank
Statistically significantly above the OECD average	Korea	1	3	1	4
	Hong Kong-China	-	-	1	4
	Finland	1	3	1	4
	Japan	1	3	1	4
	New Zealand	4	6	5	8
	Macao-China	-	-	5	9
	Australia	4	7	5	10
	Liechtenstein	-	-	5	11
	Canada	4	7	6	10
	Belgium	6	9	8	12
	Switzerland	7	12	9	15
	Netherlands	7	12	10	15
	France	7	13	10	16
	Denmark	8	13	11	16
	Czech Republic	8	14	11	17
	Germany	10	15	13	18
	Sweden	12	16	16	19
	Iceland	14	17	17	20
Not statistically significantly different from the OECD average	Austria	13	17	16	20
	Hungary	15	19	18	22
	Ireland	17	19	20	22
Statistically significantly below the OECD average	Luxembourg	18	21	21	24
	Slovak Republic	18	22	21	26
	Norway	19	22	22	26
	Poland	20	23	23	27
	Latvia	-	-	24	29
	Spain	22	24	25	29
	Russian Federation	-	-	25	30
	United States	23	25	26	30
	Portugal	24	26	28	31
	Italy	24	26	29	31
	Greece	27	27	32	32
	Thailand	-	-	33	34
	Serbia	-	-	33	35
	Uruguay	-	-	34	36
	Turkey	28	28	34	36
	Mexico	29	29	37	37
	Brazil	-	-	38	39
	Indonesia	-	-	38	39
	Tunisia	-	-	40	40

*Note: Because data are based on samples, it is not possible to report exact rank order positions for countries. However, it is possible to report the range of rank order positions within which the country mean lies with 95 per cent likelihood.

Source: *OECD PISA 2003 database.*

Reading performance in PISA 2003

PISA 2000 looked in detail at reading performance. PISA 2003 provides a brief update, with most assessment time having been devoted to mathematics.

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 a range of different kinds of written text, ranging from prose to lists, graphs and diagrams. For each text, they are set a series of tasks, requiring them to retrieve specified information, to interpret the text and to reflect on and evaluate what they read. These texts are set in a variety of reading situations, including reading for private use, occupational purposes, education and public use.

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.

Only 8 per cent of students in OECD countries are proficient at the highest reading level, Level 5. These students are capable of sophisticated, critical thinking and may contribute to a pool of world-class knowledge workers in tomorrow's economy. At least 12 per cent of students in Australia, Belgium, Canada, Finland, Korea, New Zealand and *Liechtenstein* are proficient at reading Level 5.

See Fig. 6.2, main report

Just over a quarter of OECD students are capable of difficult reading tasks at least at Level 4, and just over half can at least perform medium-difficulty tasks at least at Level 3. However, in some countries the great majority of students can function at this midrange reading level:

Countries with 65-80 per cent of students at reading Level 3 or above:
Australia, Canada, Finland, Ireland, Korea, the Netherlands, New Zealand, Sweden, *Hong Kong-China* and *Liechtenstein*

Students proficient at Level 2 are capable of basic reading tasks, such as 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 the text. More than three-quarters of students in OECD countries can perform these tasks. The remaining students, those who can at most perform very simple reading tasks at Level 1, are at risk of not acquiring essential life skills, partly because they do not have the foundation of literacy skills needed for continued learning and extending their knowledge horizon. A high number of students not reaching Level 2 is thus of considerable concern for education systems. While 22 per cent of students on average in OECD countries fall into this category, this varies widely across countries from less than 10 per cent to more than 50 per cent:

Countries with the fewest and the most students at reading Level 1 or below:

Fewer than 10 per cent:
Canada, Finland, Korea, *Macao-China*

Between a quarter and half:
Greece, Turkey, *the Russian Federation, Serbia, Thailand, Uruguay*

More than half:
Mexico, *Brazil, Indonesia, Tunisia*

Note that having relatively large numbers of students at the highest level of reading proficiency does not always go with having a very small number with weak reading skills. For example, Finland has 15 per cent of students at Level 5 and only 1 per cent below Level 1, whereas Belgium, which has 13 per cent of students at Level 5, has 8 per cent below Level 1.

Average reading scores

In reading, as with mathematics, reading 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 (see Table 4).

Finland's average reading score is above those of all other countries, and is over half a proficiency level above the OECD mean and more than two proficiency levels above the lowest-scoring countries. Despite this wide range of country performances, most variations take place within countries, although the range of student performance is wider in some countries than in others. Finland and Korea not only show the best overall performance but also are the two countries with the narrowest internal differences. Canada also has relatively small internal variations in its reading score, and is among the countries with the highest mean scores.

Table 4

Mean performance on the reading scale

		Range of ranks*			
		OECD countries		All countries	
		Upper rank	Lower rank	Upper rank	Lower rank
Statistically significantly above the OECD average	Finland	1	1	1	1
	Korea	2	3	2	3
	Canada	2	4	2	5
	Australia	3	5	3	6
	Liechtenstein	-	-	2	6
	New Zealand	4	6	4	7
	Ireland	6	8	6	10
	Sweden	6	9	7	10
	Netherlands	6	9	7	11
	Hong Kong-China	-	-	7	12
	Belgium	8	10	9	12
Not statistically significantly different from the OECD average	Norway	10	15	11	18
	Switzerland	10	17	12	20
	Japan	10	18	12	22
	Macao-China	-	-	12	19
	Poland	10	18	12	21
	France	10	18	12	22
	United States	10	19	12	23
	Denmark	12	20	15	24
	Iceland	14	20	17	24
	Germany	12	20	15	24
	Austria	12	21	14	25
	Latvia	-	-	14	25
	Czech Republic	14	21	17	25
Statistically significantly below the OECD average	Hungary	20	24	24	28
	Spain	20	25	24	29
	Luxembourg	21	25	25	29
	Portugal	21	26	25	30
	Italy	21	26	26	31
	Greece	23	27	27	31
	Slovak Republic	25	27	29	31
	Russian Federation	-	-	32	34
	Turkey	28	28	32	34
	Uruguay	-	-	33	34
	Thailand	-	-	35	36
	Serbia	-	-	35	37
	Brazil	-	-	36	38
	Mexico	29	29	37	38
	Indonesia	-	-	39	40
	Tunisia	-	-	39	40

*Note: Because data are based on samples, it is not possible to report exact rank order positions for countries. However, it is possible to report the range of rank order positions within which the country mean lies with 95 per cent likelihood.

Source: *OECD PISA 2003 database.*

Change since 2000

In PISA 2003, reading performance was scored on the same scale as in PISA 2000, with the average score of OECD countries participating in the 2000 survey set at 500. On average for the 25 OECD countries with valid results reported in both surveys, average reading performance had not changed statistically significantly over the three years. However, performance in some individual countries improved, and in others it went down.

Table 5

Countries with statistically significant changes in reading performance

PISA 2000 to PISA 2003

	Increase	Decrease
Average for all students	Poland	Austria, Iceland, Ireland, Italy, Japan, Mexico, Spain
	Latvia, Liechtenstein	*Hong Kong-China, the Russian Federation*
Score among higher performing students[1]	Korea	Canada, Denmark, Finland, Ireland
	Brazil, Latvia, Liechtenstein	*Hong Kong-China, the Russian Federation*
Score among lower performing students[2]	Poland	Austria, Iceland, Italy, Japan, Mexico, Spain
	Latvia, Liechtenstein	*Brazil, the Russian Federation*

1. Shows countries with change at the 75th, 90th and 95th percentiles, where in at least two of these cases the change is statistically significant.
2. Shows countries with change at the 25th, 10th and 5th percentiles, where in at least two of these cases the change is statistically significant.

Changes in performance were not always even across the whole student population. In some cases they were concentrated among either lower or higher performers. Thus, for example, in Poland a substantial improvement in average scores was caused by improvement among lower-performers, while a smaller rise in performance in Korea was caused by increased scores among higher-performers. In some countries, such as Denmark and Finland, small drops in reading performance in parts of the distribution were not sufficient to produce a statistically significant fall in average scores.

Gender differences

As in PISA 2000, females showed significantly higher average reading performance than males in every country in PISA 2003 (except in the partner country *Liechtenstein* in 2003). The female advantage in reading is generally greater than the male advantage in mathematics: on average it is 34 points, or half a proficiency level. However, the difference ranges from 58 points in Iceland to 21 points in Korea, Mexico and the Netherlands and 13 points in the partner country *Macao-China*.

See Table 6.3, Fig. 6.6, main report

Countries with the greatest gender gap in reading:

Females on average are at Level 4, males at Level 3:
Finland

Females on average are at Level 3, males at Level 2:
Austria, Germany, Iceland, Norway, Poland

Females on average are at Level 2, males at Level 1:
Serbia, Thailand

Science performance in PISA 2003

PISA 2003 looked that science more briefly than mathematics, devoting less assessment time to this subject. As in 2000, this gives a snapshot rather than a detailed portrait of performance in science. Science will become the main focus of PISA in 2006.

The emphasis in the PISA science assessment is the application of scientific knowledge and skills to real-life situations, as opposed to being a test of particular curricular components. In PISA 2003, the science assessment focused on a sample of concepts that have particular relevance to real life, as well as having enduring significance. Students were required to show a range of scientific skills, involving the recognition and explanation of scientific phenomena, the understanding of scientific investigation and the interpretation of scientific evidence. Tasks were set in a variety of contexts relevant to people's lives, related to life and health, technology and the Earth and environment.

More difficult science tasks in PISA involve more complex concepts and greater skill requirements, as well as requiring more sophisticated scientific knowledge. However, since science has not yet been assessed in detail in PISA, proficiency levels have yet to be defined.

Average science scores

As with mathematics and reading, 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.

Finland and Japan have the highest mean scores and rank between first and third on the science scale, but their performance is not statistically significantly different from that in Korea and the partner country *Hong Kong-China,* who both rank between second and fourth.

Table 6

Mean performance on the science scale

		Range of ranks*			
		OECD countries		All countries	
		Upper rank	Lower rank	Upper rank	Lower rank
Statistically significantly above the OECD average	Finland	1	2	1	3
	Japan	1	3	1	3
	Hong Kong-China	-	-	2	4
	Korea	2	3	2	4
	Liechtenstein	-	-	5	11
	Australia	4	7	5	10
	Macao-China	-	-	5	10
	Netherlands	4	8	5	11
	Czech Republic	4	8	5	11
	New Zealand	4	8	6	11
	Canada	6	9	8	12
	Switzerland	7	13	10	15
	France	9	13	12	16
	Belgium	9	13	12	16
	Sweden	10	15	13	18
	Ireland	10	15	13	18
Not statistically significantly different from the OECD average	Hungary	11	16	14	19
	Germany	11	17	14	21
	Poland	14	19	17	22
	Slovak Republic	15	21	18	25
Statistically significantly below the OECD average	Iceland	16	19	19	23
	United States	17	23	20	27
	Austria	16	23	19	28
	Russian Federation	-	-	20	30
	Latvia	-	-	20	29
	Spain	19	24	22	29
	Italy	19	25	22	30
	Norway	20	25	24	30
	Luxembourg	22	25	26	30
	Greece	21	26	25	31
	Denmark	25	27	30	32
	Portugal	26	27	31	32
	Uruguay	-	-	33	35
	Serbia	-	-	33	36
	Turkey	28	28	33	36
	Thailand	-	-	34	36
	Mexico	29	29	37	37
	Indonesia	-	-	38	39
	Brazil	-	-	38	40
	Tunisia	-	-	39	40

*Note: Because data are based on samples, it is not possible to report exact rank order positions for countries. However, it is possible to report the range of rank order positions within which the country mean lies with 95 per cent likelihood.

Source: *OECD PISA 2003 database.*

Change since 2000

In 2003, PISA science performance was scored on the same scale as in PISA 2000, with the average score of OECD countries participating in the 2000 survey set at 500.

Among the 25 OECD countries with valid results reported in both surveys, average science performance has not changed over the three years. However, performance in some countries improved, and in others it went down. Changes in performance were not always even across the whole student population. In some cases they were concentrated among either lower or higher performers.

In Korea, while there was some improvement in performance among the top 5 per cent of students, a more general drop across groups in the bottom 25 per cent dragged overall performance down.

Table 7

Countries with statistically significant changes in science performance

PISA 2000 to PISA 2003

	Increase	Decrease
Average for all students	Belgium, the Czech Republic, Finland, France, Germany, Greece, Poland, Switzerland	Austria, Canada, Korea, Mexico, Norway
	Brazil, Latvia, Liechtenstein, the Russian Federation	
Score among higher-performing students[1]	Belgium, the Czech Republic, Finland, France, Germany, Greece, Italy, Japan, Poland, Switzerland	Austria
	Brazil, Latvia, Liechtenstein, the Russian Federation	
Score among lower-performing students[2]		Austria, Canada, Japan, Korea, Mexico, Norway, Sweden
	Latvia, the Russian Federation	

1. Shows countries with change at the 75th, 90th and 95th percentiles, where in at least two of these cases the change is statistically significant.
2. Shows countries with change at the 25th, 10th and 5th percentiles, where in at least two of these cases the change is statistically significant.

Gender differences

Even though males have often shown higher performance in science in the past, there are no systematic differences between the performances of males and females in this domain in PISA 2003. In the minority of countries where gender differences exist, they are small. Moreover, similar proportions of males and females achieve particularly high and particularly low results in science. These results are encouraging even though it will take time for them to translate into corresponding participation patterns in higher education as well as occupational structures.

See Table 6.7, Fig. 6.13, main report

PISA Publications

PISA 2003 Initial Reports

Learning for Tomorrow's World – First Results from PISA 2003
Problem Solving for Tomorrow's World – First Measures of Cross-Curricular Competencies from PISA 2003

PISA 2003 Thematic Reports

Mathematical Literacy: Student Performance and Engagement (December 2005)
Teaching and Learning Strategies (April 2006)

PISA 2003 Assessment Information

The PISA 2003 Assessment Framework: Mathematics, Reading, Science and Problem Solving Knowledge and Skills
Programme for International Student Assessment (PISA): PISA 2003 Technical Report (September 2005)
Programme for International Student Assessment (PISA): Manual for the PISA 2003 Database (April 2005)

PISA 2000 Initial Reports

Knowledge and Skills for Life: First Results from PISA 2000
Literacy Skills for the World of Tomorrow: Further Results from PISA 2000

PISA 2000 Thematic Reports

Reading for Change: Performance and Engagement across Countries: Results from PISA 2000
Learners for Life: Student Approaches to Learning: Results from PISA 2000
Student Engagement at School: A Sense of Belonging and Participation: Results from PISA 2000
What Makes School Systems Perform?: Seeing School Systems through the Prism of PISA
Reviews of National Policies for Education: Denmark: Lessons from PISA 2000
School Factors Related to Quality and Equity (February 2005)

PISA 2000 Assessment Information

Measuring Student Knowledge and Skills: The PISA 2000 Assessment of Reading, Mathematical and Scientific Literacy
Sample Tasks from the PISA 2000 Assessment: Reading, Mathematical and Scientific Literacy
Programme for International Student Assessment (PISA): PISA 2000 Technical Report
Programme for International Student Assessment (PISA): Manual for the PISA 2000 Database

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