# Knowledge and Skills for the New Millennium:

## Results from PISA 2006 for Qatar

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## Results from PISA 2006 for Qatar



December 4, 2007

المجلس الأعلى للتعليم

SUPREME EDUCATION COUNCIL

تعليم لمرحلة جديدة

Education for a New Era

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# Foreword

The Programme for International Student Assessment (PISA) is a collaborative effort among Member countries of the Paris-based Organisation for Economic Co-operation and Development (OECD) and 25 partner countries in all regions of the world. In 2006, the State of Qatar took part in the study for the first time.

The programme is designed to assess, on a regular basis, the achievement of 15-year-olds in reading, mathematical and scientific literacy, using a common international test. The 2006 survey had a special focus on student achievement in science. An almost inclusive census of 15-year-olds residing in Qatar and attending schools in Qatar – 6265 children in a population of 7271 – was fielded for the assessment.

This report presents the results of the PISA assessment of student performance in reading, science and mathematics in Qatar in 2006 and compares this with the achievement of students internationally. The report describes not only the summary findings for the three subjects overall, but also analyses the differences in performance in science between several groups, such as boys and girls, students attending different school types, and children whose parents have different levels of educational attainment.

The findings indicate that Qatar's 15-year-olds were outperformed in reading, in mathematics and in science by the great majority of their peers in other countries, and that most students in Qatar did not adequately solve even the relatively simple items at the lower end of the proficiency scale in all three subjects tested. These results for Qatar leave no doubt that the recently initiated education reform "Education for a New Era" is much needed, and that efforts to further improve the quality of schooling must continue in many dimensions and at all levels.

Whilst it is true that overall performance in science is inadequate, the data also indicate that satisfactory results are, in fact, achieved in some of our schools and classrooms. Hence the potential for attaining good results does exist. Moreover, it is important to note that the country has recently launched numerous education changes, including large investments in early childhood education and care, elementary, preparatory and secondary education, and that the students assessed as part of PISA 2006 did not have the benefit of these initiatives. Education is a cumulative process, with early success in learning building subsequent success. The recent education reform efforts are therefore expected to bear fruit in decades to come, as today's young children will be coming of age. The extent to which this will hold true can be known only when

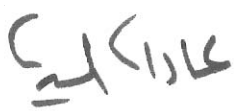
our children take part in international assessments such as PISA a decade hence. In this sense the PISA 2006 results for Qatar should be seen as providing a baseline for gauging future school improvement.

Yet the data also show the extent of the challenges our country faces in further upgrading the quality of the education system. This applies, in particular, to raising the reading and mathematics performance of youth in Qatar to world-class levels. Once achieved, these skills will in turn provide the foundation for improving science skills to the level needed to meet our long-term economic and social goals.

We cannot, however, rely solely upon the Qatari formal education system to realise these gains. Enriching the literacy environments at home, at the workplace and in Qatari society at large will have to be part of the solution. The global, comparative perspective brought by this report is valuable in illuminating the policy choices before us. This also underscores the value of taking part in internationally co-ordinated studies of educational achievement.

It is important to point out that educational assessment, as currently implemented in Qatar as part of the on-going reform, integrates several actions at different levels. Teachers assess students in the classroom in order to gauge their daily progress and grade their performance; schools adopt different models of tests to assess their students, so as to provide principals, teachers and parents with information on how different sections within a school compare; and the Qatar Comprehensive Educational Assessment (QCEA) programme tests all students in independent schools, so as to provide the Supreme Education Council, teachers, parents and students with a comparative and comparable indication of learners' performance in Arabic, English, mathematics and science. All these assessments are tools for learning, articulated into a systemic framework. At its top are placed the international comparisons that allow one to position Qatari education with respect to the rest of the world. The participation of Qatar in other international studies, such as PISA 2009 for 15-year-olds, the Trends in Mathematics and Science Study (TIMSS 2007) in 4th and 8th grade, and the Progress in Reading Literacy Survey (PIRLS 2006) in 4th grade, is intended to provide further and detailed information on how these comparisons evolve and which are the guidelines for improvement.

I would like to thank the students, the parents and the school principals, who gave of their precious time to participate in the survey and respond to, at times, demanding tasks. The high-level support for the project afforded by the Supreme Education Council, most particularly its President, His Highness the Heir Apparent Sheikh Tamim Bin Hamad Bin Khalifa Al-Thani and the Vice-President, Her Highness Sheikha Moza Bint Nasser Al Misned, is gratefully acknowledged. Sincere thanks are due also to the Ministry of Education, the members of the Evaluation Institute, the staff of the Qatar PISA National Centre and the Data Collection and Management Office, who have supported and implemented the study throughout.



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Evaluation Institute
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# Introduction

## New educational orientations in the Qatari society

In Qatar, rapid economic development and accelerating social progress have been accompanied by major demographic changes and the evolution of new trends in population attitudes and expectations. These changes were enhanced by factors such as ease of commuting and foreign travel, widespread access to telecommunications, a huge influx of foreign workers, the diffusion of new customs and lifestyles including, to some extent, women entering the world of work, and openness to international markets. Simultaneously, the economy and society more broadly have been impacted by "new sources of wealth, novel patterns of international trade, and a shift in the balance between capital and labour" (Kirsch *et al.*, 2007).

The Qatari education system has been particularly challenged because the changes have brought more diversity to the student population and have drawn into focus the balance to be struck in preserving "the old" while preparing for "the new". In response to the challenges posed, in 2001 the Supreme Education Council was appointed by His Highness the Emir, and charged with the task to develop an education reform initiative, "Education for a New Era", as part of a comprehensive, national strategy to improve the Qatari formal education system at all levels. The reform strategy targets the quality of education on offer, the transfer from secondary to tertiary education, and the correspondence between what is taught in formal education and the knowledge and skills actually demanded on the Qatari labour market vis-à-vis the demands of the global economy. The reform initiative promotes new forms of governance in the education system, with strengthened and more independent school leadership, more scope for parental involvement, and stronger emphasis on student engagement and students' responsibility for their own learning. Improved performance in the education system is also pursued through the upgrading of both pre-service and on-the-job teacher training, in an effort to galvanize the teaching and learning process with a focus on developing competent individual learners, and underscoring the centrality of learning orientations that go beyond traditional, school-based curricular skills and that require individuals to constantly connect and apply existing and new knowledge to novel situations and manage their own lifelong learning.

Adults with these learning orientations are more likely to participate in professional development activities and succeed in the labour market. The fast growing economies and technologically challenging labour markets of the Arab Gulf States require citizens to possess high levels of reading literacy, communication and critical thinking skills (Sum *et al.*, 2002). Individuals are now expected to have a set of skills and learning strategies that are dynamic, flexible and updated throughout their lives. Such skills represent a combination of school-based learning and its application to experiences gained through a lifetime. The strong relationship between basic skills and performance in challenging labour markets has been established in studies where people with low levels of skills were not expected to earn above-average wages (OECD & Statistics Canada, 2000, 2005; Sum *et al.*, 2002, 2004). The skills that individuals "do or do not develop have increasingly important implications in terms of workforce participation, long-term self-sufficiency, acculturation, and citizenship" (Tamassia *et al.*, 2007, p.9). In summary, in Qatari economy and society individuals are increasingly required to possess a dynamic set of basic skills, to be mathematically, scientifically and technologically literate, and to be competent lifelong learners.

The extraordinary level of economic success achieved by Qatar should not be taken as a reason for complacency. Current estimates suggest that Qatar has sufficient energy reserves to cover about 50 years of exploitation and rising export revenues. Once these reserves are depleted, however, the ability of Qatari firms to compete in the global economy, and to manage the wealth they have accumulated, will depend largely upon the Qatari labour force having acquired world-class skills.

It is for this reason that the education reform initiative put in place by the Supreme Education Council and the Qatari government is critical to ensuring the future economic security of the country. Although the reform envisioned is encompassing and should yield tangible improvements in the performance of students in Qatar, evidence available from other countries, such as Ireland and Korea, suggests that it could take up to 40 years to realise gains of the magnitude required in Qatar – in large part because the outcomes of such a pervasive reform also depend on factors beyond the school system. Literacy rich home environments and a supportive community that values intellectual achievement are but two factors. Building such environments demands a massive cultural shift on the part of all participants: students, parents, educators, professionals, employers, and society at large. A further challenge arises because Qatar is not the only country desiring to transform its education system. Today almost all countries with some means to do so are devoting sometimes scarce resources to improve the quality and quantity of education. These investments will inevitably increase the global supply of economically important skills. This, in turn, will sharpen the economic consequences of having low skills.

Societal and economic changes such as those referred to above have motivated policy makers, researchers and educators to look beyond their national school system towards what is occurring in education in other countries and, particularly, how students in those countries perform. This international orientation now informs definitions of appropriate and adequate levels of schooling across countries, and is increasingly used as a global reference for excellence, with the resulting internationalisation of learning thus becoming a new trend.

While educators have long understood the importance of formal schooling to one's life career, this awareness has expanded beyond education circles and has become an issue of widespread, common interest. Consequently, the broader public and hence the media now demand regular reporting on the condition of education. National policy makers also more keenly demand timely information about the performance of their education systems. Thus, the demand for monitoring education systems has grown, which in turn explains the increasing participation by countries in international education studies.

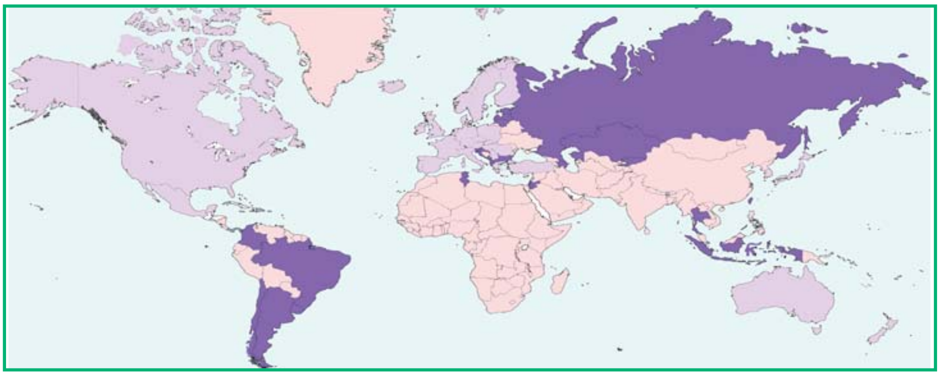
The Programme for International Student Assessment represents a novel approach to comparing student competencies that relies on the examination of a broad set of skills related to the students' future. This approach is based on a definition of literacy that extends beyond the school curriculum – or the common denominator across the curricula of participating countries – towards the application of knowledge based on the type of skills that are essential for future life (OECD, 2003).

## The PISA surveys

The Programme for International Student Assessment (PISA) was established in 1997 by the Organisation for Economic Co-operation and Development (OECD) in order to monitor educational outcomes in the 30 OECD nations, using an international framework. It represents a collaborative effort to assess the preparedness of 15-year-olds to meet the challenges of life. The programme is primarily intended to provide regular indicators of students' achievement at age 15, an age that represents the end of mandatory schooling in many OECD countries, when students have accumulated knowledge over the approximately 10 years of formal schooling they will have acquired at that point. In addition to the OECD Member countries, several partner countries also have joined the programme, with participation continuously increasing: from four partner countries in PISA 2000 and 15 partner countries in PISA 2003, to 26 partner countries in the 2006 survey. Therefore, PISA 2006 counts with the participation of 57 countries. As can be inferred from Figure I.1, together these represent one-third of the world's population and almost 90 per cent of global gross domestic product (GDP).

**Figure I.1**

**Countries participating in PISA 2006**



**OECD countries**

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Japan
Korea
Luxemburg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

**PISA partner countries**

Albania
Argentina
Azerbaijan
Brazil
Bulgaria
Chile
China (Shanghai)
Chinese Taipei
Colombia
Croatia
Estonia
Hong Kong-China
Indonesia
Israel
Jordan
Kyrgyz Republic
Latvia
Liechtenstein
Lithuania
*Macao-China*
Macedonia
Panama
Peru
Qatar
Republic of Montenegro
Republic of Serbia
Romania
Russian Federation
Singapore
Slovenia
Thailand
Tunisia
Uruguay

Source: OECD (2006b).

In its first data strategy, PISA was designed as a periodic programme, with assessments taking place in 2000, 2003, and 2006. A new data strategy will replicate this nine-year cycle, beginning in 2009. Although not longitudinal (i.e., assessing the same group of students twice or more to determine their progress over time), PISA is a cross-sectional study where the results are anchored over successive same age samples. Countries repeating participation can examine trend information while new countries, as in the case of Qatar, are able to establish baseline data. The study assesses reading, mathematical and scientific literacy in every three-yearly cycle, but each assessment focuses on one subject that takes up about two-thirds of student testing time. PISA 2000 assessed reading literacy as the major domain, with mathematical and scientific literacy assessed as minor domains. The major domain was shifted to mathematical literacy in 2003. In the current assessment scientific literacy is assessed as the major domain, with reading and mathematical literacy as minor domains. With the second nine-year data strategy starting in 2007 with assessment in 2009, reading literacy will again be the major domain. This design enables trends in student achievement in all three domains to be monitored on a recurrent basis.

The design of PISA is the result of a collaborative process that involves two levels of management and strong participation by all countries. Internationally, PISA was established by the OECD and is managed at the policy level through a PISA Governing Board (PGB) represented by government officials. PISA is presently implemented through an international consortium integrated by the Australian Council for Educational Research (ACER), CITO Groep in the Netherlands, the National Institute for Educational Research (NIER) in Japan, and Westat in the United States. The OECD serves as the Secretariat for the PGB and is responsible for overseeing the implementation and the work of the PISA consortium as well as preparing reports and disseminating information. The consortium is responsible for the technical aspects of implementation within countries, including the development of instruments, management of data collection, analyses of data sets, quality control, technical support to and supervision of countries during implementation, as well as contact with the OECD and countries during the reporting phase. National expertise and participation are important components of PISA and, as such, experts from participating countries serve on working groups that link objectives with the best available expertise in the field of international comparative assessment of educational outcomes. In the countries, national centres are also important players in the implementation of PISA. Led by a designated national project manager (NPM), national centres are responsible for implementing the project in their countries following the international guidelines and procedures as well as for providing input during crucial phases of the project such as item submission and dissemination.

## What PISA measures

The primary objective of PISA is to "measure how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies" (OECD, 2004, p.20). It assesses students' readiness to participate in the larger society and is primarily concerned with the transition from school to work and/or tertiary education. Instead of focusing on what students are expected to have learned, PISA is forward looking and examines what students can do with what they have learned. Consistently, PISA focuses on a broader approach to assessing literacy domains than the traditional school-based content. It emphasises the capacity of students to analyse, reason and communicate ideas effectively. This connotation is particularly germane to the general approach of the Qatari education reform, since it places the emphasis upon higher mental processes, as opposed to rote learning. One of the main reasons for Qatar joining PISA 2006, as its first participation ever in an international study, is precisely its focus on what students can do with knowledge rather than what they know about a particular subject.

By assessing the ability of youth to apply curriculum-based knowledge to meet life challenges, rather than how well they master specific school subjects, PISA is a cross-curricular based assessment with emphasis on the "mastery of processes, the understanding of concepts and the ability to function in various situations within each domain" (OECD, 2006a). Thus the notion of basic knowledge and skills has been expanded to also include their application in everyday situations.

The PISA frameworks were first developed for PISA 2000 and have been updated each time a domain became major (i.e., PISA 2006 finalised the framework for scientific literacy, whereas a previous version was used in guiding the PISA 2000 and 2003 assessments). Assessment frameworks provide a common language for communicating the purpose of the assessment and what it measures. It is also an important element in describing performance and identifying variables that explain item difficulty and differences between levels of performance. The process of developing these frameworks is complex and involves experts from participating countries and the scientific community, forcing them to determine an agreed-upon definition of the domain and the type of skills to be assessed.

The PISA assessment, as mentioned previously, covers three broad domains – scientific literacy, reading literacy, and mathematical literacy. Each domain is defined in terms of three broader components: the content that students need to acquire and that is used to solve the problems that are presented; the processes that are used in solving the tasks; and the contexts or situations in which knowledge and skills are applied. These are briefly described in Table I.1 (OECD, 1999, 2003). An emphasis is placed on the mastery of processes, the understanding of concepts, and the ability to function in various situations within each domain.

**Table I.1**

**An overview of the PISA domains**

| Domains: | Scientific literacy | Reading literacy | Mathematical literacy |
|---|---|---|---|
| **Definition** | The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. | The capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society. | The ability of students to analyse, reason, and communicate ideas effectively as they pose, formulate, solve and interpret solutions to mathematical problems in a variety of situations. |
| **Content** | Defined as the links that aid unders tanding of related phenomena. These are represented by physics, chemistry, biological sciences, and Earth and space sciences in a way that they are applied and not only recalled. These are defined as knowledge of science and knowledge about science. | Defined as the text format: i) continuous text or prose organized in sentences and paragraphs; and ii) non-continuous texts that present information in alternative ways such as lists, forms, graphs, or diagrams. | Defined by four overarching ideas: i) quantity; ii) space and shape; iii) change and relationships; and iv) uncertainty. The second level includes the curricular strands traditionally known as numbers, algebra or geometry. |
| **Process** | The ability to acquire, interpret and act upon evidence involving: i) identifyingscientific issues; ii) explaining phenomena scientifically; and iii) using scientific evidence. | The ability to perform a variety of typeof reading tasks, including: i) forming a broad general understanding; ii) retrieving specific information; iii) developing an interpretation; and iv) reflecting on the content or form of the text. | The ability of individuals to use mathematical language, modelling, and problem solving skills. The concept of mathematical literacy embeds these across items, as a range of these competencies will be needed to perform a given mathematical task. |
| **Situations or context** | The context in which scientific tasks are performed including general life focusing on the self, family and peer groups (personal), to the community (social), life across the world (global), and historical. | Defined as the use for which the text was constructed: personal use, public use, occupational use, and educational use. | Defined as the situations in which mathematics is used, based on their distance to the students: personal, educational or occupational, public, and scientific. |

## Scientific literacy

PISA approaches scientific literacy as the application of science knowledge and skills. The definition of scientific literacy evolves around "an individual's scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues; understanding of the characteristic features of science as a form of human knowledge and enquiry; awareness of how science and technology shape our material, intellectual, and cultural environments; and, willingness to engage in science-related issues and with the ideas of science, as a reflective citizen" (OECD, 2006a, p.12). In addition to the cognitive aspects of science such as students' knowledge and their ability to use that knowledge effectively, PISA 2006 also examines attitudes and other affective aspects of scientific literacy.

The distinction between scientific literacy and science is emphasised throughout the framework. Scientific literacy focuses on "the application of scientific knowledge in the context of life situations, compared with the simple reproduction of traditional school science knowledge" (OECD, 2006a, p.23). Scientific content or knowledge is assessed through students' understanding of the natural world on the basis of scientific knowledge that includes *knowledge of science* (i.e., natural world) and *knowledge about science*. "*Knowledge of science* refers to the knowledge of the natural world across the major fields of physics, chemistry, biological science, earth and space science, and science-based technology. *Knowledge about science* refers to knowledge of the means (scientific enquiry) and goals (scientific explanation) of science" (Idem, p.22).

Scientific process refers to competencies that 15-year-olds are expected to demonstrate and that are particularly important for scientific investigation. PISA 2006 assesses three such competencies. Identifying scientific issues is related to recognising issues that are possible to investigate scientifically; identifying keywords to search for scientific information; and recognizing key features of a scientific investigation. Second, explaining phenomena scientifically involves applying knowledge of science in a given situation; describing or interpreting phenomena scientifically and predicting changes; and identifying appropriate descriptions, explanations, and predictions. Finally, using scientific evidence involves interpreting scientific evidence and making and communicating conclusions; identifying the assumptions, evidence and reasoning behind conclusions; and reflecting on the societal implications of science and technological developments.

PISA takes an innovative approach to scientific literacy in also assessing students' attitudes about scientific issues. The PISA 2006 framework specifies that one of the goals of science education "… is for students to develop attitudes that make them likely to attend to scientific issues and subsequently to acquire and apply scientific and technological knowledge for personal, social and global benefit" (OECD, 2006a, p.35). These attitudes, believed to be part of an individual's scientific literacy are assessed through questions in the student questionnaire focusing on the areas of: interest in science; support for scientific enquiry; and responsibility towards resources and the environment.

PISA 2006 defines *scientific literacy* in terms of an individual's:

- Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues. These phrases express the central components of scientific literacy. For example, when students read about a health related issue, can they separate scientific from non-scientific aspects of the story, and can they apply knowledge and justify personal decisions?
- Understanding of the characteristic features of science as a form of human knowledge and enquiry. For example, can students recognise scientific from non-scientific explanations? Do they know the difference between evidence-based explanations and personal opinions?
- Awareness of how science and technology shape our material, intellectual and cultural environments. Here, the component of scientific literacy centres on the influence of science and technology on society. Can students recognise and explain the role of technologies as they

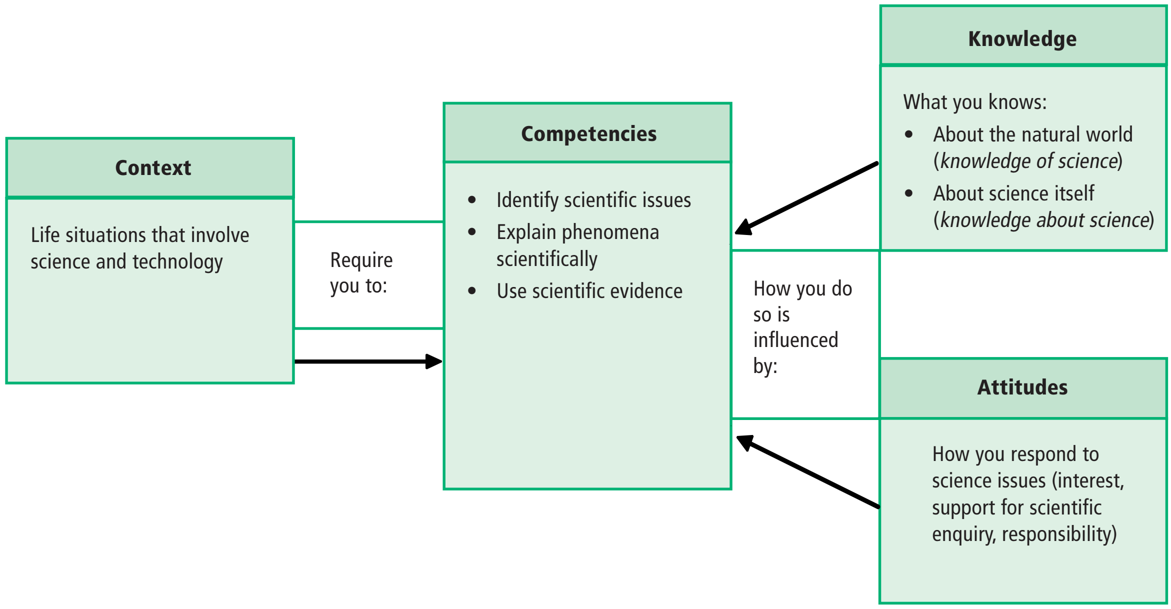
influence a nation's economy, social organisation, and culture? Are individuals aware of environmental changes and the results of those changes for economic and social stability?

- Willingness to engage with science-related issues, and with the ideas of science, as a reflective citizen. Finally, this dimension of scientific literacy underscores the attitudinal dynamics of scientific literacy. Are students interested in science? Memorising and reproducing information does not necessarily mean students will select scientific careers, engage in science-related issues, or support funding for scientific and technological studies. Determining 15-year-olds' interest in science, support for scientific enquiry, and responsibility for resolving environmental issues provides policy makers with early indicators of citizens' support of science as a force for social progress.

PISA 2006 situates its definition of *scientific literacy* and its science assessment questions (science items) within a framework of four interrelated aspects, as illustrated by Figure I.2.

**Figure I.2**

**The PISA framework for scientific literacy**




In PISA 2006 scientific literacy is reported in ways similarly to those used for previous cycles. There is a consolidated scale of scientific literacy, but there are also subscales. The described competencies form the primary basis for reporting scientific literacy using the subscales. The secondary basis of reporting will be the scientific knowledge (or content) that includes knowledge of science and knowledge about science. On each scale, student performance is reported on six levels, with Level 6 the highest and Level 1 the lowest. In addition, in most countries, there are students who fail to respond correctly to even a minimum of the easiest items classified at Level 1. Therefore, the graphs presented in Chapter 1 and further chapters also, on occasion, show an additional level, entitled *Below Level 1*. Table I.2 describes what students typically can do at each level on the main science scale.

## Table I.2

## What students typically can do at each level on the science scale

| Level | What students typically can do: |
|---|---|
| 6 | At **Level 6**, students can consistently identify, explain and apply scientific knowledge . and knowledge about science in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they are willing to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, social, or global situations. |
| 5 | At **Level 5**, students can identify the scientific components of many complex life situations, apply both scientific concepts and *knowledge about science* to these situations, and can compare, select and evaluate appropriate scientific evidence forresponding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to these situations. They can construct evidence-based explanations and arguments based on their critical analysis. |
| 4 | At **Level 4**, students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence. |
| 3 | At **Level 3**, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short communications using facts and make decisions based on scientific knowledge. |
| 2 | At **Level 2**, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving. |
| 1 | At **Level 1**, students have such a limited store of scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow concretely from given evidence. |

The creation of six proficiency levels presents a situation where students with a range of scores on a continuous scale are grouped together into single bands. PISA applies an easy-to-understand criterion to assigning students to levels: each student is assigned to the highest level for which he or she would be expected to answer correctly the majority of assessment items. Thus, for example, in a test composed of items spread uniformly across Level 3 (with difficulty ratings of 482 to 555 scale points) all students assigned to that level would expect to get at least 50 per cent of items correct. However, the score points for students would vary within a level. For example, a student at the bottom of the level (scoring lowest number entered above points) would be expected to get close to 50 per cent of the items correct. A student near the top of the level would get a higher percentage of items correct. For this to be true, a student scoring needs to have a 50 per cent chance of completing an item in the middle of Level 3 and thus a greater than 50 per cent chance of correctly answering an item rated at his or her score. Given the width of bands adopted for PISA Science 2006, this latter probability needs to be 62 per cent to fulfil these conditions.

## Reading literacy

Reading literacy is defined as "an individual's capacity to understand, use and reflect upon written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society" (OECD, 2006a, p.12). It emphasises the use of written information, which is beyond the ability of decoding information or literal interpretation. The domain is organised around text format, reading processes (aspects), and situations or contexts.

In real-life, students are faced with a variety of text formats, which are represented in the assessment by two main types of texts. Continuous texts represent the more traditional types that are organised in sentences and paragraphs. These include a variety of prose forms such as narrative, exposition and argumentation. Additionally, non-continuous texts such as lists, forms, graphs and diagrams are also assessed because they require a different reading approach.

A second dimension includes the reading processes or aspects that go beyond the basic ability of reading. Students in PISA are expected to retrieve information, form a broad understanding, develop an interpretation, and reflect on or evaluate the content of a text.

Finally, reading does not occur in isolation but rather it is embedded into a context that is represented by the use for which the text was constructed. Students may read for their own private or personal use; for example, when they read a novel, they may read official documents or announcements for public use, they may read a manual or a report for occupational use, or they many read a textbook for educational purposes.

Reporting in reading literacy has been based on a single reading literacy scale but also through subscales. Subscales have been based on both the content and the processes dimensions. The initial reports of PISA 2000 and 2003 reported reading literacy in terms of three process subscales: retrieving information, interpreting, and reflecting and evaluating (OECD, 2001, 2004). In a separate reading report, the content scales were subsequently also used as reporting categories generating continuous and non-continuous text subscales, and this analysis may be replicated at a later stage for PISA 2006 as well (OECD, 2002b).

## Mathematical literacy

Mathematical literacy is defined as "an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (OECD, 2006a, p.12). Within this concept, mathematical literacy is associated with the capacity of individuals to analyse, reason and communicate effectively as they face mathematical problems in a variety of everyday situations. Similar to the other domains, mathematical literacy is also organised around three dimensions. Problems in mathematical literacy are posed in real-world settings, where mathematical knowledge would bring in an advantage in solving it (OECD, 2004).

The four overarching ideas — quantity, space and shape, change and relationships, and uncertainty — represent the ways in which mathematical content is presented to people. Although presented differently from the traditional mathematics curriculum, these encompass the range of mathematical topics taught in the traditional curriculum. As an overview, space and shape is related to spatial and geometric phenomena and relationships; change and relationship is closest to algebra referring to mathematical manifestations and relationship among variables; quantity is related to quantitative relationships and patterns; and uncertainty involves probabilistic and statistical phenomena and relationships.

The competency clusters — reproduction, connections and reflection — represent the processes that are involved in mathematics based on the level of cognitive demands that are required in order to do the different tasks. Together these represent mathematics competence. The reproduction cluster is related to the simplest cognitive level requiring the knowledge of facts, recognition of equivalence and recollection of mathematical objects and properties among others. Problems in the connections cluster involve tasks beyond reproduction towards more interpretation. Finally, the reflection cluster involves tasks with the highest level of cognitive ability by requiring students to link relevant knowledge to create, explain or justify solutions.

Finally, mathematical content is related to four situations. Tasks may be related to students' personal life and everyday situations, educational or occupational tasks that are related to the students' school or work life; public situations that are related to local community and society; and scientific situations that involve understanding technological processes.

Consistent with other domains, mathematical literacy was reported in 2003 on a single mathematical literacy scale in addition to subscales. Subscales in mathematical literacy were based on the content dimension of space and shape, change and relationships, quantity, and uncertainty (OECD, 2004). The plans call for a similar approach to be used for PISA 2006.

## How PISA assesses students and collects information

The assessments of knowledge and skills through PISA involve a long-time commitment, with one assessment every three-years in order to produce three types of outcomes. The first type — basic indicators — profile the knowledge and skills of students on the three domains. The second type — contextual indicators — link the basic performance indicators with important demographic information about the students and their schools, thus contextualising performance within the home and educational background of students and systems. Finally, the trend indicators emerge from the continuous data collections and identify changes over time in both the basic and contextual indicators. To achieve these purposes, data collection is based on a series of instruments that collect performance information and associate these with information related to the students' characteristics and background as well as the school's characteristics and learning environment.

Cognitive instruments assess students' knowledge of scientific, reading, and mathematical literacy. The tests are based on agreed upon frameworks that were collectively developed by OECD countries to define the types of skills that were judged as important for students to have for their future. These frameworks are developed by domain experts nominated by the participating countries and the international consortium responsible for implementing PISA, but are also reviewed by Member countries and their national committees. Participating countries contribute to the development through submission of new items and review of proposed items on aspects from appropriateness to 15-year-olds and the curriculum to problems with translation or cultural aspects.

The cognitive instruments are built around units of assessment where one text or stimulus is followed by a series of questions. In order to cover a broader content of the domain and keep the testing time for each student reasonably brief, testing booklets are organised using a complex matrix-sampling design where each student only responds to a subset of the items that are included in the assessment. These instruments are organised using a matrix design where in PISA 2006, 255 items were allocated to 30-minute clusters that were grouped into 14 testing booklets with four clusters in each. In this design, there were seven science clusters, two reading clusters, and four mathematics clusters. While 6.5 hours of testing material is included in the assessment, each student only responds to two hours of that testing material. Two-thirds of the total testing time is devoted to the assessment of scientific literacy as the major domain. Due to the use of this design no individual student scores can be reported for PISA.

The majority of the PISA instruments are paper-and-pencil and composed of a variety of types of questions including multiple-choice items where students select the correct answer as well as items where students have to construct their own response, either in short or in long form. The large numbers of open-ended items (i.e., questions) that are included in the cognitive instrument represent an important characteristic of PISA that is essential in representing the direction and content specified in the PISA frameworks. Around half of all items require some type of human judgment during the marking process. This characteristic has strong implications in various aspects of implementation such as international and local training of markers, procedures to ensure comparability across countries, cognitive labs as well as in aspects related to national resources such as hiring and training markers and on the costs of the marking process because of time. In order to ensure comparable marking across countries, multiple marking is applied to a portion of the booklets and both within- and between-countries marking reliability studies are conducted.

Contextual questionnaires are essential for understanding the home and school contexts in which learning takes place. All countries implemented two questionnaires:

- Student Questionnaire. A 30-minute questionnaire answered by students that collects information about: i) the students and their families including economic, social and cultural capital; ii) students' views on various issues related to science; iii) the learning environment; iv) their careers and science; iv) learning time; and v) teaching and learning of science.
- School Questionnaire. A 20 to 30-minute questionnaire answered by school principals that collects information about: i) characteristics of schools; ii) student body; iii) schools' resources; iv) staffing; v) schools' organisation; vi) schools' environment; vii) curriculum; and viii) career guidance and preparation of students for further education.[1]

1. The school questionnaire focuses on the field of science and defines it as following: "Science refers only to the core science subjects of physics, chemistry, Earth science and biology, either taught in the curriculum as separate science subjects, or taught within a single 'integrated-science' subject. It does *not* include related subjects such as engineering, technology, mathematics, psychology, economics, nor possible earth science topics included in geography courses. If in doubt as to whether a school subject other than physics, chemistry, earth science, biology or integrated-science is science or not, treat the subject as *not* being science."

Qatar also fielded two additional questionnaires as international options in PISA 2006:

- Parent Questionnaire. The students brought home a questionnaire addressed to their parents. This questionnaire was developed specifically to add value to analytical areas of contextual focus, including parental educational attainment and occupational status, parental support for education and their degree of involvement in out-of-school and informal science instruction, interaction of the parents with their child's school, awareness of environmental issues, and the importance parents attach to science in the labour market and for their child's future educational and occupational career.
- IT Familiarity Questionnaire. This brief questionnaire was administered to the students in order to assess how familiar students are with information and communication technologies.

Results from the contextual questionnaires are presented as raw variables (as raw responses to actual questionnaire items) as well as summarised variables that are called indices. Indices are constructed by scaling sets of raw responses into new variables based on theoretical considerations or previous research. An example from PISA 2003 includes the index of teacher support, which is derived from students' reports on the frequency with which: i) the teacher shows an interest in every student's learning; ii) the teacher gives extra help when students need it; iii) the teacher helps students with their learning; iv) the teacher continues teaching until the students understand; and v) the teacher gives students an opportunity to express opinions.[2]

Additionally, optional components are offered internationally that allow countries to explore specific aspects of education. Some previous examples included self-regulated learning, computer familiarity and an assessment of problem solving skills. These components are experimental in nature, vary from cycle to cycle, are developed and administered centrally, and are analysed and reported internationally for the set of countries that participated in these options.

Within this framework of international components, PISA 2006 offered a parent questionnaire that was implemented in most countries including Qatar. It examined the following issues: the student's past science activities; parents' views on the role of school science in the student's intended career and the need for scientific knowledge and skills in the labour market; parents' views on science and the environment; the cost of education services; and finally, the parents' educational attainment and occupational status.

National components are also important elements and are offered for countries to examine additional national issues and associate them to PISA. Their use must be approved by the PISA consortium responsible for overseeing the implementation of the programme and can only be implemented in a way that does not jeopardise the implementation of the international instruments. These national components can vary in format ranging from additional questionnaires to additional cognitive materials.

2. The full set of PISA indices can be found in Annex A1 of the PISA 2000 and PISA 2003 initial reports (OECD, 2001, 2004).

However, contextual information is not limited to these instruments. National indicators that describe the general structure of education systems are available through other OECD programmes or international organisations. These may include demographic and economic contexts such as physical and human resources invested in education, teachers' characteristics, and learning processes. In Qatar a range of national assessment instruments are available and can be used to complement en enrich the analyses and interpretation of the PISA data.

## Sampling design

Central to the validity of the results, comparable target populations must be assessed in each participating country. The age-based sampling design of PISA adds complexity to this definition as the education systems of countries vary in policies such as the inclusiveness of early childhood education or the school starting age. PISA examined students between the age of 15 years and 3 months to 16 years and 2 months enrolled in grades seven or above. PISA uses a two-stage stratified sample design. In its first stage, it selects a sample of schools attended by 15-year-old students using the probability-proportional-to-size (PPS) technique. In its second stage, it samples students within the selected schools. A national minimum sample size of 4,500 students per country is required — approximately 35 students are sampled from a minimum of 150 schools (OECD, 2002a, 2005b). Countries have the opportunity of opting for using a sample according to the minimum sample sizes established in the PISA standards, over-sample some groups of special interest, or implement a census-based approach, which requires testing all 15-year-olds in all schools in the country. Qatar opted for the latter approach.

This age-based definition implies that it may not be possible to sample intact classes as students in the target population often are spread across a number of grades, and/or single classes will likely include students that do not satisfy the population definition. Consequently, PISA samples include students from a number of different classes, which optimises age comparability and allows comparisons of education systems in terms of the yield of educational experiences (i.e., the cumulative effect). As such, PISA plays a limited role in examining issues such as the influence of classroom characteristics, teacher characteristics and instructional practices. Because of this situation no average classroom scores can be reported from PISA, although average school scores can be estimated.

Overall, the exclusion rate within each country must be limited to five per cent, with restrictions added to: i) school-level exclusions based on inaccessibility of schools, size of schools, feasibility reasons, and status of special-need schools; and ii) within-school exclusions for special-need students (OECD, 2005a). A school response rate of 85 per cent for initially selected students and a student response rate of 80 per cent are required. For PISA 2006, in Qatar, 6,265 students were assessed, representing most of the 7,271 children in the target population. There were 131 schools, and on average 47.8 children were tested per school.

## Interpreting the results of PISA

Performance results in PISA are presented in terms of one proficiency scale for each domain. Within the domains, proficiency scales are also developed for the subscales. Generally, the PISA scales are centred at an OECD average of 500 points and a standard deviation of 100 points — characteristics that are fixed for the major domains.[3] Therefore, two-thirds of the OECD students will perform between 400 and 600 points. As it could be expected, these scales are independent, thus, not allowing direct comparisons between scores across domains.

The PISA proficiency scales are also divided into skill levels that describe what learners can do based on the type of tasks that they were able to attain (cf. Table I.1). These skill levels facilitate understanding and add meaning to the results. This process orders the tasks in ascending levels of difficulty and interprets the cognitive domain required to succeed at tasks at that level. Therefore, rather than statistically defined, levels are research defined — a process that identified points along the scale where a shift in the cognitive demand occurred. Thus, Level 1 represents the most basic level while Levels 5 or 6 define the most difficult types of knowledge and skills. For example, PISA 2000 described reading literacy in terms of five proficiency levels, whereas PISA 2003 described mathematical literacy in terms of six proficiency levels. In PISA 2006 scientific literacy is also described on six proficiency levels, with a residual seventh category comprised of those students who were unable to succeed at the easiest test items in Level 1.

In addition to the proficiency levels mentioned above, some students are not able to reach the lowest level of performance that is described by the PISA frameworks or assessed in the instruments. Consequently, although these students may have some knowledge and skills in reading, mathematical or scientific literacy, their levels have not reached the most basic knowledge and skills assessed in PISA. Thus, these students are classified into an additional level, labelled *Below Level 1* for which no description of tasks exist, since there were no items assessing these very basic knowledge and skills.

## Overview of Qatar's implementation of PISA

Comparative educational data figure prominently in the decision-making processes of governments around the world for many reasons, some of which were mentioned previously in the Foreword. Qatar's participation in PISA was driven by a series of factors that are particularly associated with the fast pace of change in the society, which affected demographic and economic aspects.

Globalisation has moved countries to look beyond their own situation to what is occurring elsewhere. Consistent with other countries, Qatar's government identified a need to compare the country with others on the performance of 15-year-olds in reading, mathematical and scientific literacy.

3. The OECD average of 500 points is specified in the cycle when the domains become major. For example, reading literacy was established in 2000; mathematical literacy in 2003, with the results from 2000 mapped into the 2003 scale; and scientific literacy is established in 2006, with the science results from PISA 2000 and PISA 2003 mapped into this new scale.

The increasing use of assessment as a tool for policy development and decision-making has tended to create an assessment culture, comprising not only educators and teachers, but also policy makers, the general public and media. This culture should be technically and methodologically appropriate to address the many needs and aspects of today's society. International assessments can live up to these demands in a multicultural context, while also providing empirical evidence of outcomes that can inform decision-making.

Because PISA is a competency based assessment it will be necessary to develop an alignment with Qatar's standards-based system. Qatar used a census-based testing approach that included all 15-year-old students enrolled in schools. The sampling frame included 7,271 students from 131 schools that were divided among schools dependent on the Ministry of Education, private Arabic schools, independent schools and international schools.

It has to be pointed out that Qatar joined PISA well into the first year of the 2006 cycle (nine months later than most of the other participating countries). Hence its small national project team had to cope with extremely tight deadlines, as well as with a task that, for most of its members was completely new. Notwithstanding, quality standards were thoroughly implemented, deadlines were duly complied with and a high level of quality was attained in the implementation of the study.

The implementation of PISA in Qatar was managed under the responsibility of the Student Assessment Office (SAO) within the Evaluation Institute (EI), under the authority of the Supreme Education Council (SEC). The primary contact for PISA 2006 in Qatar is Dr. Juan Enrique Froemel, the Director of the SAO at the Evaluation Institute.

## The organisation of this report

The primary purpose of this report is to present the first results of PISA 2006 for Qatar. Figure I.3 illustrates the overall structure of this report, consisting of six chapters.

The Introduction has presented PISA in general – what it measures and how the results are reported and can be interpreted – as well as for Qatar more in particular. Its purpose was to describe PISA as an international programme and outline its characteristics. This included a description of the domains assessed in PISA, the instruments used, sampling characteristics, guidelines for interpreting results, and the specifics of the national context in which PISA was implemented in Qatar.

Chapter 1 focuses on the distribution of student achievement in reading, mathematical and scientific literacy, in Qatar compared with other countries, using the average score, the mean score and confidence intervals, percentile scores, and the proficiency levels.

Chapter 2 examines the science proficiency of Students in Qatar more in depth, by looking at domain specific results and the relationships between these results and attitudinal scales, such as attitude towards science and support for science.

Chapter 3 investigates how the relationships between the contextual variables and science performance in Qatar compare with those of other countries, focusing on explanatory variables such as gender, school type, citizenship, parental education, and school choice. In its last section, the chapter examines the relationship between student achievement in scientific literacy on the one hand, and socio-economic gradients on the other (i.e., the relationship illustrating the impact of parental socio-economic background on student performance). Past PISA results have shown this relationship to vary greatly across countries and to be particularly important for policy decisions. Contextual variables that describe or explain possible differences in student performance are thus identified.

Chapter 4 presents the findings of a complex, empirical, multi-level analysis of major determinants of science proficiency in Qatar. Although PISA 2006 represents the third cycle of PISA, it is the first cycle in which Qatar participates. Consequently, the analytical results for Qatar will address the first two types of indicators that were previously described — basic and contextual indicators — but not yet the trend indicators. Thus the purpose of this chapter is to explore relationships and establish a baseline for future comparisons in coming cycles. Subsequent reports will draw on other available data sources, particularly the Qatar National Educational Data System, to complement and enrich the analyses presented in this chapter.[4]

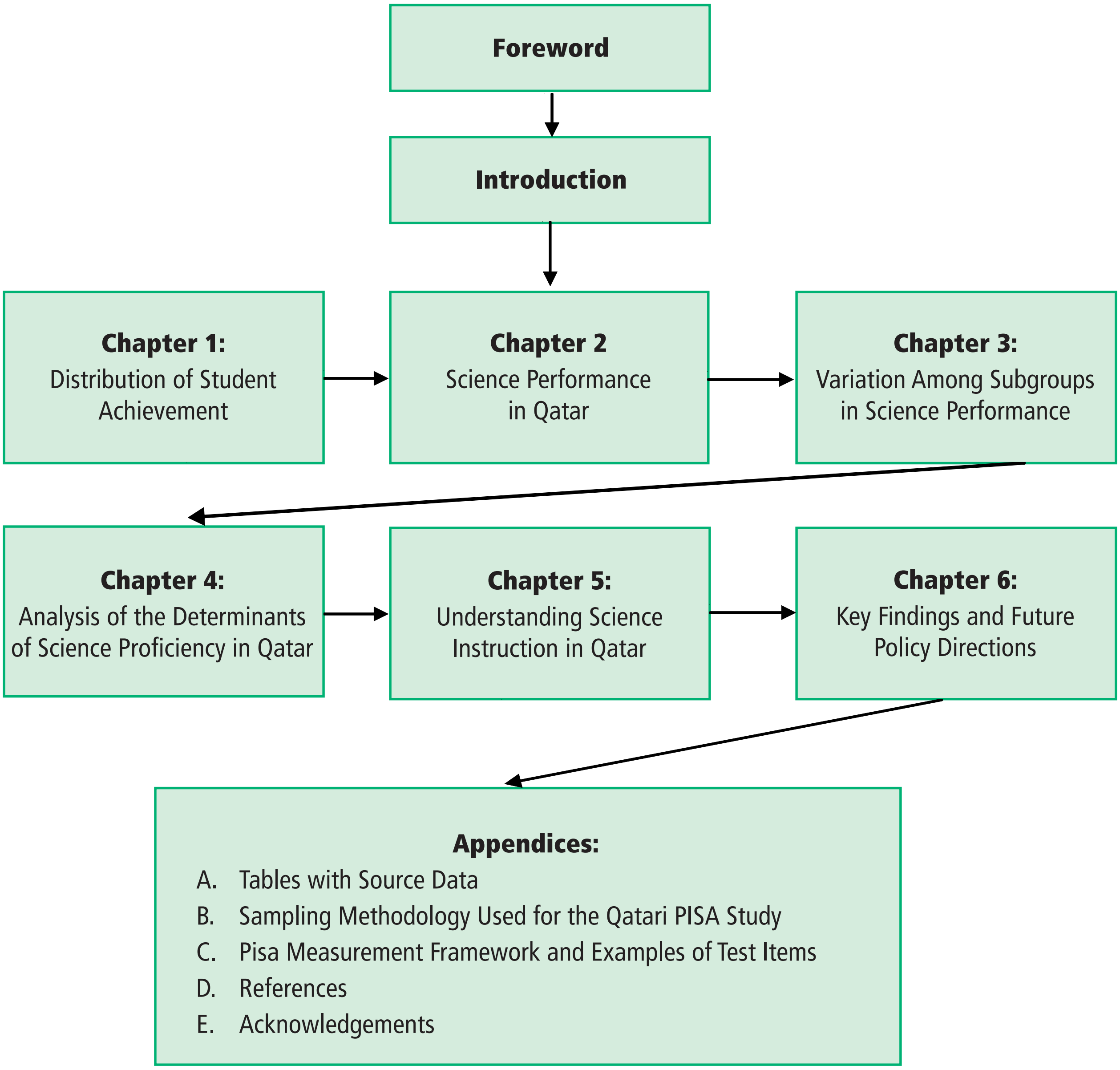
Chapter 5 presents an item-level analysis of the difficulty and appropriateness of the test items as experienced by the Students in Qatar. This informs understanding of the implications of the assessment for the design of school curricula and the adequacy of teaching strategies employed by educators in Qatar.

Chapter 6, finally, presents a summary of key findings and some suggestions for future education policy directions.

4. Implementation of the "Education for a New Era" initiative called for the establishment of several new agencies to provide the infrastructure for the reforms to succeed, and to support the school principals and teachers. One of them is the Evaluation Institute's Office of Data Collection and Management, charged with the task of building the capacity needed to collect data to support and assess the reform outcomes. This included the development of large-scale studies of students, and other methodologies to collect data from teachers and parents. It also involved the creation and implementation of the Qatar National Educational Data System (QNEDS) to track the reforms. The QNEDS work has three major components: i) development of an integrated data warehouse and portal to provide a comprehensive picture of education in Qatar; ii) development of a comprehensive suite of IT systems to facilitate survey operations, data collection and processing; and iii) development of local capacity for the training of field staff, logistics and operation of data collection, survey design, and the development of system requirements.

**Figure I.3**

**An overview of the PISA 2006 report for Qatar**



# Notes to readers

The PISA proficiency scales allow comparisons across countries and across cycles. However, these are independent across domains and do not allow direct comparisons between domains. As one of the purposes of this report is to compare the results of Qatar with those of the OECD countries it is important to understand the distinction between the two approaches that are used to report international averages (OECD, 2004, p.33):

The OECD average takes the OECD countries as a single entity, to which each country contributes with equal weight. For statistics such as percentages of mean scores, the OECD average corresponds to the arithmetic mean of the respective country statistics. In contrast, for statistics relating to variation, the OECD average may differ from the arithmetic mean of the country statistics because it not only reflects variation within countries, but also variation that lies between countries

The OECD total takes the OECD countries as a single entity, to which each country contributes in proportion to the number of 15-year-olds enrolled in its schools. It illustrates how a country compares with the OECD area as a whole.

As true for most social science research, the data collected in surveys such as PISA are based on estimation procedures calculated from a sample rather than every student in the population. As such, they contain errors or uncertainties from a variety of sources. Therefore, it is important to indicate the degree of uncertainty around these estimations by presenting standard errors for every statistic. These are presented in the tables with source data included in Appendix A, and should be considered when interpreting the results. Only results that are statistically significantly meaningful should be considered. These are indicated in the tables.

The development of the PISA assessment instruments is an interactive process between the PISA consortium, the participating countries, experts and the OECD. This process is described in working documents and reports. The cognitive frameworks are published as separate documents prior to each assessment and the questionnaires are disseminated through publications and the Internet. Complete documentation for this and previous cycles as well as contact information and database are available through the OECD PISA website at www.pisa.oecd.org.


جهاز رقم ٨
از رقم ٧

# Chapter 1

## The Distribution of Student Achievement in Qatar

### 1.1 Introduction

Qatar is implementing its “Education for a New Era” initiative – one of the world’s most ambitious and forward-looking education reform programmes. In order to support and guide implementation of this comprehensive effort, Qatar has developed a state of the art education management information system – the Qatar National Educational Data System (QNEDS) – which also includes an assessment component, the Qatar Comprehensive Educational Assessment (QCEA) programme, and a set of dedicated surveys of key education stakeholders, entitled the Qatar Comprehensive Survey System (QCSS).

The decision to field PISA in Qatar was largely made because this international comparative study about the knowledge and skills levels acquired by students near the end of their compulsory schooling would produce the external, OECD-benchmarked competency thresholds needed to complement and compare the results of the QNEDS, and thus enhance the capacity of policy analysts, decision makers, educators and the general public to track the progress of the reform. Linked with the QNEDS, the information gathered through PISA enables the thorough comparative analysis of the skills levels of 15-year-old students in three key subjects. This also allows for the investigation of the distributions of these skills in the student population, the study of the ways that skills vary across different groups of students, and the exploration of the factors that influence the levels and distributions of skills within Qatar and among other countries participating in PISA 2000.

International assessment data hold the power to transform education systems. Realising this potential depends upon creating a range of information products and services that address several purposes, from communicating insights derived from education policy analysis to decision makers, the media and parents, to targeting curriculum-specific portfolios at designated categories of educators.

The bottom-line question all stakeholder groups continually ask is about the quality of schooling and the standards of student achievement realised in Qatar compared with other countries. The purpose of this chapter is to address this key question directly.

First, overall comparative distributions of reading, mathematical and scientific literacy proficiency in Qatar, compared to the OECD countries, are presented. As will be seen, these comparisons show that Students in Qatar, as a group, are not performing well relative to their peers in almost all other PISA countries. Second, the chapter explores the shape of the proficiency distribution, an analysis that demonstrates the marked impact that having large numbers of students with low skills has on average performance. Third, scores at key points along the proficiency distribution (specifically the scores at the 10th, 25th, 75th and 90th percentiles) are examined, an analysis that is performed separately for each of the three skill domains. Finally, the chapter concludes with a comparison of proficiency scores by performance levels for the three domains.

## 1.2 International comparisons of student achievement

Previous research studies have shown that differences in the average level of proficiency in the domains assessed in PISA matter both economically and socially. For example, country differences in the average reading literacy of adults matter to key indicators of macro-economic success over the long term, explaining over half of the differences in rates of GDP growth and labour productivity observed in the period 1950 through 2000 in OECD countries (Coulombe, Tremblay and Marchand, 2005, Coulombe and Tremblay, 2006).

Research has also established that differences in average literacy proficiency exert a profound influence on a range of valued educational outcomes, including secondary completion rates, transition to and persistence in tertiary education, and rates of participation in both formal and non-formal adult learning (Tuijnman and Boudard, 2001; Tuijnman and Hellström, 2001; Rothman and McMillan, 2003; Willms, 2004; Knighton and Bussière, 2006; Marks, 2007).

Moreover, differences in levels of knowledge and skills influence a range of labour market outcomes at the individual level, such as the prevalence of employment, the stability of employment, weeks worked, wage rates and, by extension, personal income (OECD and Statistics Canada, 2000).

Differences in average skills level have been shown to have a marked impact on a range of health and social outcomes, including the degree of participation in community institutions, voluntary associations, and democratic processes. Low skilled individuals are much more likely to be in poor or fair health and impose much greater costs upon the health care system compared with high skilled individuals (OECD and Statistics Canada, 2005). Finally, the skills assessed in PISA play a central role in sustaining and promoting one's language and culture, in what Marshall McLuhan (1992) has dubbed "the global village".

It is because of these well-documented relationships between knowledge and skills, on the one hand, and a range of beneficial educational, employment, health, social and economic outcomes on the other, that countries are interested in assessing the proficiency of students particularly nearing the end of the mandatory cycle of education. Naturally, such assessments are not ends in themselves, but a means of identifying strengths and weaknesses, and finding the policy levers that can be used to effect improvement. The standards of excellence achieved by students leaving the secondary system play a central role in determining the efficiency and effectiveness of tertiary education systems, and in the longer run, the levels of inequality observed in individual prosperity, aggregate economic performance, and the efficiency and effectiveness of tax expenditures.

## 1.3 Comparisons of average proficiency scores by country and skill domain

Figures 1.1, 1.2 and 1.3 compare the estimated average scores and 95 per cent confidence intervals on the reading, mathematics and science proficiency scales observed between countries in PISA 2006. Overall, 15-year-old students in Qatar did not perform well on any of the three skill domains compared with the other countries.

### Box 1A
### Note on statistical comparisons

For the majority of the countries participating in PISA 2006, the averages presented in this report were computed from the scores of random samples of students in each country and not from the entire population of students in each country. In Qatar, in contrast, the study used a census of all eligible 15-year-old students. Consequently, for most countries, it cannot be said with certainty that the sample average has the same value as the population average that would have been obtained had all 15-year-old students been assessed. Because an inclusive census of all students was used, the degree of uncertainty surrounding the true values of student population mean scores is probably less pronounced in Qatar compared with some other PISA countries where complex sample survey designs were used, but it is likely not zero either, since 100 per cent inclusiveness is seldom reached even in a census. Moreover, if a sample survey is well designed and implemented, it can yield population estimates with the same degree of reliability as those obtained in a well executed census, albeit at an often much reduced cost.

Additionally, a degree of measurement error is associated with the scores describing student proficiencies because such scores are estimated on the basis of students' responses to test items. A statistic, called the *standard error*, is used throughout this report to express the degree of uncertainty associated with sampling error and measurement error. The standard error can be used to construct a *confidence interval*, which provides a means of making inferences about the population mean scores and proportions in a manner that reflects the uncertainty associated with sample estimates. A 95 per cent confidence interval is used in this report and represents a range of plus or minus about two standard errors around the sample average. Using this confidence interval, it can be inferred that the population mean score or proportion would lie within the confidence interval in 95 out of 100 replications of the measurement, using different samples randomly drawn from the same population.

When comparing scores among countries or population subgroups the degree of error in each average should be considered in order to determine if averages are different from each other. *Only statistically significant differences at the 0.05 level are noted in this report, unless otherwise stated.*

Among the total of 57 countries taking part in the PISA 2006 study, the average scores of students in 54 countries were statistically significantly above Qatar's average in all three literacy domains. The average scores of students in only one country - the Kyrgyz Republic - were statistically below Qatar's average scores.

Figure 1.1 reveals that the average level of reading proficiency among 15-year-old students in Qatar is lower compared to those in many other countries participating in PISA 2006. Students in Qatar' average score was 312 points, which is approximately 172 points below the average reading score achieved by students in OECD countries and 243 points below the average score obtained by Korean students, the best performing country. Appendix Table 1.1 provides estimates of the mean scores, standard deviations, and skewness in the distribution of reading scores for each country.

## Figure 1.1

### Estimated average reading scores of 15-year-old students and 95 per cent confidence intervals, by country, PISA 2006[1]

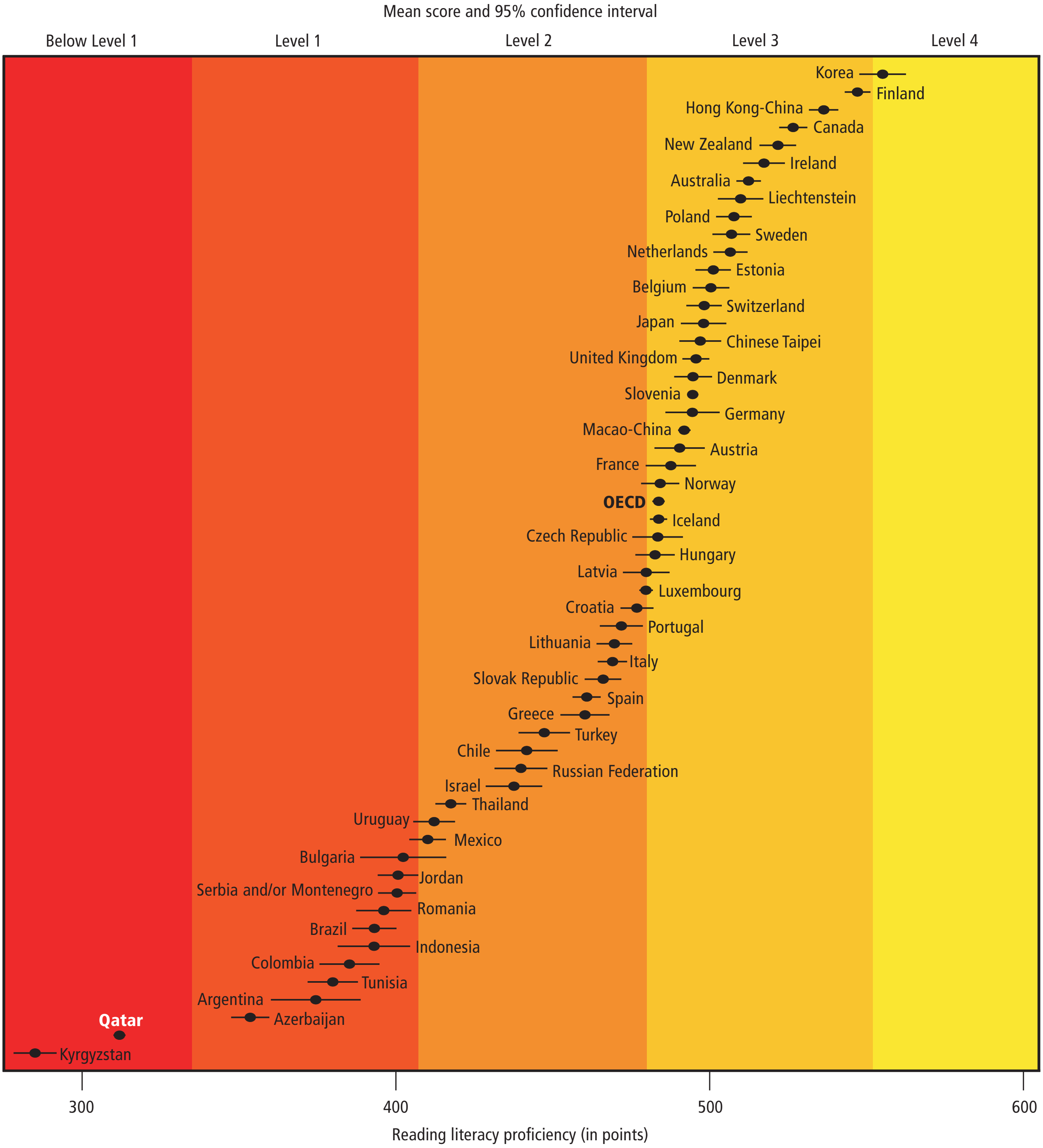


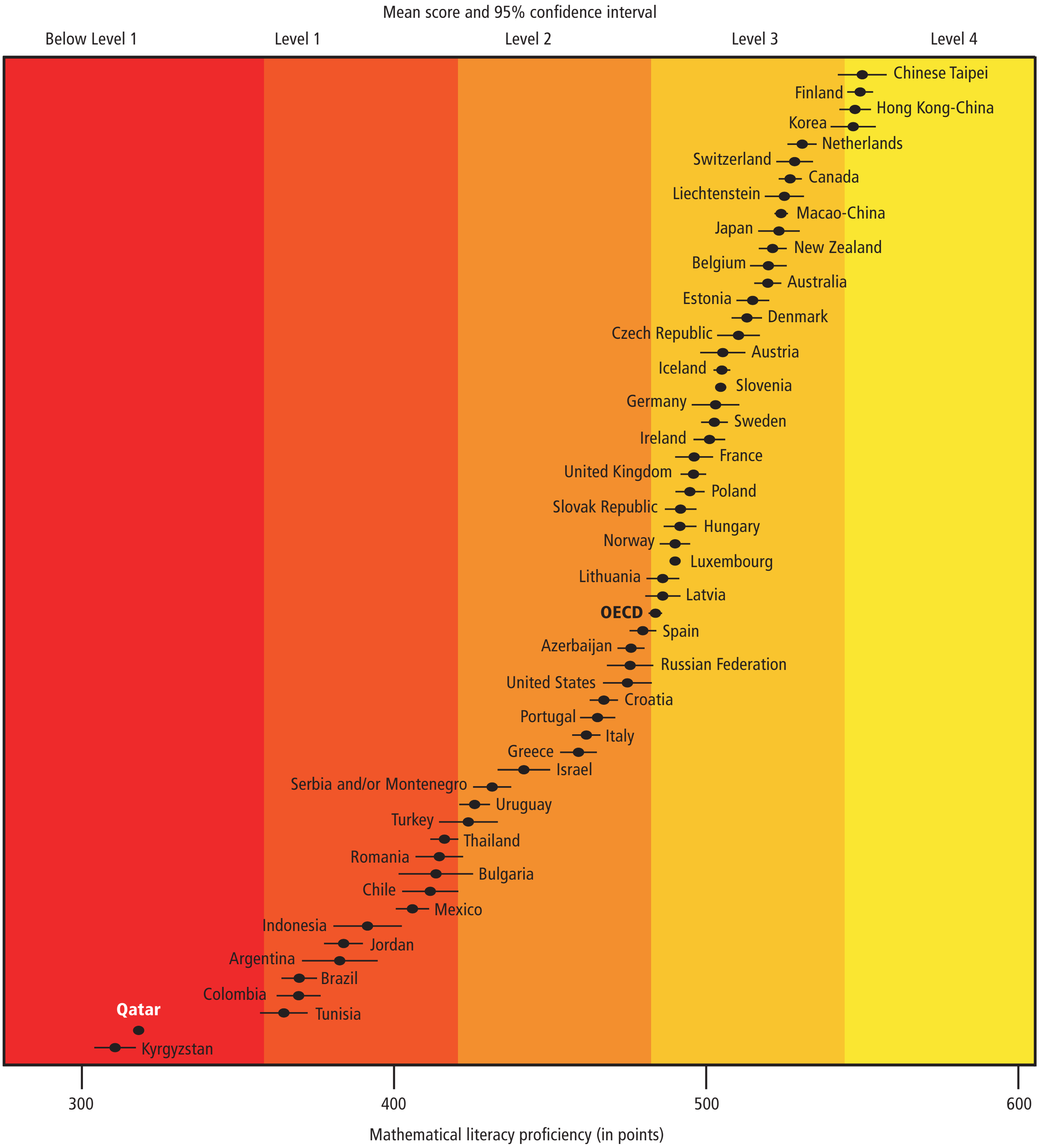

Figure 1.2 displays the average level of proficiency in mathematics by country. As in reading, the results for Qatar are lower than those observed in many other countries participating in PISA 2006. The average score of Qatar's students on the mathematics scale was 318 points, which falls 165 points below the OECD average and about 230 points below the scores realised by the best

1. Analysis based on the OECD weighted average of 484 points.

performing countries: Chinese-Taipei (500), Finland (549), China-Hong Kong SAR (548) and Korea (547). Appendix Table 1.2 provides estimates of the mean scores, standard deviations and skewness in the distribution of the mathematics scores for each country.

## Figure 1.2

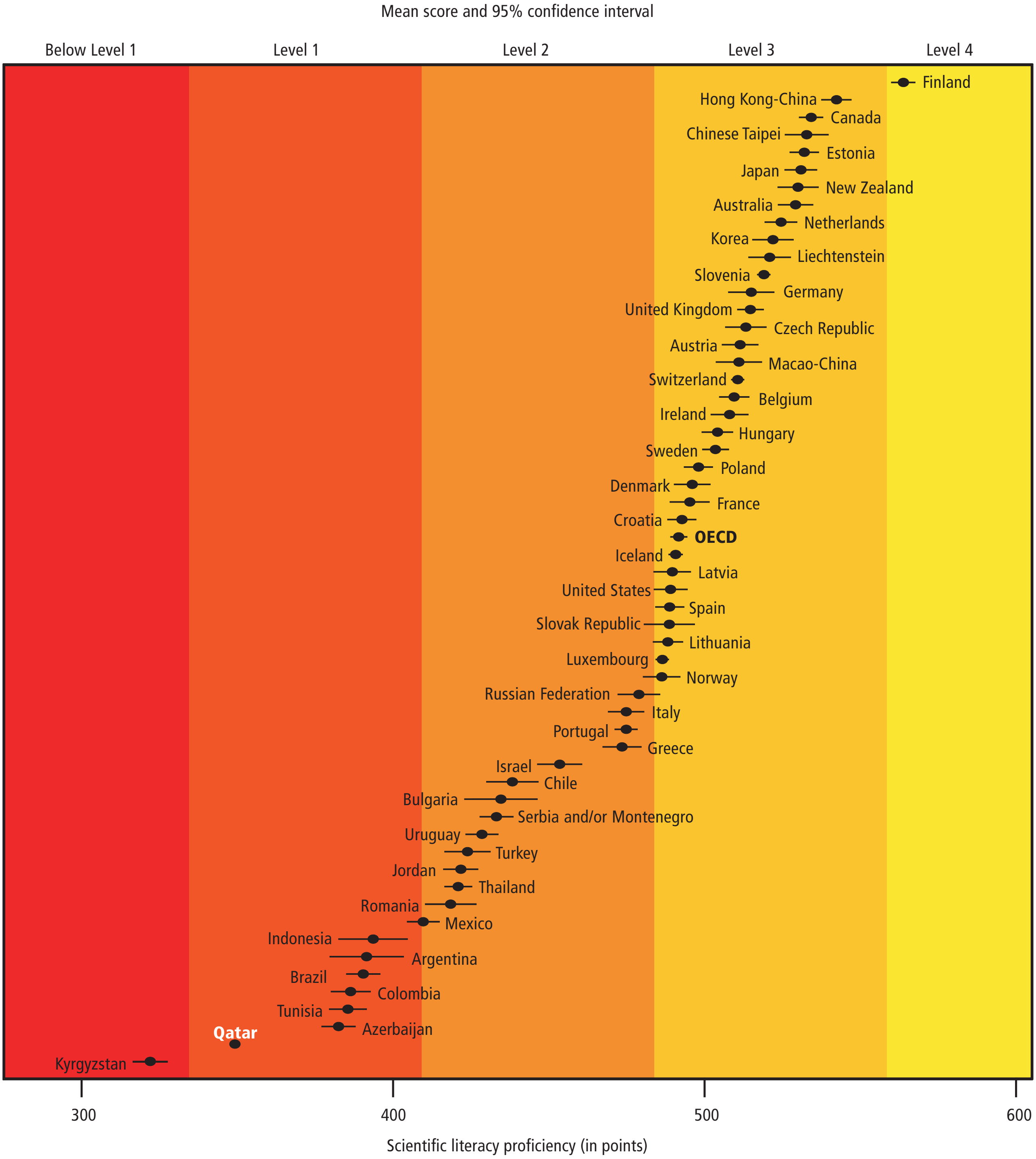
## Estimated average mathematics scores of 15-year-old students and 95 per cent confidence intervals, by country, PISA 2006[2]




2. Analysis based on the OECD weighted average of 491 points

## Figure 1.3

### Estimated average science scores[3] of 15-year-old students and 95 per cent confidence intervals, by country, PISA 2006[4]




3. Combined science scale.
4. Analysis based on the OECD weighted average of 484 points.

Figure 1.3 presents the average levels of science proficiency[1] for the PISA 2006 countries. Not surprisingly, the average performance in science of 15-year-old students in Qatar parallels the pattern observed in average reading and mathematics scores. Students in Qatar have an average science proficiency of 349 points, a value that places them among a group of countries with the lowest average scores. The average science proficiency of students in Qatar falls 141 points below the OECD average and 215 points below that realised by the best performing country, Finland (564).

## 1.4 Comparisons of proficiency distributions by country and skill domain

Figures 1.4, 1.5 and 1.6 examine the distributions of proficiency that underlie the average country scores in reading, mathematics and science, presented in the previous section. The graphs compare the full distributions of student proficiency in reading, mathematical and scientific literacy in Qatar to that of students in the OECD countries.

**Box 1B**

**Note on interpreting differences**

Although PISA measures knowledge and skills beyond the school curriculum, most science skills are in fact learned in school. Therefore, students in higher grades may have an advantage in science simply because they have been exposed to more advanced topics. Most students born in 1990 were in grade 10 in 2006. However, national education policies concerning the age of first enrolment and grade repetition result in differences among the proportions of 15-year-olds enrolled in higher or lower grades. Interpretation of national differences in performance should consider that the PISA 2006 results describe the performance of all 15-year-olds and *not* the performance of 15-year-olds by grade, although this is a national option for some countries.

5. Throughout this chapter the data analyses are based on the combined, overall science proficiency scale. See Chapter 2 for an explanation of the combined science scale and the three underlying sub-scales.

**Figure 1.4**

**Estimated distribution of reading literacy proficiency scores, Qatar and OECD average, PISA 2006**

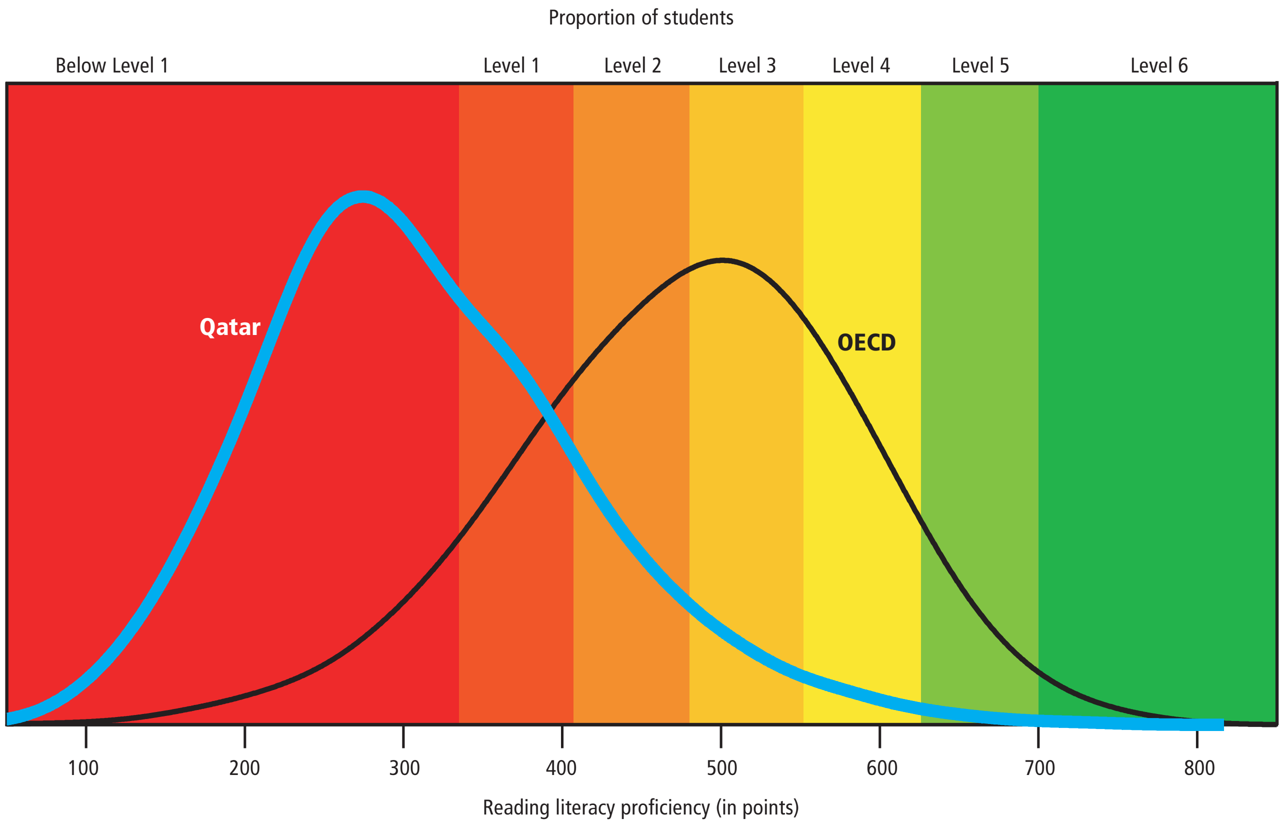



Figure1.4 reveals that the distribution of reading proficiency of 15-year-old students in Qatar lies well below that of students in the OECD countries. The overwhelming majority of the students in Qatar perform in the range characterised as *Below Level 1*, a level below the minimum threshold required to understand and successfully respond to the easier test items in the reading literacy domain. This is likely the most striking finding of the PISA 2006 study for Qatar, and one that holds profound importance for both education policy and practice.

Few, if any, students in Qatar are sufficiently skilled to be placed at reading Levels 4, 5 and 6 – the levels believed to be required to take full advantage of tertiary education and to compete in the emerging global knowledge economy (OECD and Statistics Canada, 2005). Most crucially, Figure 1.4 shows that the reading literacy proficiency of students in Qatar is highly skewed, with a far greater proportion of students falling below the mean score of 312 points.

## Figure 1.5

## Estimated distributions of mathematical literacy proficiency scores, Qatar and OECD average, PISA 2006

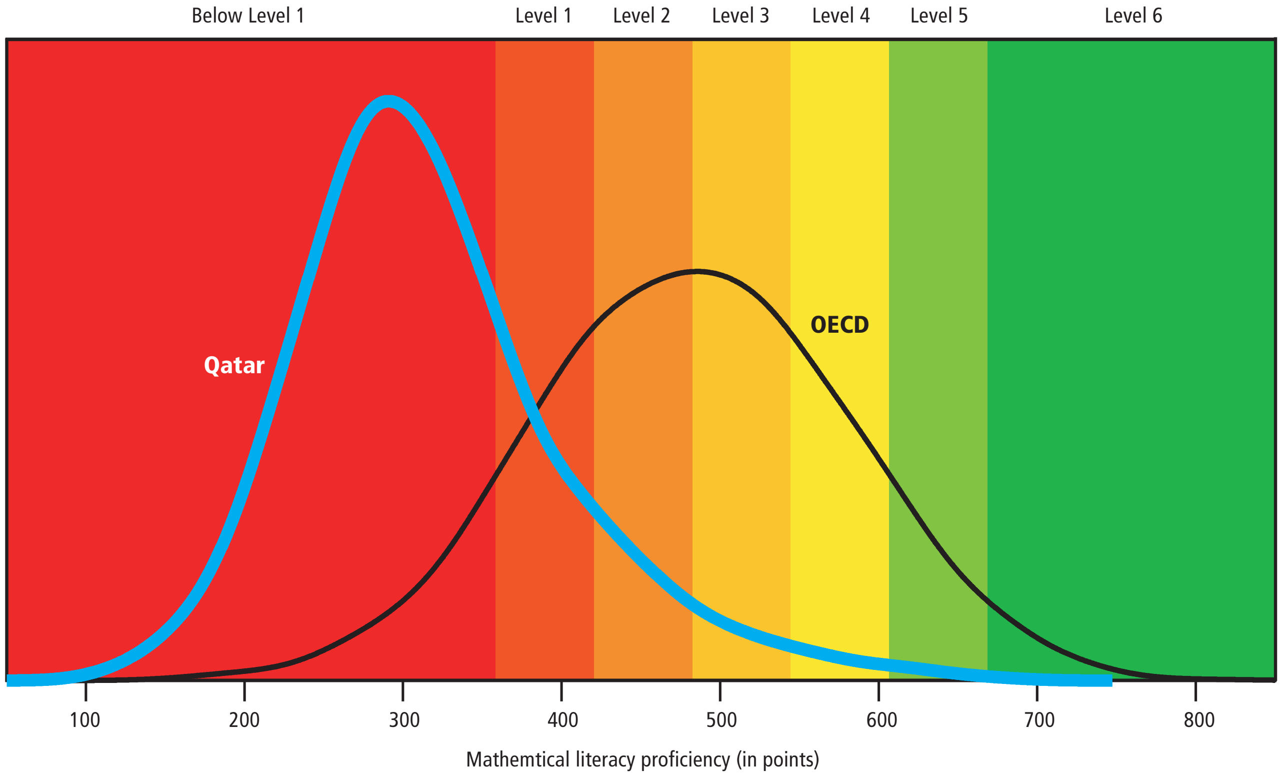
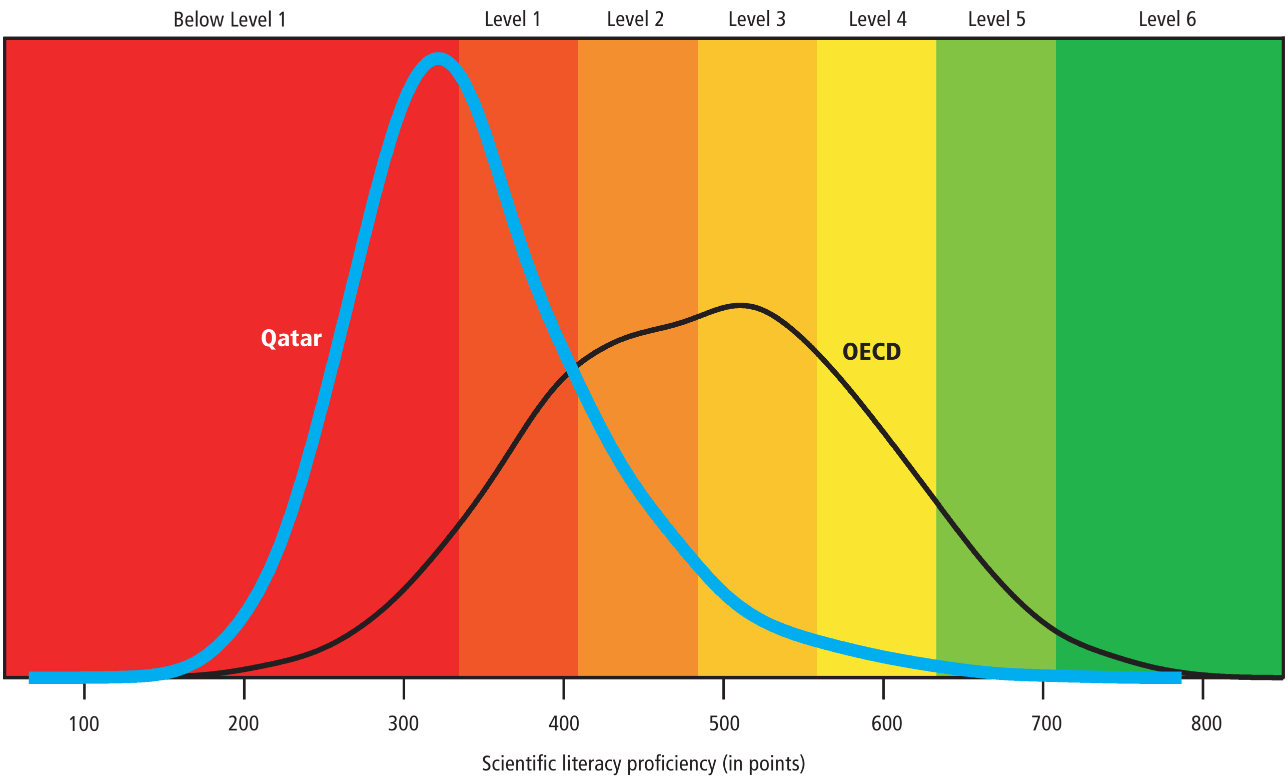



Figure 1.5 shows that the distribution of mathematics proficiency of Students in Qatar is also significantly below the level of students in the OECD countries. As in reading, the majority of 15-year-old students in Qatar are placed at *Below Level 1*. The overall mathematics proficiency of students in Qatar is so low, in fact, that it too would seriously impair their ability to respond to science test items that demand a basic understanding of mathematics.

Figure 1.6 displays the distribution of science literacy proficiency of students in Qatar. Not surprisingly, it shows that the overwhelming majority of students in Qatar perform in the range characterised as *Below Level 1*, a skill level well below their peers in OECD countries and in a range of proficiency where the PISA assessment offers little measurement.

**Figure 1.6**

**Estimated distribution of scientific literacy proficiency scores,[6] Qatar and OECD average, PISA 2006**




## 1.5 Comparisons of the shape of the proficiency distribution for Qatar and the OECD

Skewness is a measure of the extent to which a distribution is asymmetric. Distributions that are negatively skewed have low scores that extend further below the mean than the high scores extend above it; although the bulk of the distribution is placed to the right of the mean score; the reverse is the case for positively skewed distributions. PISA reading literacy scores are negatively skewed in all 30 OECD countries. The skewness is also negative in 22 of the 26 non-OECD countries that participated in PISA 2006. The exceptions are: Azerbaijan, Indonesia, Kyrgyz Republic, and Qatar. In these four countries the majority of the students scored at a low level, with few students performing at the higher levels above the OECD mean score (484 points).

The average mean reading score for all OECD countries is 484 points, with an average standard deviation of 107 points, and an average skewness of -0.35 points. For Qatar the corresponding estimates are 312 points, 108 points, and +41 points respectively.

6. Combined science scale.

Figure 1.7 below plots the relationship between the skewness in the science proficiency distribution against average science proficiency. The results reveal a strong negative relationship between mean science proficiency and skewness; the correlation is -0.76 at the country level. The extent to which scores for a country are skewed depends partly on the proportion of students that make sufficient progress in reading literacy performance during the early grades. If students fall off track without making the crucial transition from 'learning-to-read' to 'reading-to-learn' at about age 8 or 9 years, most often they make little progress in their skills thereafter. If a large proportion of students fail to make the transition successfully, then at age 15 there is a large proportion with very low levels of skills. Countries with high levels of performance and negatively skewed distributions tended to have strong levels of reading performance in the early years (Willms, 2006).

Another reason that scores can be skewed is that the OECD-PISA proficiency tests do not adequately capture the range of skills in countries with low levels of performance. Therefore, there is a 'floor effect' on the tests, such that students' observed scores are higher than they would be if the assessments had a broader range. This can also cause the distribution of scores to be positively skewed. This is likely to have been the case in Qatar because large proportions of students were unable to answer any test items correctly, or were only able to answer a few of the easier items correctly.

**Figure 1.7**

**Country-level average scientific literacy performance versus average distribution skewness, PISA 2006**

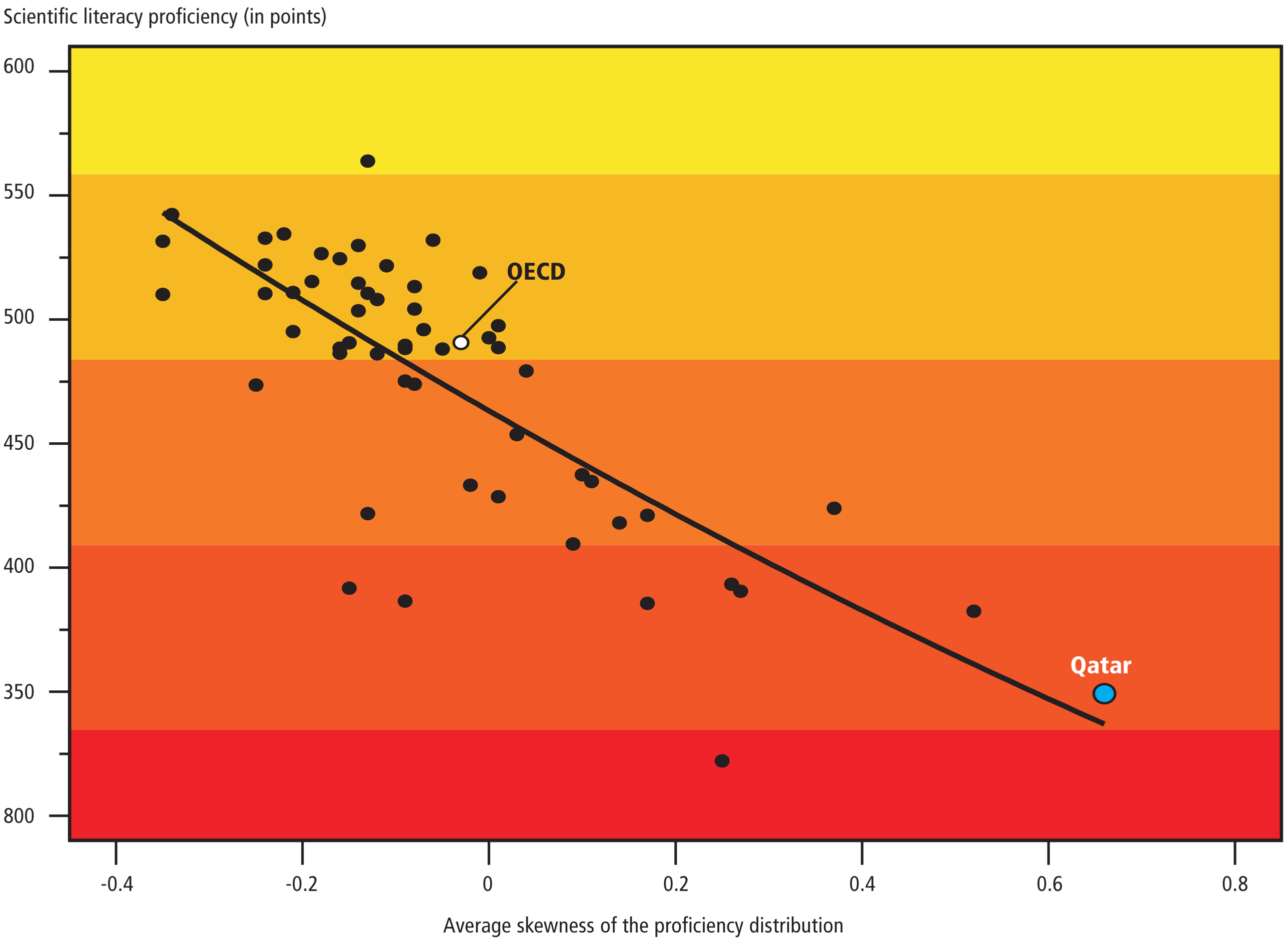
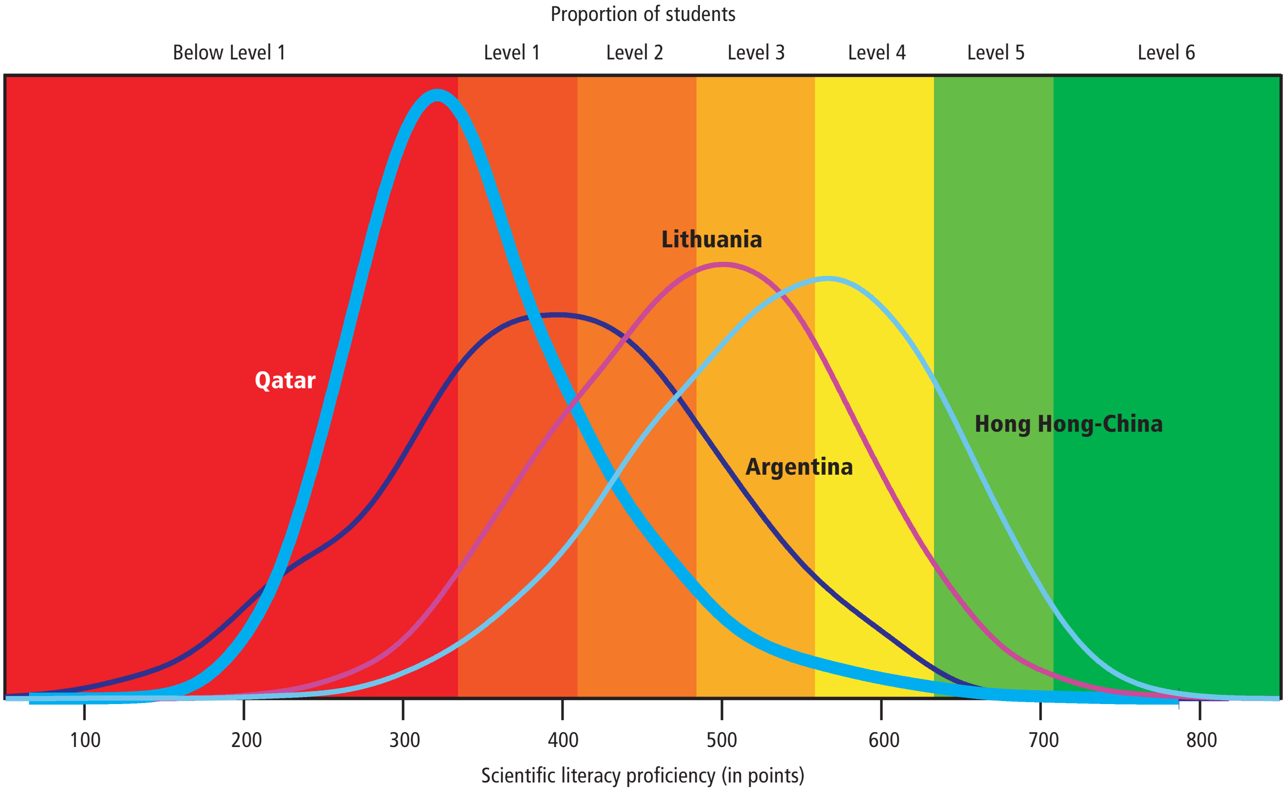


Figure 1.8 sharpens the analysis of the impact that the shape of the distribution of proficiency scores has on average performance by comparing the distribution of Qatar with those of three comparison countries: Argentina, Lithuania and China-Hong Kong SAR.

Like Qatar, Argentina has relatively low average science proficiency levels. In contrast to Qatar, however, Argentina has a distribution of proficiency that is negatively skewed. Lithuania provides a good example of a country with average science proficiency scores and a balanced distribution. In contrast, China-Hong Kong SAR exhibits a high average science proficiency score in science and a distribution that is strongly negatively skewed.

**Figure 1.8**

**Distribution of science scores, Qatar, Argentina, Lithuania, and China-Hong Kong SAR, PISA 2006**



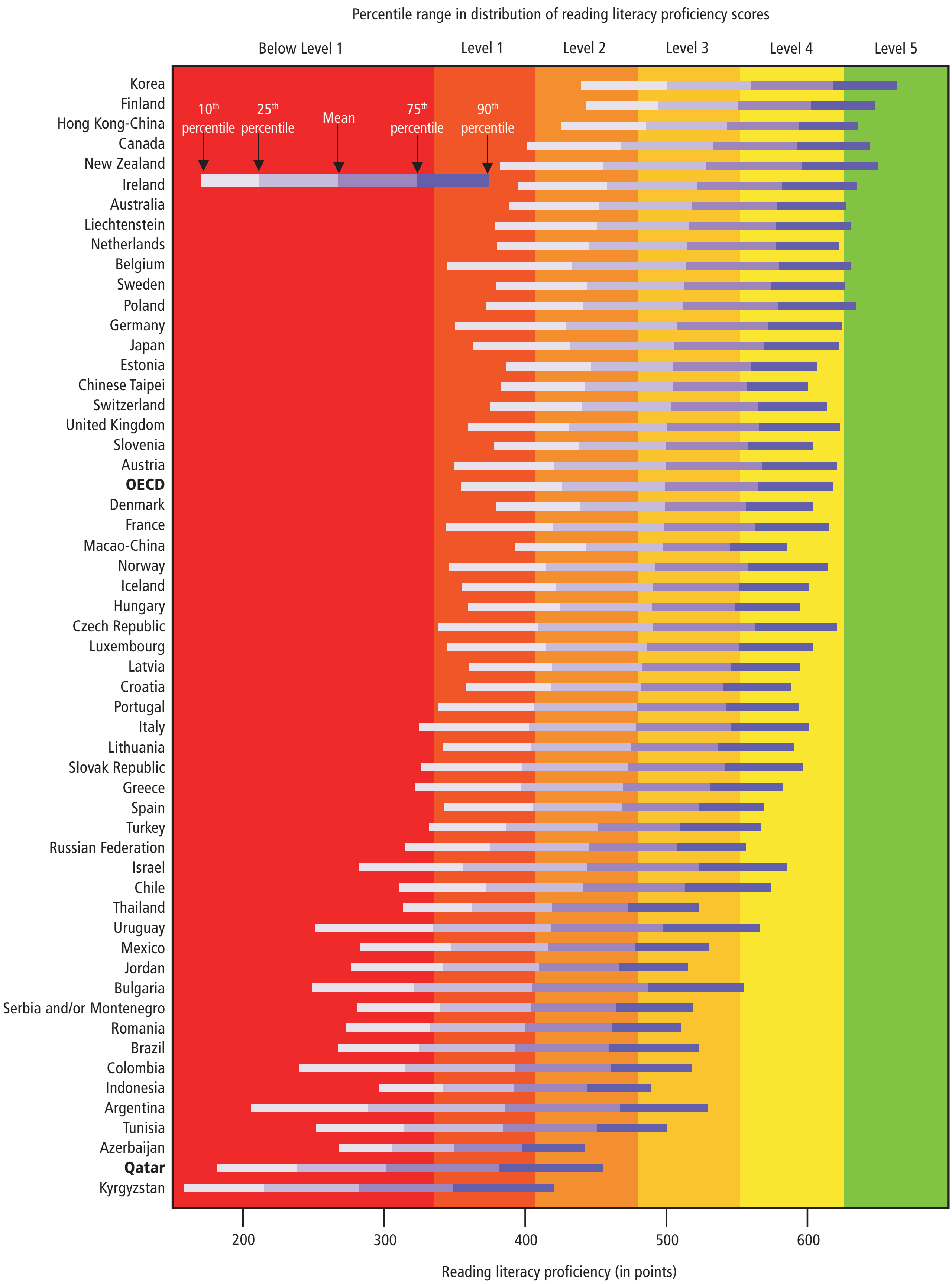

## 1.6 Comparisons of the percentile distribution of scores by country and skill domain

Figures 1.9, 1.10 and 1.11 further extend the distributional analyses by comparing the proficiency scores of 15-year-old students in Qatar at key points along the scales. Specifically, score values are computed and displayed at the $10^{th}$, $25^{th}$, $50^{th}$, $75^{th}$, and $90^{th}$ percentiles. This display allows one to identify parts of the distribution where students in Qatar might be either over or under performing.

Figure 1.9 presents the percentile scores for the reading literacy scale. The analysis indicates that students in Qatar consistently under perform across the entire range of ability. Figures 1.10 and 1.11 show the percentile scores for mathematical and scientific literacy, respectively. The data consistently indicate that students in Qatar under perform across the entire range of the ability distribution.

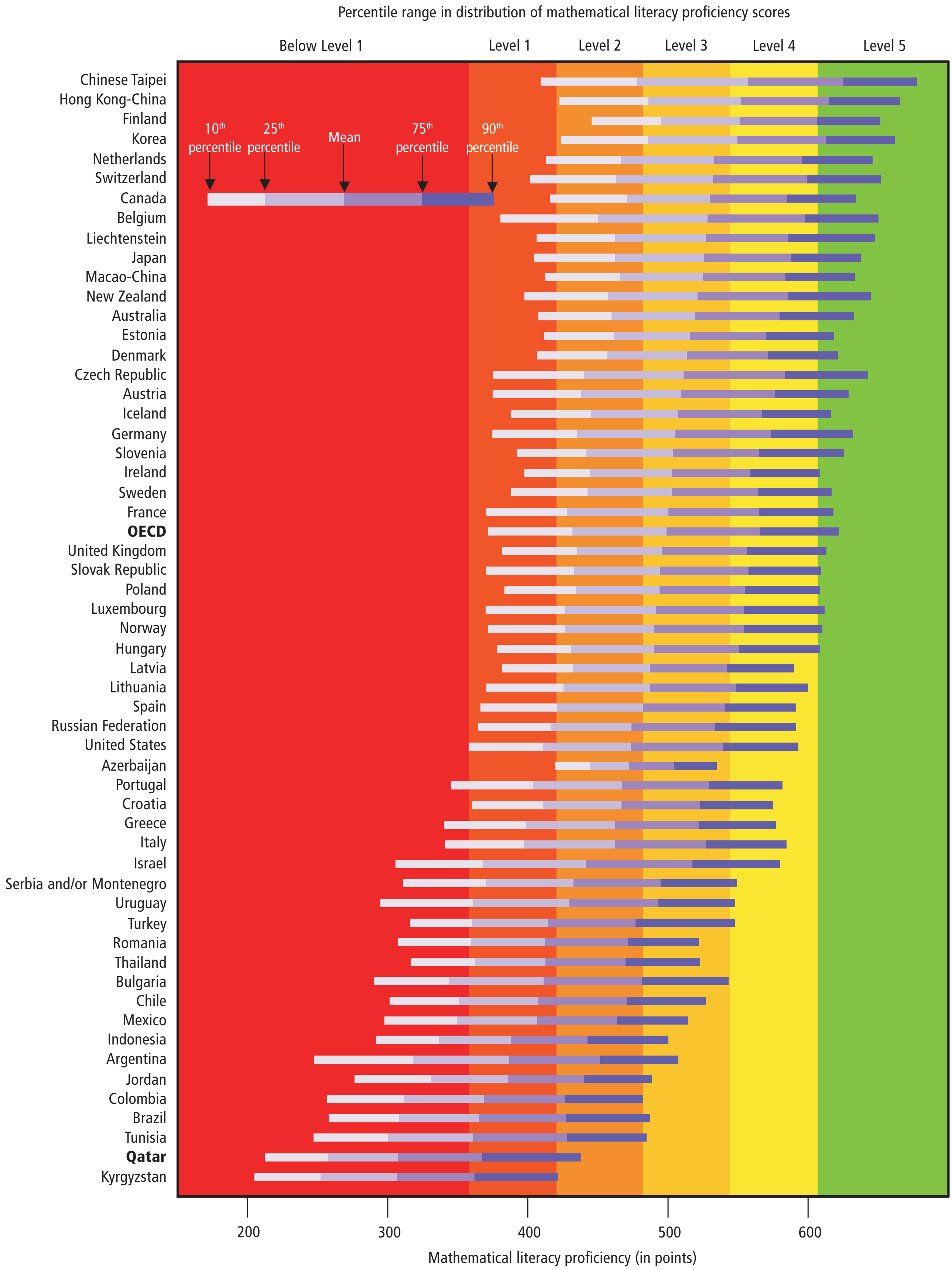
## Figure 1.9

## Distribution of literacy proficiency scores on the reading scale, from 10th to 90th percentile, by country, PISA 2006



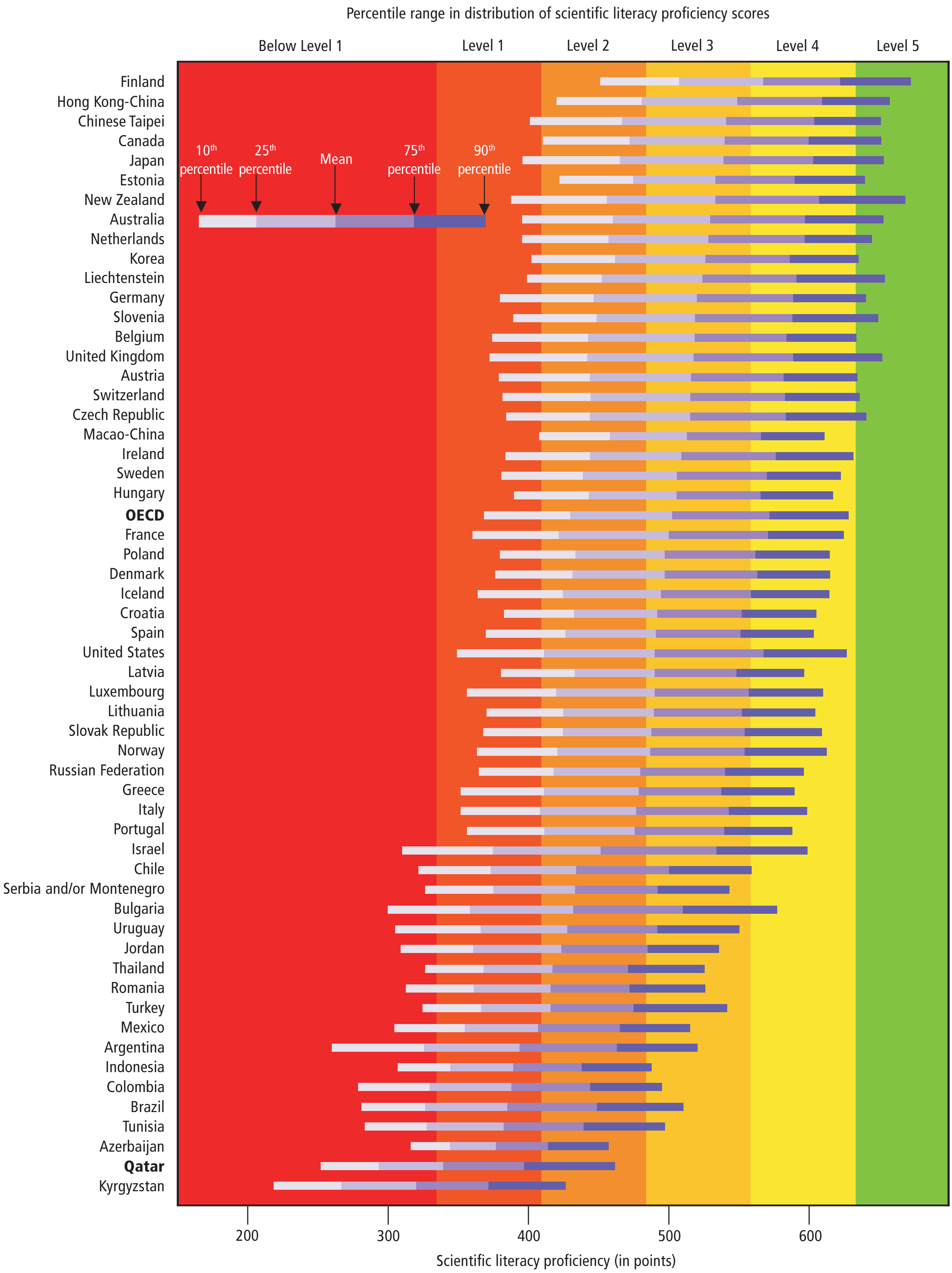
## Figure 1.10

## Distribution of literacy proficiency scores on the mathematics scale, from 10th to 90th percentile, by country, PISA 2006



## Figure 1.11

## Distribution of literacy proficiency scores on the combined science scale, from 10th to 90th percentile, by country, PISA 2006



# 1.7 Comparisons of proficiency by performance levels by country and skill domain

In addition to the impact that differences in the average level of skill proficiencies have upon rates of social and economic progress, research studies have shown that the distribution of proficiency by performance level influences rates of economic growth. Specifically, the evidence suggests that higher proportions of adults with low skills reduce long term rates of economic growth (Coulombe, Tremblay and Marchand, 2005; Coulombe and Tremblay, 2006). Furthermore, education policy analysis has suggested that students need to score at least at Level 3 if they are to profit fully from tertiary education (OECD, 2004).

Figure 1.12 confirms the previous finding that Qatar has a high proportion of students with scores in the *Below Level 1* range in reading and among the lowest proportions of students with reading literacy skills in Levels 3, 4, 5 and 6. In Qatar, as in some other countries, the proportions of students scoring at the highest proficiency levels are so low that no statistically reliable estimates can be obtained. In such cases fewer than seven levels are shown in the charts.

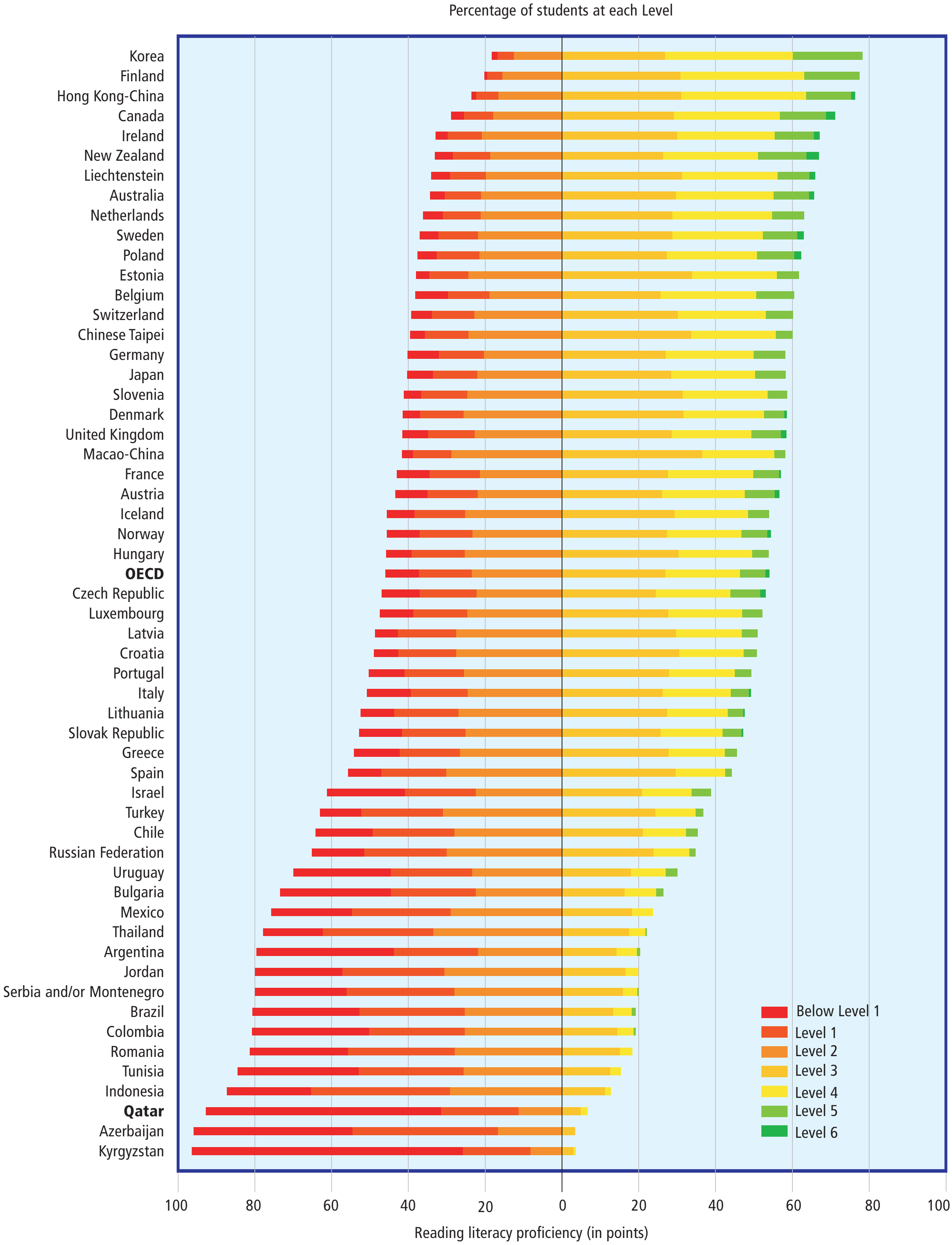
This finding implies that – happily, since the Qatar comprehensive education reform is expected to raise children's school readiness – future cohorts of 15-year-old students in Qatar will have improved chances of overcoming the shortcomings in science observed in the PISA 2006 study. It also suggests a concurrent need for the country to strengthen the provision of remedial youth and adult education programming, so as to ensure that the youth – and all other eligible Qatari residents – who have the desire and capacity to upgrade their reading literacy skills are afforded adequate opportunities to succeed.

The data in Figure 1.13 indicate that the distribution of proficiency by performance level in mathematics parallels the one observed for reading literacy. Relative to the other PISA countries, Qatar has among the highest proportion of students performing *Below Level 1* in mathematical literacy and among the lowest proportions of students scoring at Levels 4, 5 and 6.

Figure 1.14 presents similar results for the combined scientific literacy scale. As might be expected given the results already reviewed, Qatar has among the highest proportions of students with science performance at *Below Level 1*.

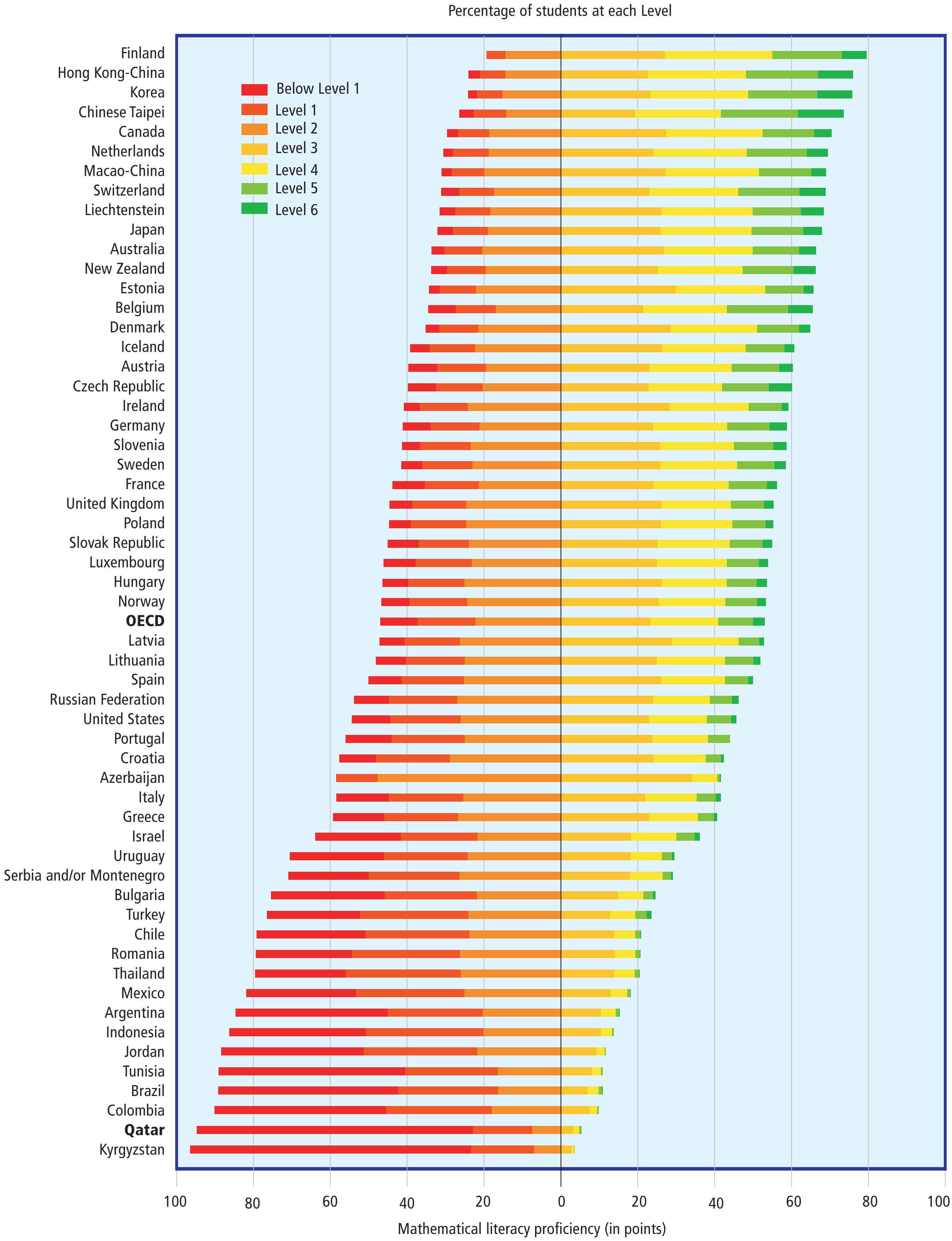
## Figure 1.12

## Percentage of students scoring at each of seven reading literacy proficiency levels, by country, PISA 2006



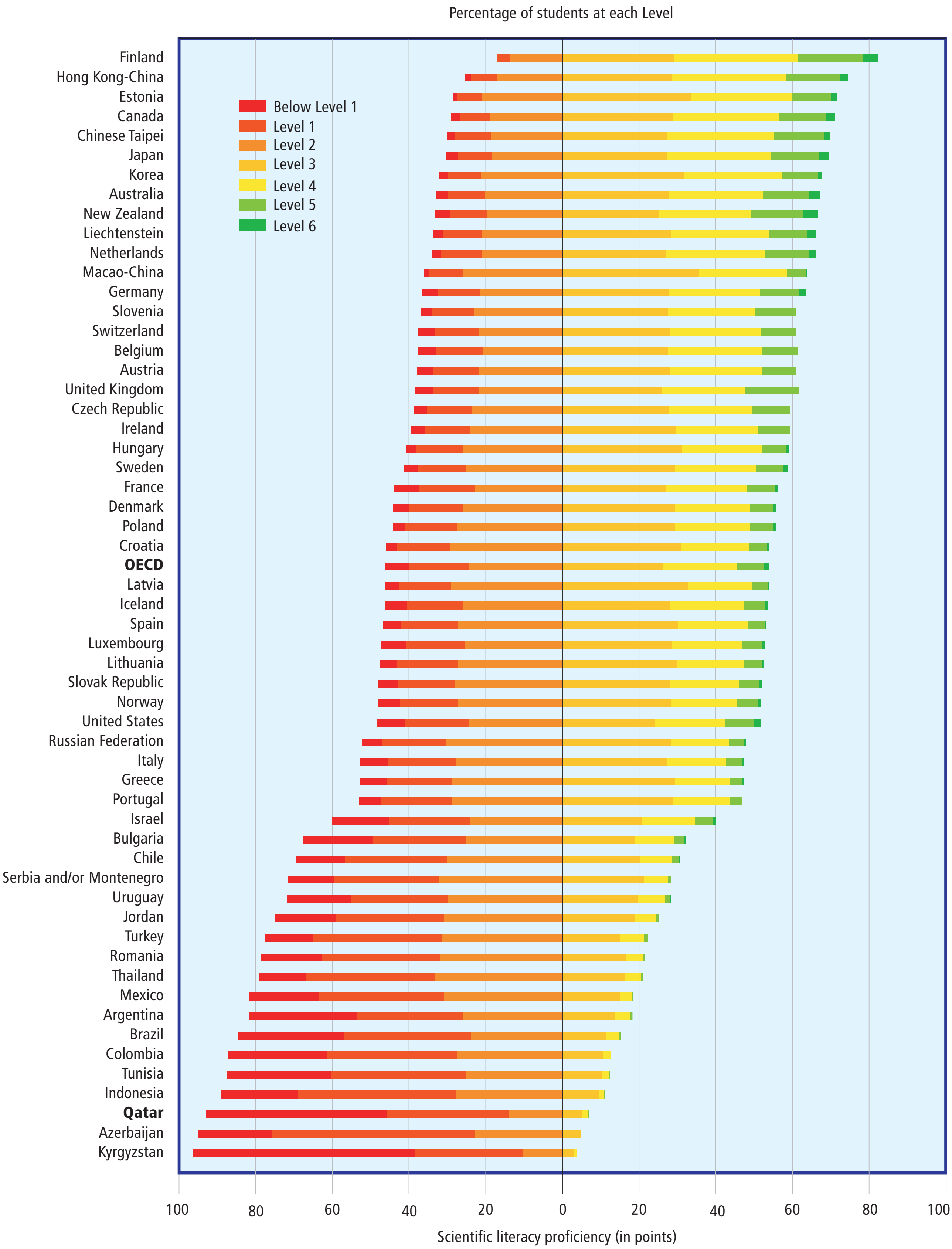
## Figure 1.13

## Percentage of students scoring at each of seven mathematical literacy proficiency levels, by country, PISA 2006



## Figure 1.14

### Percentage of students scoring at each of seven scientific literacy proficiency levels, combined science scale, by country, PISA 2006



# 1.8 Summary and conclusions

Chapter 1 has explored the distribution of proficiency in three skill domains among 15-year-old students in Qatar in a comparative framework. The data analyses have revealed several important findings, which should be of paramount interest to decision makers, educators, the students themselves, and indeed all other members of society who are concerned with school quality and its significance for the long-term prosperity of Qatar as a nation.

## Notable are the following facts about Qatar:

- Average proficiencies in reading, mathematical and scientific literacy are among the lowest observed in the 57 countries that participated in the PISA 2006 assessment. Qatar's 15-year-old students are, on average, somewhat ahead of their peers only when compared with the Kyrgyz Republic.
- The low average proficiencies observed in Qatar are to a large extent coincidental with the fact that the entire distributions of the proficiency scores are shifted down into the lower levels of the proficiency scales. This shift is observed for all three skill domains – reading, mathematics and science.
- Average proficiencies in all three skill domains are lowered further by the fact that relatively higher proportions of Students in Qatar have scores below the national average. The degree of positive skewness in the distribution of proficiency scores is particularly high in the mathematics and science domains. Finding ways of lifting the literacy proficiencies of the disproportionally high number of students at the tail end of the proficiency distribution should be a necessary element of any strategy to raise Qatar's average scores. Other research suggests that distributions tend to be skewed when a high proportion of students do not attain the necessary reading skills during the primary grades that enable them 'read-to-learn' during the later grades.
- Judged against the OECD distribution, average scores at key points along the proficiency distribution in Qatar are uniformly low. Judged in relative terms, average Qatari scores at the 10$^{th}$ and 25$^{th}$ percentiles are significantly lower than comparable scores of their OECD peers. This finding applies to all three skill domains – reading, mathematics and science.
- The overwhelming majority of students in Qatar are classified at the performance level *Below Level 1*.
- Very small percentages of Students in Qatar have skills that are sufficiently advanced, measured against OECD benchmarks, to place them at performance Levels 3, 4, 5 or 6 in all three skill domains.

These findings carry several important implications for current policy – not only education policy but also for policies impacting family welfare, youth affairs, social work, culture, and, importantly, economic policies aimed at creating a Qatari environment amenable to sustainable development.

First and foremost, the findings of the PISA study provide unequivocal support for Qatar's "Education for a New Era" reform strategy and the concomitant new investments aimed at raising the quality of education in the country.

Second, the strikingly low levels of performance of today's 15-year-old students, measured against OECD benchmarks, suggest that the education reforms instituted over the past few years have had limited impact upon this cohort of students in Qatar. This is particularly true with respect to performance in reading and mathematics, both of which currently are much below the levels needed to support the efficient teaching and learning of science concepts and content. The on-going effort to afford high-quality early childhood education to all Qatari families should evidently be vigorously pursued, and measures now being implemented that are designed to improve learning at the early stages in primary schooling deserve centre stage.

It is important to note in this context that the 15-year-old students assessed in the PISA 2006 study for Qatar had, at best, only partially benefited from the initial stage of the reforms launched by the "Education for a New Era" initiatives. Hence any beneficial effects were realised during the last three years of their secondary education, a stage when the essential foundations of reading literacy and numeracy are normally already well established. This fact has profound implications for the interpretation of the findings presented in this report. The PISA 2006 estimates of the proficiency of Qatar's 15-year-olds are best thought of as benchmarks for gauging future improvements, and as unequivocal proof that the current reform initiatives were indeed urgently needed

Third, although the PISA 2006 findings will no doubt be interpreted by some educators and other members of Qatari society as discomforting, they should nevertheless be welcomed, not least because they offer objective confirmation that the "Education for a New Era" reform programme is essential to the future well being of the nation.

They also provide strong support for continued standardised education assessment in the same sense that the critical condition of a patient has to be monitored, the more often the more critical that condition is. Particularly helpful would be the assessment of reading, mathematics and science achievement at earlier ages, both to capture the effects of the recent reforms and to better understand what factors might play the greatest role in raising the performance of future cohorts of Students in Qatar. The participation of Qatar in the 2007 Progress In Reading Literacy Study (PIRLS), whose results were released on November 28$^{th}$, represents an important next step in building the required knowledge base. Coincidentally, additional and innovative approaches to standardised testing in early grades, already planned, should now be implemented.

Finally, the obligation of Qatari society to pursue social fairness in the long term dictates that the comparatively low performance of the current cohort of youth and young adolescents cannot merely be written off as an "accident of history". Clearly, there is an objective need for the country to strengthen the provision of remedial youth and adult education programming, so as to ensure that all those who have the motivation to upgrade their skills are afforded with adequate opportunities to do so. Moreover, steps should be taken for those lacking such motivation to develop it.

## The findings also carry important future repercussions

First, not many students in Qatar in the cohort assessed in PISA 2006 have skill levels sufficiently high to take full advantage of tertiary education. In the absence of the current reform, this fact might have limited the efficiency and effectiveness of tertiary education provision in Qatar and, probably, in the other Gulf States. The Qatar comprehensive education reform should prevent such a situation – hindering the ability of Students in Qatar to perform well in the world's elite universities – from persisting.

Second, as Qatar's economy diversifies, thanks to recent policy decisions favouring new investments in education, more Qatari adults can be expected to possess the levels of skills needed to participate in the tasks demanded in the global, knowledge-based economy. Nevertheless, this initiative needs to be complemented with a renewed effort to build an efficient system to educate and train adults. Because this will take time, however, the labour market in Qatar is likely to remain temporarily dependent on imported human capital, at least for some time.

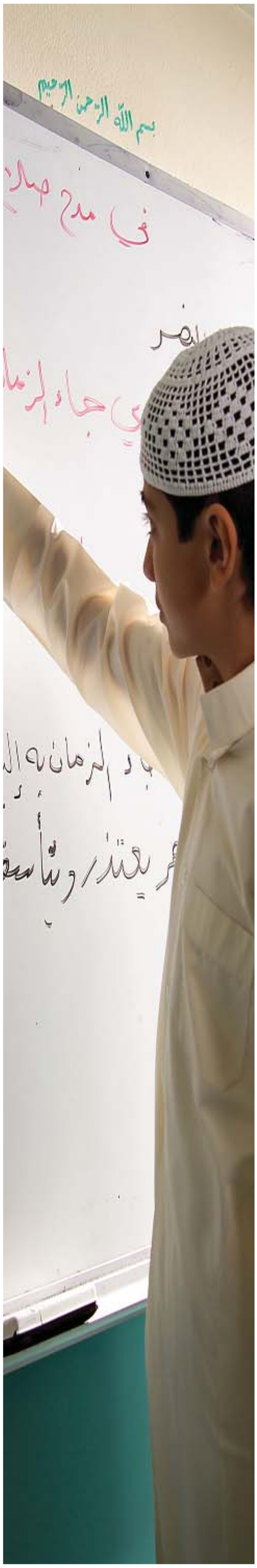
Third, while average skill levels are not high, the recent changes in education in Qatar should help prevent the generation of a notorious degree of variability in proficiency scores, to potentially create some inequality in important social and economic outcomes. High levels of inequality are a source of potential social instability, and they may constrain productivity growth, reduce the return on education investments, and reduce levels of social cohesion and engagement.

It is also worth noting that the findings presented in this chapter carry implications for how to interpret the PISA results for Qatar. For instance, PISA proficiency in both reading and mathematical literacy of Qatar's 15-year-old students is so low that it is reasonable to infer that the ability of these students to understand and respond to the PISA science items is seriously constrained.

Finally, the fact that most students in Qatar showed low performance levels, and particularly the high number scoring at *Below Level 1*, means that their proficiency scores are less reliable than those estimated for countries in which the range of proficiency is more closely aligned with the distribution of item difficulties current for OECD countries.

# Chapter 2

## Science Performance and Attitudes towards Science in Qatar




## 2.1 Introduction

The differences among countries in the average proficiencies and the distributions of scores, documented in Chapter 1, are the product of underlying differences in a wide range of educational, social and economic factors. The present chapter builds upon the analyses previously presented in two ways.

First, this chapter explores the degree to which the performance of 15-year-old students in Qatar is uniformly low in each of the three science sub-domains assessed in the PISA 2006 study. These sub-domains, which are described in greater detail in Annex C, are:

- Identifying scientific issues;
- Scientifically explaining phenomena; and
- Using scientific evidence.

Until the recent "Education for a New Era" reform was instituted, science education in Qatar was oriented almost exclusively towards the memorisation of scientific facts, rather than focused on the comprehension of scientific concepts and the use of scientific evidence. Thus, one might expect to find differences in performance across the three science sub-domains – differences that possibly could be traced back to the instructional practices widely used by educators in Qatar. If no such differences are found, however, then one ought to search for alternative explanations.

The second part of the chapter presents a comparative analysis of two factors that have been shown in research studies to be positively associated with science performance:

- Student attitudes towards science; and
- Support provided for science instruction.

## 2.2 Domain-specific science proficiency in Qatar

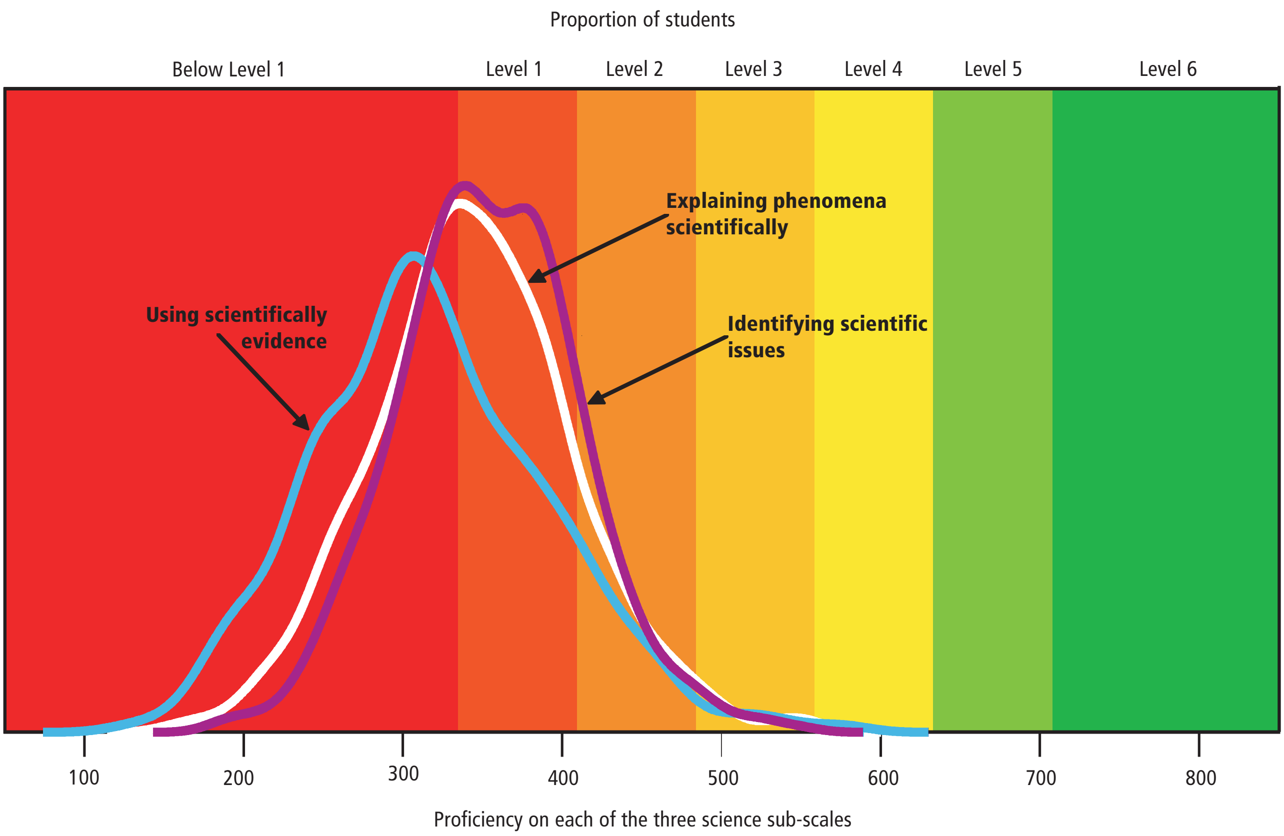
As noted above, PISA 2006 assessed three distinct science sub-domains, namely identifying scientific issues, scientifically explaining phenomena, and using scientific evidence. A sufficiently large number of science test items were administered so as to allow the separate measurement and scaling of each science sub-domain. These three sub-scales were combined to produce the overall science proficiency scale, reported on in the previous chapter.

There is no reason why performance on these sub-scales should be uniform across education systems. On the contrary, one would expect to see variation, reflecting the approaches taken to science instruction in different countries. Figure 2.1 shows the distribution of proficiency scores on the three science sub-scales for students in Qatar. Several important facts emerge from this Figure.

The most striking finding is that the performance of Qatar's 15-year-old students is uniformly low across the three science sub-domains. This result provides strong indirect support for the hypothesis set out in Chapter 1, namely that the cohort of Students in Qatar assessed by PISA 2006 did not have the requisite literacy and numeracy skills needed to understand and respond to the science test items.

**Figure 2.1**

**Distribution of proficiency scores on three science sub-scales, Qatar, PISA 2006**



The second finding is that 15-year-old students in Qatar did somewhat better in identifying scientific issues and explaining scientific phenomena than in using scientific information. However, in all three sub-domains the majority of students scored at Level 1 or below.

The remaining findings mirror those for the overall science proficiency scale presented in Chapter 1.

First, as is the case with the overall science proficiency scale, the average proficiency scores on each of the science sub-scales are among the lowest observed in the 57 countries that participated in the PISA 2006 assessment.

Second, the comparatively low average proficiencies observed on the science sub-scales in Qatar are to an extent coincidental with the fact that the entire student population distribution of proficiency scores is shifted down into the lower levels of each of the three science proficiency sub-scales.

Third, average proficiencies in all three sub-domains are lowered further by the fact that relatively higher proportions of students in Qatar have scores below the national mean score. The comparative degree of skewness in the distribution of science among sub-domains proficiency scores is fairly uniform.

Finally, small percentages of students in Qatar have science skills that are high enough to place them at performance Levels 3, 4, 5 or 6 on any of the science sub-domains.

## 2.3 Domain scores – Attitudes towards science and science support

The fact that the performance on the science sub-scales of 15-year-old students in Qatar mirrors that on the overall science scale suggests that instructional practice is not the only factor responsible for the comparatively low performance in science. Thus, other explanations must be sought as well.

One possible explanation might be that students in Qatar have less positive attitudes to science than their OECD peers. The PISA 2006 student questionnaire included a large set of questions designed to profile students' attitudes to science. These questions were used to construct two composite scales that can be analysed to explore the relationships between students' attitudes to science and science proficiency. These scales measure students' interest in science and the extent to which they feel they receive support for scientific inquiry. The attitude and support scales were standardised so as to assign to them the same measurement and scaling properties as the overall science scale. The individual attitude and support items used to build the composite scales are presented in Chapter 5.

Before presenting the results of the data analysis for Qatar, it should be explicitly noted that there is disagreement amongst measurement experts about the appropriateness of the attitudinal scales developed for PISA 2006. Although for most countries both scales show a high and acceptable degree of reliability, there is concern about their validity. For a significant number of countries participating in PISA 2006, analyses of the data sets do not show the moderately strong and positive relationships between science support, interest and proficiency that are expected on the basis of previous research findings. For a number of countries the relationship between students' interest in science and science proficiency is zero or even negative. Further analyses are currently being undertaken, under the guidance of the OECD secretariat, to investigate this apparent anomaly.

**Figure 2.2**

**Distribution of scores on the combined science scale, support for scientific inquiry, and interest in science, Qatar, PISA 2006**

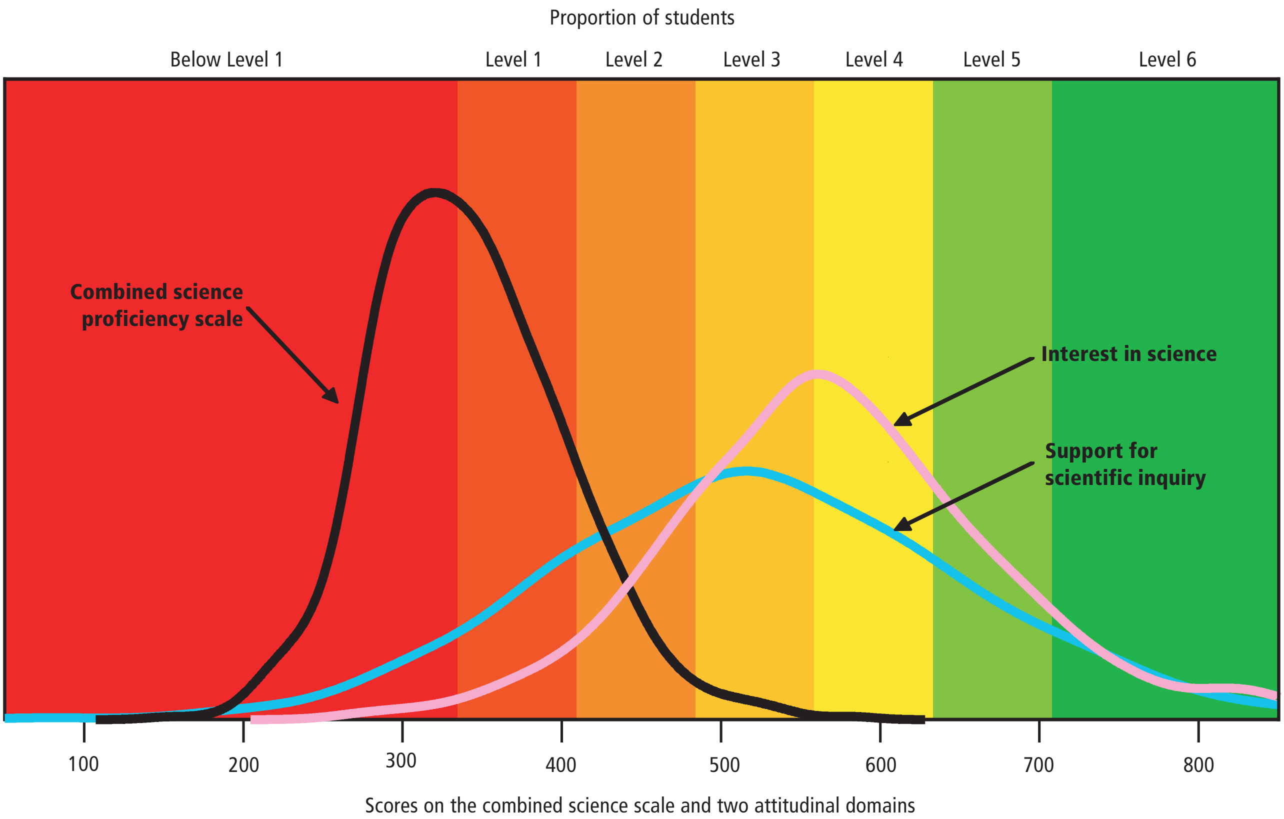


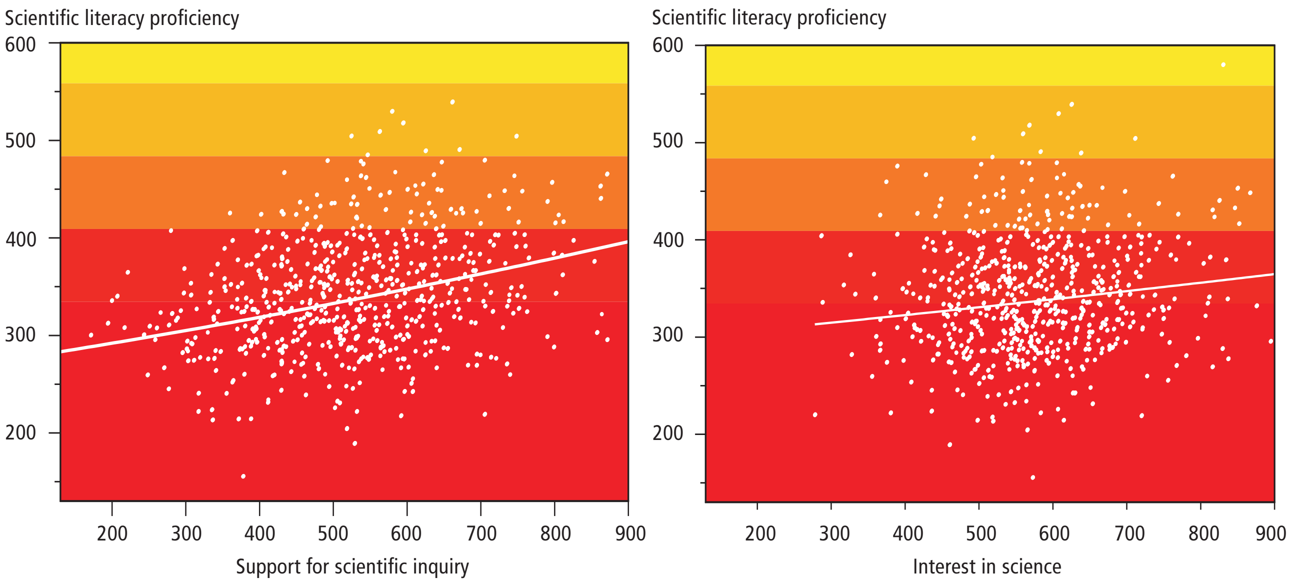

Figure 2.2 shows the distribution of students in Qatar' scores in support for scientific inquiry and interest in science alongside the distribution of scores on the combined science performance scale, which was portrayed in Chapter 1. The average score for support for scientific inquiry is 520 points, which is about 20 per cent of a standard deviation above the OECD mean score. The average score for interest in science is even higher – 565 points – about 65 per cent of a standard deviation above the OECD mean score. These results suggest that students in Qatar do not lack the interest to learn science, nor do they feel they lack support. This finding is consistent with the hypothesis that the 15-year-old students in Qatar assessed in PISA 2006 lacked the fundamental reading and numeracy skills to learn the science knowledge and competencies taught at this advanced level.

## 2.4 Relationships between science proficiency, interest in science and science support

Figure 2.3 shows the relationships between science proficiency and support for scientific inquiry, on the one hand, and between science proficiency and interest in science on the other, for the sample of 15year-old students assessed in Qatar. The analysis shows, as might be expected, that the relationships are both positive, with increasing levels of proficiency associated with increasing levels of support and interest. However, the relationship between science proficiency and interest is relatively weak compared with the relationship between science proficiency and support.

**Figure 2.3**

**Within-country relationships between science proficiency and support for scientific inquiry, and between science proficiency and interest in science, Qatar, PISA 2006**




The above results are consistent with other work that shows that positive attitudes to science are associated with high proficiency scores (Bussière et al., 2004; OECD, 2007). Such cross-sectional results must, however, be interpreted with great care. One requires longitudinal data that follow individual students over time to show that the relationship between attitudes to science and science proficiency is a dynamic, self-reinforcing system in which proficiency interacts with attitudes to science over the life course (Keeves & Morgenstern, 1992; Wylie, 2004).

Students' interest and engagement in science and their scientific proficiency are linked in reciprocal relationships that begin early in the school career (Chiarelott and Czerniak, 1985). Generally, students' engagement in a subject is not only related to their interest and motivation, but also to an appraisal of their ability (Guthrie and Wigfield, 1997). Therefore, students' early experiences in learning science not only affect their interest in learning science, but also whether they believe they can succeed in science and whether they understand and value the process of scientific inquiry. Students who have some initial success in learning science are more likely to believe they can succeed and value the scientific process (Pekrun, 2000).

Therefore, one cannot simply consider science attitudes as an input measure for proficiency, as something that automatically leads to higher scores. Rather, one must think of it as an outcome measure, as something that leads to more positive attitudes. Policy measures designed solely to improve students' attitudes to science are unlikely to yield improvements in either average science scores or reductions in levels of social inequality in skills. On the contrary, policy decisions aiming at improving science achievement would most likely also yield more favourable attitudes towards science on the part of the students.

**Figure 2.4**

**Between-country relationships between science proficiency and support for scientific inquiry, and between science proficiency and interest in science, Qatar, PISA 2006**

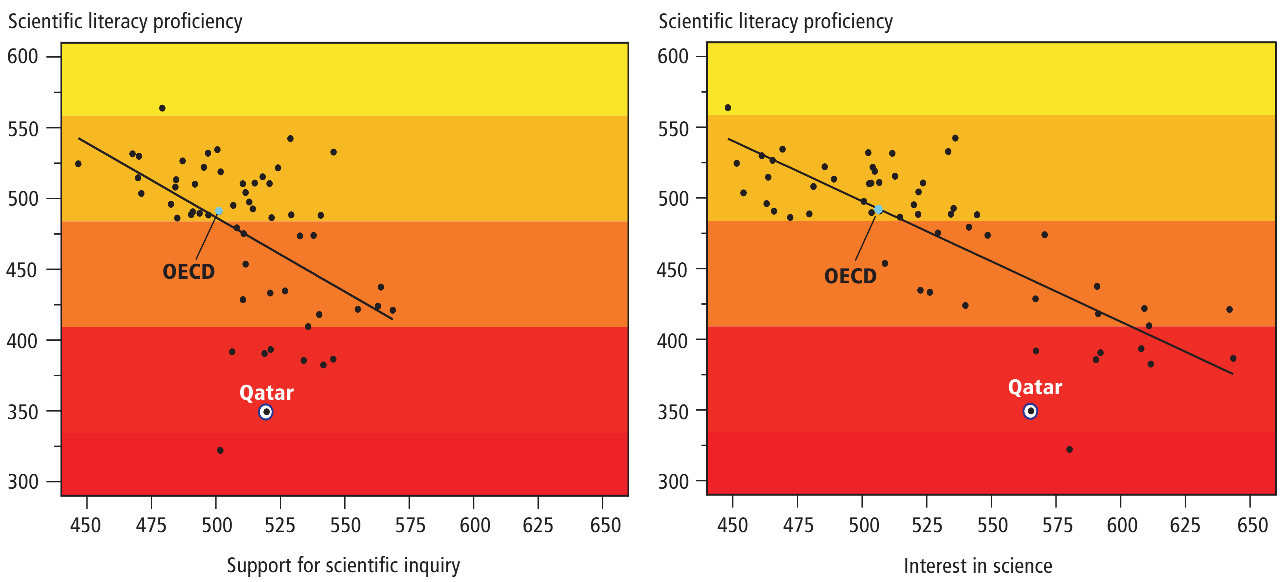



Figure 2.4 shows the relationship at the country level between science proficiency and support for scientific inquiry, and between science proficiency and interest in science for the countries that participated in PISA 2006. Contrary to what one might expect, there is a negative relationship between average levels of proficiency and average levels of support for scientific inquiry, and between average levels of proficiency and average levels of interest in science: countries with high levels of support and interest tend to have lower proficiency scores.

This inverse relationship may have stemmed from the manner in which these items were administered. The support and interest items were included in the test booklets, alongside the proficiency test items. It may be that students who were struggling with the proficiency items tried to compensate for their low perceived performance by responding positively on the attitudinal items. This might be a possible explanation for the apparently anomalous relationships between the attitudinal scales and science proficiency found in the PISA data sets for some countries. Another explanation might be that students' perceptions about interest in science and the adequacy of science support are by definition subjective in the sense that they are necessarily coloured by their life experiences and expectations framed by the surrounding cultural and economic context.

In any event, Qatar is somewhat anomalous here as well. The evidence demonstrates that the level of science support offered in Qatar is superior to that of most OECD countries. This fact might reflect the considerable investment that Qatar has made, since the launch of the "Education for a New Era" initiative, in improving all aspects of the education system. However, the level of proficiency for the country is below the regression line in both cases, indicating that the science proficiency of students in Qatar is much lower than might be expected given their level of interest and perceived support. This finding suggests that students in this cohort, and their teachers, may not have what it takes to convert these assets into improved science performance.

It should be noted that factors other than attitudes and support, undoubtedly also play a role in improving science proficiency. For example, secondary research using the 2003 PISA data base for Canada, has shown that students whose parents work in occupations that demand high levels of mathematics and science tend to perform significantly higher in both mathematics and science than their peers (Bussière *et al.*, 2004). This finding suggests that parental attitudes to science, the use of mathematics and science in the home, and the availability of science and mathematics resources in the home, all play an important role in stimulating science achievement in the current generation.

## 2.5 Conclusion

This chapter has examined the levels of proficiency in science in three specific domains: identifying scientific issues; explaining scientific phenomena and using scientific evidence; and students' interest and support in science.

Students in Qatar scored slightly higher on test items involving the identification of scientific issues and the explanation of scientific phenomena than on items that required the use of scientific evidence. However, their scores in all domains were low when compared with other countries participating in PISA.

The analysis of students' perceived support for learning science and their interest in science revealed that Students in Qatar had high levels of perceived support and interest in the subject. However, the level of proficiency in science is much lower than one would expect given their strong interest and their perceptions of generous levels of support received. No strong conclusions about these findings should be drawn at this point in time, however, because there is disagreement amongst PISA experts about the validity of the attitudinal scales. As the possibility that the relationships observed for Qatar are spurious cannot be ruled out, further investigation will be required to examine and clarify this issue.

On the whole, the results offer a degree of support for the hypothesis that Qatari 15-year-old students lacked the fundamental reading literacy and numeracy skills required for learning the more advanced scientific knowledge and concepts being assessed.

# Chapter 3

## Variation among Students and School Strata in Science Performance

## 3.1 Introduction

This chapter commences the exploration of the factors that can explain the observed levels and distributions of science proficiency in Qatar, as set out in Chapters 1 and 2.

The primary goal of the analysis is to determine if the overall low performance of 15-year-old students in Qatar can be attributed to the relatively poor performance of specific strata in the population. Research has shown quite clearly that many of the differences in student performance observed among countries can be traced to differences in the performance of boys and girls, or of students born in and outside Qatar, or the relatively low performance of the children of parents with low socio-economic backgrounds (OECD, 2006). Performance often varies also among students attending particular types of schools. In this report, we use the term 'strata' to refer to schools with differing school organisation and funding arrangements. This latter dimension is of considerable interest in the context of schooling in Qatar because one of the key elements pursued as part of the on-going reform is the creation of a new stratum of school, characterised as independent.

For example, it is widely known that, in general, girls perform better in reading prose whereas boys generally outperform girls in reading documents in mathematics and science (OECD, 2001; 2004). Thus, differences in the ratio of boys to girls attending school in different countries can translate into shifts in the rank order of countries based upon average scores.

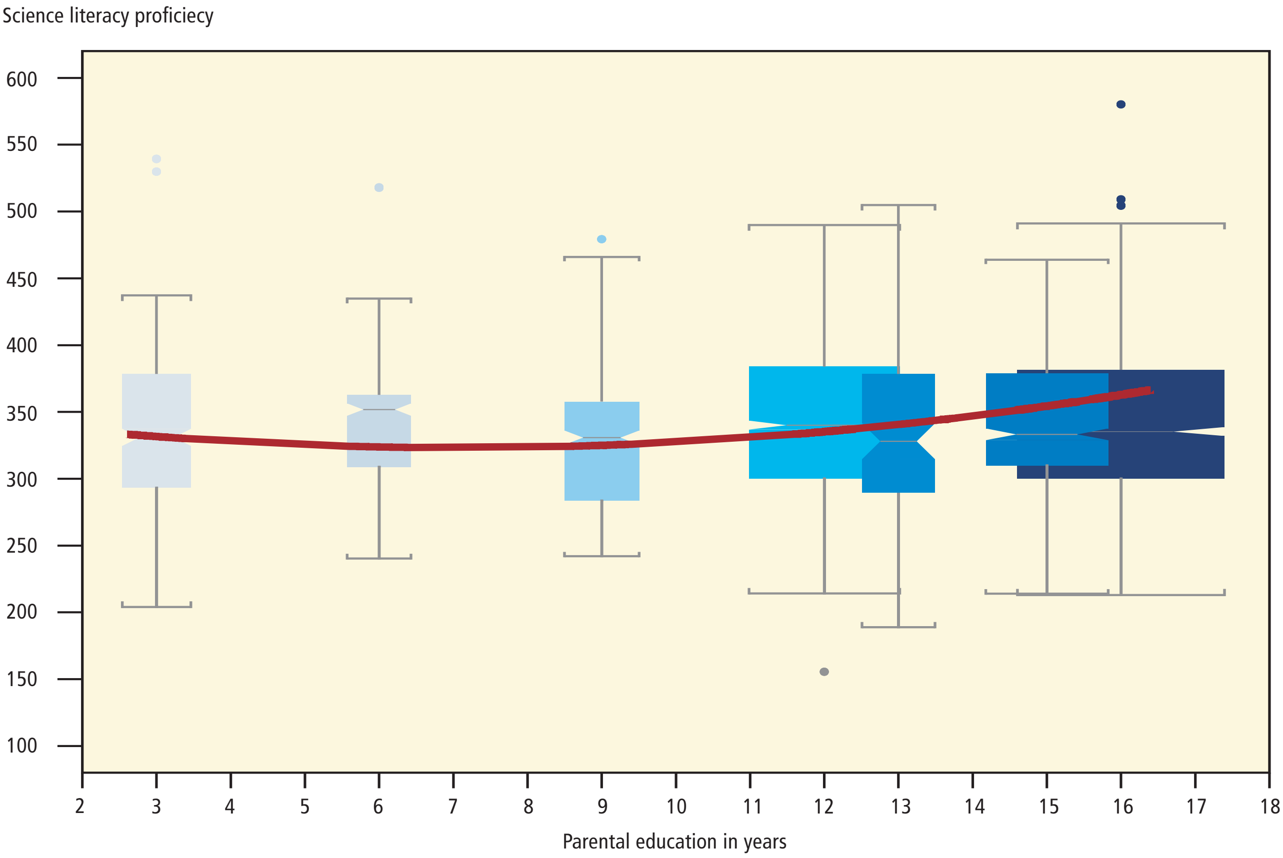
Similarly, school strata have been shown to have a marked impact on average performance, often because of the differences in the characteristics of the students that chose to attend different school strata. For example, students attending Catholic schools in the United States of America have been shown to outperform those attending secular institutions (NCES, 2006). These performance differences emerge not because Catholic schools do a better job of educating students but rather because parents who send their children to Catholic schools tend to have higher levels of education and income than their non-

Catholic peers. These differences afford students in Catholic schools with higher learning expectations and more educational resources, both matters that lead to improved performance (Mok and Flynn, 1998).

The relative scores of students with an immigrant background have also been shown to vary among countries (OECD, 2006). Therefore, an analysis of the variation in performance among population sub-groups can help focus the efforts of policy makers charged with the responsibility of improving the performance of students in Qatar, and for getting some sense of how rapidly one might expect to accomplish improvements.

**Figure 3.1**

**Relationship between science performance and parental education, 15-year-olds, Qatar, PISA 2006**




## 3.2 Parental education

A large body of evidence demonstrates the positive impact that socio-economic status has on the performance of students around the world (OECD, 2001, 2004; Willms, 2000, 2006).

Figure 3.1 explores the relationship between science scores and the parental education for 15-year-old students in Qatar. The term, 'socio-cultural status,' is used in this report, as a measure of family income was not available. At each level of parental education, measured in years, a 'box plot' shows the range of science scores attained by students whose parents have that level of education (see Box 3A). The red line is the socio-cultural 'gradient,' which displays the relationship between science performance and parental education. The gradient is drawn from the 5th to the 95th percentile of parental education.

## Text Box 3A

## Box plots

A box plot provides a convenient summary of the distribution of scores in a set of data. They show the minimum value, the lower (25th) quartile, the median (where 50% of the distribution scores are located), the upper (75th) quartile, and the maximum value. The box itself runs from the lower quartile to the upper quartile, and therefore includes the middle half of the scores in the distribution. The lower 'fence' of the plot is either the minimum value, or 1.5 times the inter-quartile range (75th percentile minus the 25th percentile), whichever is larger. 'Outliers' that fall below the lower fence are displayed separately with dots. Similarly, the upper fence is the maximum value, or 1.5 times the inter-quartile range, whichever is smaller. 'Outliers' that fall above the upper fence are displayed separately with dots. The boxes are drawn with a width proportional to the square root of the sample size. This helps one discern the relative size of the various groups. Finally, the boxes are notched at their median values. One can compare the notches for two boxes, and if the notches do not overlap, then the differences between the medians are statistically significant.

Socio-cultural gradients are useful for characterising the performance of an education system (Willms, 2006). They portray the relative level of proficiency in Qatar and the extent of inequalities among people with differing socio-cultural backgrounds. In this analysis, the indicator of socio-cultural background is comprised only of the respondent's parents' levels of education (See Box 3B).

Socio-cultural gradients are summarized by three components: their level, their slope, and the strength of the relationship (Willms, 2006). The *level* of the gradient is defined as the expected score on the outcome measure for a person with a particular level of socio-cultural status. In this case, the levels of the gradients reflect the average science scores at each level of parental education. The height of the gradient in the middle of the distribution of parental education scores is approximately 325 points.

The *slope* of a socio-cultural gradient indicates the extent of inequality among sub-populations that are attributable to socio-cultural status. In this case, the slope of the gradients indicates the extent to which parental education has influenced the development of science skills among 15-year-old students in Qatar. A shallow gradient indicates that there are relatively few inequalities in science proficiency among students with differing levels of socio-cultural status. A steep slope suggests that students with relatively low levels of parental education tend to be low skilled, and conversely, students who have the benefit of higher levels of parental education tend to be more skilled. Large differences indicate that access to good science instruction and engagement in science, interest in science and use of science are systematically related to socio-cultural differences.

The gradient for science performance in Qatar has a relatively gradual slope overall, but with a slightly steeper slope at higher levels of parental education. For youth whose parents had at least 12 years of education, average levels of performance are slightly higher. However, even for those whose parents had completed 16 or 17 years of education, the average levels of scores are extremely low, with an average of about 360, or 140 points below the overall

OECD mean score. Qatar is somewhat unique in that there is a relatively weak relationship between parental education and family income. For this reason, it is important to consider the variation in student performance at each level of parental education.

The *strength* of a socio-cultural gradient refers to the proportion of variance in science performance that is explained by SES. If the strength of the relationship is strong, then a considerable amount of the variation in the outcome measure is associated with socio-cultural status, whereas a weak relationship indicates that relatively little of the variation is associated with socio-cultural status.

The gradient in Qatar is relatively weak; that is, there is considerable variation in student performance that is not explained by parental education. This is evident in Figure 3.1 by the wide range in performance displayed by the box plots at each level of performance.

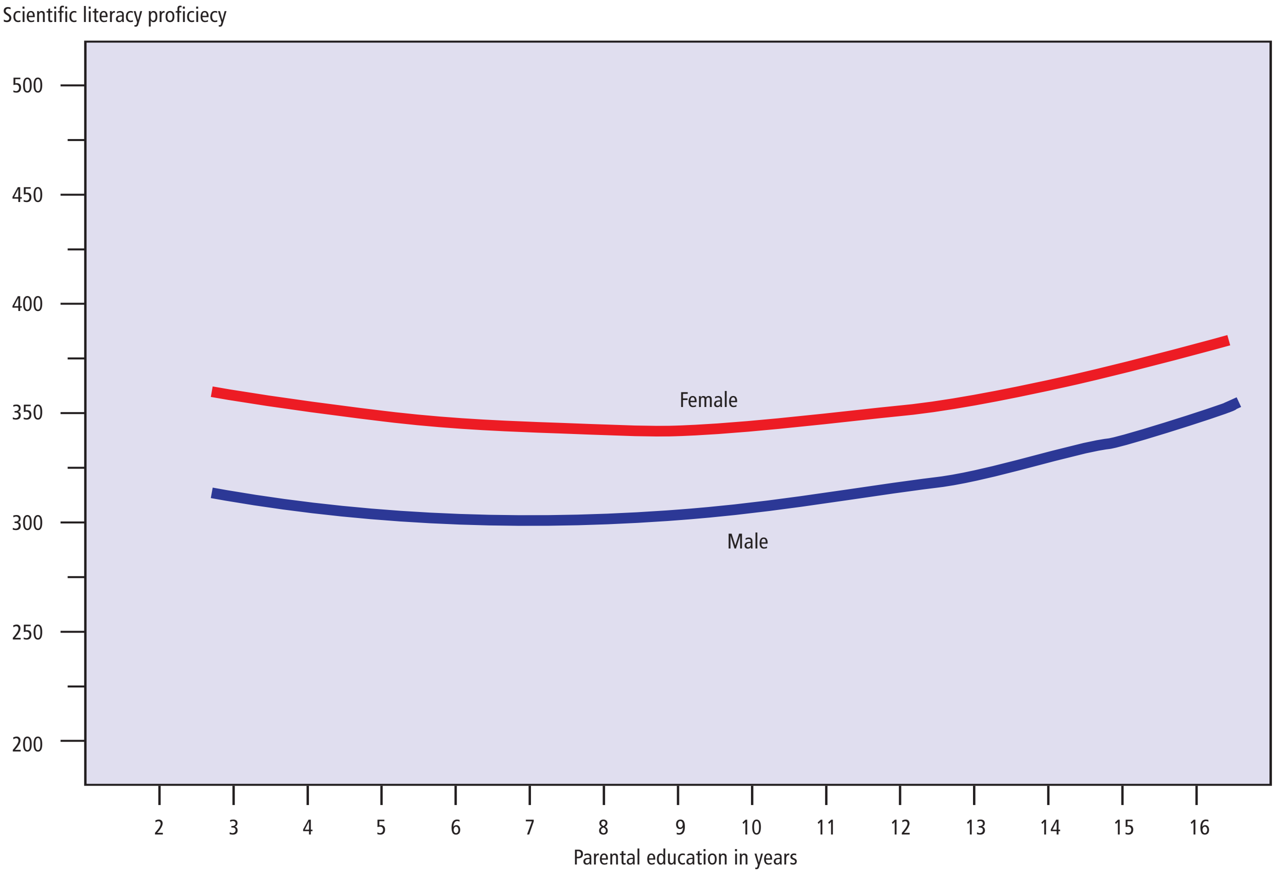
**Box 3B**

**What are socio-cultural gradients and what do they show?**

A socio-cultural gradient describes the relationship between a social outcome and socio-cultural status for individuals in a specific jurisdiction, such as a school, a province or state, or a country (Willms, 2006). For the purposes of this analysis, the social outcome is students' science scores on the 2006 PISA scale. The term socio-economic status (SES) refers to people's relative position on a social hierarchy, based on their access to, or control over, wealth, prestige and power (Mueller and Parcel, 1981). Standard practice in the educational literature relies on an index of student socio-economic status, derived from a combination of parental education, occupation, home possessions and income, as an indicator of their SES. The analysis presented in this chapter uses an indicator based solely upon the educational attainment of each parent. This approach was selected because of high levels of non-response to the PISA questions on parental occupation, and the unique relationship between income, home possessions and education that is seen in Qatar. For this reason, the term 'socio-cultural' gradient is used in this report.

**Figure 3.2**

**Relationship between science performance and parental education for 15-year-old male and female students, Qatar, PISA 2006**



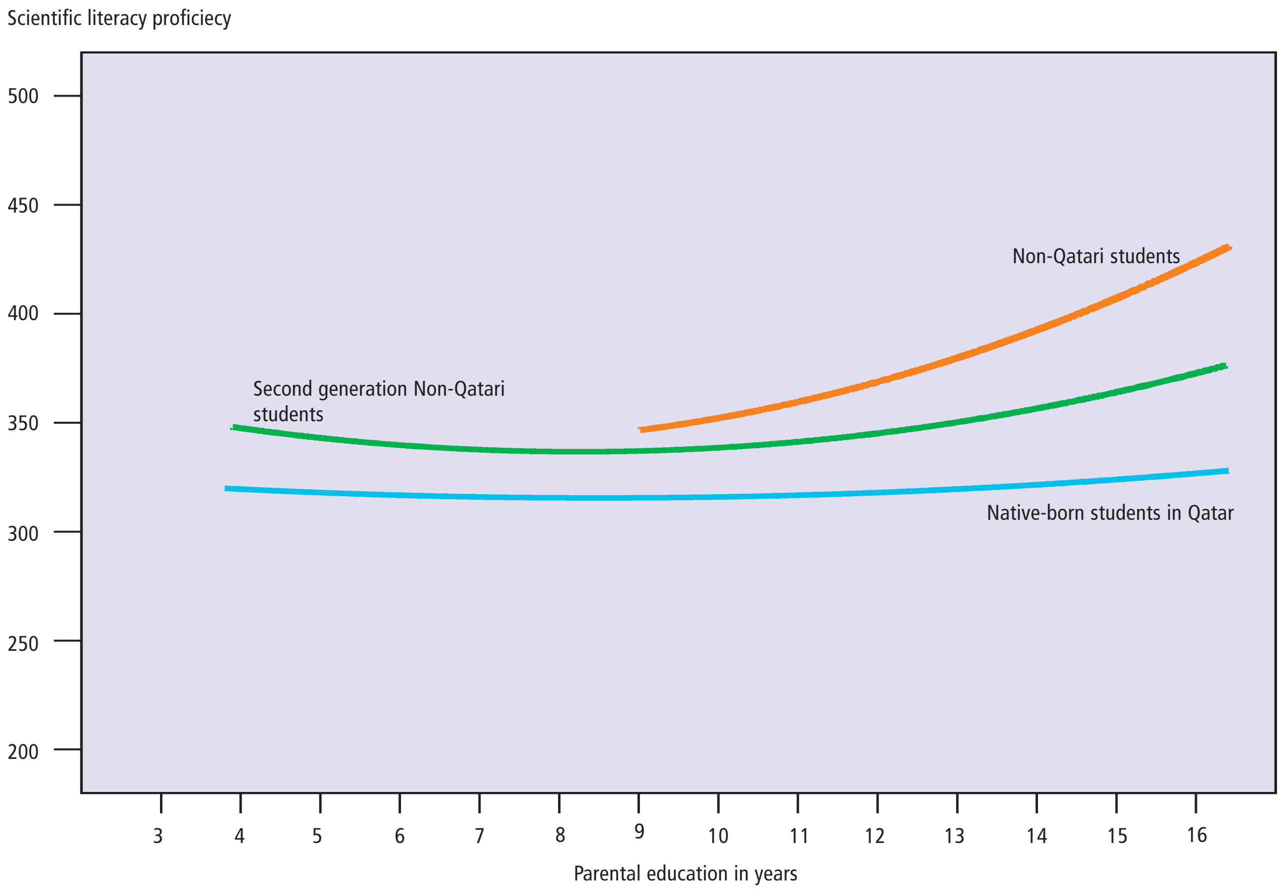

## 3.3 Gender

A relatively unique feature of the Qatar education system compared with the sample of countries that participated in the 2006 PISA assessment is the extent to which boys and girls are educated in separate schools.

Figure 3.2 displays the relationship between science performance and parental education separately for male and female students. The analysis shows that there is a large gap between boys and girls, with girls outperforming boys at all levels of parental education. At lower levels of parental education (i.e., 4 to 8 years), the gap is about 40 to 45 points, while at higher levels of education (i.e., 14 to 16 years), it is about 30 to 33 points. This suggests that in Qatar higher levels of parental education are associated with less inequality in performance between girls and boys.

**Figure 3.3**

**Relationship between science performance and parental education for native-born students in Qatar, second generation non-Qatari students, and non-Qatari students, Qatar, PISA 2006**




## 3.4 Citizenship

One measure of the success of education systems is the degree to which they attenuate differences in the proficiencies of expatriate students.

Figure 3.3 explores the relationship between science proficiency and sociocultural background for students in Qatar born to Qatari parents (Native-born), students born in Qatar to Non-Qatari parents (Second Generation), and Non-Qatari students born outside the country. The gradients are drawn from the 5th to the 95th percentile in parents' education for each group.

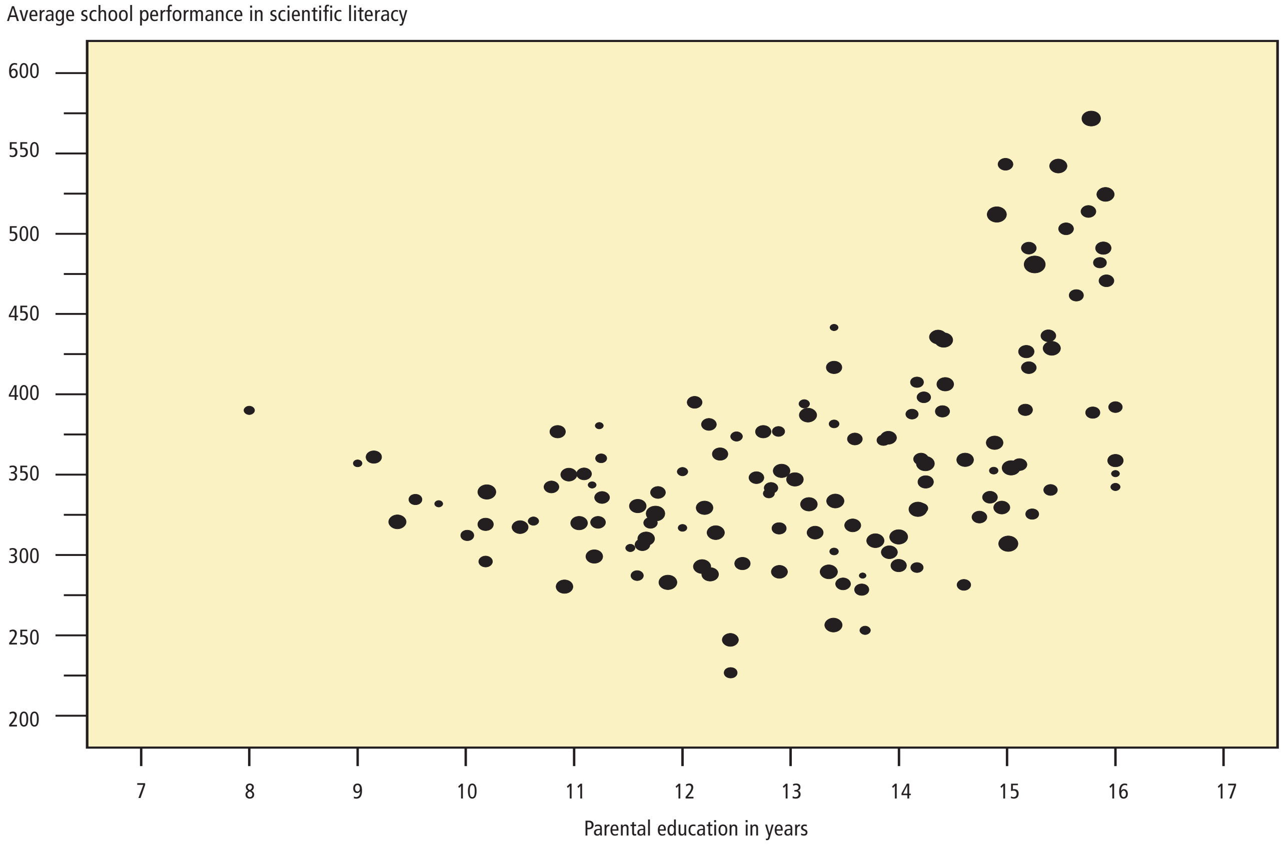
The results displayed in Figure 3.3 reveal that second generation Non-Qatari students outperformed Qatari-born students of Qatar by about 25 points at lower levels of parental education (i.e., 4 to 8 years). The achievement gap increases with increasing levels of parental education to about 50 points for children of parents with higher levels of education (i.e., 14 to 16 years). Very few of the Non-Qatari students have parents with levels of education below 12 years. The average score for Non-Qatari-born students whose parents had completed secondary school (i.e., 12 years of parental education) was about 369 points, which is about 13 points higher than second generation Qatari-born students and nearly 50 points above the students of Qatar For students with higher levels of parental education (i.e., 14 to 16 years), the achievement gaps are even larger, with Non-Qatari-born students outperforming students of

Qatar by about 80 points, and second generation Qatari-born students by about 40 points.

Some of these differences may be attributable to the school strata attended by these sub-populations. For example, many of the foreign students in Qatar are educated in international schools and community schools. The relationships between science proficiency, citizenship and school strata are examined in the next section.

**Figure 3.4**

**Relationship between school mean science performance and mean parental education for schools in Qatar, PISA 2006**

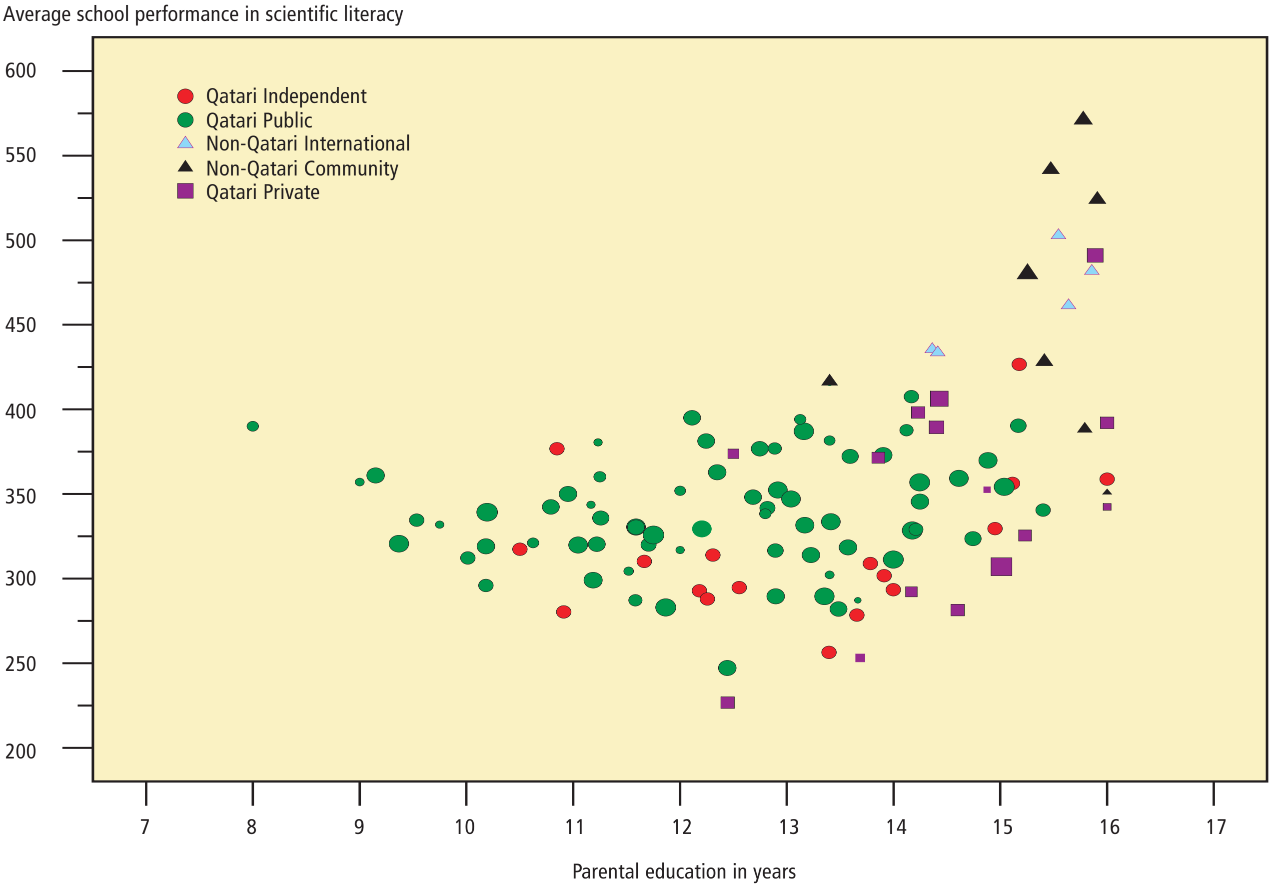



# 3.5 School strata

The Qatari education system has several school strata. An important policy question concerns the degree to which the different school strata perform, given the family background of the students they serve. Figure 3.4 shows the mean science proficiency scores for all Qatari schools plotted against mean levels of parental education. Each black dot represents a school, with the size of the dots proportional to (the square root of) the school enrolment. This type of plot is referred to as a school 'profile' (Willms, 2006). The Qatari school profile provides strong evidence that there is a wide range of performance, at all levels of parental education. For example, among schools serving students whose parents on average had completed 12 years of schooling, the range between the lowest and highest-performing schools is more than 100 points. The range is even larger, about 200 points, among schools serving students whose parents had completed 15 or 16 years of education.

## Figure 3.5

### Relationship between school mean science performance and mean parental education, by school type, Qatar, PISA 2006




There are five main school strata in Qatar – Public Independent schools, Qatari Public, International schools, Community schools, and Private Arabic schools. The Independent and Public schools are identified in Figure 3.5 with red and green dots respectively. The International and Community schools are displayed with pink and blue triangles, while the Qatari Arabic Private schools are shown with magenta squares. As in Figure 3.4, the size of the symbols is related to school enrolment.

The profile shows clearly a substantial gap in performance between Qatari Public and Independent schools, with the Public schools outperforming the Independent schools by about 22 points (see Appendix Table 3.1). The average scores of the Private Arabic schools are, on average, comparable to those of the Qatari Public schools, but there is a considerable range of performance among the schools in this group. The Private Arabic schools include some of the lowest and highest performing schools in the country.

The two strata of International and Community schools stand apart from the rest. They mainly serve students whose parents have high levels of education, and the range of school performance is comparable to that observed in many OECD countries. On average, the Community schools scored 108 points higher than the Qatari Public schools run by the Ministry of Education, while the International schools scored 143 points higher.

## Figure 3.6

## Relationship between school mean science performance and mean parental education for single-sex and co-educational schools, Qatar, PISA 2006

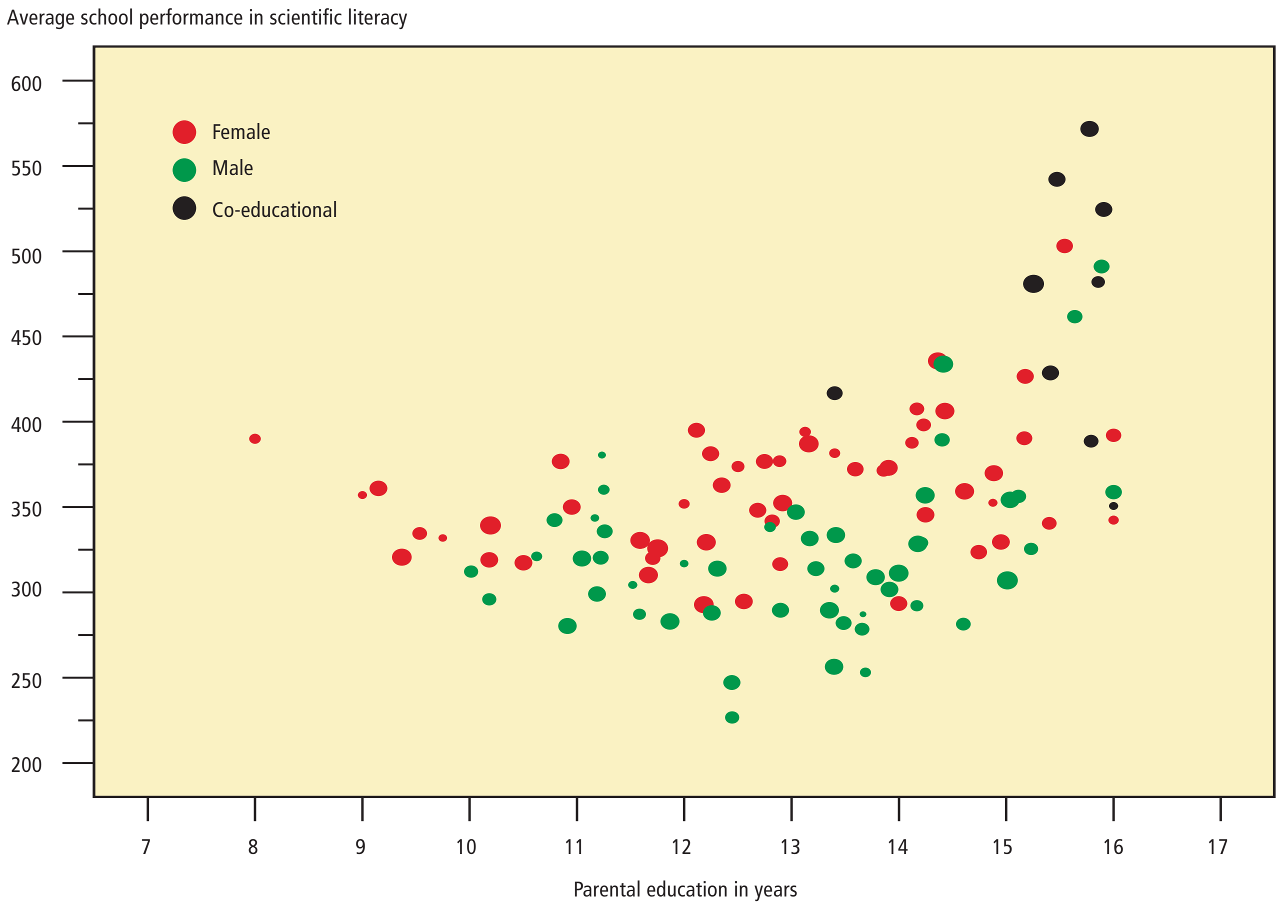



Figure 3.6 shows the performance of the schools in Qatar for single-sex and co-educational schools. The profile shows that single-sex girls' schools (red dots) dramatically outperform single-sex boys' schools (green dots). This is consistent with the gradient analysis previously presented, which indicated an achievement gap of about 30 to 45 points between male and female students in Qatar.

Co-educational schools are predominantly serving students whose parents have high levels of education. They outperform the single-sex schools on average by at least 100 points. However, one cannot attribute the co-educational nature of these schools to the difference in science performance, as the majority of these schools are private schools.

## 3.6 Conclusion

The data analyses presented in this chapter reveal several important features of the education system of Qatar.

First, in contrast to what one observes in other countries with low performance in the PISA 2006 assessment, it clearly emerges that there is little variation in students' science achievement by level of parental education.

Second, the level of science proficiency, as represented by average scores, is uniformly low at all levels of parental education, well below the OECD average at each point.

Third, girls outperform boys by a significant margin at all levels of parental education. This finding differs from that observed in most PISA countries, where boys outperform girls in science by a significant margin.

Fourth, the children born to Non-Qatari parents outperform the students of Qatari parents at all levels of parental education. Moreover, the gap in performance between Non-Qatari students and students of Qatar rises with increasing parental education. The proficiencies of students born to Non-Qatari parents outside the country, whose parents have relatively high levels of education, are significantly better than their peers.

Fifth, the analyses indicate that the performance of schools in Qatar is highly variable. Schools differ in the average level of parental education of the students they serve, yet at each level of parental education one can identify schools that manage to generate higher average science scores.

The Qatari independent schools do not appear to be consistently outperforming the Ministry schools. This result is to be expected given the fact that the 15-year-old students assessed in the PISA 2006 study did not have the benefit of the recently implemented reforms when they attended primary school – the stage when the foundations of reading literacy and numeracy are laid.

As expected, the international schools outperform the schools of Qatar by a significant margin – but they themselves also exhibit a significant degree of variation in average science scores at school level.

The findings set out above carry implications for policy and offer some reason for optimism.

Whilst the performance of Qatari schools is generally low one does not see the levels of social inequality in science scores that are evident in many countries. As noted above, schools differ markedly in the type of students they serve as defined by parental education. The fact that one can identify schools at each level of parental education that are outperforming their peers serving students from the same backgrounds opens the way to rapid improvement in scores if the means are put in place to transfer "best practice" from the best performing schools to their under-performing peers. The mechanisms for such "knowledge mobilisation and transfer" are well known, easy to implement and relatively inexpensive, depending as they do on various forms of in-service training for teachers. The analysis of error patterns in test items set out in Chapter 5 of this report, and the associated web-tool, are designed to support this type of intervention in terms that teachers can understand. Well done, these are among the most powerful forms of transformational change one can synthesise from the PISA study, because the best teachers and principals drive the reform process themselves.

# Chapter 4

## Determinants of Science Performance in Qatar

### 4.1 Introduction

The first three chapters of this report have given compelling evidence indicating that most students in Qatar score below the desired OECD standards in their achievement at age 15. On the tests of performance in reading, mathematical, and scientific literacy, the majority of students scored *Below Level 2* – a level considered inadequate to meet the needs of the knowledge economy according to OECD experts. However, the results also show that there is wide variation among schools in Qatar in their average performance, and that some of this variation is associated with the family background of students. This chapter explores whether some of the observed variation in school performance is associated with particular student, classroom and school factors. As in the previous chapter the data analysis integrates information derived from both PISA and the QNEDS data system.

The approach to data analysis taken in this chapter is based on the theory of economic production functions (Levin, 1980) that underpins the study of 'school effects' (Raudenbush and Willms, 1995). The theory posits that educational achievement is to a large extent a product of children's experiences at home and at school, and that the 'school effect' is determined by structural features of the educational system, school policies, school resources, and classroom practice. The aim of this approach, known as a production function analysis, is to separate the variation associated with students' family background from the variation attributable to the quality of schooling. The analysis in this report uses a powerful statistical technique, entitled Hierarchical Linear Models, to identify the most relevant factors affecting student learning (Raudenbush and Bryk, 1986).

There are many potential determinants of schooling outcomes at all levels of the educational system. Many of these factors are difficult to measure, and most models of how schools work are complex, as they try to specify how many potential factors interact with each other within and across levels of the school system. Levels in educational systems can be defined in a number of ways depending upon how the system is structured. Levels are meant to capture dimensions of the educational system that influence the efficiency or effectiveness of process of instruction, either positively or negatively. The most common and obvious level is grade. Other levels can include the classroom, the school and the school district. Carroll (1963) proposed a simple, straightforward model for school learning that underpinned earlier international comparative studies of student achievement in science (Keeves, 1992). The critical elements of Carroll's model include students' aptitude to learn a specific task, students' perseverance in trying to learn a new task, the time provided for learning a task, the quality of instruction, and student's ability to understand instruction.

The Carroll model has been revisited in recent years as part of the literature on effective schooling and its present relevance confirmed. The model for learning underlying the analyses in this report builds upon Carroll's model. It views school learning as a complex interplay among five key factors:

Quality of Instruction, which is primarily concerned with how effectively important concepts are taught by classroom teachers;

Appropriate level of instruction, which pertains to the delivery of instruction at a level that is consistent with students' abilities to learn the material;

Time, which refers to students' 'opportunity to learn,' which entails not only the total amount of time devoted to instruction, but also the efficiency with which class time is used;

Attitudes to learning, which refers to students' active Involvement in learning, which is related to their interest in a subject and the extent to which they value schooling outcomes;

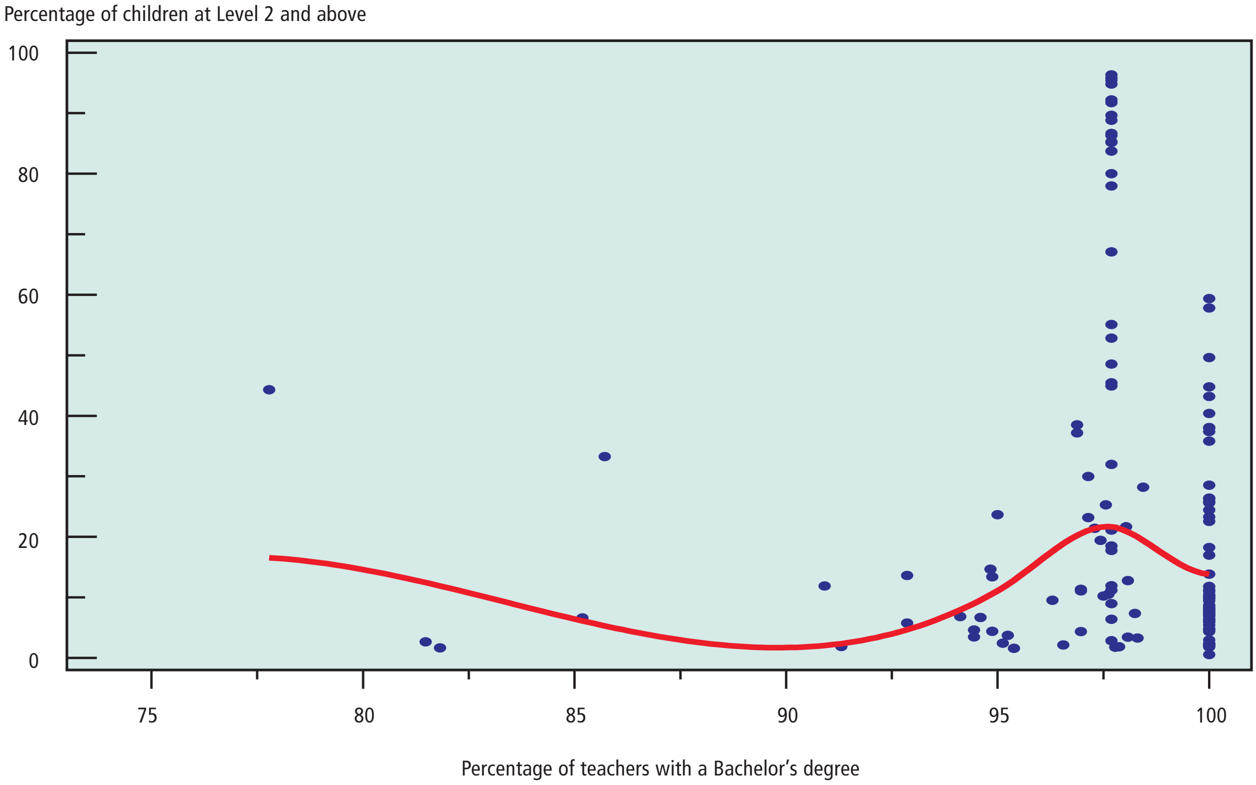
Resources, which includes both material and human resources dedicated to student learning.

## 4.2 Quality of instruction and student performance in science

Figure 4.1 shows the percentage of students scoring at Level 2 or higher on the PISA science assessment, plotted against the percentage of teachers who had completed a Bachelor's degree or higher degree. The red line on this and subsequent graphs is a locally-weighted regression line called 'loess,' which is derived by fitting a linear regression model to the data locally, similar to a moving average (Cleveland and Devlin, 1988). The graph indicates that in the majority of schools in Qatar, over 90 per cent of the teachers had completed a bachelor's degree. The multilevel analysis revealed that a 10 per cent increase in the percentage of teachers with a Bachelor's degree is associated with an increase of 23 per cent in the odds of a student achieving at Level 2 or higher in scientific literacy. However, this relationship is not statistically significant.

**Figure 4.1**

**Relationship between science performance and teachers' qualifications, 15-year-olds, Qatar, PISA 2006**



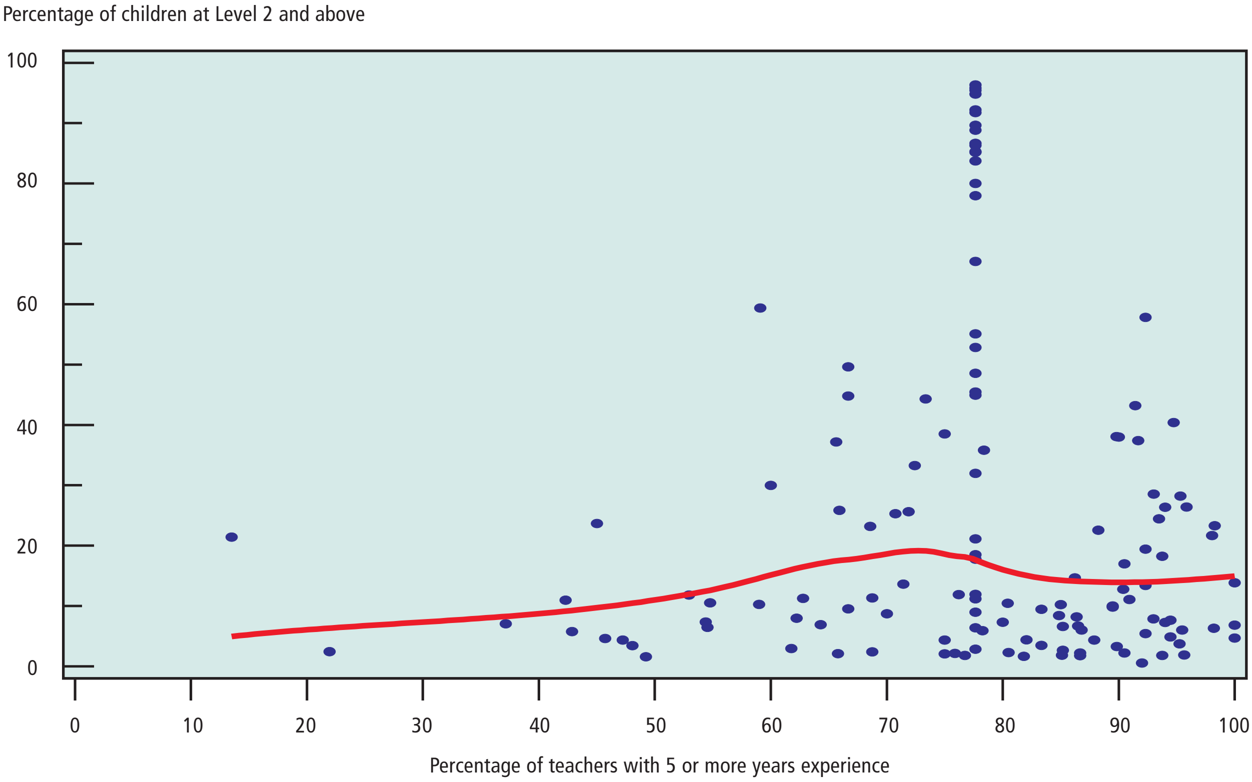

Source: QNEDS, PISA 2006.

Figure 4.2 shows the percentage of students that scored at Level 2 or higher on the PISA science assessment, plotted against the percentage of teachers who had at least five years of teaching experience. The graph indicates that in the majority of schools in Qatar at least 50 per cent of the teaching staff had five or more years of work experience. The analysis shows that a 10 per cent increase in the proportion of teachers with at least five years of experience is associated with an increase of only two per cent in the odds of a student achieving at Level 2 or higher on the combined scientific literacy scale. As with the findings for teachers' qualifications, however, this relationship is not statistically significant.

Taken together, these results suggest that teachers in Qatar are generally well qualified; the majority has at least a Bachelor's degree and several years of teaching experience. Consequently, the present levels of teacher qualifications and/or experience explain little of the variation in school performance in Qatar.

**Figure 4.2**

**Relationship between science performance and teachers' experience, 15-year-olds, Qatar, PISA 2006**




Source: QNEDS, PISA 2006.

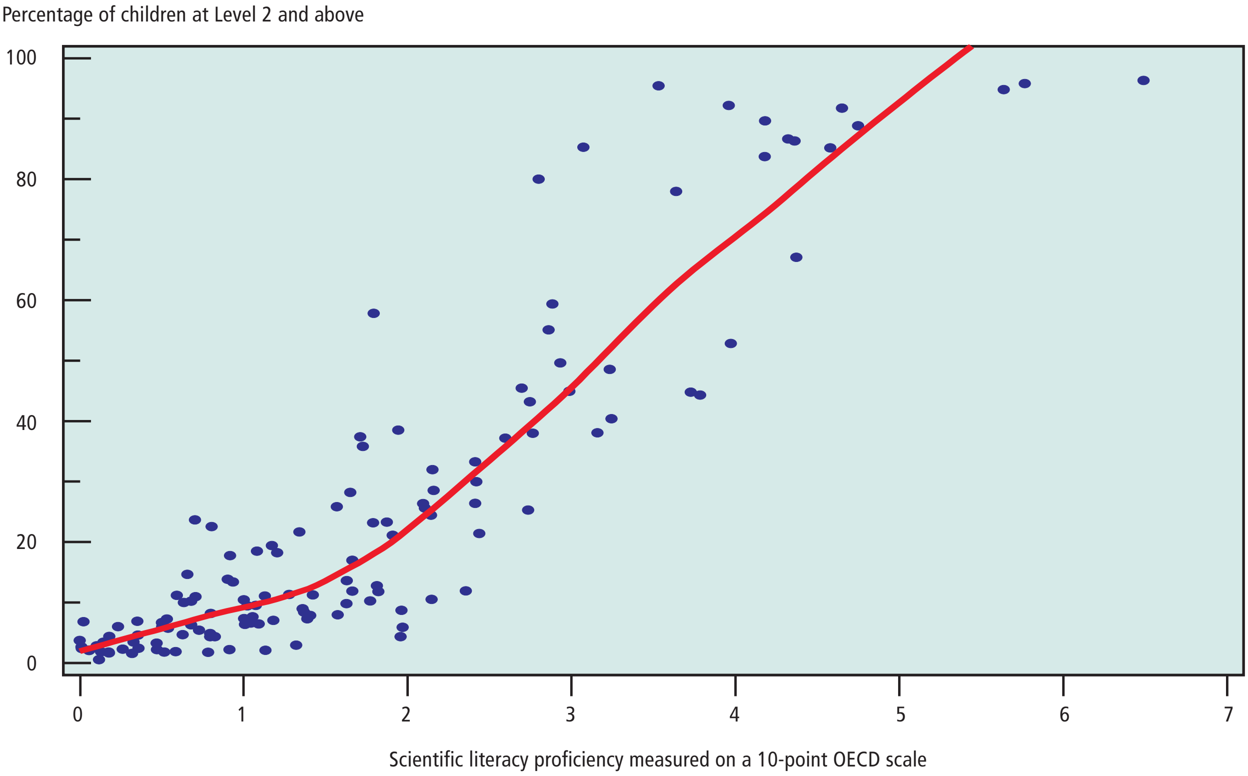
## 4.3 Appropriate level of instruction and approach to learning science

Figure 4.3 shows the relationship between the percentage of students scoring at Level 2 or higher on the PISA science assessment and the schools' average student scores on reading literacy. Not surprisingly, there is a strong relationship between science performance and students' ability to read. The results presented indicate that there are many schools in Qatar where the average reading score of the students, measured on a 10-point OECD scale, is below 3. However, even among these schools, the schools with students who have better reading literacy skills also have a higher percentage of students with scores at Level 2 or above in scientific literacy proficiency.

The odds of a student achieving at Level 2 or higher in science increase by a factor of 3.7 for each one-point increase in reading literacy skills on the 10-point scale. This increase of nearly 400 per cent is strong evidence of the fundamental importance of reading literacy skills for performance on the PISA science assessment and for success in learning generally.

## Figure 4.3

## Relationship between science performance and reading skills, 15-year-olds, Qatar, PISA 2006

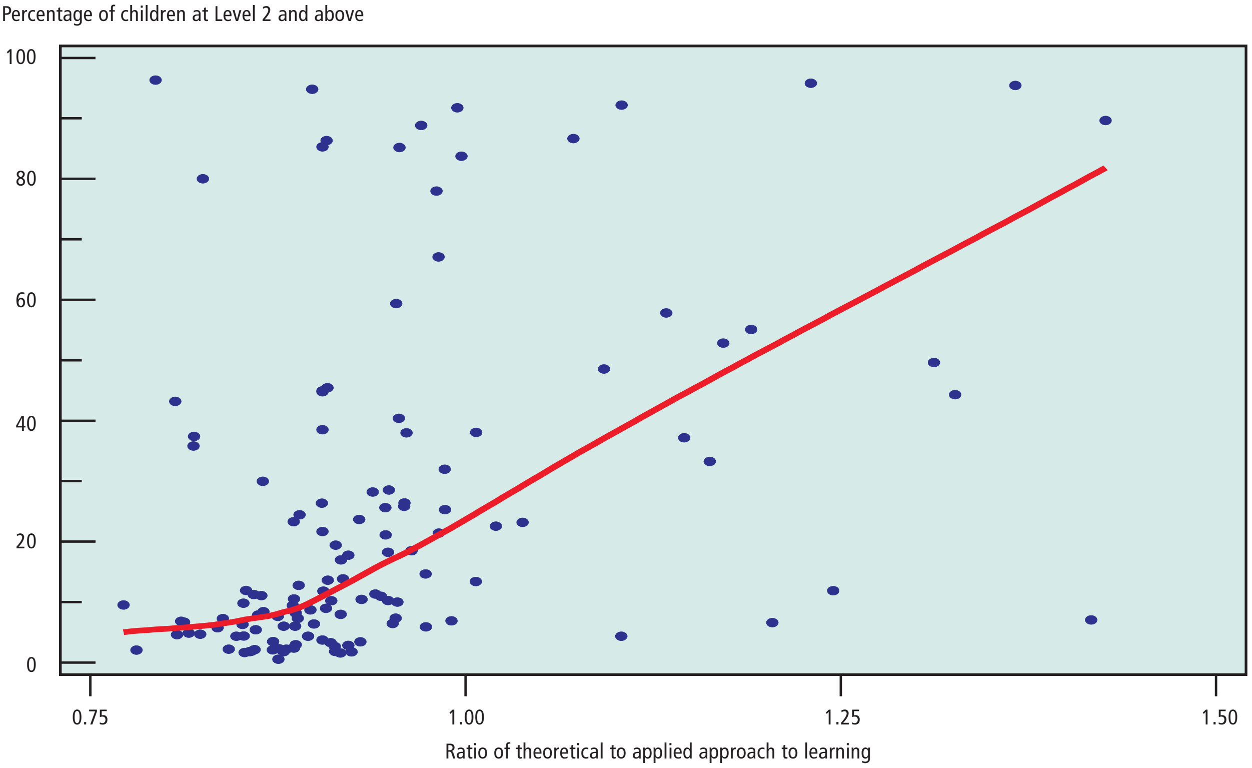



Source: PISA 2006.

The PISA student questionnaire included a number of questions asking about the predominant approach taken to science instruction in the classroom. Two scales were derived from these questions, indicating whether the approach to instruction was predominantly theoretical or applied. Hence the data set allows one to study whether schools with a more or less theoretical versus applied approach to instruction tend to have better science performance. Figure 4.4 shows this relationship. It portrays the relationship between the percentage of students that scored at Level 2 or higher on the PISA science assessment and the ratio of theoretical to applied approach in the school. Most Qatari schools favour an applied approach. Schools with a more theoretical approach, however, tend to have a higher percentage of students with science performance at Level 2 or higher. An increase in the ratio of theoretical to applied of 0.1 is associated with an odds-ratio of 1.87 of being at Level 2 or higher.

**Figure 4.4**

**Relationship between science performance and approach to learning, 15-year-olds, Qatar, PISA 2006**



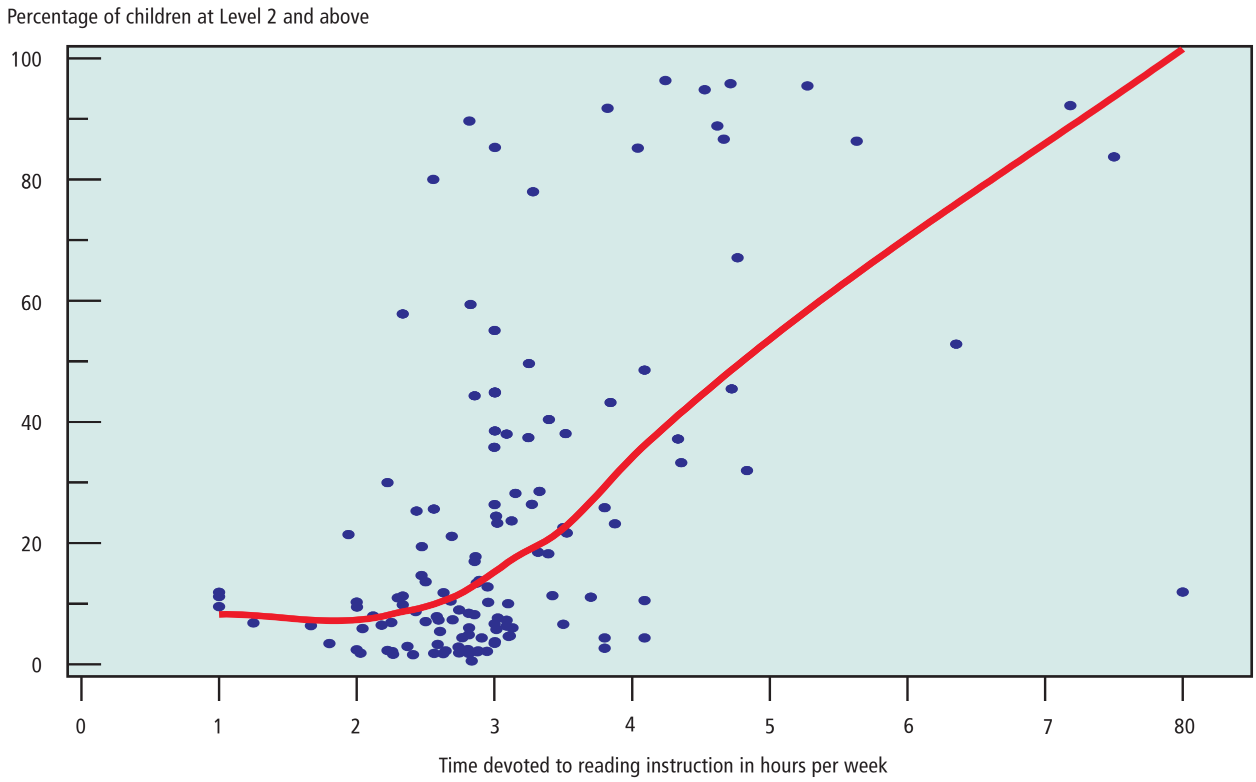

Source: PISA 2006.

## 4.4 Time for learning

The number of hours schools devote to learning reading and science is also related to students' science performance. These relationships are shown in Figures 4.5 and 4.6. Figure 4.5 suggests that the average number of hours spent each week on reading instruction is between two and three hours in most Qatari schools. Each one hour increase in reading instruction, and hence in opportunity to master reading, increases the odds of a student achieving at Level 2 or higher on the scientific literacy scale by a factor of 3.7.

**Figure 4.5**

**Relationship between science performance and class time devoted to reading, 15-year-olds, Qatar, PISA 2006**

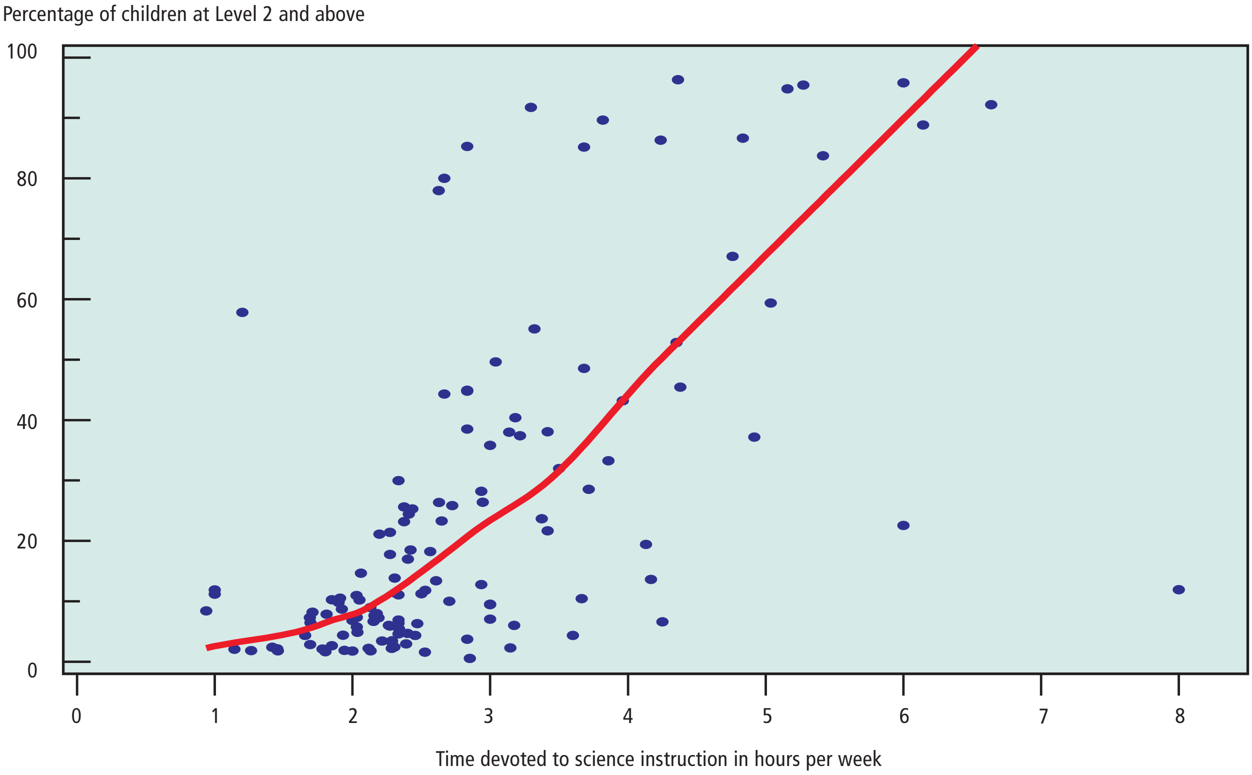



Source: PISA 2006.

Figure 4.6 indicates that the average number of hours spent per week on science instruction is more variable than the time spent on reading instruction; it is between one and three hours in most schools in Qatar. Each one hour increase in the time spent on science instruction increases the odds of a student achieving at Level 2 or higher on the science test by a factor of 3.8.

**Figure 4.6**

**Relationship between science performance and class time devoted to science, 15-year-olds, Qatar, PISA 2006**



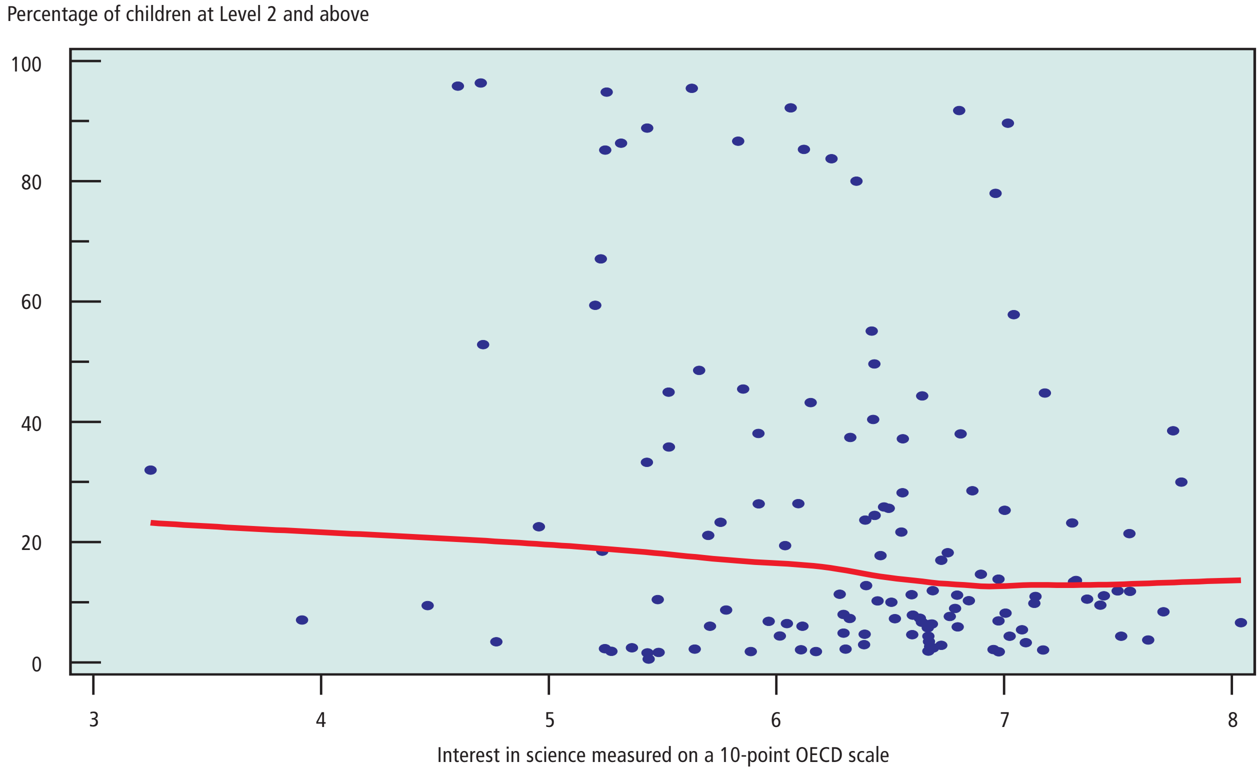

Source: PISA 2006.

## 4.5 Attitudes to science and student performance

The relationship between student's attitudes towards science and their science performance was examined in Chapter 2. The results indicated that 15-year-old students in Qatar had relatively positive attitudes towards learning science, and within Qatar there was a positive relationship between science performance and student interest in science. Figure 4.7 shows this relationship at the school level. The results indicate that the average level of interest in science is relatively high in most schools, with mean scores ranging from five to seven on a 10-point scale. However, the overall relationship is negative at the school level, a result consistently observed at the international level. Schools whose students express higher levels of interest in science tend to have a lower percentage of students scoring at or above Level 2. The odds ratio associated with a one-point increase in school mean level of interest in science is 0.52. As noted in Chapter 2, however, because these results are at variance with common sense knowledge and findings from previous studies, OECD experts are examining these relationships in more depth.

## Figure 4.7

**Relationship between science performance and interest in science, 15-year-olds, Qatar, PISA 2006**

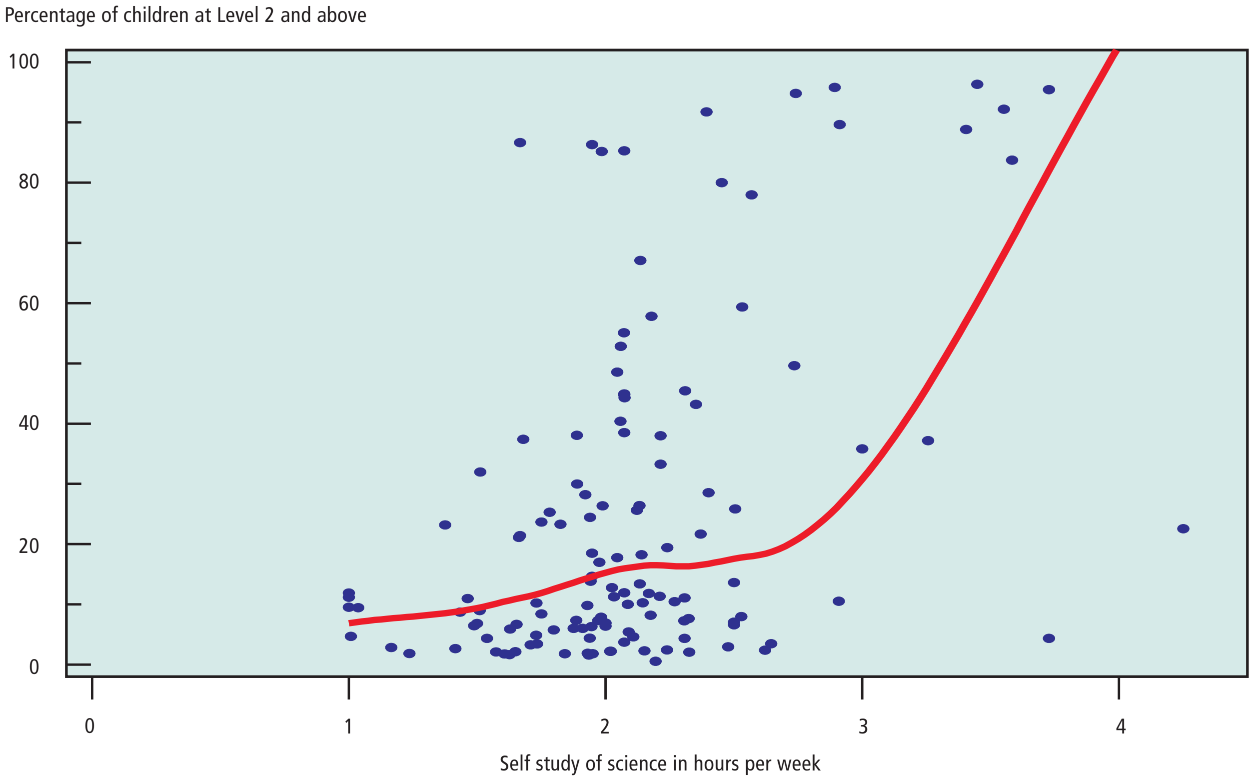



Source: PISA 2006.

As might be expected, students who spend more time studying science on their own have substantially higher levels of science performance. This relationship is shown in Figure 4.8. In most schools in Qatar, the average time spent by students on self study is between 1.5 and 2.5 hours per week. The odds of a student scoring at Level 2 and above increases by over eight times for each one-hour increase in the school average in student self study.

**Figure 4.8**

**Relationship between scientific literacy proficiency and self study of science, 15-year-olds, Qatar, PISA 2006**



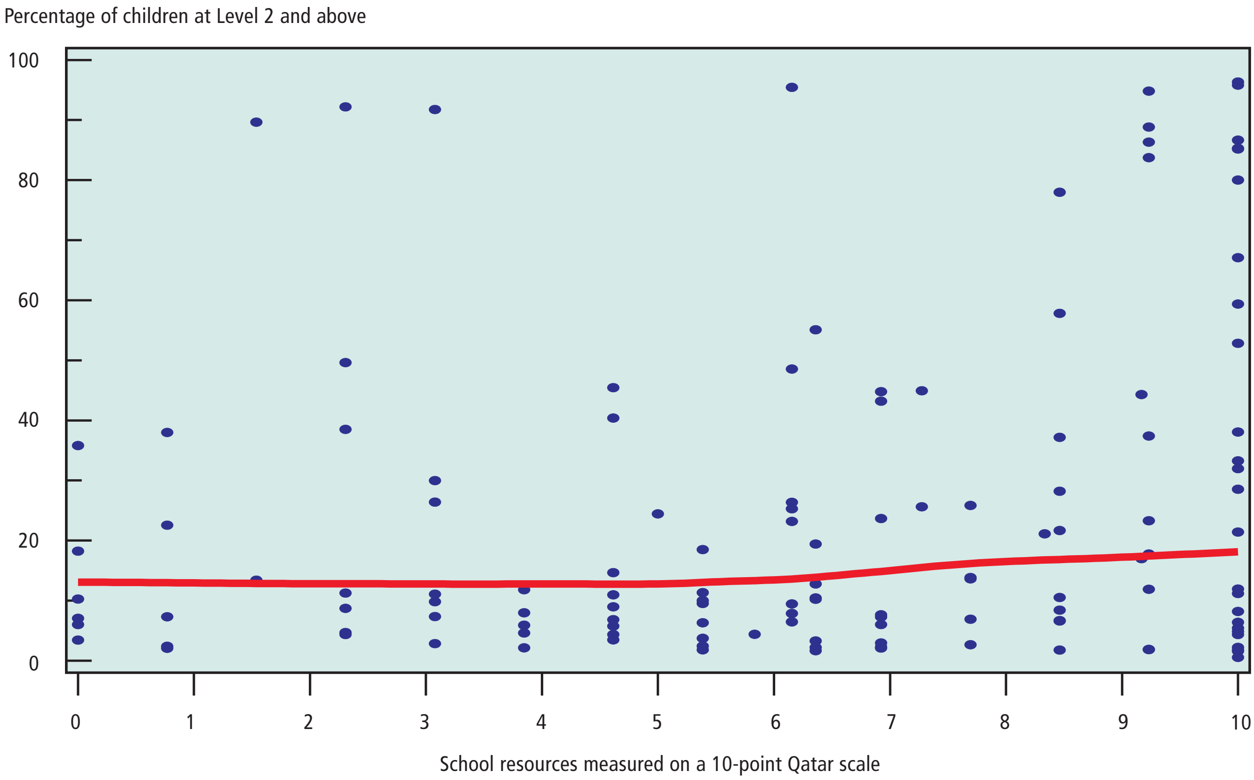

Source: PISA 2006.

## 4.6 School resources and student performance in science

The level of school resources can also have an impact on student learning. The PISA data include a measure of school resources that pertains the availability of qualified science teachers, laboratory equipment, library materials, and other resourceThe level of school resources can also have an impact on student learning. The PISA data set includes a measure of school resources based on the availability of qualified science teachers, laboratory equipment, library materials, and other resources relevant to student leaning. An index combining these variables was constructed, measured on a 10-point scale for the schools of Qatar. Figure 4.9 shows that there is a moderately strong relationship between school resources and the percentage of students scoring at Level 2 or higher on the PISA assessment of scientific literacy proficiency. The odds ratio associated with a one-point increase is 1.1.

**Figure 4.9**

**Relationship between science performance and school resources, 15-year-olds, Qatar, PISA 2006**

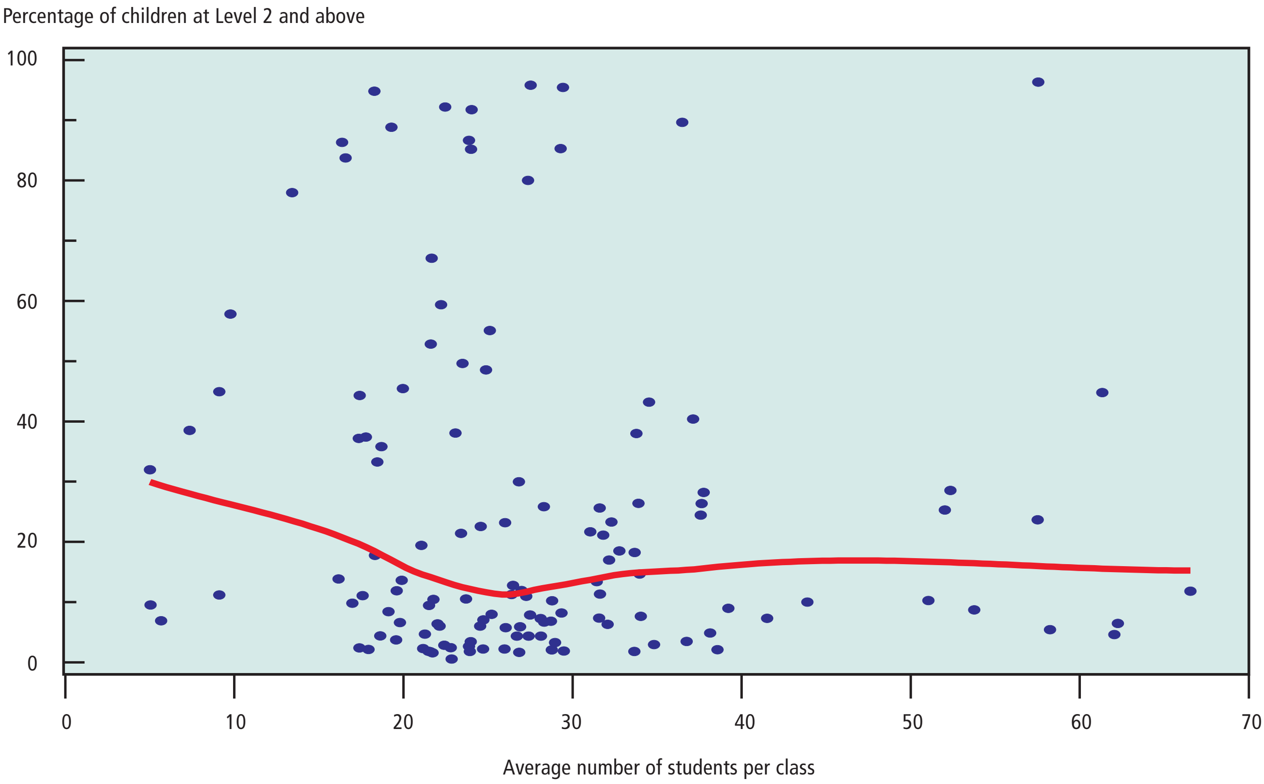



Source: PISA 2006.

Previous research based on PISA has examined the impact of the 'student-to-staff teaching ratio' (a measure closely related to class size) on students' performance (OECD, 2002b). The results suggested that there was a relatively small impact of the reductions in student-to-staff teaching ratio in the range from 10 to 25, but when it exceeded 25 performance began to decline (Willms, 2006). Data on average class size in a school were combined with the PISA science data to examine this relationship for Qatar. The results, shown in Figure 4.10, suggest there is a moderately weak relationship. In most Qatari schools, average class size is between 15 and 35 students. In the range of class size between 15 and 25 students per class, performance decreases with increasing class size. At levels above 25, the relationship is flat. The odds ratio associated with decreasing class size by 10 students is 1.09.

**Figure 4.10**

**Relationship between science performance and school resources, 15-year-olds, Qatar, PISA 2006**




Source: PISA 2006.

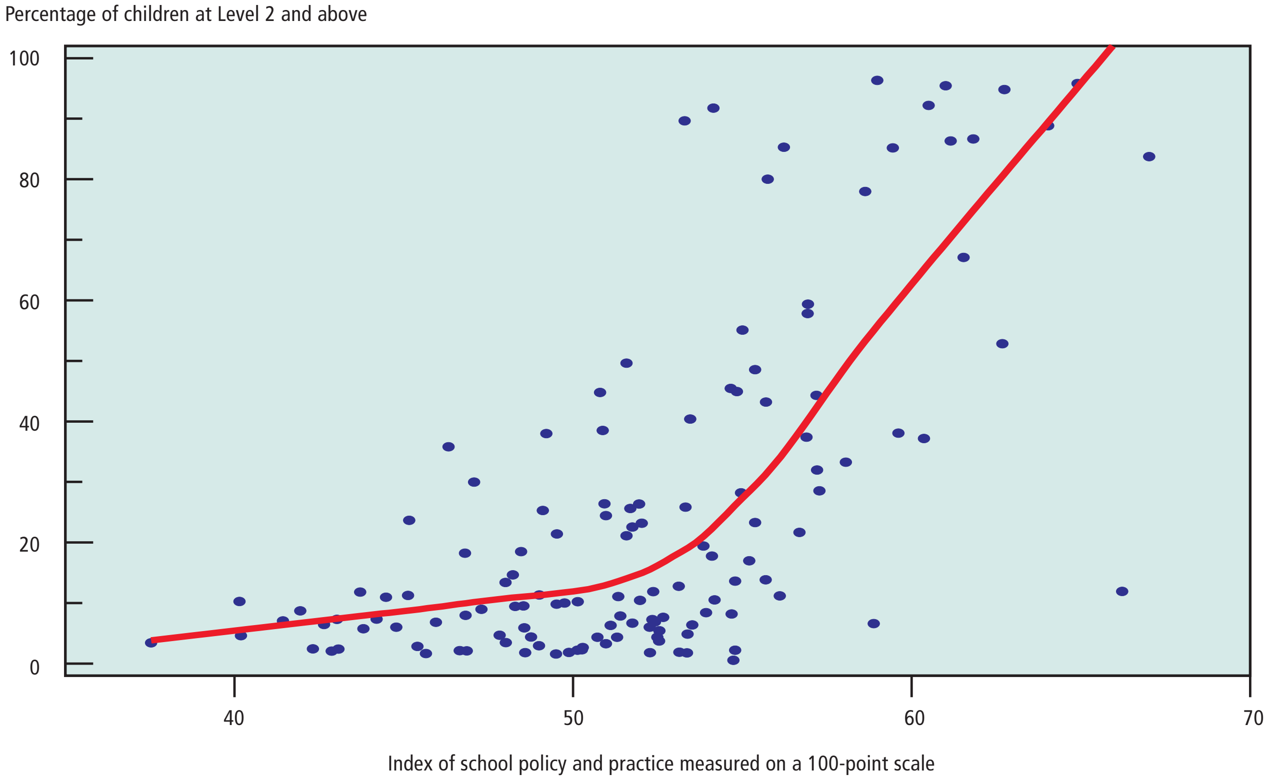
## 4.7 Results for a composite model of learning

The data analyses presented in this chapter are based on a model of school learning that includes five key factors: Quality of instruction, Appropriate level of instruction, Time on task, Attitudes to learning, and Resources (QATAR). The analyses examined the relationship between school performance in science, as gauged by the percentage of students scoring at or above Level 2 on the PISA assessment, and 10 factors describing classroom and school policy and practice. The findings suggested that all of the factors had a moderate impact on performance, although not all of the relationships were statistically significant. However, with the exception of students' reading skills, each of the factors, by itself, had a relatively small impact on performance within the range on the factors covered by the majority of schools in Qatar. Therefore, it cannot be concluded that there is a single factor, other than improving students' reading literacy skills, which should be the primary focus of education policy in the country.

Instead, the results suggest that it is the cumulative effect of several factors that lead to higher student and school performance. Figure 4.11 provides evidence that this is the case. The 10 factors examined in this chapter were scaled on a 10-point scale, and a total or combined score that could potentially range from 0 to 100 was estimated for each school. The relationship between the percentage of students scoring at Level 2 or higher and the 100-point index is shown in Figure 4.11. The schools' scores on this index range from about 35 to nearly 70. The analysis shows that there is a moderately strong positive relationship within the range between 35 and 55, and thereafter there is a strong relationship.

**Figure 4.11**

**Relationship between science performance and school policy and practice summary score, 15-year-olds, Qatar, PISA 2006**



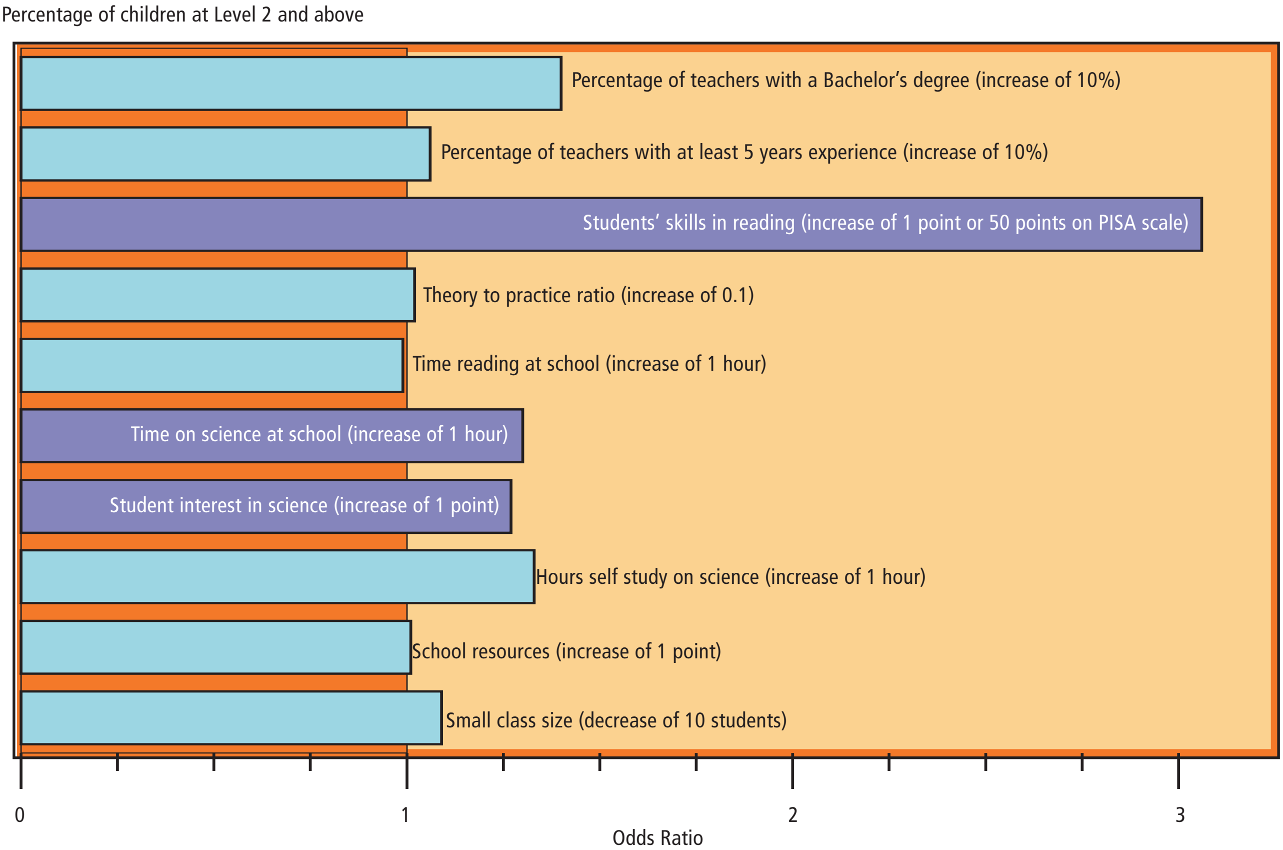

Source: QNEDS, PISA 2006.

The analyses presented thus far have shown the bivariate relationships between school performance and the various factors specified in the QATAR learning model. However, many of these factors are likely also related to students' family background. For example, students hailing from more advantaged backgrounds may be more likely to attend a school that has more experienced teachers, smaller class sizes, or more school resources. Moreover, the 10 factors examined in this chapter are intercorrelated. Accordingly, the schools that score high on one factor are likely to score high also on other factors.

The final analysis examines the combined affects of these factors in a multivariate model that controls for the educational level of the students. The results are summarised in Figure 4.12. The bars indicate the odds ratios associated with specific increases in each factor. Factors that are statistically significant are shown with dark blue bars. The most important factor by far is students' reading literacy proficiency. This confirms the results reported in earlier chapters, that reading skills are fundamental to success on the PISA science test. After reading literacy skills, the time spent on instruction in science and students' interest in science were positively related to school performance.

**Figure 4.12**

**Odds ratios for the relationship between science performance and school policy and practice factors, adjusted for parental education, 15-year-olds, Qatar, PISA 2006**




Note. Factors that are statistically significant ($P < 0.05$) are indicated with dark blue bars.
Source: QNEDS, PISA 2006.

## 4.8 Conclusion

This chapter employed 10 variables to explore a complex web of interrelationships specific in the QATAR model of school success: Quality of instruction, Appropriate level of instruction, Time on task, Attitudes to learning, and Resources. The findings suggested that all of the factors had a modest to moderate impact on performance, although not all of the relationships were statistically significant.

The one notable exception provides strong support for the lead hypothesis advanced throughout this report, namely that attention should focus, in the first instance, on raising the reading literacy skills of students early in their educational life. An increase of 50 points on the PISA reading literacy scales raises the probability of performing at Level 2 or above by over three-fold. A critical transition for students is moving from 'learning-to-read' to 'reading-to-learn,' which for most students occurs at about age 8 or 9 (Sloat, Beswick and Willms, 2007). Investments in the elementary years aimed at increasing the proportion of students making this transition successfully can therefore be expected to significantly increase the science performance of students in Qatar. This analysis found that among the Qatari schools with average levels of reading performance, about 90 per cent of the students achieved scores at or above Level 2 in science.

The amount of time spent on science instruction at school and students' self declared interest in science were also shown to have a positive effect upon the students scientific literacy proficiency, but the effect sizes are relatively small compared with the effects associated with increasing students' proficiency in reading literacy.

The analyses show that each of the remaining seven factors, by themselves, had a relatively small impact on proficiency. The results suggest that it is the cumulative effect of several factors that lead to higher science performance. The analysis shows that there is a relationship between scientific literacy proficiency and an index that combines all of the variables into one multivariate and multilevel analysis – moderately strong and positive in the lower regions of the combined index, and thereafter there is a strong relationship.

This latter finding offers hopeful prospects for the future. The Qatari educational reform initiative has already put into place most of the building blocks required for raising science proficiency. If the will and means can be found to raise the reading literacy levels of future cohorts of Qatari students to world class levels, then the relationships documented in this chapter suggest that performance in science will improve to the same levels.

# Chapter 5

## Qatar Student-level and School-level Reports on Understanding Science and Attitudes to Science

### 5.1 Introduction

The State of Qatar is committed to improving student performance in reading, mathematics and science. Achieving this goal depends upon a range of factors. Among them is gaining a better understanding of how students in Qatar perform with respect to international benchmarks. The data analyses presented in this chapter provide a clear sense of the size of the challenges facing Qatari educators. The chapter also provides insights into the factors that are the most amenable to change and that would support the most rapid improvement in student performance. As useful as these insights might be for driving forward the "Education for a New Era" reform initiatives in Qatar, the fact of the matter is that most progress will be realised on the fundamentals – through the steady improvement in the teaching practices of Qatar's educators and by promoting literacy rich environments at home, at work, and in the wider community.

The purpose of this chapter is to introduce the information available on the Qatar PISA private website. This site will be made available to Qatari educators to help improve the instructional practices of teachers. This website lists a selection of reports on the responses of Qatari students who responded to the 2006 PISA science assessment. The chapter introduces the reader to the multiple choice, vector and coded response reports, which are designed to assist educators in interpreting and understanding what the students know, and where there might be lacunae in students' understanding. The analysis presented takes advantage of the fact that the PISA test items represent a rich sample of the content specified in the Qatari science curricula and reflect the learning expectations demanded of Qatari students. The analysis is restricted to the PISA science items because the sets of reading and mathematics items, while sufficient to generate reliable estimates of proficiency for different groups of students, is not sufficiently large to offer good coverage of the intended curricula in these subjects.

The *Qatar Web Based Response Reports*, summarised in this chapter, are based on Qatar's data collected at the student level on each test item used to assess scientific literacy. The reports cover the seven science clusters that include 192 science items whose understanding requires knowledge of science as well as knowledge about science. The *Qatar Item-Level Response Analysis Reports* cover multiple-choice responses (37), vector responses (27) and coded responses (39) items. Opinions and attitudes towards science are measured by an additional 89 questions reviewed on the homepage.

## 5.2 Multiple-choice test reports

The multiple-choice test reports target specific content areas that give the students four choices to select the correct response. Incorrect responses are designed to represent plausible errors in students' understanding at the level of content or process knowledge.

The Qatar multiple-choice item-level response reports contain information on all incorrect responses generatedby students. Each row in the report represents a test item and each column represents a characteristic of that item. The report presents a description of students' common misconceptions with regard to content or process knowledge (i.e., cognitive level) corresponding to the item in question. Table 5.1 contains an excerpt of the multiple-choice item report for Qatar.

**Table 5.1**

**Example of students' common misconceptions relating to a multiple-choice science item, PISA 2006**

| Curriculum Domain | Cognitive Level (competency) | Number of Students who Responded to the Item | Percentage of Students who Answered Incorrectly | Specific Curricular Aspect that Needs Attention [>20% selected incorrect response] |
|---|---|---|---|---|
| Scientific enquiry | Identifying scientific issues | 1,796 | 75 | • Students did not understand the purpose of one of the steps in the scientific experiment and confused keeping the substances being tested the same thickness with stopping the substances from drying out.<br>• Students did not understand the purpose of one of the steps in the scientific experiment and confused keeping the substances being tested, the same thickness with spreading out the drops as far as possible.<br>• Students did not understand the purpose of one of the steps in the scientific experiment and confused keeping the substances being tested the same thickness with keeping the drops inside the circles. |

Qatar's multiple choice item-level response reports point out that Qatari students consistently chose incorrect responses for almost every curriculum domain and at almost every cognitive level. Table 5.2 shows the percentage of students who answered incorrectly each of the 37 multiple-choice items across the curriculum domain and at the respective cognitive level. For instance, 35 per cent of students answered incorrectly a question about physical systems that required a scientific explanation.

## Table 5.2

## Cognitive levels at which students' common misconceptions are located with regard to content or process knowledge of multiple-choice science items, PISA 2006

| Curriculum domain | Cognitive level (competency) | Percentage of students who answered incorrectly |
|---|---|---|
| Technology systems | Scientifically explaining phenomena | 62 |
| Physical systems | Scientifically explaining phenomena | 35 |
| Scientific enquiry | Identifying scientific issues | 53 |
| Living systems | Scientifically explaining phenomena | 63 |
| Physical systems | Scientifically explaining phenomena | 63 |
| Scientific explanations | Using scientific evidence | 63 |
| Living systems | Scientifically explaining phenomena | 77 |
| Scientific enquiry | Identifying scientific issues | 77 |
| Technology systems | Using scientific evidence | 56 |
| Earth and space systems | Scientifically explaining phenomena | 59 |
| Scientific explanations | Using scientific evidence | 72 |
| Scientific enquiry | Identifying scientific issues | 56 |
| Earth and space systems | Scientifically explaining phenomena | 58 |
| Earth and space systems | Scientifically explaining phenomena | 60 |
| Scientific explanations | Using scientific evidence | 73 |
| Scientific explanations | Using scientific evidence | 66 |
| Physical systems | Scientifically explaining phenomena | 47 |
| Physical systems | Scientifically explaining phenomena | 73 |
| Physical systems | Scientifically explaining phenomena | 69 |
| Scientific enquiry | Using scientific evidence | 67 |
| Scientific enquiry | Identifying scientific issues | 78 |
| Scientific enquiry | Identifying scientific issues | 70 |
| Scientific enquiry | Identifying scientific issues | 75 |
| Earth and space systems | Scientifically explaining phenomena | 61 |
| Earth and space systems | Scientifically explaining phenomena | 64 |
| Scientific explanations | Using scientific evidence | 61 |
| Living systems | Scientifically explaining phenomena | 45 |
| Living systems | Scientifically explaining phenomena | 55 |
| Living systems | Scientifically explaining phenomena | 67 |
| Living systems | Scientifically explaining phenomena | 40 |
| Living systems | Scientifically explaining phenomena | 50 |
| Living systems | Scientifically explaining phenomena | 78 |
| Living systems | Scientifically explaining phenomena | 63 |
| Scientific enquiry | Identifying scientific issues | 68 |
| Scientific enquiry | Identifying scientific issues | 66 |
| Physical systems | Scientifically explaining phenomena | 63 |
| Physical systems | Scientifically explaining phenomena | 49 |

Qatar's multiple-choice item-level response reports show that Qatari students chose incorrect responses for almost every item, -regardless of curriculum domain, and at almost every cognitive level.

## 5.3 Vector response reports

The vector response reports address a particular aspect of the scientific topic under discussion. Incorrect responses are designed to represent plausible errors in students' understanding at the level of content or process knowledge for each vector response item.

The Qatar vector response test item reports consist of multiple-item questions with variable numbers of items in each scale (i.e., between 2 to 4 single items). The report provides descriptions of students' common misconceptions with regard to the content or knowledge processing corresponding to the item in question. The maximum score level depends on how many single questions were in each vector response item (e.g., 0 to 2; 0 to 3; 0 to 4). Table 5.3 contains an excerpt of the vector response report for two questions each containing three test items.

### Table 5.3

### Examples of students' common misconceptions relating to two multiple-item vector response questions, PISA 2006

| Curriculum Domain | Cognitive Level (competency) | Respondents | | Score 0 | | Score 1 | | Score 2 | | Score 3 | | Score 4 | | Specific curricular aspect that needs attention |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number | % | Number | % | Number | % | Number | % | Number | % | Number | % | |
| Physical systems | Scientifically explaining phenomena | 1,871 | 100 | 128 | 7 | 425 | 23 | 503 | 27 | 815 | 44 | N/A | N/A | Students did not understand that the Internet or the library could be a source of information about keeping grass healthy and green, while the evening news on television is not. |
| Scientific enquiry | Identifying scientific issues | 1,866 | 100 | 217 | 12 | 371 | 20 | 557 | 30 | 721 | 39 | N/A | N/A | 1. Students did not understand the design of the scientific experiment and did not realise that the paper represented an area of forest; or<br>2. Students did not understand the design of the scientific experiment and did not realise that the soil exposed did not represent an area of the land where trees never grew; or<br>3. Students did not understand the design of the scientific experiment and did not realise that the blown air represented wind. |

N/A: not applicable.

Qatari students exhibited few high scores (i.e., score 2, 3 or 4, depending on the maximum available score for each question) in their understanding at the level of content or knowledge processing. Table 5.4 identifies the percentage of students who answered correctly across each of the curriculum domains and at the respective cognitive level. For instance, only four per cent of students answered correctly (and acquired a maximum score of 3) all aspects of a question using scientific evidence and requiring scientific explanation.

**Table 5.4**

**Students' common misconceptions with regard to content or process knowledge of vector response science items, PISA 2006**

| Curriculum domain | Cognitive level (competency) | Percentage students score 2 | Percentage students score 3 | Percentage students Score 4 |
|---|---|---|---|---|
| Scientific enquiry | Identifying scientific issues | 26 | 39 | 12 |
| Physical systems | Scientifically explaining phenomena | 38 | 17 | 16 |
| Living systems | Scientifically explaining phenomena | 45 | 13 | N/A |
| Living systems | Scientifically explaining phenomena | 33 | 22 | N/A |
| Technology systems | Using scientific evidence | 32 | 16 | N/A |
| Scientific enquiry | Identifying scientific issues | 30 | N/A | N/A |
| Scientific enquiry | Identifying scientific issues | 35 | 18 | N/A |
| Scientific enquiry | Identifying scientific issues | 49 | N/A | N/A |
| Physical systems | Scientifically explaining phenomena | 27 | 44 | N/A |
| Living systems | Using scientific evidence | 33 | 26 | N/A |
| Scientific enquiry | Identifying scientific issues | 30 | 39 | N/A |
| Scientific enquiry | Identifying scientific issues | 36 | N/A | N/A |
| Scientific explanations | Using scientific evidence | 26 | 22 | N/A |
| Living systems | Scientifically explaining phenomena | 43 | N/A | N/A |
| Living systems | Scientifically explaining phenomena | 58 | 22 | N/A |
| Living systems | Scientifically explaining phenomena | 53 | N/A | N/A |
| Scientific explanations | Using scientific evidence | 44 | 13 | N/A |
| Scientific explanations | Using scientific evidence | 24 | N/A | N/A |
| Scientific enquiry | Identifying scientific issues | 35 | 19 | N/A |
| Scientific enquiry | Identifying scientific issues | 27 | 37 | N/A |
| Scientific enquiry | Identifying scientific issues | 40 | N/A | N/A |
| Physical systems | Scientifically explaining phenomena | 34 | 0 | N/A |
| Physical systems | Scientifically explaining phenomena | 48 | N/A | N/A |
| Technology systems | Using scientific evidence | 30 | 0 | N/A |
| Scientific explanations | Using scientific evidence | 34 | 4 | N/A |
| Earth and space systems | Scientifically explaining phenomena | 36 | 0 | N/A |
| Earth and space systems | Scientifically explaining phenomena | 28 | 34 | N/A |

N/A: not applicable.

The results displayed in Table 5.4 confirm that most Qatari students' proficiency in scientific literacy at the level of understanding scientific content and applying process knowledge was weak.

## 5.4 Coded response reports

The coded response item reports contain open-ended questions that required students to provide brief answers or perform some calculation, giving one or more reasons or explanation for a certain issue. Full credit indicates a valid response to a question. A double full credit corresponds to a question for which two different responses are acceptable. Partial credit indicates that the student answered the question but made some errors. No credit indicates an incorrect response. Incorrect responses are designed to represent plausible errors in students' understanding at the level of content or process knowledge for each coded response item. The marking is based on scoring codes (full-credit, double full-credit, partial credit, no credit) and is specific for each question. The number and percentage of valid responses is given for each category. Table 5.5 contains an excerpt of the coded response item report for Qatar.

## Table 5.5

## Examples of students' common misconceptions relating to three open-ended questions, PISA 2006

| Curriculum domain | Cognitive level (competency) | Respondents | | Full credit 1 | | Full credit 2 | | Partial credit | | No credit | | Specific curricular aspect that needs attention |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number | % | Number | % | Number | % | Number | % | Number | % | |
| Scientific explanations | Using scientific evidence | 1,271 | 100 | 211 | 17 | 30 | 2 | N/A | N/A | 1,030 | 81 | Students did not correctly interpret the nature of the relationship between two quantities represented graphically, or referred only to one's variation in explaining how they relate. |
| Scientific explanations | Using scientific evidence | 1,046 | 100 | 79 | 8 | N/A | N/A | 67 | 6 | 900 | 86 | Students had difficulties in comparing two curves and identifying parts of two graphs that showed similar variation. |
| Earth and space systems | Scientifically explaining phenomena | 1,121 | 100 | 75 | 7 | 63 | 6 | N/A | N/A | 983 | 88 | Students could not refer to various causes responsible for a physical phenomenon, either in relation to a natural component or in relation to a human action. |

N/A: not applicable.

Table 5.6 sets out the percentage of students who received no credit for each of the 39 coded response items across the curriculum domain and at the respective cognitive level. It can readily be seen Qatar's students overwhelmingly received no credits for the 39 coded response items that are essentially open-ended test items. For instance, 93 per cent of the students received no credit for a question about using scientific evidence and requiring scientific explanation. Qatari students' understanding at the level of content or process knowledge was weak.

**Table 5.6**

**Students' common misconceptions with regard to content or process knowledge of coded response science items, PISA 2006**

| Curriculum Domain | Cognitive Level (competency) | No credit % |
|---|---|---|
| Scientific explanations | Using scientific evidence | 81 |
| Scientific explanations | Using scientific evidence | 86 |
| Earth and space systems | Scientifically explaining phenomena | 88 |
| Scientific explanations | Using scientific evidence | 87 |
| Scientific enquiry | Identifying scientific issues | 91 |
| Living systems | Scientifically explaining phenomena | 86 |
| Earth and space systems | Scientifically explaining phenomena | 75 |
| Living systems | Scientifically explaining phenomena | 77 |
| Physical systems | Using scientific evidence | 80 |
| Technology systems | Using scientific evidence | 81 |
| Technology systems | Scientifically explaining phenomena | 85 |
| Scientific explanations | Using scientific evidence | 70 |
| Scientific explanations | Using scientific evidence | 73 |
| Living systems | Scientifically explaining phenomena | 90 |
| Physical systems | Scientifically explaining phenomena | 87 |
| Scientific explanations | Using scientific evidence | 81 |
| Physical systems | Scientifically explaining phenomena | 76 |
| Earth and space systems | Scientifically explaining phenomena | 69 |
| Living systems | Scientifically explaining phenomena | 78 |
| Scientific enquiry | Using scientific evidence | 91 |
| Living systems | Scientifically explaining phenomena | 83 |
| Physical systems | Scientifically explaining phenomena | 69 |
| Scientific enquiry | Identifying scientific issues | 88 |
| Scientific explanations | Using scientific evidence | 93 |
| Living systems | Scientifically explaining phenomena | 90 |
| Scientific explanations | Using scientific evidence | 70 |
| Living systems | Scientifically explaining phenomena | 80 |
| Physical systems | Scientifically explaining phenomena | 71 |
| Physical systems | Identifying scientific issues | 83 |
| Living systems | Scientifically explaining phenomena | 83 |
| Scientific explanations | Using scientific evidence | 82 |
| Scientific explanations | Using scientific evidence | 77 |
| Physical systems | Scientifically explaining phenomena | 85 |
| Technology Systems | Using scientific evidence | 48 |
| Earth and space systems | Scientifically explaining phenomena | 84 |
| Technology Systems | Using scientific evidence | 87 |
| Scientific explanations | Using scientific evidence | 83 |
| Scientific enquiry | Identifying scientific issues | 87 |
| Scientific explanations | Using scientific evidence | 85 |

# 5.5 Attitude response reports

The attitude response items are multiple single questions that describe respondents' interest in science and support for scientific enquiry. For each question, students checked one of the four categories on Likert scales (high, medium, low, none) that measure the level of interest in specific scientific information, or the level of agreement with particular statements. The items shown in Table 5.7 and Table 5.8 are drawn from PISA items that measure, first, students' interest in science and, second, students' support for scientific enquiry.

## Table 5.7

## How much interest do you have in the following information, PISA 2006?

| Respondents | | | High | | Medium | | Low | | None | |
|---|---|---|---|---|---|---|---|---|---|---|
| Number | % | Statement | Number | % | Number | % | Number | % | Number | % |
| 1,790 | 100 | Knowing how to control weeds without using poisons | 261 | 15 | 511 | 29 | 841 | 47 | 177 | 10 |
| 1,791 | 100 | Understanding how scientists accurately identify plants | 368 | 21 | 720 | 40 | 518 | 29 | 185 | 10 |
| 1,791 | 100 | Learning about the different ways that plants spread their seeds | 395 | (22 | 568 | 32 | 560 | 31 | 268 | 15 |

## Table 5.8

## How much do you agree with the following statements?

| Respondents | | | High | | Medium | | Low | | None | |
|---|---|---|---|---|---|---|---|---|---|---|
| Number | % | Statement | Number | % | Number | % | Number | % | Number | % |
| 1,756 | 100 | I am in favour of research that helps us understand the functions of objects too small to see. | 263 | 15 | 679 | 39 | 686 | 39 | 128 | 7 |
| 1,782 | 100 | Research into conserving the habitats of endangered species should be supported. | 110 | 6 | 594 | 33 | 1005 | 56 | 73 | 4 |
| 1,777 | 100 | Systematic investigation is needed to understand threats to the survival of an endangered species. | 255 | 14 | 872 | 49 | 571 | 32 | 79 | 4 |

The level of interest in specific scientific information and the level of agreement of Qatar's 15-year-old students with particular statements were consistently low. Further research studies could be undertaken to ascertain the reasons for these low scores. It might be the case that the questions were simply misunderstood, or that reference was made to issues that were unfamiliar for students in Qatar.

Table 5.9 shows the percentages of students in Qatar who have low or no interest in a series of statements referring to knowledge of scientific principles and processes. For example, 57 per cent of the student body reported none or low interest in knowing how to control weeds without using poisons, or knowing how micro-organisms can affect cells in the body.

## Table 5.9

## Student interest in specific scientific knowledge or information, PISA 2006

| Interest in the Following Scientific Knowledge or Information | Low | None |
|---|---|---|
| | % | % |
| Knowing how to control weeds without using poisons | 47 | 10 |
| Understanding how scientists accurately identify plants | 29 | 10 |
| Learning about the different ways that plants spread their seeds | 31 | 15 |
| Knowing how plastics are produced | 44 | 10 |
| Learning how plastics can be developed for specific purposes | 26 | 10 |
| Understanding how the molecular structures of various plastics differ | 28 | 20 |
| Knowing why the full moon seems to be bigger at the horizon | 47 | 6 |
| Understanding why lunar eclipses occur only at certain times of the year | 45 | 7 |
| Learning more about useful bacteria | 41 | 8 |
| Knowing about other kinds of food that are produced by the actions of bacteria | 35 | 7 |
| Understanding why some bacteria can survive at very low temperatures | 31 | 15 |
| Knowing how foam fire extinguishers work | 43 | 11 |
| Learning about dry powder fire extinguishers | 30 | 11 |
| Understanding how fires in oil wells are extinguished | 44 | 13 |
| Learning how fertilisers affect different plants in different ways | 39 | 13 |
| Knowing more about the design of experiments to test the effects of fertilizers | 23 | 14 |
| Understanding the way in which the acidity level in soil affects plant growth | 27 | 19 |
| Learning more about the inheritance of distinguishing features | 45 | 7 |
| Learning what factors influence changes in species over long periods of time | 30 | 9 |
| Understanding how genetic mutations (changes) take place in animals | 31 | 14 |
| Knowing why forest fires spread more quickly uphill than downhill | 46 | 7 |
| Learning how research is carried out on the speed of spread of forest fires | 30 | 10 |
| Understanding how plants and animals have adapted to life in fire-prone areas | 38 | 12 |
| Knowing more about the functions of the human circulatory system | 44 | 6 |
| Understanding how an artificial lung works | 34 | 8 |
| Learning about animal hearts that are different from human hearts | 33 | 16 |
| Knowing how micro-organisms can affect cells in the body | 52 | 5 |
| Learning more about how antibiotics work | 35 | 7 |
| Understanding how micro-organisms can become resistant to antibiotics | 41 | 12 |
| Knowing which human activities contribute most to acid rain | 40 | 10 |
| Learning about technologies that minimise the emission of gases that cause acid rain | 26 | 11 |
| Understanding the methods used to repair buildings damaged by acid rain | 32 | 14 |
| Knowing about the work of early researchers in the study of digestion | 44 | 8 |
| Understanding how different food substances are digested | 33 | 7 |
| Learning how other major body system functions were discovered | 40 | 12 |
| Learning about the process by which plants are genetically modified | 35 | 11 |
| Learning why some plants are not affected by herbicides | 29 | 11 |
| Understanding better the difference between cross-breeding and genetic modification of plants | 26 | 21 |
| Knowing how to build safely on mountainside terraces | 49 | 7 |
| Learning about methods used to stabilise landfill | 29 | 9 |
| Learning how tall buildings can be designed to withstand earthquakes | 48 | 11 |
| Knowing why airbags can be dangerous in some accidents | 57 | 6 |
| Learning what collision speeds will cause an airbag to inflate | 38 | 6 |
| Understanding how the triggering mechanism of airbags works | 36 | 12 |
| Understanding how propane is produced | 34 | 13 |
| Knowing about other fuels that are used in portable stoves | 26 | 13 |
| Learning more about Fleming's accidental discovery | 43 | 9 |
| Knowing why it took 16 years after penicillin's discovery to produce it in usable form | 30 | 10 |
| Understanding why pharmaceutical equipment is often constructed from stainless steel | 35 | 14 |
| Knowing how scientists determine what dinosaurs ate | 48 | 11 |
| Understanding more about the theories of dinosaur extinction | 37 | 9 |
| Learning how the age of fossil footprints is estimated | 34 | 4 |

Table 5.10 shows the percentages of students in Qatar who are in disagreement with a series of scientific statements. For example, 62 per cent of the students reported none or low agreement with a statement about the importance of developing more precise scientific instruments.

## Table 5.10

## Student agreement with particular science related statements, in per cent, PISA 2006

| Science Related Statement | Low | None |
|---|---|---|
| | % | % |
| Having a systematic way to identify weeds is important | 46 | 6 |
| Planning weed control requires scientific research | 35 | 6 |
| Research into how weed seeds spread should be supported | 40 | 11 |
| The phases of the Moon are best explained by scientific reasoning | 41 | 4 |
| Lunar eclipses are best predicted using scientific methods | 42 | 5 |
| The work of astronomers in exploring the universe is important | 47 | 8 |
| It is important to develop more and more precise scientific instruments | 59 | 3 |
| I am in favour of research that helps us understand the functions of objects too small to see | 39 | 7 |
| Research into conserving the habitats of endangered species should be supported | 56 | 4 |
| Systematic investigation is needed to understand threats to the survival of an endangered species | 32 | 4 |
| Action to save endangered species should be based on scientific evidence | 40 | 8 |
| The systematic study of fossils is important | 48 | 6 |
| Action to protect national parks from damage should be based on scientific evidence | 33 | 6 |
| Scientific investigation of geological layers is important | 43 | 9 |
| It was a good idea for the gardener to experiment with all the fertilisers rather than just choosing one | 47 | 16 |
| The best conditions for growing grass can only be found by systematic investigation | 31 | 6 |
| Scientific knowledge is important in garden management | 50 | 9 |
| It is important to investigate why particular animal species have become extinct | 49 | 5 |
| Even small changes within particular species deserve careful study | 32 | 5 |
| Scientific evidence is necessary to decide whether a species is threatened with extinction | 43 | 8 |
| Theories about long-term climate change should be based on scientific evidence | 38 | 4 |
| It is important to study why climates change over time | 42 | 8 |
| Effective heart surgery is the result of extensive scientific research | 46 | 5 |
| Innovations like artificial hearts should be tested rigorously before they are used in humans | 57 | 6 |
| It is important to continue research into the causes of heart disease | 60 | 7 |
| I am in favour of research to develop vaccines for new strains of influenza | 65 | 3 |
| The cause of a disease can only be identified by scientific research | 38 | 5 |
| The effectiveness of unconventional treatments for diseases should be subject to scientific investigation | 42 | 6 |
| Preservation of ancient ruins should be based on scientific evidence concerning the causes of damage | 52 | 5 |
| Statements about the causes of acid rain should be based on scientific research | 36 | 8 |
| Opposing theories can help advance scientific investigation | 43 | 6 |
| Experiments need to be repeated even if the conclusions seem obvious | 40 | 7 |
| Research evidence on the effectiveness of safety features is more important than how they look | 50 | 4 |
| Ratings of car safety features should be based on scientifically conducted crash tests | 38 | 5 |
| I would feel safer using a combined seatbelt/airbag system than a seatbelt by itself | 49 | 8 |
| The extinction of dinosaurs is best explained by scientific research | 46 | 7 |
| Scientific study of the history of the Earth is important | 49 | 7 |

Table 5.10 suggests that the level of Qatar student's interest in specific scientific information and the level of agreement with particular science related statements were consistently low.

# 5.6 Conclusion

In the PISA science framework, science proficiency depends upon students being able to: explain phenomena scientifically; identify scientific issues; and, use scientific evidence. The acquisition of science proficiency as defined in the PISA context also depends upon student attitudes to science and the level of support for scientific enquiry that is provided by the education system. The findings presented in the previous chapter indicate that students' attitudes to science are also impacted by factors beyond the immediately influence of the school, particularly the parents' level of education and the reading resources available in the home environment.

In practice, students demonstrate these competencies by responding to a sample of science test items that have been carefully selected to represent the anticipated range of knowledge and skills supposedly possessed by the student population. The samples of science knowledge and skill questions administered in the PISA 2006 assessment are sufficiently extensive to provide insights into the degree to which 15-year-old students in Qatar have mastered the content and skills specified in the science curricula used in the country.

Chapter 5 has summarised the results of an analysis of the performance of Qatari students on individual science test items.

The summary reveals that small proportions of the students managed to get even the least difficult of science test items correct, such as items requiring the students to identify particular scientific issues.

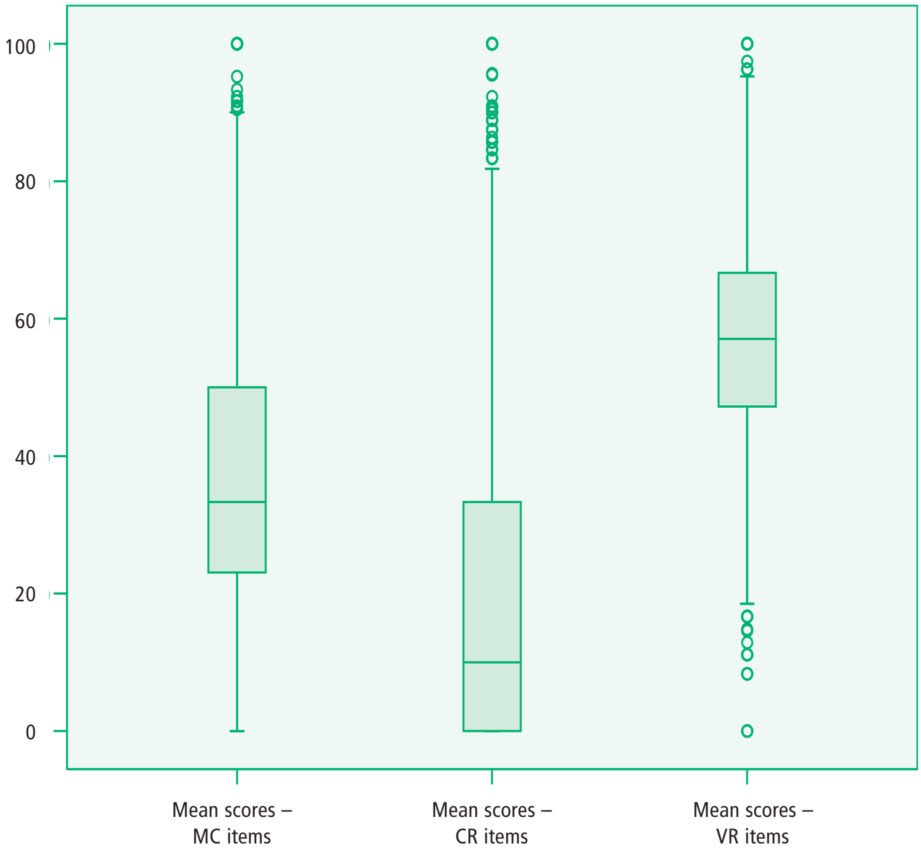
Were low performance in science related to a misfit between the Qatari curriculum and the content covered by the PISA assessment, one would expect to see sub-domains where Qatari students do relatively well. This is not the case. In comparison with OECD countries, Qatari students score low on all of the science content covered by the PISA 2006 assesment.

In fact, the proportions of correct responses are so low that it is most likely that many students in Qatar lacked the prerequisite reading literacy and numeracy skills they needed in order to understand and respond to the PISA science items. Evidence from previous studies (Gonzales *et al.*, 2004) indeed confirms that, as an underlying cause, the level of science proficiency demonstrated by students depends upon these students having mastered the requisite reading literacy skills as well as the basic mathematical competence needed to understand and respond to the science items presented to them.

This finding suggests that the efforts to raise the quality of educational provision in Qatar should focus, in the first instance, upon improving the reading and mathematics proficiencies of students in the country. Broadening access to high-quality early childhood education would represent one important step forward in this respect.

The distribution of Qatari student scores on different types of test items suggests that, once these measures are in place, the science proficiency of Qatari students is likely to rise rapidly. The following figure plots the distribution of correct response on multiple choice, coded response and vector response items.

**Distribution of proportions correct by item type**




The Figure indicates that Qatari students do relatively better on multiple-choice response items, and relatively worse on coded response items. These facts suggest that the previous focus on memorisation may have impaired Qatari students' ability to deal with situations when they are required to frame issues in scientific terms. The fact that they do relatively well on vector response items confirms that they have the requisite conceptual grasp of science, so the science scores of future cohorts of students are likely to rise rapidly as the effects of the revised approach to instruction works its way through the system.

Notwithstanding Qatar's overall low performance on the PISA 2006 science scales, even a cursory review of the results at the school level reveals that some teachers have found ways to surmount the barriers to science acquisition posed by inadequate literacy and numeracy foundation skills. Educators and education officials in the country should endeavour to find the means and mechanisms to transfer and diffuse this knowledge about good practice more widely.

# Chapter 6

## Key Findings and Options for Policy and Further Study

### 6.1 The PISA study for Qatar in context

Ensuring that all children and youth in Qatar are equipped with the knowledge and skills they need to fully participate in society and the increasingly global and competitive world of work is among the key objectives pursued by the Supreme Education Council, and shared widely by all stakeholders in the community. Qatar's "Education for a New Era" initiative, being implemented by the Council, is among the world's most comprehensive and ambitious education reform programmes. Experience from OECD countries, as well as others worldwide, suggests that, under normal circumstances, such wide-ranging, systemic reforms cannot be expected to yield spectacular results overnight. On the contrary, achieving the objective of raising the levels of knowledge and skill of children and youth in Qatar to at least the OECD average might well take a generation. But Qatar does possess the three assets that experience of school improvement in some East Asian nations shows may allow it to accelerate the reform process: resources, ambition, and sheer determination to succeed, which translates into a strong political will of the authorities.

The PISA 2006 study, the key results of which were presented in previous chapters of this report, has provided the baseline data for measuring the reading, mathematical and scientific literacy of 15-year-old students in Qatar within an international context. Both the labour markets, and society in general, place a high premium on these competencies, since they provide the foundation and the tools for effectively receiving, processing and understanding information, and hence are the essential basis for achieving success in lifelong learning. Qatar's participation in the PISA 2006 study represents an important step in benchmarking the education reform process.

The fact that 15-year-old students in the country exhibit a comparatively low level of proficiency in all three skill domains assessed in the PISA study, as documented in this report, will not come entirely as a surprise to decision makers in Qatar. In reality, the finding that average student performance is below the

OECD average was anticipated. Nevertheless, the PISA findings for Qatar provide ample justification for the urgency with which decision makers in the country are pursuing the "Education for a New Era" initiative, launched by Emiri Decree in November 2002, at all levels of the education system.

## 6.2 Lead hypotheses investigated

To Qatar's credit, most of the elements have already been put in place to precipitate a more rapid and sustained improvement in student performance over the next decade. Essential educational inputs such as adequately equipped school buildings, modern and demanding standards, curricula and textbooks, teacher qualifications, and the resources invested in the education system, are generally adequate, or even better than the OECD averages.

Given these resource inputs, however, the question arises as to what might explain the comparatively low scores of students in Qatar on scientific literacy. The hypotheses advanced in this report are, first, that since all learning is cumulative and early achievement in learning builds later success, the 15-year-old students assessed in PISA 2006 must have been ill prepared for the complex tasks required of them, and second, that they were not exposed for long enough to the present reform in order to bridge the gap.

The above hypotheses do not necessarily point to deficiencies in school inputs, such as teacher qualifications per se, although this cannot be totally excluded. The two most likely explanations are, first, that the students apparently had not mastered the requisite reading and mathematical literacy foundations needed for success in the science assessment, and second, that students must have been taught in ways that did not require them to solve scientific problems derived from realistic and everyday situations arising in many different cultural and natural contexts in different parts of the real world. These findings for Qatar strongly support the emphasis placed in the on-going education reform on the modernisation of the school curriculum and the changing of teaching styles from traditional classroom instruction and memorisation of facts to an individualised and curiosity-driven pedagogy.

In this context, participation in the PISA study at this early stage in the reform process was a bold, brave and realistic step, as the skills assessed by PISA represent the sum of learning since birth. The 15-year-old students assessed in the OECD study had, at best, only benefited from the initial stage of the reforms. Hence any beneficial effects were realised during the last three years of their secondary education, a stage when the essential foundations of reading literacy and numeracy are normally supposed to have already been established. This fact has profound implications for the interpretation of the findings presented in this report. The PISA 2006 estimates of the proficiency of Qatar's 15-year-olds are best thought of as benchmarks for gauging future improvements, and as unequivocal proof that the current reform initiative was indeed urgently needed.

## 6.3 Overview of key findings

This PISA report for Qatar is designed to provide readers with answers to an ordered set of issues, briefly summarised below.

The introduction sets out why the knowledge and skills assessed by PISA are economically and socially important, and how PISA went about measuring proficiency levels across a heterogeneous group of 56 countries.

Chapter 1 placed Qatar's performance in reading, mathematical and scientific literacy in an international context. The data analyses confirmed, using a variety of measures, that Qatar's 15-year-old students exhibited one of the lowest levels of proficiency in the PISA sample of countries. In fact, average reading and mathematical literacy proficiency were so low that it is reasonable to assume that most students may have lacked the requisite literacy skills to respond to the science items.

Chapter 2 sought to determine whether the low levels of science proficiency could be attributed to relatively poor performance on one or more of the three science sub-domains assessed by PISA – identifying scientific issues; scientifically explaining phenomena; and using scientific evidence. The data provide an unequivocal answer to this question, as the performance of students in Qatar is consistently low, irrespective of the science sub-domain. This fact lends some support, once more, to the hypothesis that the majority of 15-year-old students must have lacked the foundational reading literacy and numeracy skills required in order to do well in science. Tellingly, in comparing scores on the three science sub-domains, Qatari students were found to be least proficient in using scientific evidence. This result can be taken to be an unintended consequence of the pre-reform approach to pedagogy and science instruction. Again, this finding also lends strong support to the on-going reform.

Chapter 2 also explored the relationships between the perceived level of science support, and students' interest in science, on the one hand, and the science proficiency of these students on the other. The "Education for a New Era" initiative has afforded Qatar's students a number of advantages, including increasingly well qualified teachers, high levels of expenditure per student, demanding and updated standards and curricula, a state of the art standardised assessment system, world class levels of support for science instruction, and triggered high levels of student interest in science. Unfortunately, the evidence suggests that the cohort of 15-year-olds tested in PISA 2006 did not have the foundation skills to translate these advantages in higher levels of science proficiency, or alternatively, their time of exposure to the benefits of the reform was insufficient.

Chapter 3 investigated the degree to which the comparatively low overall science performance of Qatari students could be attributed to the performance of specific sub-groups of students that have been shown to have an influence in the overall performance in other countries. Whereas the data analyses uncovered some interesting variation in performance among sub-groups, these differences were not of sufficient magnitude to support the basic hypothesis. More specifically, the expected improvements in science proficiency, expected to flow from the creation of the independent schools, were not yet evident in the cohort of students tested.

Chapter 4 refines and extends the analysis presented in Chapter 3. It explores the complex interplay between science performance and a set of factors that theory and evidence suggest exert a strong positive influence upon observed proficiency. These factors – grouped under the headings of quality of Instruction, appropriate level of instruction, time, attitudes to learning, and resources – confirm the hypothesis advanced throughout this volume - that attention should focus, in the first instance, on raising the literacy scores of Qatari students early in their educational careers. An increase of 50 points on the PISA reading literacy scales raises the probability of performing at Level 2 or above by over threefold. In the majority of Qatari schools no more than 20% of the students achieved at Level 2 or higher on the Science proficiency test. However, in those Qatari schools with average to above average level of reading proficiency, about 90% of the students achieved at Level 2 or higher.

The findings from the data analysis that combined a range of variables indicate that the cumulative effect of several factors can lead to higher science proficiencies, provided that students have the reading literacy skills to enable these effects. The analysis shows that this is particularly true in the upper regions of the combined science scale, where few Qatari schools are currently performing. This finding, again, suggests that improvements in the reading literacy skills of future cohorts of students in turn will precipitate improvements in science scores. Similarly beneficial effects could be expected to occur in other subject matters.

Chapter 5 opened a lens on a potential means of improving student achievement in reading, mathematical and scientific literacy in the near term. The test items used to assess proficiency represent a rich source of knowledge about which parts of the curricula this cohort of 15-year-olds were having difficulty mastering. At the same time, the data analyses of differences in performance at the school level showed that, in serving students from similar intake conditions, certain schools had evidently been able to impart significantly higher levels of knowledge and skills than other schools. These two sources of data can help frame and focus the in-service training of teachers in a powerful way, one in which the teachers themselves are empowered to drive reform.

## 6.4 Specific findings by chapter

This first PISA report for Qatar is intended to establish a baseline for future comparisons in coming cycles. The foregoing paragraphs provide a succinct summary of what the study has discovered about the levels and distributions of reading, mathematical and scientific proficiency of students towards the end of the cycle of secondary education. The data analyses have also documented a wealth of other important, more specific findings.

### Chapter 1:

- Average proficiencies in reading, mathematical and scientific literacy are among the lowest observed in the 56 countries that participated in the PISA 2006 assessment. Qatar's 15-year-old students are, on average, somewhat ahead of their peers only in the Kyrgyz Republic.
- The low average proficiencies observed in Qatar are to a large extent coincident with the fact that the entire distributions of the proficiency scores are shifted down into the lower levels of the proficiency scales. This shift is observed for all three domains – reading, mathematics and science.
- Average proficiencies in all three domains are lowered further by the fact that relatively higher proportions of Qatari students have scores below the national average. The degree of skewness in the distribution of proficiency scores is particularly high in the mathematics and science domains. Finding ways of reducing the degree of skewness in proficiency

will be a necessary element of any strategy to raise average scores. Other research suggests that distributions tend to be skewed when a high proportion of students do not attain the necessary reading skills during the primary grades that enable them to 'read-to-learn' during the later grades.

- Judged against the OECD distribution, average scores at key points along the proficiency distribution in Qatar are uniformly low. Judged in relative terms, average Qatari scores even – even as low as the $10^{th}$ and $25^{th}$ percentiles – are significantly under the comparable scores of their OECD peers. This finding applies to all three domains – reading, mathematics and science.
- The overwhelming majority of Qatari students are classified at the performance level *Below Level 1*. Hence only small percentages of students have skills that are sufficiently advanced, measured against OECD benchmarks, to place them at performance Levels 3, 4, 5 or 6 in all three skill domains.

## Chapter 2:

- The students scored slightly higher on test items involving the identification of scientific issues and the explanation of scientific phenomena, than on items requiring the use of scientific evidence.
- The analysis of students' perceived support for learning science and their interest in science showed that Qatari students had comparatively high levels of perceived support and interest in the subject.
- However, the level of proficiency in science is much lower than one would expect given the students' strong expression of interest and level of perceived support. The fact that these findings appear to be at odds with what is known from the research literature, has raised concerns about the validity of the PISA 2006 interest and support scales, and requires further study.

## Chapter 3:

- In Qatar, in contrast to what one observes in other countries with low performance in the PISA 2006 assessment, it clearly emerges that there is little variation in students' science proficiency by level of parental education, as a proxy of socio-cultural status.
- The level of science proficiency, as represented by average scores, is uniformly low at all levels of parental education, well below the OECD average at each point.
- In science, girls outperform boys by a significant margin, at all levels of parental education. This finding differs from that observed in most PISA countries, where boys tend to outperform girls in science by a significant margin.
- Children of non-Qatari born students outperform Qatari-born students at all levels of parental education.
- The gap in performance between non-Qatari born and Qatari-born students rises with increasing parental education.
- The data analyses indicate that the performance of schools in Qatar is highly variable. Schools differ in the average level of parental education of the students served, yet at each level of parental education one can identify schools that manage to generate higher average science scores.

- Qatari independent schools do not appear to be consistently outperforming the Ministry schools, at this point, and for this cohort of 15-year-old students. This result is, nevertheless, to be expected, given the fact that the 15-year-old students assessed in the PISA 2006 study did not have the benefit of the recently implemented reforms when they attended primary school – the stage when the foundations of reading literacy and numeracy are established.
- International schools outperform other schools in Qatar by a significant margin – but they themselves also exhibit a significant degree of variation in average science scores at school level.

## Chapter 4:

- The analyses suggested that all of the factors explored had a moderate impact on performance, although not all of the relationships were statistically significant.
- The one notable exception provides strong support for the hypothesis advanced throughout this volume – that attention should focus, in the first instance, on raising the literacy scores of Qatari students early in their educational life. An increase of 50 points on the PISA reading literacy scales raises the probability of performing at Level 2 or above by over three fold.
- The amount of time spent on science at school, as well as student interest in science, both show a positive effect upon the students' science proficiencies, but the size of these effects is relatively small.
- The data analyses show that each of the remaining seven factors, by themselves, had a relatively small impact on performance within the range on the factors covered by the majority of Qatari schools.
- The results suggest that it is the cumulative effect of several factors that lead to higher performance. The analysis thus shows that there is a relationship between science proficiency and an index combining all of the factors into one analysis. The effect is moderately strong and positive in the lower regions of the combined index, and thereafter there is a strong and positive relationship.

## Chapter 5:

- Only small proportions of the students managed to get the least difficult of science test items correct, such as those requiring them to identify particular scientific issues. Were low performance related to a misfit between the Qatari curriculum and the content covered by the PISA test, then one would expect to see sub-domains or clusters of items on which Qatari students did relatively well. This is not the case. In comparative terms, Qatari students scored low on all of science content covered by the test. Consequently a curriculum based explanation does not seem plausible in this case.
- These results strengthen support for the hypothesis that the cohort of 15-year-olds lacked the rudimentary reading literacy and numeracy skills required for mastering the more advanced scientific knowledge and concepts assessed by PISA, since they did not benefit of the ongoing reform assets when they were in the early school stages.

# 6.5 Implications for current and future Policy

The specific findings reviewed above carry several important implications for current policy – not only related to education but also to policies impacting family welfare, youth affairs, social work, culture, immigration to an extent, and, importantly, economic policies aimed at creating a Qatari environment amenable to sustainable development.

First and foremost, the findings of the PISA study provide unequivocal support for Qatar's "Education for a New Era" reform strategy and the concomitant new investments aimed at raising the quality of education.

Second, the strikingly low levels of science knowledge and skills of 15-year-old students, measured against OECD benchmarks, suggest that the education reforms instituted over the past several years have had little impact on this cohort of students, most likely because they had already went through the fundamental education stages at the time the reform was implemented. The efforts to raise the quality of educational provision in Qatar should focus upon improving the foundational reading literacy and numeracy proficiencies of children in the country. The on-going effort to afford high-quality early childhood education to all Qatari families should evidently be vigorously pursued, and measures now being implemented that are designed to improve learning at the early stages in primary schooling deserve centre stage.

Third, although the PISA 2006 findings will no doubt be interpreted by some educators and other members of Qatari society as discomforting, they should nevertheless be welcomed, not least because they offer objective confirmation that the "Education for a New Era" reform programme is essential to the future well being of the nation, and was adopted in anticipation of these results. They also provide strong support for continued technically sound standardized and comparative assessment of education and its related longitudinal inferential research efforts. Particularly helpful would be the assessment of reading, mathematics and science achievement at earlier ages, both to capture the effects of the recent reforms and to use these results to better understand what factors might play the greatest role in raising the performance of future cohorts of Qatari students. The participation of Qatar in the 2007 Progress In Reading Literacy Study (PIRLS) represents an important complementary step in building the required knowledge base.

Future repercussions can be inferred from the findings as well.

First, few Qatari students in the cohort assessed in PISA 2006 appear to have knowledge and skills levels sufficiently high to take full advantage of tertiary education. Unless somehow mitigated, this fact will limit the efficiency and effectiveness of tertiary education in Qatar and the other Gulf States. It will also hinder the ability of Qatari students to perform well in the world's elite universities. This might require that universities in Qatar develop ad-hoc remedial programmes for bringing this cohort to the required skill level. Similar programmes could also be devised for those students in this particular age group intending to go and study abroad.

Second, as Qatar's economy diversifies, few Qatari adults will possess the levels of skills needed to participate in the tasks demanded in the global, knowledge-based economy, unless the school reform recently initiated accelerates in order to be effective in the short term, and unless the initiative is complemented by a renewed effort to build an efficient system of remedial and continuing education and training. Because this will much effort and requires ample resources, however, the labour market in Qatar is likely to remain highly dependent on imported human capital, at least for some time.

Third, while average skill levels are low, there is sufficient variability in proficiency to create significant inequality in important social and economic outcomes. High levels of inequality are a source of potential social instability, and they may constrain productivity growth, reduce the return on educational investments, and reduce levels of social cohesion and engagement.

Fourth, the fact that most students in Qatar scored at the lowest performance levels, and particularly at *Below Level 1*, means that their proficiency scores are much less reliable than those estimated for countries in which the range of proficiency is more closely aligned with the distribution of item difficulties current for OECD countries. In fact, so many students in Qatar had none – or fewer than 10 items – correct, that their proficiency scores classified at *Below Level 1* are likely to be over-estimates of their true proficiencies.

Finally, notwithstanding the comparatively low rank of Qatar among the PISA 2006 countries, the results presented in this report nevertheless offer reason for optimism. Provided the will and means can be found to raise the reading literacy levels of future cohorts of Qatari children to world-class levels, then the relationships revealed in the data analyses hold the promise that significant improvement in science scores can be realised relatively rapidly. This finding alone justifies both the current education reform and the need to monitor performance over time.

## 6.6 Policy options

The findings and future implications, reviewed above, have relevance for policy and offer some reason for optimism.

### • *Building literacy rich communities*

One of the defining characteristics of the countries that achieved the highest scores in the PISA study is the degree to which they have managed to create a social milieu that is literacy rich and which values reading as a social practice. Governments can play a central role in supporting the development of such literacy rich environments, beginning with measures that encourage and motivate parents to read to their children and that make reading materials widely available. Qatar should consider a range of measures to ensure that this is the case.

### • *Extending early childhood education*

Many of those countries whose 15-year-olds perform well on the PISA scales attribute their success to a large degree to the fact that they have implemented systems of near-universal early childhood education and care that teach the basics of reading literacy and rudimentary numeracy to a large proportion of children at a young age. Such systems serve to increase school readiness and reduce the level of social inequality in readiness to learn at the point of entry to formal education. This in turn raises overall proficiency achieved in the primary and secondary cycles of initial education. To date Qatar appears not to have invested sufficiently in developing these systems.

### • Strengthening initial teacher training

According to indicators from the Qatar National Educational Data System (QNEDS), Qatar's teachers are well qualified when measured in levels of educational attainment, even compared to their colleagues in the OECD area. While formal levels of qualification are high, this does not necessarily mean that the teachers are well prepared for the challenging tasks they will face in developing and implementing an individualised, modern and skills-oriented curriculum. Particularly for teachers in the lower grades it may be necessary to strengthen formal instruction in the art and science of teaching children to read at increasing levels of competence. Care should be taken to ensure that all graduating teachers have the requisite skills in this area.

### • Focusing in-service training

Whilst the performance of Qatari schools is generally low one does not see the levels of social inequality in science scores that are evident in many countries, although as noted above, schools differ markedly in the type of students they serve as defined by parental education. The fact that one can identify schools at each level of parental education that are outperforming their peers serving students from the same backgrounds, opens the way to rapid improvement in scores if the means are put in place to transfer "best practice" from the best performing schools to their under-performing peers.

The mechanisms for such "knowledge mobilisation and transfer" are well known, easy to implement and relatively inexpensive, depending as they do on various forms of in-service training for teachers. Well done, these are among the most powerful forms of transformational change one can synthesise from the PISA study, because the best teachers and principals will drive the reform process themselves. Another aspect of in-service training must focus on changing the traditional pedagogical and didactic methods many teachers still use in the classroom. Being capable and motivated to apply individualised, curiosity driven and problem oriented teaching styles requires not only expertise in modern pedagogy, but also, in many instances, a change of mind set – something that is bound to take time.

### • Building a lifelong learning society

Finally, the obligation of Qatari society to pursue social fairness in the long term dictates that the comparatively low performance of the current cohort of adolescents and young adults cannot merely be written off. Clearly, there is an objective need for the country to strengthen the provision of remedial youth and adult education programming, so as to ensure that all those who have the motivation to upgrade their skills are afforded with adequate opportunities to do so. Moreover, policies should be put in place to help motivate youth and adults to take advantage of these programmes.

All the OECD countries with the highest performance in the PISA study are committed to building a culture and system of lifelong learning, and most have already succeeded in opening up access to continuing education and training programmes to their entire adult populations. In the case of Qatar, while the "Education for a New Era" reform programme targets measures at all levels of the education system, priority is deservedly given to the efforts to improve the quality of formal, initial education for children and youth. In parallel, though, the country will need to broaden educational provision for the adolescents, adults and senior citizens who missed out on their learning opportunities earlier in life.

# 6.7 Opportunities for further study

As noted above, participation in PISA provides a mechanism to monitor change in the levels and population distribution of key skills among students close to the end of the mandatory cycle of education. Focused as it is upon students at the age of 15 years, however, PISA is limited in its contribution to the unveiling of the cumulative aspects of teaching and learning processes that lead to improved performance.

Qatar has invested heavily in developing and implementing the Qatar Comprehensive Educational Assessment (QCEA) programme and its broader referent, the Qatar National Educational Data System (QNEDS). These databases should be used deeply and extensively, to make it possible to study many of the factors influencing school outcomes, and to further investigate the PISA related hypotheses advanced in this report. Qatar should, therefore, maintain and expand these data systems, and invest the resources required to link and analyse the PISA, QCEA and QNEDS databases, as well as those of PILRS 2006 and TIMSS 2007, as means to monitor changes in key inputs and outputs, and to identify opportunities for improvement in school structures and processes.

Qatar is particularly commended for having participated in the 2007 (PIRLS assessment, as this will provide an international benchmark for a young cohort of children, who should have benefited from the education reforms under way since 2002.

Whilst it is recommended that Qatar should continue its participation in the PISA study, particularly in its 2009 cycle, focusing on reading skills, the country could consider adopting a design in which additional blocks of items with lower levels of difficulty are added, in order to obtain better measurement properties and improved discrimination of proficiency at the lower end of the scales, where most students in Qatar are located. This would guard against the floor effects observed in the 2006 PISA study that likely result in over estimates of the true average proficiency levels of the students in the country.

Qatar is also encouraged to field the Adult Literacy and Life Skills Survey (ALL). The ALL study could offer comparative information, again benchmarked against OECD countries, about the levels and distributions of knowledge and skills of the entire adult population aged 16 years and older. Over-sampling teachers in such a study might provide an objective measure of teacher quality. This would also make it possible to investigate how the skills measured in PISA influence valued outcomes at the individual, group and national level. At the individual level, the ALL study examines the impact of skills on participation in tertiary education and adult education and training, on key indicators of labour market success, on the use of information and communication technologies, on individual health, and on the level of social engagement. At the macro level the ALL study investigates the impact of skills upon rates of macro-economic growth, levels of population health and social development.

Finally, Qatar could consider providing teachers with web-based assessment tools that assist them in identifying children whose early reading acquisition is off track. By offering results in real time, at a low cost, such systems open the possibility of early intervention in the critical kindergarten to Grade 4 age range, when the foundations for reading literacy and numeracy are established. The Learning Bar's Early Years Evaluation (EYE) is one example of this type of tool.

## 6.8 Concluding remark

In conclusion, the PISA findings presented in this report have offered compelling evidence in support of the "Education for a New Era" reform initiative. Subjecting oneself to the harsh light of international comparison so early in the reform process took a high level of political courage and openness that, we have to acknowledge, is absent in many other countries.

Provided that Qatar keeps the endurance and political will to stay the course in its "Education for a New Era" reform over time, the nation can expect to see steady improvements in the scores of its students in future PISA cycles and other international studies. In that scenario it is easy to imagine that Qatar will realise its ambition of building one of the world's elite education systems, a prerequisite to developing a sustainable economic powerhouse.

# Appendix A

## Tables with Source Data

### Table 1.1

### Distribution of reading scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Australia | 512.4 | 94.3 | -0.36 |
| SE | 2.0 | 0.9 | 0.03 |
| Austria | 490.4 | 107.8 | -0.46 |
| SE | 4.1 | 3.2 | 0.07 |
| Belgium | 500.4 | 109.9 | -0.56 |
| SE | 3.0 | 2.7 | 0.05 |
| Canada | 526.6 | 95.9 | -0.43 |
| SE | 2.3 | 1.3 | 0.05 |
| Czech Republic | 483.4 | 110.8 | -0.29 |
| SE | 4.1 | 2.9 | 0.08 |
| Denmark | 494.7 | 88.9 | -0.30 |
| SE | 3.1 | 1.5 | 0.05 |
| Finland | 547.1 | 80.6 | -0.21 |
| SE | 2.1 | 1.0 | 0.04 |
| France | 487.6 | 104.2 | -0.47 |
| SE | 4.1 | 2.7 | 0.06 |
| Germany | 494.5 | 111.8 | -0.67 |
| SE | 4.4 | 2.6 | 0.10 |
| Greece | 460.2 | 102.8 | -0.50 |
| SE | 4.0 | 3 | 0.06 |
| Hungary | 482.6 | 94.7 | -0.48 |
| SE | 3.2 | 2.3 | 0.10 |
| Iceland | 483.7 | 97.4 | -0.43 |
| SE | 1.4 | 1.2 | 0.05 |
| Ireland | 517.3 | 92.5 | -0.26 |
| SE | 3.4 | 1.6 | 0.05 |
| Italy | 469 | 108.9 | -0.49 |
| SE | 2.4 | 1.8 | 0.04 |
| Japan | 498 | 101.9 | -0.34 |
| SE | 3.7 | 2.2 | 0.05 |

## Table 1.1 (continued)

## Distribution of reading scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Korea | 555.1 | 89.1 | -0.46 |
| SE | 3.8 | 2.7 | 0.06 |
| Luxembourg | 479.7 | 99.7 | -0.38 |
| SE | 1.1 | 1.0 | 0.03 |
| Mexico | 410.1 | 96.2 | -0.29 |
| SE | 3.0 | 2.3 | 0.05 |
| Netherlands | 506.6 | 97.2 | -0.51 |
| SE | 2.8 | 2.5 | 0.09 |
| New Zealand | 521.7 | 105 | -0.31 |
| SE | 3.0 | 1.4 | 0.04 |
| Norway | 484.2 | 104.7 | -0.36 |
| SE | 3.1 | 1.8 | 0.04 |
| Poland | 507.7 | 101 | -0.27 |
| SE | 2.9 | 1.5 | 0.05 |
| Portugal | 471.8 | 98.8 | -0.36 |
| SE | 3.5 | 2.3 | 0.05 |
| Slovak Republic | 466 | 105.2 | -0.33 |
| SE | 3.0 | 2.3 | 0.09 |
| Spain | 460.8 | 88.7 | -0.43 |
| SE | 2.3 | 1.1 | 0.05 |
| Sweden | 506.9 | 97.5 | -0.36 |
| SE | 3.1 | 1.7 | 0.05 |
| Switzerland | 498.2 | 93.1 | -0.37 |
| SE | 2.9 | 1.7 | 0.04 |
| Turkey | 447.3 | 93.9 | -0.16 |
| SE | 4.2 | 2.7 | 0.11 |
| United Kingdom | 495.6 | 101.7 | -0.25 |
| SE | 2.2 | 1.6 | 0.05 |
| United States | N/A | N/A | N/A |
| SE | N/A | N/A | N/A |
| **OECD** | **483.7** | **106.9** | **-0.35** |
| **SE** | **1.0** | **0.7** | **0.02** |
| Azerbaijan | 353.6 | 70 | 0.39 |
| SE | 3.1 | 2.1 | 0.08 |
| Argentina | 374.5 | 125.7 | -0.35 |
| SE | 7.3 | 3.5 | 0.06 |
| Brazil | 393.1 | 101.5 | -0.05 |
| SE | 3.6 | 3.2 | 0.11 |
| Bulgaria | 402.3 | 118.1 | -0.17 |
| SE | 7 | 4.2 | 0.10 |
| Chile | 441.7 | 103.7 | -0.15 |
| SE | 5.0 | 2.4 | 0.08 |
| Chinese Taipei | 497 | 84.6 | -0.35 |
| SE | 3.4 | 1.8 | 0.04 |
| Colombia | 385.2 | 108.5 | -0.32 |
| SE | 4.9 | 2.7 | 0.09 |
| Croatia | 476.8 | 89.2 | -0.26 |
| SE | 2.7 | 2.1 | 0.05 |
| Estonia | 501.1 | 84.7 | -0.34 |
| SE | 2.9 | 1.8 | 0.05 |
| Hong Kong-China | 536.3 | 81.9 | -0.40 |
| SE | 2.4 | 1.9 | 0.05 |
| Indonesia | 393 | 74.6 | 0.01 |
| SE | 5.9 | 2.3 | 0.07 |

## Table 1.1 (concluded)

## Distribution of reading scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Israel | 437.6 | 118.7 | -0.21 |
| SE | 4.6 | 2.9 | 0.06 |
| Jordan | 400.7 | 94 | -0.45 |
| SE | 3.3 | 2.3 | 0.06 |
| Kyrgyzstan | 285 | 102.9 | 0.18 |
| SE | 3.5 | 2.4 | 0.06 |
| Latvia | 479.8 | 91.4 | -0.24 |
| SE | 3.8 | 1.8 | 0.05 |
| Liechtenstein | 509.8 | 97.3 | -0.30 |
| SE | 3.7 | 3.3 | 0.12 |
| Lithuania | 469.6 | 95.4 | -0.21 |
| SE | 2.9 | 1.5 | 0.05 |
| Macao-China | 491.9 | 76.9 | -0.40 |
| SE | 1.0 | 0.9 | 0.03 |
| **Qatar** | **311.9** | **108.3** | **0.41** |
| **SE** | **1.0** | **0.9** | **0.03** |
| Romania | 396.1 | 91.4 | -0.12 |
| SE | 4.5 | 2.8 | 0.06 |
| Russian Federation | 439.8 | 93.7 | -0.22 |
| SE | 4.3 | 1.9 | 0.04 |
| Serbia and/or Montenegro | 400.4 | 91.7 | -0.20 |
| SE | 3.1 | 1.5 | 0.05 |
| Slovenia | 494.6 | 88.1 | -0.39 |
| SE | 0.9 | 0.8 | 0.03 |
| Thailand | 417.5 | 81.9 | -0.15 |
| SE | 2.5 | 1.6 | 0.06 |
| Tunisia | 379.9 | 97.1 | -0.27 |
| SE | 4.1 | 2.6 | 0.09 |
| Uruguay | 412.2 | 121.7 | -0.26 |
| SE | 3.4 | 2.1 | 0.05 |

N/A: not available
SE: Standard error
Source: OECD PISA 2006.

## Table 1.2

## Distribution of mathematics scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Australia | 519.7 | 88.2 | -0.06 |
| SE | 2.2 | 1.1 | 0.03 |
| Austria | 505.3 | 97.3 | -0.22 |
| SE | 3.7 | 2.3 | 0.07 |
| Belgium | 519.9 | 106.1 | -0.43 |
| SE | 3 | 3.5 | 0.13 |
| Canada | 526.9 | 85.1 | -0.15 |
| SE | 1.9 | 1.0 | 0.03 |
| Czech Republic | 510.3 | 103.3 | -0.1 |
| SE | 3.5 | 2..0 | 0.04 |
| Denmark | 513 | 84.7 | -0.1 |
| SE | 2.5 | 1.4 | 0.05 |
| Finland | 549.3 | 80.8 | -0.11 |
| SE | 2.1 | 0.9 | 0.03 |
| France | 496.1 | 95.6 | -0.13 |
| SE | 3.1 | 1.9 | 0.05 |
| Germany | 503 | 98.9 | -0.16 |
| SE | 3.9 | 2.6 | 0.07 |
| Greece | 459.1 | 93.1 | -0.23 |
| SE | 3.0 | 2.3 | 0.09 |
| Hungary | 491.6 | 91.1 | -0.06 |
| SE | 2.7 | 1.8 | 0.07 |
| Iceland | 505 | 88.3 | -0.15 |
| SE | 1.4 | 1.1 | 0.03 |
| Ireland | 501 | 82.1 | -0.09 |
| SE | 2.6 | 1.4 | 0.04 |
| Italy | 461.6 | 96.4 | -0.12 |
| SE | 2.3 | 1.7 | 0.07 |
| Japan | 523.3 | 90.5 | -0.17 |
| SE | 3.4 | 2.0 | 0.05 |
| Korea | 547.1 | 92.3 | -0.18 |
| SE | 3.7 | 3.2 | 0.08 |
| Luxembourg | 490 | 93.3 | -0.09 |
| SE | 0.9 | 0.7 | 0.03 |
| Mexico | 405.9 | 85.0 | -0.11 |
| SE | 2.7 | 2.0 | 0.08 |
| Netherlands | 530.7 | 88.6 | -0.09 |
| SE | 2.4 | 2.1 | 0.07 |
| New Zealand | 521.3 | 93.1 | -0.04 |
| SE | 2.3 | 1.1 | 0.03 |
| Norway | 490 | 92.1 | -0.12 |
| SE | 2.5 | 1.3 | 0.03 |
| Poland | 494.8 | 86.2 | 0.03 |
| SE | 2.4 | 1.1 | 0.03 |
| Portugal | 465.2 | 90.9 | -0.12 |
| SE | 2.9 | 1.9 | 0.07 |
| Slovak Republic | 491.8 | 94.3 | -0.28 |
| SE | 2.6 | 2.3 | 0.10 |
| Spain | 479.7 | 88.5 | -0.21 |
| SE | 2.2 | 1.0 | 0.05 |
| Sweden | 502.6 | 88.9 | -0.09 |
| SE | 2.2 | 1.1 | 0.04 |
| Switzerland | 528.3 | 97.1 | -0.20 |
| SE | 3.0 | 1.5 | 0.04 |

## Table 1.2 (continued)

## Distribution of mathematics scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Turkey | 423.8 | 92.5 | 0.49 |
| SE | 4.8 | 4.2 | 0.10 |
| United Kingdom | 495.9 | 88.5 | 0.00 |
| SE | 2.1 | 1.4 | 0.05 |
| United States | 474.7 | 90.2 | 0.06 |
| SE | 4 | 2 | 0.04 |
| **OECD** | **483.7** | **98.1** | **-0.04** |
| **SE** | **1.1** | **0.7** | **0.02** |
| Azerbaijan | 475.9 | 47.6 | 0.64 |
| SE | 2.2 | 1.5 | 0.19 |
| Argentina | 382.6 | 101.2 | -0.16 |
| SE | 6.2 | 3.4 | 0.80 |
| Brazil | 369.6 | 91.3 | 0.31 |
| SE | 2.9 | 2.5 | 0.08 |
| Bulgaria | 413.4 | 100.8 | 0.03 |
| SE | 6.1 | 3.8 | 0.12 |
| Chile | 411.6 | 87.8 | 0.09 |
| SE | 4.6 | 1.9 | 0.07 |
| Chine Taipei | 550.0 | 103 | -0.25 |
| SE | 4.0 | 2.2 | 0.05 |
| Colombia | 369.4 | 88 | 0.03 |
| SE | 3.6 | 2.4 | 0.07 |
| Croatia | 467.2 | 83.3 | 0.01 |
| SE | 2.3 | 1.4 | 0.04 |
| Estonia | 514.9 | 80.3 | -0.08 |
| SE | 2.7 | 1.4 | 0.05 |
| Hong Kong-China | 547.7 | 93.4 | -0.27 |
| SE | 2.6 | 2.1 | 0.05 |
| Indonesia | 391.5 | 79.8 | 0.17 |
| SE | 5.6 | 3.2 | 0.07 |
| Israel | 441.6 | 106.7 | -0.09 |
| SE | 4.3 | 3.3 | 0.11 |
| Jordan | 383.8 | 83.4 | -0.21 |
| SE | 3.2 | 2 | 0.05 |
| Kyrgyzstan | 310.6 | 86.4 | 0.28 |
| SE | 3.4 | 1.9 | 0.05 |
| Latvia | 486.1 | 82 | -0.15 |
| SE | 2.9 | 1.3 | 0.06 |
| Liechtenstein | 525 | 91.4 | -0.1 |
| SE | 3.2 | 2.7 | 0.12 |
| Lithuania | 486.1 | 89.2 | -0.1 |
| SE | 2.7 | 1.6 | 0.04 |
| Macao-China | 524 | 84.8 | -0.09 |
| SE | 1.1 | 0.8 | 0.03 |
| **Qatar** | **318.2** | **90.7** | **0.66** |
| **SE** | **0.8** | **0.7** | **0.03** |
| Romania | 414.5 | 83.6 | 0.08 |
| SE | 3.9 | 2.7 | 0.07 |
| Russian Federation | 475.6 | 88.7 | 0.06 |
| SE | 3.8 | 1.3 | 0.03 |
| Serbia and/or Montenegro | 431.4 | 92.1 | -0.06 |
| SE | 3.1 | 1.5 | 0.04 |
| Slovenia | 504.6 | 89.1 | 0.05 |
| SE | 0.9 | 0.8 | 0.03 |

## Table 1.2 (concluded)

## Distribution of mathematics scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Thailand | 416.1 | 82 | 0.12 |
| SE | 2.3 | 1.5 | 0.05 |
| Tunisia | 364.7 | 91.8 | 0.12 |
| SE | 3.9 | 2.3 | 0.06 |
| Uruguay | 425.8 | 98 | -0.12 |
| SE | 2.5 | 1.5 | 0.05 |

SE: Standard error

Source: OECD PISA 2006.

## Table 1.3

## Distribution of science scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Australia | 526.5 | 100.2 | -0.18 |
| SE | 2.2 | 0.9 | 0.02 |
| Austria | 510.9 | 97.2 | -0.21 |
| SE | 4.0 | 2.4 | 0.05 |
| Belgium | 510.1 | 99.4 | -0.35 |
| SE | 2.5 | 2.0 | 0.04 |
| Canada | 534.5 | 93.9 | -0.22 |
| SE | 2.0 | 1.1 | 0.03 |
| Czech Republic | 513.3 | 98.5 | -0.08 |
| SE | 3.4 | 2.0 | 0.05 |
| Denmark | 496 | 92.6 | -0.07 |
| SE | 3.0 | 1.4 | 0.04 |
| Finland | 563.8 | 85.9 | -0.13 |
| SE | 2.0 | 0.9 | 0.04 |
| France | 495.2 | 101.9 | -0.21 |
| SE | 3.3 | 2 | 0.05 |
| Germany | 515.3 | 100 | -0.19 |
| SE | 3.8 | 1.9 | 0.04 |
| Greece | 473.6 | 92.8 | -0.25 |
| SE | 3.2 | 2.0 | 0.07 |
| Hungary | 504.2 | 88.5 | -0.08 |
| SE | 2.6 | 1.4 | 0.04 |
| Iceland | 490.6 | 96.7 | -0.15 |
| SE | 1.5 | 1.1 | 0.04 |
| Ireland | 508.1 | 94.9 | -0.12 |
| SE | 3.1 | 1.4 | 0.04 |
| Italy | 475.2 | 95.7 | -0.09 |
| SE | 2.0 | 1.4 | 0.05 |
| Japan | 531.6 | 99.5 | -0.35 |
| SE | 3.4 | 2 | 0.05 |
| Korea | 522 | 90.3 | -0.24 |
| SE | 3.4 | 2.4 | 0.04 |
| Luxembourg | 486.4 | 97.1 | -0.16 |
| SE | 1.1 | 0.9 | 0.03 |
| Mexico | 409.6 | 80.7 | 0.09 |
| SE | 2.6 | 1.5 | 0.04 |
| Netherlands | 524.5 | 95.5 | -0.16 |
| SE | 2.7 | 1.6 | 0.04 |
| New Zealand | 529.9 | 107.4 | -0.14 |
| SE | 2.7 | 1.3 | 0.03 |

## Table 1.3 (continued)

## Distribution of science scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Norway | 486.2 | 96.7 | -0.12 |
| SE | 3.1 | 1.8 | 0.04 |
| Poland | 497.5 | 90.0 | 0.01 |
| SE | 2.3 | 1.1 | 0.03 |
| Portugal | 474 | 88.5 | -0.08 |
| SE | 3.0 | 1.6 | 0.04 |
| Slovak Republic | 488.3 | 93.4 | -0.09 |
| SE | 2.5 | 1.7 | 0.06 |
| Spain | 488.5 | 90.3 | -0.16 |
| SE | 2.5 | 0.8 | 0.04 |
| Sweden | 503.5 | 93.9 | -0.14 |
| SE | 2.2 | 1.3 | 0.04 |
| Switzerland | 510.5 | 98.8 | -0.24 |
| SE | 3.0 | 1.6 | 0.04 |
| Turkey | 424 | 83.4 | 0.37 |
| SE | 3.8 | 3.1 | 0.08 |
| United Kingdom | 514.7 | 106.9 | -0.14 |
| SE | 2.2 | 1.5 | 0.05 |
| United States | 488.7 | 106.2 | 0.01 |
| SE | 4.2 | 1.7 | 0.03 |
| **OECD** | **490.7** | **104.2** | **-0.03** |
| **SE** | **1.2** | **0.6** | **0.01** |
| Azerbaijan | 382.5 | 55.5 | 0.52 |
| SE | 2.7 | 1.9 | 0.06 |
| Argentina | 391.8 | 101.1 | -0.15 |
| SE | 6.1 | 2.5 | 0.06 |
| Brazil | 390.5 | 89.9 | 0.27 |
| SE | 2.8 | 1.9 | 0.06 |
| Bulgaria | 434.7 | 106.7 | 0.11 |
| SE | 6 | 3.2 | 0.07 |
| Chile | 437.4 | 91.7 | 0.10 |
| SE | 4.3 | 1.6 | 0.07 |
| Chine Taipei | 532.8 | 94.7 | -0.24 |
| SE | 3.6 | 1.6 | 0.04 |
| Colombia | 386.5 | 85.2 | -0.09 |
| SE | 3.3 | 1.9 | 0.06 |
| Croatia | 492.7 | 85.7 | 0.00 |
| SE | 2.3 | 1.3 | 0.04 |
| Estonia | 532 | 83.7 | -0.06 |
| SE | 2.4 | 1.0 | 0.03 |
| Hong Kong-China | 542.3 | 91.9 | -0.34 |
| SE | 2.5 | 1.8 | 0.05 |
| Indonesia | 393.3 | 69.4 | 0.26 |
| SE | 5.5 | 2.7 | 0.07 |
| Israel | 453.6 | 110.7 | 0.03 |
| SE | 3.7 | 1.8 | 0.04 |
| Jordan | 421.8 | 89.9 | -0.13 |
| SE | 2.9 | 1.8 | 0.06 |
| Kyrgyzstan | 322.1 | 84.2 | 0.25 |
| SE | 2.9 | 2.0. | 0.08 |
| Latvia | 489.6 | 84.5 | -0.09 |
| SE | 3.1 | 1.4 | 0.05 |
| Liechtenstein | 521.7 | 95.7 | -0.11 |
| SE | 3.7 | 3.0 | 0.12 |

## Table 1.3 (concluded)

## Distribution of science scores among countries

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Lithuania | 488.1 | 89.8 | -0.05 |
| SE | 2.6 | 1.6 | 0.04 |
| Macao-China | 510.6 | 78 | -0.13 |
| SE | 1.1 | 0.7 | 0.03 |
| **Qatar** | **349.3** | **82.9** | **0.66** |
| **SE** | **0.8** | **0.6** | **0.03** |
| Romania | 418 | 80.4 | 0.14 |
| SE | 4.0 | 2.4 | 0.06 |
| Russian Federation | 479.3 | 89.5 | 0.04 |
| SE | 3.6 | 1.2 | 0.03 |
| Serbia and/or Montenegro | 433.3 | 85.2 | -0.02 |
| SE | 2.8 | 1.4 | 0.05 |
| Slovenia | 518.8 | 97.7 | -0.01 |
| SE | 1.1 | 1 | 0.03 |
| Thailand | 421.1 | 77.4 | 0.17 |
| SE | 2.0 | 1.4 | 0.04 |
| Tunisia | 385.6 | 82.3 | 0.17 |
| SE | 3.1 | 2.1 | 0.06 |
| Uruguay | 428.6 | 93.9 | 0.01 |
| SE | 2.7 | 1.6 | 0.05 |

SE: Standard error

Source: OECD PISA 2006.

## Table 1.4
## Percentiles for reading performance

| | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| Australia | 388.4 | 453.1 | 518.6 | 578.9 | 628.5 |
| Austria | 347.7 | 420.7 | 499.2 | 568.1 | 621.3 |
| Belgium | 347.4 | 432.7 | 514.6 | 580.7 | 630.9 |
| Canada | 401.5 | 467.9 | 534.0 | 593.2 | 644.0 |
| Czech Rep | 335.2 | 407.9 | 488.7 | 563.6 | 621.4 |
| Denmark | 378.3 | 437.5 | 498.7 | 556.7 | 604.4 |
| Finland | 440.7 | 494.0 | 550.0 | 603.0 | 648.6 |
| France | 345.9 | 420.8 | 499.2 | 563.8 | 613.6 |
| Germany | 349.5 | 428.7 | 507.8 | 572.6 | 625.0 |
| Greece | 321.4 | 397.9 | 469.5 | 530.8 | 582.9 |
| Hungary | 358.9 | 422.4 | 490.2 | 549.1 | 595.5 |
| Iceland | 355.4 | 423.3 | 491.4 | 552.3 | 602.7 |
| Ireland | 395.3 | 456.9 | 521.8 | 582.0 | 632.7 |
| Italy | 324.5 | 402.3 | 478.0 | 546.2 | 598.9 |
| Japan | 360.7 | 433.0 | 505.3 | 569.0 | 623.0 |
| Korea | 440.2 | 502.8 | 562.8 | 617.4 | 662.8 |
| Luxembourg | 344.4 | 415.4 | 487.4 | 551.8 | 601.8 |
| Mexico | 284.9 | 348.0 | 414.9 | 477.9 | 529.8 |
| Netherlands | 378.8 | 446.1 | 515.1 | 577.9 | 622.2 |
| New Zealand | 380.8 | 453.0 | 528.0 | 594.9 | 650.8 |
| Norway | 345.7 | 416.4 | 491.7 | 558.1 | 613.5 |
| Poland | 373.9 | 441.0 | 512.5 | 579.1 | 633.2 |
| Portugal | 339.3 | 407.6 | 479.4 | 543.1 | 593.9 |

## Table 1.4 (concluded)
## Percentiles for reading performance

| | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| Slovak Republic | 326.2 | 397.7 | 472.7 | 541.7 | 596.8 |
| Spain | 343.1 | 405.3 | 467.8 | 522.9 | 569.2 |
| Sweden | 378.4 | 445.2 | 512.9 | 575.4 | 628.7 |
| Switzerland | 373.4 | 439.7 | 505.5 | 566.1 | 615.1 |
| Turkey | 329.5 | 388.2 | 449.9 | 510.0 | 563.8 |
| United Kingdom | 358.8 | 430.6 | 501.1 | 565.8 | 620.7 |
| **OECD** | **354.7** | **426.1** | **499.1** | **564.9** | **618.3** |
| Azerbaijan | 266.1 | 305.3 | 349.8 | 397.1 | 441.6 |
| Argentina | 209.2 | 291.4 | 383.1 | 463.8 | 526.5 |
| Brazil | 263.6 | 325.8 | 393.7 | 460.2 | 522.6 |
| Bulgaria | 250.7 | 320.5 | 404.0 | 485.9 | 553.6 |
| Chile | 309.7 | 373.0 | 442.6 | 512.7 | 574.8 |
| Chine Taipei | 381.4 | 441.8 | 503.8 | 555.9 | 598.4 |
| Colombia | 242.5 | 315.5 | 391.7 | 461.8 | 518.1 |
| Croatia | 359.4 | 418.0 | 482.4 | 540.4 | 588.7 |
| Estonia | 389.0 | 447.6 | 505.1 | 559.9 | 606.5 |
| Hong Kong-China | 426.2 | 484.2 | 542.6 | 593.9 | 635.9 |
| Indonesia | 298.1 | 342.4 | 391.6 | 443.6 | 490.3 |
| Israel | 279.8 | 355.6 | 445.3 | 525.6 | 587.8 |
| Jordan | 276.9 | 342.2 | 408.5 | 466.5 | 514.1 |
| Kyrgyzstan | 158.5 | 215.9 | 281.3 | 349.3 | 418.6 |
| Latvia | 360.9 | 418.9 | 482.7 | 542.9 | 592.9 |
| Liechtenstein | 379.6 | 451.7 | 518.1 | 577.8 | 624.4 |
| Lithuania | 342.6 | 405.0 | 474.0 | 537.9 | 590.7 |
| Machao-China | 393.6 | 444.8 | 496.4 | 544.8 | 586.8 |
| **Qatar** | **181.1** | **236.5** | **302.8** | **380.3** | **456.0** |
| Romania | 273.9 | 332.7 | 398.8 | 461.2 | 512.2 |
| Russian Federation | 316.3 | 376.9 | 445.3 | 505.1 | 555.9 |
| Serbia and/or Montenegro | 281.5 | 338.5 | 402.7 | 465.1 | 517.1 |
| Slovenia | 376.6 | 437.2 | 500.8 | 558.5 | 603.5 |
| Thailand | 312.2 | 362.6 | 418.4 | 472.5 | 522.3 |
| Tunisia | 252.4 | 314.7 | 385.0 | 449.7 | 502.3 |
| Uruguay | 253.0 | 333.2 | 418.0 | 497.3 | 564.9 |

## Table 1.5
## Percentiles for mathematics performance

| | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| Australia | 406.4 | 460.0 | 520.8 | 580.7 | 633.0 |
| Austria | 372.7 | 437.5 | 510.5 | 576.6 | 629.6 |
| Belgium | 380.5 | 450.6 | 528.1 | 598.4 | 650.5 |
| Canada | 415.6 | 470.3 | 529.2 | 586.7 | 635.2 |
| Czech Republic | 376.2 | 440.6 | 509.7 | 582.2 | 643.7 |
| Denmark | 404.1 | 456.3 | 514.2 | 571.6 | 621.5 |
| Finland | 443.8 | 493.8 | 550.2 | 605.2 | 651.8 |
| France | 368.5 | 429.2 | 499.1 | 564.8 | 617.3 |
| Germany | 374.9 | 437.3 | 505.1 | 573.6 | 632.2 |
| Greece | 340.9 | 399.0 | 461.3 | 521.6 | 575.4 |
| Hungary | 376.9 | 430.7 | 490.1 | 550.5 | 608.6 |
| Iceland | 391.0 | 446.0 | 506.9 | 567.3 | 617.9 |
| Ireland | 396.1 | 445.0 | 502.7 | 559.0 | 607.7 |
| Italy | 341.2 | 398.2 | 462.0 | 527.2 | 583.7 |
| Japan | 403.9 | 462.7 | 525.7 | 587.1 | 637.6 |
| Korea | 426.3 | 485.3 | 550.4 | 612.3 | 664.1 |
| Luxembourg | 368.3 | 426.5 | 492.1 | 555.2 | 609.5 |
| Mexico | 298.7 | 349.0 | 405.9 | 463.0 | 514.1 |
| Netherlands | 412.1 | 466.8 | 533.5 | 595.9 | 644.6 |
| New Zealand | 400.6 | 458.0 | 522.4 | 587.3 | 643.1 |
| Norway | 373.1 | 428.2 | 490.3 | 552.5 | 608.6 |
| Poland | 383.6 | 434.7 | 494.5 | 556.7 | 609.8 |
| Portugal | 348.4 | 404.0 | 468.0 | 529.8 | 582.6 |
| Slovak Republic | 370.5 | 432.6 | 494.2 | 557.7 | 611.5 |
| Spain | 366.0 | 420.8 | 482.4 | 541.9 | 592.6 |
| Sweden | 386.6 | 441.9 | 502.5 | 565.0 | 617.2 |
| Switzerland | 401.2 | 464.4 | 533.7 | 600.0 | 651.6 |
| Turkey | 316.0 | 359.9 | 415.0 | 477.3 | 550.1 |
| United Kingdom | 381.2 | 434.5 | 494.4 | 556.5 | 612.1 |
| United States | 358.1 | 411.2 | 472.4 | 537.3 | 592.7 |
| **OECD** | **371.9** | **431.8** | **499.2** | **565.8** | **622.1** |
| Azerbaijan | 418.6 | 443.3 | 472.9 | 505.1 | 535.6 |
| Argentina | 248.8 | 315.6 | 385.1 | 450.6 | 508.1 |
| Brazil | 255.4 | 307.6 | 365.3 | 426.9 | 487.0 |
| Bulgaria | 287.3 | 345.4 | 412.1 | 481.4 | 542.8 |
| Chile | 302.2 | 350.2 | 407.9 | 470.1 | 527.0 |
| Chine Taipei | 409.1 | 477.2 | 556.9 | 625.2 | 677.5 |
| Colombia | 257.5 | 311.3 | 369.2 | 428.3 | 481.8 |
| Croatia | 360.9 | 410.5 | 466.4 | 524.3 | 575.6 |
| Estonia | 411.0 | 461.0 | 515.6 | 570.3 | 617.7 |
| Hong Kong-China | 422.9 | 486.1 | 551.7 | 614.1 | 665.0 |
| Indonesia | 292.7 | 336.3 | 387.2 | 443.5 | 498.2 |
| Israel | 304.1 | 368.3 | 441.8 | 517.8 | 580.6 |
| Jordan | 278.6 | 329.7 | 385.6 | 441.2 | 489.5 |
| Kyrgyzstan | 204.3 | 252.5 | 305.9 | 363.5 | 423.5 |
| Latvia | 378.4 | 431.8 | 488.7 | 542.0 | 590.3 |

## Table 1.5 (concluded)
## Percentiles for mathematics performance

| | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| Liechtenstein | 401.7 | 464.5 | 525.9 | 588.2 | 643.4 |
| Lithuania | 369.2 | 425.9 | 486.8 | 549.3 | 602.1 |
| Machao-China | 415.5 | 466.8 | 526.3 | 584.9 | 632.2 |
| **Qatar** | **212.4** | **257.0** | **307.8** | **367.7** | **437.9** |
| Romania | 307.1 | 358.4 | 414.0 | 470.4 | 522.8 |
| Russian Federation | 362.6 | 415.6 | 474.3 | 534.9 | 591.9 |
| Serbia and/or Montenegro | 314.9 | 370.7 | 433.1 | 494.4 | 550.1 |
| Slovenia | 390.4 | 441.1 | 502.6 | 566.3 | 623.3 |
| Thailand | 317.4 | 362.2 | 413.9 | 469.7 | 523.8 |
| Tunisia | 250.0 | 301.3 | 361.3 | 427.3 | 488.0 |
| Uruguay | 296.3 | 359.8 | 430.0 | 495.4 | 551.2 |

## Table 1.6
## Percentiles for science performance

| | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| Australia | 394.5 | 459.4 | 530.4 | 597.7 | 653.2 |
| Austria | 378.1 | 443.1 | 516.4 | 582.3 | 633.4 |
| Belgium | 373.7 | 442.2 | 518.3 | 584.5 | 633.8 |
| Canada | 409.6 | 471.9 | 539.8 | 600.9 | 651.1 |
| Czech Republic | 384.6 | 442.8 | 514.5 | 582.8 | 640.8 |
| Denmark | 373.2 | 432.3 | 497.9 | 562.1 | 615.5 |
| Finland | 452.6 | 506.3 | 565.6 | 622.0 | 672.8 |
| France | 359.2 | 423.9 | 501.2 | 569.6 | 623.4 |
| Germany | 380.7 | 446.6 | 520.6 | 587.4 | 641.7 |
| Greece | 353.1 | 412.9 | 477.1 | 537.2 | 588.7 |
| Hungary | 388.4 | 442.4 | 505.8 | 566.0 | 617.1 |
| Iceland | 364.3 | 423.8 | 493.4 | 559.8 | 614.4 |
| Ireland | 385.3 | 443.6 | 509.7 | 575.2 | 630.3 |
| Italy | 351.5 | 408.9 | 477.1 | 542.6 | 598.5 |
| Japan | 396.4 | 465.3 | 538.6 | 602.7 | 654.6 |
| Korea | 403.2 | 462.5 | 526.2 | 586.5 | 635.0 |
| Luxembourg | 357.9 | 418.9 | 490.4 | 556.0 | 609.0 |
| Mexico | 306.0 | 353.8 | 407.5 | 464.9 | 516.0 |
| Netherlands | 394.6 | 455.9 | 530.0 | 596.1 | 646.2 |
| New Zealand | 389.1 | 455.4 | 534.0 | 608.5 | 667.1 |
| Norway | 364.8 | 421.7 | 488.1 | 553.5 | 610.5 |
| Poland | 380.9 | 434.1 | 497.5 | 561.7 | 614.8 |
| Portugal | 357.4 | 411.2 | 476.2 | 538.6 | 588.4 |
| Slovak Republic | 367.6 | 425.5 | 488.7 | 554.6 | 609.5 |
| Spain | 370.0 | 426.7 | 491.2 | 552.0 | 603.6 |
| Sweden | 381.0 | 438.8 | 505.2 | 569.4 | 622.4 |
| Switzerland | 378.3 | 445.2 | 516.5 | 583.7 | 635.6 |
| Turkey | 324.9 | 366.3 | 415.8 | 475.3 | 539.9 |
| United Kingdom | 375.6 | 440.9 | 517.6 | 590.5 | 651.9 |

## Table 1.6 (concluded)
## Percentiles for science performance

| | 10 | 25 | 50 | 75 | 90 |
|---|---|---|---|---|---|
| United States | 349.4 | 411.6 | 488.3 | 566.9 | 628.2 |
| **OECD** | **368.4** | **429.9** | **502.5** | **571.7** | **628.3** |
| Azerbaijan | 316.3 | 344.0 | 377.5 | 414.2 | 456.3 |
| Argentina | 258.9 | 324.4 | 394.0 | 461.5 | 519.7 |
| Brazil | 281.1 | 327.7 | 384.3 | 447.2 | 509.7 |
| Bulgaria | 299.6 | 357.7 | 430.4 | 509.4 | 576.6 |
| Chile | 322.5 | 373.8 | 433.7 | 500.9 | 560.5 |
| Chine Taipei | 401.6 | 466.3 | 539.6 | 602.3 | 650.6 |
| Colombia | 279.5 | 331.7 | 388.9 | 444.9 | 495.8 |
| Croatia | 383.2 | 433.2 | 492.9 | 552.9 | 604.5 |
| Estonia | 422.3 | 474.2 | 532.8 | 588.8 | 639.7 |
| Hong Kong-China | 418.0 | 481.9 | 549.1 | 608.7 | 655.1 |
| Indonesia | 307.5 | 344.5 | 389.1 | 438.1 | 488.4 |
| Israel | 309.8 | 374.1 | 452.0 | 534.6 | 601.1 |
| Jordan | 309.5 | 362.0 | 422.8 | 484.1 | 536.8 |
| Kyrgyzstan | 220.4 | 267.0 | 319.6 | 371.9 | 427.6 |
| Latvia | 379.7 | 432.5 | 491.2 | 547.2 | 596.6 |
| Liechtenstein | 392.7 | 456.7 | 522.7 | 591.5 | 643.9 |
| Lithuania | 370.0 | 424.8 | 489.6 | 551.3 | 604.3 |
| Machao-China | 408.4 | 457.7 | 513.2 | 566.1 | 610.5 |
| **Qatar** | **252.5** | **292.4** | **339.1** | **395.9** | **461.8** |
| Romania | 314.2 | 360.8 | 416.0 | 472.9 | 526.3 |
| Russian Federation | 364.4 | 417.9 | 478.8 | 540.9 | 596.4 |
| Serbia and/or Montenegro | 325.1 | 374.2 | 432.5 | 492.5 | 542.9 |
| Slovenia | 390.5 | 448.7 | 519.0 | 588.6 | 647.4 |
| Thailand | 325.4 | 368.4 | 416.9 | 471.3 | 524.3 |
| Tunisia | 282.5 | 328.2 | 382.9 | 440.0 | 495.2 |
| Uruguay | 306.0 | 363.5 | 428.3 | 492.8 | 549.7 |

## Table 1.7

## Percentage scoring at each proficiency level of reading performance

| | Below Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|---|---|
| Australia | 3.8 | 9.5 | 21.0 | 29.8 | 25.3 | 9.2 | 1.3 |
| Austria | 8.4 | 13.0 | 21.9 | 26.0 | 21.6 | 7.8 | 1.2 |
| Belgium | 8.6 | 10.7 | 18.9 | 25.8 | 24.8 | 9.9 | 1.3 |
| Canada | 3.4 | 7.5 | 17.9 | 29.1 | 27.6 | 12.0 | 2.4 |
| Czech Republic | 9.9 | 14.7 | 22.3 | 24.4 | 19.6 | 7.7 | 1.4 |
| Denmark | 4.6 | 11.4 | 25.6 | 31.7 | 21.0 | 5.3 | 0.6 |
| Finland | .8 | 3.9 | 15.5 | 30.9 | 32.3 | 14.3 | 2.3 |
| France | 8.5 | 13.1 | 21.3 | 27.7 | 22.2 | 6.7 | 0.5 |
| Germany | 8.3 | 11.7 | 20.3 | 27.0 | 22.9 | 8.2 | 1.5 |
| Greece | 12.0 | 15.6 | 26.6 | 27.9 | 14.5 | 3.2 | 0.3 |
| Hungary | 6.6 | 13.9 | 25.3 | 30.4 | 19.2 | 4.3 | 0.3 |
| Iceland | 7.1 | 13.2 | 25.2 | 29.3 | 19.2 | 5.4 | 0.5 |
| Ireland | 3.2 | 8.8 | 20.9 | 30.0 | 25.5 | 10.1 | 1.5 |
| Italy | 11.5 | 14.8 | 24.5 | 26.3 | 17.8 | 4.6 | 0.5 |
| Japan | 6.7 | 11.6 | 22.0 | 28.4 | 21.9 | 7.9 | 1.4 |
| Korea | 1.4 | 4.3 | 12.5 | 26.8 | 33.3 | 18.2 | 3.5 |
| Luxembourg | 8.6 | 14.1 | 24.6 | 27.7 | 19.3 | 5.2 | 0.4 |
| Mexico | 21.1 | 25.7 | 28.9 | 18.3 | 5.4 | 0.5 | 0.0 |
| Netherlands | 5.2 | 9.8 | 21.2 | 28.8 | 26.0 | 8.3 | 0.7 |
| New Zealand | 4.7 | 9.8 | 18.6 | 26.3 | 24.8 | 12.6 | 3.2 |
| Norway | 8.5 | 13.9 | 23.2 | 27.4 | 19.3 | 6.7 | 0.9 |
| Poland | 5.0 | 11.1 | 21.5 | 27.3 | 23.5 | 9.8 | 1.8 |
| Portugal | 9.3 | 15.5 | 25.5 | 27.9 | 17.1 | 4.3 | 0.3 |
| Slovak Republic | 11.2 | 16.5 | 25.1 | 25.8 | 16.1 | 4.9 | 0.5 |
| Spain | 8.7 | 16.8 | 30.1 | 29.7 | 12.9 | 1.7 | 0.1 |
| Sweden | 5.0 | 10.2 | 21.9 | 28.7 | 23.6 | 9.0 | 1.6 |
| Switzerland | 5.4 | 11.0 | 22.9 | 30.2 | 22.9 | 7.0 | 0.6 |
| Turkey | 10.8 | 21.2 | 31.0 | 24.4 | 10.5 | 2.0 | 0.1 |
| United Kingdom | 6.8 | 12.1 | 22.7 | 28.5 | 20.9 | 7.6 | 1.3 |
| **OECD** | **7.4** | **12.6** | **22.7** | **27.7** | **21.1** | **7.4** | **1.1** |
| Azerbaijan | 41.3 | 37.9 | 16.6 | 3.4 | 0.6 | 0.1 | 0.0 |
| Argentina | 35.9 | 21.8 | 21.9 | 14.2 | 5.3 | 0.8 | 0.1 |
| Brazil | 27.9 | 27.4 | 25.3 | 13.4 | 4.9 | 1.0 | 0.1 |
| Bulgaria | 28.9 | 22.0 | 22.4 | 16.3 | 8.3 | 1.8 | 0.2 |
| Chile | 14.9 | 21.3 | 28.0 | 21.1 | 11.2 | 3.1 | 0.4 |
| Chine Taipei | 3.8 | 11.4 | 24.3 | 33.7 | 22.0 | 4.4 | 0.3 |
| Colombia | 30.6 | 24.9 | 25.3 | 14.4 | 4.2 | 0.6 | 0.0 |
| Croatia | 6.2 | 15.2 | 27.5 | 30.6 | 16.8 | 3.5 | 0.2 |
| Estonia | 3.4 | 10.2 | 24.4 | 33.8 | 22.2 | 5.7 | 0.3 |
| Hong Kong-China | 1.3 | 5.8 | 16.5 | 31.1 | 32.5 | 11.7 | 1.1 |
| Indonesia | 21.9 | 36.2 | 29.1 | 11.2 | 1.5 | 0.1 | 0.0 |
| Israel | 20.3 | 18.5 | 22.3 | 20.9 | 12.9 | 4.3 | 0.7 |
| Jordan | 22.8 | 26.6 | 30.6 | 16.5 | 3.3 | 0.2 | 0.0 |
| Kyrgyzstan | 70.6 | 17.5 | 8.2 | 3.0 | 0.6 | 0.1 | 0.0 |
| Latvia | 6.0 | 15.1 | 27.5 | 29.8 | 17.1 | 4.1 | 0.4 |

## Table 1.7 (concluded)

### Percentage scoring at each proficiency level of reading performance

| | Below Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|---|---|
| Liechtenstein | 4.9 | 9.4 | 19.8 | 31.3 | 24.9 | 8.3 | 1.5 |
| Lithuania | 8.7 | 16.8 | 26.9 | 27.4 | 15.8 | 4.1 | 0.3 |
| Macao-China | 2.9 | 10.0 | 28.8 | 36.5 | 18.9 | 2.9 | 0.1 |
| **Qatar** | **61.3** | **20.2** | **11.3** | **4.9** | **1.8** | **0.5** | **0.1** |
| Romania | 25.7 | 27.7 | 27.9 | 15.1 | 3.3 | 0.2 | 0.1 |
| Russian Federation | 13.6 | 21.5 | 30.0 | 23.9 | 9.3 | 1.6 | 0.1 |
| Serbia and/or Montenegro | 23.9 | 28.1 | 28.0 | 15.9 | 3.8 | 0.3 | 0.0 |
| Slovenia | 4.5 | 12.0 | 24.7 | 31.4 | 22.2 | 5.0 | 0.2 |
| Thailand | 15.6 | 28.8 | 33.5 | 17.5 | 4.3 | 0.3 | 0.0 |
| Tunisia | 31.6 | 27.3 | 25.6 | 12.7 | 2.7 | 0.2 | 0.0 |
| Uruguay | 25.4 | 21.1 | 23.4 | 18.0 | 9.0 | 2.6 | 0.5 |

## Table 1.8

### Percentage scoring at each proficiency level of mathematics performance

| | Below Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|---|---|
| Australia | 3.3 | 9.8 | 20.5 | 26.8 | 23.1 | 12.1 | 4.3 |
| Austria | 7.5 | 12.7 | 19.5 | 23.2 | 21.3 | 12.3 | 3.5 |
| Belgium | 7.2 | 10.3 | 16.9 | 21.3 | 21.8 | 15.9 | 6.4 |
| Canada | 2.8 | 8.1 | 18.6 | 27.4 | 25.1 | 13.6 | 4.4 |
| Czech Republic | 7.3 | 12.1 | 20.4 | 22.8 | 19.1 | 12.3 | 6.0 |
| Denmark | 3.6 | 10.1 | 21.4 | 28.6 | 22.4 | 10.9 | 2.9 |
| Finland | 1.2 | 4.9 | 14.4 | 27.0 | 28.0 | 18.1 | 6.4 |
| France | 8.4 | 14.0 | 21.3 | 24.1 | 19.6 | 9.9 | 2.6 |
| Germany | 7.4 | 12.6 | 21.2 | 23.9 | 19.4 | 11.0 | 4.5 |
| Greece | 13.4 | 19.2 | 26.7 | 23.0 | 12.6 | 4.2 | 0.9 |
| Hungary | 6.7 | 14.6 | 25.1 | 26.3 | 16.9 | 7.7 | 2.6 |
| Iceland | 5.2 | 11.8 | 22.3 | 26.4 | 21.7 | 10.1 | 2.5 |
| Ireland | 4.1 | 12.4 | 24.3 | 28.3 | 20.6 | 8.6 | 1.7 |
| Italy | 13.6 | 19.5 | 25.4 | 22.0 | 13.3 | 5.0 | 1.3 |
| Japan | 4.0 | 9.2 | 18.9 | 25.9 | 23.7 | 13.5 | 4.8 |
| Korea | 2.3 | 6.6 | 15.2 | 23.3 | 25.4 | 18.0 | 9.1 |
| Luxembourg | 8.4 | 14.6 | 23.1 | 25.1 | 18.2 | 8.3 | 2.4 |
| Mexico | 28.5 | 28.2 | 25.1 | 13.0 | 4.3 | 0.8 | 0.1 |
| Netherlands | 2.5 | 9.2 | 18.8 | 24.2 | 24.1 | 15.8 | 5.4 |
| New Zealand | 4.1 | 10.1 | 19.5 | 25.3 | 22.0 | 13.2 | 5.7 |
| Norway | 7.4 | 15.1 | 24.3 | 25.4 | 17.4 | 8.3 | 2.2 |
| Poland | 5.7 | 14.3 | 24.6 | 26.1 | 18.6 | 8.7 | 2.0 |
| Portugal | 12.0 | 18.9 | 25.0 | 23.9 | 14.4 | 4.9 | 0.8 |
| Slovak Republic | 8.2 | 12.9 | 24.0 | 25.2 | 18.8 | 8.6 | 2.4 |
| Spain | 8.6 | 16.3 | 25.2 | 26.0 | 16.7 | 6.1 | 1.2 |
| Sweden | 5.4 | 13.1 | 22.9 | 25.8 | 20.0 | 9.7 | 2.9 |
| Switzerland | 4.6 | 9.1 | 17.4 | 23.0 | 23.2 | 15.9 | 6.8 |

## Table 1.8 (concluded)

### Percentage scoring at each proficiency level of mathematics performance

| | Below Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|---|---|
| Turkey | 24.2 | 28.2 | 24.1 | 12.7 | 6.6 | 3.0 | 1.2 |
| United Kingdom | 6.0 | 14.0 | 24.7 | 26.2 | 18.1 | 8.7 | 2.5 |
| United States | 10.0 | 18.3 | 26.0 | 22.9 | 15.0 | 6.4 | 1.3 |
| **OECD** | **7.8** | **13.7** | **21.9** | **24.2** | **19.1** | **10.0** | **3.4** |
| Azerbaijan | 0.2 | 10.6 | 47.7 | 34.1 | 6.6 | 0.6 | 0.2 |
| Argentina | 39.6 | 24.8 | 20.2 | 10.5 | 3.8 | 0.9 | 0.1 |
| Brazil | 46.8 | 26.0 | 16.4 | 7.0 | 2.8 | 0.8 | 0.2 |
| Bulgaria | 29.6 | 24.0 | 21.9 | 14.8 | 6.7 | 2.5 | 0.6 |
| Chile | 28.3 | 27.1 | 23.7 | 13.8 | 5.6 | 1.3 | 0.1 |
| Chine Taipei | 3.7 | 8.4 | 14.3 | 19.3 | 22.3 | 20.1 | 11.9 |
| Colombia | 44.8 | 27.4 | 18.0 | 7.5 | 1.9 | 0.4 | 0.0 |
| Croatia | 9.4 | 19.4 | 28.8 | 24.1 | 13.5 | 4.0 | 0.8 |
| Estonia | 2.8 | 9.4 | 22.1 | 29.9 | 23.3 | 10.0 | 2.6 |
| Hong Kong-China | 3.0 | 6.7 | 14.4 | 22.6 | 25.6 | 18.7 | 9.1 |
| Indonesia | 35.5 | 30.6 | 20.2 | 10.5 | 2.8 | 0.4 | 0.0 |
| Israel | 22.3 | 19.9 | 21.7 | 18.2 | 11.8 | 4.8 | 1.3 |
| Jordan | 37.1 | 29.6 | 21.7 | 9.2 | 2.2 | 0.2 | 0.0 |
| Kyrgyzstan | 73.1 | 16.4 | 7.0 | 2.8 | 0.7 | 0.0 | 0.0 |
| Latvia | 6.5 | 14.4 | 26.2 | 28.9 | 17.4 | 5.5 | 1.1 |
| Liechtenstein | 4.1 | 9.1 | 18.4 | 26.2 | 23.7 | 12.5 | 6.0 |
| Lithuania | 7.9 | 15.3 | 25.0 | 25.0 | 17.8 | 7.3 | 1.8 |
| Macao-China | 2.6 | 8.4 | 19.9 | 27.2 | 24.4 | 13.6 | 3.8 |
| **Qatar** | **71.8** | **15.4** | **7.4** | **3.3** | **1.4** | **0.5** | **0.1** |
| Romania | 25.0 | 28.1 | 26.2 | 14.1 | 5.4 | 1.1 | 0.1 |
| Russian Federation | 9.1 | 17.7 | 26.9 | 24.1 | 14.7 | 5.8 | 1.7 |
| Serbia and/or Montenegro | 20.9 | 23.6 | 26.3 | 17.9 | 8.6 | 2.3 | 0.4 |
| Slovenia | 4.6 | 13.3 | 23.4 | 25.9 | 19.1 | 10.3 | 3.4 |
| Thailand | 23.5 | 29.9 | 26.1 | 13.9 | 5.3 | 1.1 | 0.2 |
| Tunisia | 48.6 | 24.0 | 16.4 | 8.0 | 2.4 | 0.5 | 0.0 |
| Uruguay | 24.5 | 21.8 | 24.2 | 18.1 | 8.1 | 2.6 | 0.6 |

## Table 1.9

### Percentage scoring at each proficiency level of science performance

| | Below Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|---|---|
| Australia | 3.0 | 9.8 | 20.2 | 27.7 | 24.7 | 11.8 | 2.9 |
| Austria | 4.2 | 11.9 | 21.8 | 28.2 | 23.8 | 8.8 | 1.2 |
| Belgium | 4.8 | 12.1 | 20.8 | 27.6 | 24.6 | 9.2 | 1.0 |
| Canada | 2.2 | 7.8 | 19.0 | 28.8 | 27.8 | 12.1 | 2.4 |
| Czech Republic | 3.4 | 11.9 | 23.4 | 27.7 | 21.8 | 9.8 | 1.8 |
| Denmark | 4.3 | 14.0 | 25.9 | 29.3 | 19.6 | 6.1 | 0.7 |
| Finland | 0.5 | 3.5 | 13.5 | 29.1 | 32.4 | 17.0 | 4.0 |
| France | 6.5 | 14.5 | 22.8 | 27.2 | 20.9 | 7.3 | 0.8 |
| Germany | 4.0 | 11.2 | 21.3 | 27.9 | 23.6 | 10.1 | 1.8 |
| Greece | 7.1 | 16.8 | 28.9 | 29.5 | 14.3 | 3.2 | 0.2 |
| Hungary | 2.7 | 12.2 | 26.0 | 31.1 | 21.1 | 6.3 | 0.6 |
| Iceland | 5.8 | 14.6 | 25.9 | 28.2 | 19.1 | 5.6 | 0.7 |
| Ireland | 3.5 | 11.8 | 24.0 | 29.7 | 21.5 | 8.3 | 1.1 |
| Italy | 7.2 | 17.9 | 27.6 | 27.5 | 15.2 | 4.2 | 0.4 |
| Japan | 3.1 | 8.8 | 18.4 | 27.4 | 27.1 | 12.5 | 2.7 |
| Korea | 2.5 | 8.6 | 21.2 | 31.7 | 25.6 | 9.3 | 1.1 |
| Luxembourg | 6.4 | 15.6 | 25.3 | 28.6 | 18.3 | 5.4 | 0.5 |
| Mexico | 18.0 | 32.7 | 30.8 | 14.9 | 3.2 | 0.3 | 0.0 |
| Netherlands | 2.3 | 10.6 | 21.1 | 26.9 | 26.0 | 11.6 | 1.7 |
| New Zealand | 4.0 | 9.6 | 19.7 | 25.1 | 24.0 | 13.7 | 4.0 |
| Norway | 5.8 | 15.1 | 27.3 | 28.5 | 17.2 | 5.5 | 0.6 |
| Poland | 3.2 | 13.7 | 27.4 | 29.5 | 19.5 | 6.1 | 0.7 |
| Portugal | 5.7 | 18.6 | 28.8 | 28.9 | 14.9 | 3.1 | 0.1 |
| Slovak Republic | 5.1 | 14.9 | 28.0 | 28.2 | 18.0 | 5.3 | 0.6 |
| Spain | 4.7 | 14.8 | 27.3 | 30.2 | 18.0 | 4.6 | 0.3 |
| Sweden | 3.7 | 12.5 | 25.1 | 29.5 | 21.2 | 6.9 | 1.1 |
| Switzerland | 4.5 | 11.4 | 21.8 | 28.2 | 23.6 | 9.1 | 1.4 |
| Turkey | 12.7 | 33.6 | 31.4 | 15.1 | 6.2 | 0.9 | 0.0 |
| United Kingdom | 4.8 | 11.8 | 21.8 | 26.0 | 21.8 | 10.9 | 2.9 |
| United States | 7.4 | 16.8 | 24.2 | 24.1 | 18.3 | 7.6 | 1.6 |
| **OECD** | **5.1** | **14.0** | **24.0** | **27.4** | **20.5** | **7.8** | **1.3** |
| Azerbaijan | 19.0 | 53.2 | 22.7 | 4.7 | 0.4 | 0.0 | 0.0 |
| Argentina | 28.2 | 27.8 | 25.7 | 13.7 | 4.1 | 0.4 | 0.0 |
| Brazil | 27.7 | 33.2 | 23.9 | 11.3 | 3.4 | 0.5 | 0.0 |
| Bulgaria | 18.2 | 24.3 | 25.2 | 18.9 | 10.4 | 2.6 | 0.4 |
| Chile | 12.9 | 26.5 | 30.0 | 20.2 | 8.5 | 1.8 | 0.1 |
| Chinese Taipei | 1.9 | 9.6 | 18.5 | 27.3 | 28.0 | 13.0 | 1.7 |
| Colombia | 25.9 | 34.0 | 27.4 | 10.6 | 1.9 | 0.2 | 0.0 |
| Croatia | 2.9 | 13.9 | 29.2 | 31.0 | 17.8 | 4.6 | 0.5 |
| Estonia | 0.9 | 6.6 | 20.9 | 33.6 | 26.3 | 10.2 | 1.4 |
| Hong Kong-China | 1.7 | 7.0 | 16.9 | 28.6 | 29.8 | 13.9 | 2.1 |
| Indonesia | 20.1 | 41.3 | 27.7 | 9.6 | 1.4 | 0.0 | 0.0 |
| Israel | 14.8 | 21.1 | 24.1 | 20.8 | 13.9 | 4.4 | 0.8 |
| Jordan | 16.0 | 28.1 | 30.8 | 18.8 | 5.6 | 0.6 | 0.0 |

## Table 1.9 (concluded)

### Percentage scoring at each proficiency level of science performance

| | Below Level 1 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 |
|---|---|---|---|---|---|---|---|
| Kyrgyzstan | 57.9 | 28.2 | 10.2 | 2.9 | 0.7 | 0.0 | 0.0 |
| Latvia | 3.5 | 13.7 | 29.0 | 32.9 | 16.8 | 3.9 | 0.3 |
| Liechtenstein | 2.6 | 10.3 | 20.9 | 28.5 | 25.4 | 9.9 | 2.3 |
| Lithuania | 4.3 | 15.9 | 27.3 | 29.9 | 17.6 | 4.6 | 0.4 |
| Macao-China | 1.4 | 8.7 | 25.9 | 35.7 | 22.9 | 5.1 | 0.3 |
| **Qatar** | **47.3** | **31.7** | **13.9** | **5.1** | **1.7** | **0.3** | **0.0** |
| Romania | 15.8 | 30.8 | 31.9 | 16.7 | 4.3 | 0.5 | 0.0 |
| Russian Federation | 5.2 | 16.8 | 30.2 | 28.4 | 15.1 | 3.7 | 0.5 |
| Serbia and/or Montenegro | 12.2 | 27.2 | 32.2 | 21.2 | 6.4 | 0.7 | 0.0 |
| Slovenia | 2.8 | 11.0 | 23.1 | 27.6 | 22.6 | 10.8 | 2.2 |
| Thailand | 12.4 | 33.4 | 33.3 | 16.4 | 4.1 | 0.4 | 0.0 |
| Tunisia | 27.4 | 35.1 | 25.1 | 10.3 | 2.0 | 0.1 | 0.0 |
| Uruguay | 16.6 | 25.3 | 29.9 | 19.8 | 7.0 | 1.3 | 0.1 |

## Table 2.1

## Distribution of science and science sub-domains for Qatar

| | Mean | Standard deviation | Skewness |
|---|---|---|---|
| Science | 349.3 | 82.9 | 0.66 |
| SE | 0.8 | 0.6 | 0.03 |
| Science experience | 356.7 | 86.8 | 0.55 |
| SE | 0.8 | 0.8 | 0.03 |
| Science identifying | 352.6 | 78.3 | 0.54 |
| SE | 0.7 | 0.7 | 0.04 |
| Science use | 324.7 | 102.2 | 0.60 |
| SE | 0.9 | 0.9 | 0.03 |
| Interest in science | 564.9 | 106.7 | 0.09 |
| SE | 1.2 | 1.2 | 0.04 |
| Support in science | 519.2 | 145.4 | 0.23 |
| SE | 1.6 | 1.5 | 0.04 |

SE: Standard error

Source: OECD PISA 2006.

## Table 2.2

## Distribution of science and science sub-domains for OECD

| | Mean | Standard Deviation | Skewness |
|---|---|---|---|
| Science | 490.7 | 104.2 | -0.03 |
| SE | 1.2 | 0.6 | 0.01 |
| Science experience | 489.0 | 106.5 | 0.02 |
| SE | 1.2 | 0.5 | 0.01 |
| Science identifying | 491.0 | 101.5 | -0.07 |
| SE | 1.1 | 0.5 | 0.01 |
| Science use | 491.6 | 116.9 | -0.10 |
| SE | 1.4 | 0.8 | 0.01 |
| Interest in science | 506.8 | 104.7 | -0.13 |
| SE | 0.9 | 0.5 | 0.02 |
| Support in science | 501.3 | 102.7 | 0.05 |
| SE | 0.8 | 0.5 | 0.02 |

SE: Standard error

Source: OECD PISA 2006.

## Table 3.1

### Multivariate regression results for models specifying sociocultural gradients and school profiles

| | Figure 3.1 | Figure 3.2 | Figure 3.3 | Figure 3.5 | Figure 3.6 |
|---|---|---|---|---|---|
| | SES gradient | SES gradient by gender | SES gradient by citizenship | School profile by strata | School profile by gender mix |
| Intercept | 335.2 | 316.6 | 317.9 | 333.9 | 311.0 |
| | ( 1.7) | ( 2.3) | (1.3) | (1.9) | (2.0) |
| Parental Education | 4.9 | 5.8 | 1.4 | 2.6 | 2.9 |
| (centered on 12 years) | (0.4) | (0.5) | (0.4) | (0.3) | (0.4) |
| Parental Education | 0.5 | 0.6 | 0.2 | 0.3 | 0.3 |
| (squared) | (0.1) | (0.1) | (0.14) | (0.1) | (0.1) |
| Female | | 35.9 | | | |
| (Reference group is males) | | (2.8) | | | |
| Female by Parental Education | | -1.1 | | | |
| | | (0.6) | | | |
| Female by Parental Education | | -0.1 | | | |
| (squared) | | (0.1) | | | |
| Second Generation | | | 27.2 | | |
| (Reference group is native-born) | | | (3.3) | | |
| Second Generation by | | 3.1 | | | |
| Parental Education | | (0.8) | | | |
| Second Generation by Parental | | | 0.4 | | |
| Education (squared) | | | (0.1) | | |
| Immigrant | | | 50.8 | | |
| (Reference group is native-born) | | | (6.1) | | |
| Immigrant by | | | 8.7 | | |
| Parental Education | | | (1.0) | | |
| Immigrant by | | | 0.7 | | |
| Parental Education (squared) | | | (0.3) | | |
| Qatari Independent | | | | -22.0 | |
| (Reference group is Qatari Public) | | | | (2.2) | |
| Qatari Private | | | | -0.3 | |
| (Reference group is Qatari Public) | | | | (4.0) | |
| Non-Qatari Community | | | | 107.7 | |
| (Reference group is Qatari Public) | | | | (6.8) | |
| Non-Qatari International | | | | 143.3 | |
| (Reference group is Qatari Public) | | | | (4.5) | |
| Single-Sex female School | | | | | 39.6 |
| (Reference group is single-sex male) | | | | | (1.8) |
| Co-educational School | | | | | 165.2 |
| (Reference group is single-sex male) | | | | | (4.5) |

Source: OECD PISA 2006.

## Table 4.1

### Hierarchical linear model regression results for models specifying the effects of school policy and practice

| | Figures 4.1 to 4.10 | Figure 4.12 |
|---|---|---|
| | Bivariate relationships (coefficient, SE, odds-ratio) | Full hierarchical model (coefficient, SES, odds-ratio) |
| **Teachers' Qualifications (% with Bachelors)** (10% increase) | 0.209 (0.501) **1.23** | 0.338 (0.181) **1.40** |
| **Teachers' Experience (% with 5 + years)** (10% increase) | 0.017 (0.090) **1.02** | 0.054 (0.038) **1.06** |
| **Reading Skills (10-point OECD scale)** (1 point increase) | 1.302 (0.059) **3.68*** | 1.117 (0.076) **3.06*** |
| **Ratio of theoretical to applied approach** (0.1 point increase) | 0.601 (0.175) **1.82*** | 0.020 (0.060) **1.02** |
| **Reading time at school (hours per week)** (1 hour increase) | 1.314 (0.218) **3.72*** | -0.013 (0.105) **0.99** |
| **Science time at school (hours per week)** (1 hour increase) | 1.340 (0.154) **3.82*** | 0.259 (0.105) **1.30*** |
| **Interest in Science (10-point OECD scale)** (1 point increase) | -0.646 (0.524) **0.52*** | 0.243 (0.106) **1.27*** |
| **Self Study in Science (hours per week)** (1 hour increase) | 2.086 (0.429) **8.05*** | 0.288 (0.211) **1.33** |
| **School Resources (10-point OECD scale)** (1 point increase) | 0.114 (0.054) **1.12*** | 0.007 (0.021) **1.01** |
| **Class size (average number of students)** (10 student increase) | -0.088 (0.916) **0.92** | -0.079 (0.057) **0.92** |
| **Parental Education (years)** (1 year increase) | | 0.061 (0.019) **1.06*** |

SE: Standard error.

* Coefficients that are statistically significant (p<.05) are indicated with an asterix.

# Appendix B

## Implementation of the PISA Study in Qatar

This appendix provides an overview of key features of the PISA 2006 study and documents how it was implemented in Qatar. The Programme for International Student Assessment (PISA) 2006 was directed by the Board of Participating Countries (BPC) and managed by the PISA secretariat based at the Organisation for Economic Co-operation and Development (OECD). The PISA 2006 study is a standardised comparative assessment of students' knowledge and skills involving 57 countries, collectively representing a total of one-third of the world population and almost nine-tenths of global gross domestic product (GDP).

### Summary of key features

The PISA study is a collaborative effort on the part of the Member countries of the OECD, plus a number of so called "partner" countries, that attempts to measure how well 15-year-old students are prepared to meet the challenges of today's societies. The PISA assessment adopts a broad approach to assessing knowledge and skills, one that seeks to reflect present reorientations in curricula and teaching and learning styles, currently underway in many countries, from the traditional preoccupation with school-based approaches emphasising the memorisation of facts, and towards an individualised, problem-oriented and curiosity-driven pedagogy that stresses the application of knowledge and skills in meeting everyday challenges and tasks. These skills reflect the ability of students to continue learning throughout their lives by applying what they got in school to non-school environments, evaluating their choices, and making decisions.

PISA 2006 assessed three skill domains – reading, mathematical and scientific literacy – not so much in terms of mastery of specific elements of the school curriculum, but of important knowledge and skills needed in adult life. Emphasis is on the mastery of processes, the understanding of concepts and the ability to function in various situations within each skills domain. This emphasis is particularly significant in light of the concern among nations to develop human capital, defined as "the knowledge, skills, competencies and other attributes embodied in individuals that are relevant to personal, social and economic well-being" (OECD, 2007).

PISA takes a distinctive approach in a number of important respects (OECD, 2006a; OECD, 2006b):

- *Its origin,* as an initiative taken by OECD governments, whose education policies have helped them reach the top tiers of economically advanced countries;
- *Its policy orientation*, with design and reporting methods determined by the need of governments to draw policy lessons;
- *Its innovative "literacy" concept,* extracted from the U.S. National Adult Literacy Survey (NALS) and the International Adult Literacy Survey (IALS), and concerned with the capacity of students to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of subject matter areas;
- *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;
- *Its regularity,* which will enable countries to monitor their progress in meeting key learning objectives;
- *The age group covered:* Assessing 15-year-old students near the end of their compulsory schooling gives a useful indication of the performance of education systems;
- *The knowledge and skills tested,* which are defined not primarily in terms of a common denominator of national school curricula, but in terms of what skills are deemed to be essential for future success; and
- *Its breadth of geographical coverage,* with 57 countries participating in the 2006 study.

## Qatar's motivation to participate in PISA 2006

Qatar decided to join the PISA 2006 study for the following main reasons:

- The need to build a 'culture of assessment', essentially in order to convey to key constituencies that studies of students' knowledge and skills are essential tools for monitoring processes of educational reform and change;
- The necessity to structure an assessment "system" organised so as to provide relevant information for decision making at different levels of aggregation, in this case the system and school levels;
- The need to compare the standards of performance of students in Qatar to those achieved by the best in the world, and to establish baseline data;
- To underscore the need for pursuing educational reforms and, over time, to monitor improvements in the quality of education;
- Coincidentally with Qatar's competency-rooted standards and with their consequential QCEA programme, PISA is also competency-based. Participation in the PISA study allows for verification and contrasting of the QCEA results; and
- The need to understand the degree to which the current and future education systems will be capable of supporting Qatar's economic, social and cultural goals.

## Study implementation in Qatar

PISA 2006 employed paper-and-pencil tests, with the assessment lasting a total of two hours for each student. A partial computer-aided assessment, not taken this time by Qatar, was a national option, used by 13 of the countries participating in the 2006 study. Test items were a mixture of multiple-choice items and questions requiring students to construct their own responses. The items were organised in blocks based on a passage or stimulus setting out a real-life situation. Appendix C of this report offers further pertinent information about the PISA 2006 measurement framework and presents a sample of test items used.

The total pool of test items covered approximately seven hours of assessment time material, with different students taking different combinations of test items organised in blocks so as to afford sufficient coverage of the target content domains. Students also answered a background questionnaire, which took about 30 minutes to complete, providing information about themselves and their homes. Parents were given a background questionnaire, asking mainly about their schooling levels and incomes, which was also a national option, this time taken by Qatar. School principals were given a 20-minute questionnaire covering items concerning their schools. In addition, Qatar fielded a brief computer familiarity questionnaire as a national option.

Prior to the main application, a pilot trial administration for PISA 2006 was successfully completed by Qatar. Although Qatar joined PISA nine months into the study implementation, the pilot results confirmed that Qatar met all quality assurance standards specified for the study, and hence was cleared to field the PISA 2006 main study. Nearly 1,600 15-year-old students were sampled and took the PISA 2005 field trial.

In Qatar, the main PISA assessment was administered in March 2006 to a census of all 15-year-old students enrolled in the originally 137 sampled schools, regardless of their grade. Of this total, 131 schools were eligible and took part in the study. The school response rate was 95.6 per cent.

The original census population for the 137 schools comprised 7,404 students. The target census population for the 131 eligible schools comprised 7,374 students. Fully or partially complete responses were obtained from 7,374 students. The non-response rate was 12.7 per cent. All these figures also complied with the PISA international quality standards, thus allowing the results for Qatar to be included in the PISA 2006 International Report, compiled by the OECD.

The translation and adaptation of the stimuli, questions and manuals into Arabic and the layout of the test booklets was done under the co-ordination and supervision of the Qatar PISA National Centre, located at the Student Assessment Office (SAO), with the support of the Data Collection and Management Office (DCM). The preparation of covers and data formats for Smart Printing was handled, under contract, by the National Opinion Research Centre (NORC), an entity affiliated with The University of Chicago. The SAO, and in particular the National Project Manager (NPM), were responsible for handling all subsequent processes of international and national data management.

# Appendix C

## PISA Measurement Framework and Examples of Test Items

This Annex presents a selection of test items used in the PISA 2006 study and describes what they are intended to measure and how the results might be interpreted. The countries participating in the study have agreed that most of the test items used in the PISA 2006 assessment should remain confidential, so that they can be used again in future rounds for linking purposes and for establishing trends. The items reproduced in this Annex are among those that have been released for public dissemination. These examples have been published (OECD, 2006) and can also be downloaded from the PISA website (www.pisa.oecd.org) or from sites of participating countries, for example the United States (www.nces.ed.gov/surveys/PISA).

## Reporting the results

The PISA 2006 results for science are primarily reported on three scales related to science competencies. Performance is also reported in an alternative way separately, as *knowledge of science* and *knowledge about science,* in addition to the overall science scale.

Figure C.1 shows a map with examples of PISA 2006 science items. For each of the three science competencies, the selected items and scores (shown in parentheses after each item) have been ordered according to difficulty, with the most difficult at the top and the least difficult at the bottom. The characteristics of the items shown in the map provide the basis for a substantive interpretation of performance at different levels on the scale. Patterns emerge that make possible to describe aspects of the science competencies that are consistently associated with different proficiency levels.

## Figure C.1
## A map of selected science items used in PISA 2006

| Level | Identifying scientific issues | Explaining phenomena scientifically | Using scientific evidence |
|---|---|---|---|
| 6<br><br>1.92 | **ACID RAIN**<br>Question 5.2 (2.02) | **GREENHOUSE**<br>Question 5 (1.96) | |
| 5<br><br>1.12 | | | **GREENHOUSE**<br>Question 4.2 (1.34)<br>(full) |
| 4<br><br>0.32 | **SUNSCREENS**<br>Question 4 (0.62)<br>Question 2 (0.54)<br>**CLOTHES**<br>Question 1 (0.37) | **PHYSICAL EXERCISE**<br>Question 5 (0.5) | **GREENHOUSE**<br>Question 4.1 (0.38)<br>(partial)<br>**SUNSCREENS**<br>Question 5 (1.00) (full) |
| 3<br><br>-0.48 | **ACID RAIN**<br>Question 5.1 (-0.16)<br>(partial)<br>**SUNSCREENS**<br>Question 3 (-0.14) | **ACID RAIN**<br>Question 2 (-0.26)<br>**MARY MONTAGU**<br>Question 4 (-0.33) | **GREENHOUSE**<br>Question 3 (-0.01) |
| 2<br><br>-1.28 | **GENETICALLY MODIFIED CROPS**<br>Question 3 (-1.14)<br>(embedded)<br>Question 4 | **GRAND CANYON**<br>Question 3 (-0.77)<br>(embedded)<br>**MARY MONTAGU**<br>Question 2<br>Question 3 | **ACID RAIN**<br>Question 3 (-0.73)<br>(embedded) |
| 1<br><br>-1.9 | | **PHYSICAL EXERCISE**<br>Question 3<br>**CLOTHES**<br>Question 2 (-1.39)<br>**GRAND CANYON**<br>Question 5 (-1.30) | |

Near the bottom of the scale, items are set in simple and relatively familiar contexts and require only the most limited interpretation of a situation. These items only require direct application of scientific knowledge and an understanding of well-known scientific processes set in familiar situations.

PHYSICAL EXERCISE, CLOTHES and GRAND CANYON (Figures 2.18, 2.16, and 2.17) are items at Level 1 (below the cut-point), at the very bottom of the scale for the competency *explaining phenomena scientifically*. In CLOTHES, question 2, for example, the student must simply recall which piece of laboratory equipment would be used to check a fabric's conductivity. In GRAND CANYON, question 5, students were required to know that when the seas recede they may reveal fossils of organisms deposited at an earlier age. In question 3 of PHYSICAL EXERCISE, students must have knowledge of the science fact that active muscles get an increased flow of blood and that fats are not formed when muscles are exercised. Question 3 from GRAND CANYON is at proficiency level 2, above the cut-point for the competency *explaining phenomena scientifically*. This item requires the students to know the fact that freezing water expands and thus may influence the weathering of rocks. For the competency *using scientific evidence*, question 3 in the unit on ACID RAIN (Figure 2.15) provides a good example for proficiency level 2. The item asks students to use information provided to draw a conclusion about the effects of vinegar on marble, a simple model for the influence of acid rain on marble.

Still towards the bottom of the scale, typical items for Level 2 are exemplified by questions 3 and 4 from the unit GENETICALLY MODIFIED CROPS (Figure 2.13), both of which are for the competency *identifying scientific issues*. Question 3 asks a simple question about varying conditions in a scientific investigation and students are required to demonstrate knowledge about the design of science experiments. Although slightly more difficult, question 4 also centres on factors that were varied in a scientific study. The students were provided with details of the scientific study and asked why this was a fair study.

Around the middle of the scale, items require substantially more interpretation, frequently in situations that are relatively unfamiliar. They often demand the use of knowledge from different scientific disciplines including more formal scientific or technological representation, and the thoughtful linking of those different knowledge domains in order to promote understanding and facilitate analysis. They often involve a chain of reasoning or a synthesis of knowledge, and can require students to express reasoning through a simple explanation. Typical activities include interpreting aspects of a scientific investigation, explaining certain procedures used in an experiment and providing evidence-based reasons for a recommendation.

An example of an item in the middle of the scale is found in ACID RAIN (Figure 2.15). In question 2, students are provided information about the effects of vinegar on marble (*i.e.* a model for the effect of acid rain on marble) and asked to explain why some chips were placed in pure (distilled) water overnight. For partial credit and a response considered to be at Level 3, they had simply to state it was a comparison, although if a student stated that the acid (vinegar) was necessary for the reaction the response would be considered Level 6. Both responses are linked to the competency *identifying scientific issues*. ACID RAIN (Figure 2.15) is also related to the competency *explaining phenomena scientifically*. In question 2, students are asked about the origin of certain chemicals in the air. Correct responses required students to demonstrate an understanding of the chemicals as originating as car exhaust, factory emission, and burning fossil fuels. For the competency, *using scientific evidence,* the units GREENHOUSE and SUNSCREENS (Figures 2.20 and 2.14) present good examples for Level 3. In GREENHOUSE, question 3, students must interpret evidence, presented in graphical form, and deduce that the combined graphs support a conclusion that both average temperature and carbon dioxide emission are increasing. *SUNSCREENS,* question 5, is an example of Level 4 for the same competency. Here students are given results from an experiment and asked to interpret a pattern of results and explain their conclusion.

Towards the top of the scale, items generally involve a number of different elements requiring even higher levels of interpretation. The prompts are unfamiliar to students and require some degree of reflection and review. Items demand thorough analysis, may involve more than one scientific explanation and may require carefully constructed arguments.

Typical items near the top of the scale involve interpreting complex and unfamiliar data, imposing a scientific explanation on a complex real-world situation, and applying scientific processes to unfamiliar problems. At this part of the scale, items tend to have several scientific or technological elements that need to be linked by students, and their successful synthesis requires several interrelated steps. The construction of evidence-based arguments and communications also requires critical thinking and abstract reasoning. Question 5 of GREENHOUSE (Figure 2.20) is an example of Level 6 and of the competency, *Explaining phenomena scientifically*. In this question, students must analyse a conclusion to account for other factors that could influence the greenhouse effect. A final example from GREENHOUSE centres on the competency, *Using scientific evidence,* and asks students to identify a portion of a graph that does not provide evidence supporting a conclusion. Students must locate a portion of two graphs where curves are not both ascending or descending and provide this finding as part of a justification for a conclusion.

Several of these selected science units contain examples of embedded questions that query students' attitudes. GENETICALLY MODIFIED CROPS, ACID RAIN, and GRAND CANYON (Figures 2.13, 2.15, and 2.17) all have embedded attitudinal questions. The embedded question in GENETICALLY MODIFIED CROPS asks students to indicate their interest in learning more about various aspects of genetically modified crops. Question 10N in ACID RAIN probes the level of students' interest in the topic of acid rain, and question 10S asks students how much they agree with statements supporting further research. Finally, the embedded question in the stimulus, GRAND CANYON, centres on students' support for scientific inquiry into questions concerning fossils, protection of national parks, and rock formations.

Based on the patterns observed when the full item set is reviewed against the proficiency scales, it is possible to characterise the increase in the levels of complexity of competencies measured along the PISA 2006 science scale by referring to the ways in which scientific competencies are associated with items located at different points ranging from the bottom to the top of the scale. The ascending difficulty of science items in PISA 2006 is associated with the following characteristics, which require all three competencies but which shift in emphasis as students progress from the identification of issues to the use of evidence to communicate an answer, decision or solution:

- The degree to which the application of knowledge is required.

At the lowest levels the application of knowledge is simple and direct. The requirement can often be fulfilled with a simple recall of single facts. At the upper levels of the scale individuals are required to identify multiple, fundamental concepts and combine domains of knowledge in order to respond correctly.

- The degree of cognitive demand required to analyse the presented situation and synthesise an appropriate answer.

Related to the discussion of knowledge application, this centres on features such as the depth of scientific understanding required, the range of scientific understanding required, and the proximity of the situation to the students' life.

- The degree of analysis needed to answer the item.

This includes the demands arising from the requirement to discriminate among issues presented in the situation, identify the appropriate knowledge of science and knowledge about science, and the use of appropriate evidence to arrive at claims or conclusions. The analysis may include the extent to which the scientific or technological demands of the situation are clearly apparent or to which students must differentiate among components of the situation to clarify the scientific issues as opposed to other, non-scientific issues.

- The degree of complexity needed to solve the problem presented.

The complexity may range from a single step where students identify the scientific issue, apply a single fact or concept, and present a conclusion to multi-step problems requiring a search for advanced scientific knowledge, complex decision-making, information processing and ability to form an argument.

- The degree of synthesis needed to answer the item.

The synthesis may range from a single piece of evidence where no real construction of justification or argument is required to situations requiring students to analyse and apply multiple sources of evidence and compare competing lines of evidence and different explanations to adequately argue a position.

## What students can do in science

By looking at how students performed on the three science competencies, alongside examples of tasks associated with the proficiency levels, it is possible to provide a profile of what PISA 2006 shows about students' competencies in science.

### *Identifying Scientific Issues*

Approximately 22 per cent of the science tasks given to students in PISA were related to the competency, *Identifying scientific issues*. Figures 2.13, 2.14, 2.15, and 2.16 show six sample tasks from this category: one at Level 2, two at Level 3, two at Level 4, and one at Level 6. The knowledge and skills required to attain each level are summarized in Figure 2.17.

Level 2 was identified as the baseline, because it represents a critical level of science literacy on the PISA test. At this point students begin to demonstrate the kind of science knowledge and abilities that enable them to actively and effectively use the science competencies. Students at Level 1 or below are at significant risk of not being competent in their work life or as citizens.

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**Question 3: GENETICALLY MODIFIED CROPS** *S508Q03*

Corn was planted in 200 fields across the country. Why did the scientists use more than one site?

A So that many farmers could try the new GM corn.
B To see how much GM corn they could grow.
C To cover as much land as possible with the GM crop.
D To include various growth conditions for corn.

**GENETICALLY MODIFIED CROPS SCORING 3**

***Full Credit***

Code 1: D. To include various growth conditions for corn.

***No Credit***

Code 0: Other responses.

Code 9: Missing

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### Question 4: GENETICALLY MODIFIED CROPS *S508Q04 – 019*

GM corn treated with the powerful new herbicide was planted on one half of each field and the conventional corn treated with a conventional herbicide was planted on the other half.

How did using each field in this way make the study fair?

.................................................................................................................................................

.................................................................................................................................................

.................................................................................................................................................

### GENETICALLY MODIFIED CROPS

***Full Credit***

Code 1: Responses should show awareness of the need to control for other factors such as climate, drainage, soil ect so that variability in growing conditions was equally represented for GM and non-GM corn.

- The crops are being grown on the same soil and under the same weather conditions.
- So both crops have equal condition for growth.
- So both crops have a control group.
- Because they were given the same amount of land use and position.
- So that they could say that location did not affect the study.

***No Credit***

Code 0: Responses.

- To make them comparable. *[Not specific enough.]*
- By seeing that they grow in two or more types of conditions. *[Refers to the use of many fields but in no way recognises that this was to enable the two treatments to be compared under different conditions.]*
- Both halves have been cropped differently and so the differences are clearly visible.

Code 9: Missing.

### Question 10N: GENETICALLY MODIFIED CROPS *S508Q10N*

How much interest do you have in the following information?

Tick only one box in each row.

| | *High Interest* | *Medium Interest* | *Low Interest* | *No Interest* |
|---|---|---|---|---|
| a) Learning about the process by which plants are genetically modified | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |
| b) Learning why some plants are not affected by herbicides | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |
| c) Understanding better the difference between cross-breeding and genetic modification of plants | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |

**Figure C.2 GENETICALLY MODIFIED CROPS**

Competency: Identifying scientific issues

Level: 2

## SUNSCREENS

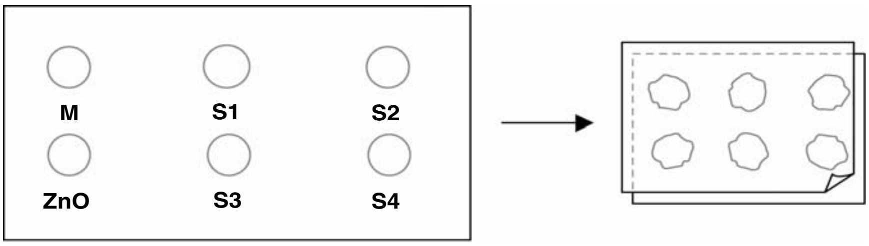
Mimi and Dean wondered which sunscreen product provides the best protection for their skin. Sunscreen products have a *Sun Protection Factor (SPF)* that shows how well each product absorbs the ultraviolet radiation component of sunlight. A high SPF sunscreen protects skin for longer than a low SPF sunscreen.

Mimi thought of a way to compare some different sunscreen products. She and Dean collected the following:

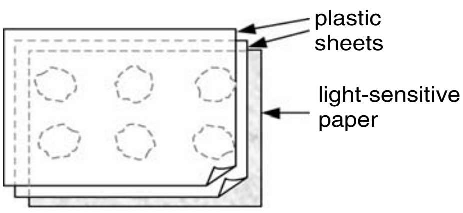
- two sheets of clear plastic that do not absorb sunlight;
- one sheet of light-sensitive paper;
- mineral oil (M) and a cream containing zinc oxide (ZnO); and
- four different sunscreens that they called S1, S2, S3, and S4.

Mimi and Dean included mineral oil because it lets most of the sunlight through, and zinc oxide because it almost completely blocks sunlight.

Dean placed a drop of each substance inside a circle marked on one sheet of plastic, then put the second plastic sheet over the top. He placed a large book on top of both sheets and pressed down.




Mimi then put the plastic sheets on top of the sheet of light-sensitive paper. Light-sensitive paper changes from dark grey to white (or very light grey), depending on how long it is exposed to sunlight. Finally, Dean placed the sheets in a sunny place.




**Translation Note: If necessary, use the explicit translation "paper sensitive to light", for "light-sensitive" paper. Do not use "photo-sensitive paper" as the translation.**

## Question 2: SUNSCREENS

*S447Q02*

Which one of these statements is a scientific description of the role of the mineral oil and the zinc oxide in comparing the effectiveness of the sunscreens?

A Mineral oil and zinc oxide are both factors being tested.
B Mineral oil is a factor being tested and zinc oxide is a reference substance.
C Mineral oil is a reference substance and zinc oxide is a factor being tested.
D Mineral oil and zinc oxide are both reference substances.

### SUNSCREENS SCORING 2

***Full Credit***

Code 1: A. How does the protection for each sunscreen compare with the others?

***No Credit***

Code 0: Other responses.

Code 9: Missing

## Question 3: SUNSCREENS

*S447Q03*

Which one of these questions were Mimi and Dean trying to answer?

A How does the protection for each sunscreen compare with the others?
B How do sunscreens protect your skin from ultraviolet radiation?
C Is there any sunscreen that gives less protection than mineral oil?
D Is there any sunscreen that gives more protection than zinc oxide?

### SUNSCREENS SCORING 3

***Full Credit***

Code 1: A. How does the protection for each sunscreen compare with the others?

***No Credit***

Code 0: Other responses.

Code 9: Missing

## Question 4: SUNSCREENS

*S447Q04*

Why was the second sheet of plastic pressed down?

A To stop the drops from drying out.
B To spread the drops out as far as possible.
C To keep the drops inside the marked circles.
D To make the drops the same thickness.

### SUNSCREENS SCORING 4

***Full Credit***

Code 1: D. To make the drops the same thickness.

***No Credit***

Code 0: Other responses.

Code 9: Missing

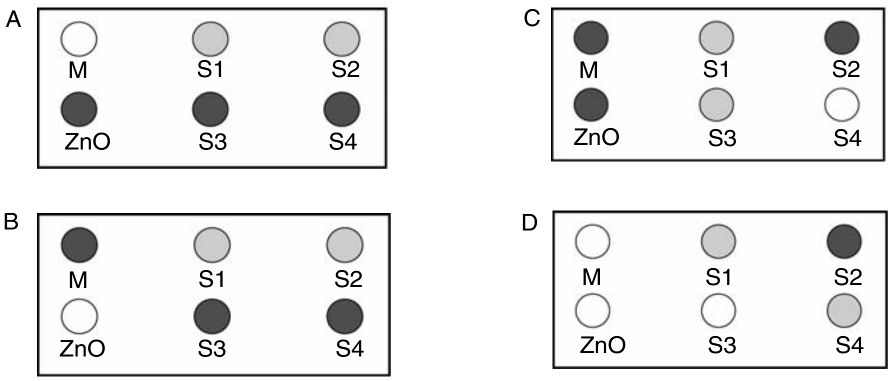
## Question 1: SUNSCREENS

*S447Q05 – 0129*

The light-sensitive paper is a dark grey and fades to a lighter grey when it is exposed to some sunlight, and to white when exposed to a lot of sunlight.

**Translation's Note: The graphic used in the Field Trial Must be replaced with the one below. Diagram C has been changed and the two grey shadings in all the diagrams have been modified so that they will be more distinct when printed.**

Which one of these diagrams shows a pattern that might occur? Explain why you chose it.




Answer: ..........................................

Explanation: ..................................................................................................

..................................................................................................................................

..................................................................................................................................

## SUNSCREENS SCORING 5

**Translation's Note: The layout of the scoring guide has been changed. It is no longer in table format.**

***Full Credit***

Code 2: A. With explanation that the ZnO spot has stayed dark grey (because it blocks sunlight) and the M spot has gone white (because mineral oil absorbs very little sunlight).

[It is not necessary (though it is sufficient) to include the further explanation that are shown in parentheses.]

- A. ZnO has blocked the sunlight as it should and M has let it through.
- I close A because the mineral oil needs to be the lightest shade while the zinc oxide is the darkest.

## Figure C.3 SUNSCREENS

Competencies: Identifying scientific issues and Using scientific evidence

Levels: 4 and 3

# ACID RAIN

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

**Translation's Note: For the Main Study, the Photo Should be place *after* the next paragraph, *not* before it as the Field Trial.**

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

## Question 2: ACID RAIN

*S485Q02 – 0129*

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

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

......................................................................................................................................................

......................................................................................................................................................

**Translation's Note: The names "sulfur oxides" and "nitrogen oxides" refer to the family of oxides made with sulfur and nitrogen- not to any one oxide in particular.**

ACID RAIN SCORING 2

***Full Credit***

Code 2: Any one of car exhausts. Factory emissions, *burning* fossil fuels such as oil and coal gases from volcanoes or other similar things

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

***Partial Credit***

Code 1: Responses that include an incorrect as well as a correct source of the pollution.

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

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

- Pollution.
- The environment in general, the atmosphere we live in — e.g. pollution.
- Gasification, pollution, fires, cigarettes. [It is *not clear what is* meant *by* gasification "fires" is nor *specific enough,* cigarette smoke is not a *specific* cause *of acid rain]*
- Pollution such as from nuclear power plants.

Scoring Comment: just mentioning "pollution" is sufficient for Code 1. Any accompanying examples are only assessed to see if the response merits Code 2 instead.

***No Credit***

Code 0: Other responses. including responses that do not mention "pollution" *and* do not give a significant cause of acid rain.

- They are emitted from plastics
- They are natural components of air.
- Ciarettes.
- Coal and oil [Not *specific enough* — no *reference to "burning"]*
- Nuclear power plants
- industrial waste. [Not specific enough]

Code 9: Missing.

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

## Question 3: ACID RAIN

*S485Q03*

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

A Less than 2.0 C grams
B Exactly 2.0 grams
C Between 2.3 and 2.4 grams
3 More than 2.4 grams

## ACID RAIN SCORING 3

***Full Credit***

Code 1: A. less than 2.0 grams

***No Credit***

Code 0: Other responses.

Code 9: Missing.

## Question 5: ACID RAIN

*S485Q05 – 0129*

Students who did this experiment also placed marble chips in pure (distilled) water overnight

Explain why the students included this step in their experiment.

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## ACID RAIN SCORING 5

***Full Credit***

Code 2: To show that the acid (vinegar) is necessary for the reaction.

- To make sure that rain water must be acidic like acid rain to cause this reaction.
- To see whether there are other reasons for the holes in the marble chips.
- Because it shows than the marble chips don't just react with any fluid since water is neutral.

***Partial Credit***

Code 1: To compare with the test of vinegar and marble, but it is not made clear that this is being done to show that the acid (vinegar) is necessary for the reaction.

- To compare with the other test tube.
- To see whether the marble chip changes in pure water.
- The students included this step to show what happens when it rains normally on the marble.
- Because distilled water is not acid.
- To act as a control.
- To see the difference between normal water and acid water (vinegar).

***No Credit***

Code 0: Other responses.

- To show the distilled water wasn't an acid.

Code 9: Missing

### Question 10N: ACID RAIN

*S485Q10N*

How much interest do you have in the following information?

Tick only one box in each row.

| | *HighI Interest* | *Medium Interest* | *Low Interest* | *No Interest* |
|---|---|---|---|---|
| a) Knowing which human activities contribute most to acid rain | ☐1 | ☐2 | ☐3 | ☐4 |
| b) Learning about technologies that minimise the emission of gases that cause acid rain | ☐1 | ☐2 | ☐3 | ☐4 |
| c) Understanding the methods used to repair buildings damaged by acid rain | ☐1 | ☐2 | ☐3 | ☐4 |

### Question 10S: ACID RAIN

*S485Q10S*

How much do you agree with the following statements?

Tick only one box in each row.

| | *Strongly Agree* | *Agree* | *Disagree* | *Strongly Disagree* |
|---|---|---|---|---|
| a) Preservation of ancient ruins should be based on scientific evidence concerning the causes of damage. | ☐1 | ☐2 | ☐3 | ☐4 |
| b) Statements about the causes of acid rain should be based on scientific research. | ☐1 | ☐2 | ☐3 | ☐4 |

### Figure C.4 ACID RAIN

Competencies: Identifying scientific issues, Explaining phenomena scientifically and Using scientific evidence

Levels: 5 and 3

# CLOTHES

Read the text and answer the questions that follow.

## CLOTHES TEXT

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

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

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

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

Source: Steve Framer, Interactive fabric promises a material gift of the garb', *The Australia*, 10 August 1998.

## Question 1: CLOTHES

*S213Q01*

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

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

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

## CLOTHES SCORING 1

***Full Credit***

Code 1: Yes, Yes, Yes, No, in that order.

***No Credit***

Code 0: Other responses

Code 9: Missing

## Question 2 CLOTHES

*S213Q02*

Which piece of laboratory equipment would be among the equipment you would need to check that the fabric is conducting electricity?

A Voltmeter
B Light box
C Micrometer
D Sound meter

## CLOTHES SCORING 2

***Full Credit***

Code 1: A. Voltmeter

***No Credit***

Code 0: Other responses

## Figure C.5 CLOTHES

Competencies: Identifying scientific issues and Explaining phenomena scientifically

Level: 1

## Table C.1

## Summary descriptions of six levels of proficiency on the competency, Identifying Scientific Issues

| General Proficiencies Students Items Should Haveat Each Level | Specific Tasks a Student Should Be Able to Do | Examples from Released |
|---|---|---|
| Level 6: 0.9% of all students across all PISA 2006 countries can perform tasks at level 6 on the Identifying Scientific Issues scale. This proportion is 0.3% for students in non-OECD countries. | | |
| Students at this level demonstrate an ability to understand and articulate the complex modelling inherent in the design of an investigation. | • Can articulate the aspects of a given experimental design that meet the intent of the scientific question being addressed.<br>• Can design an investigation to adequately meet the demands of a specific scientific question.<br>• Can identify variables that need to be controlled in an investigation and articulate methods to achieve that control. | **Acid Rain**<br>Question 5<br>Figure 2.15 |
| Level 5: 5.2% of all students across all PISA 2006 countries can perform tasks at level 5 on the Identifying Scientific Issues scale. This proportion is 2.4% for students in non-OECD countries. | | |
| Students at this level understand the essential elements of a scientific investigation and thus can determine if scientific methods can be applied in a variety of quite complex, and often abstract contexts. Alternatively, by analysing a given experiment students can identify the question being investigated and explain how the methodology relates to that question. | • Can identify the variables to be changed and measured in an investigation of a wide variety of contexts.<br>• Understands the need to control all variables extraneous to an investigation but impinging on it.<br>• Can ask a scientific question relevant to a given issue. | |
| Level 4: 15.5% of all students across all PISA 2006 countries can perform tasks at level 4 on the Identifying Scientific Issues scale. This proportion is 9.6% for students in non-OECD countries. | | |
| Students at this level can identify the change and measured variables in an investigation and at least one variable that is being controlled. They can suggest appropriate ways of controlling that variable. The question being investigated in straightforward investigations can be articulated. | • Can distinguish the control against which experimental results are to be compared.<br>• Can design investigations in which the elements involve straightforward relationships and lack appreciable abstractness.<br>• Shows an awareness of the effects of uncontrolled variables and attempts to take this into account in investigations. | **Sunscreens**<br>Questions 2 and 4<br>Figure 2.14<br>**Clothes**<br>Question 1<br>Figure 2.16 |
| Level 3: 24.6% of all students across all PISA 2006 countries can perform tasks at level 3 on the Identifying Scientific Issues scale. This proportion is 19.7% for students in non-OECD countries. | | |
| Students at this level are able to make judgements about whether an issue is open to scientific measurement and, consequently, to scientific investigation. Given a description of an investigation the student can identify the change and measured variables. | • Is able to identify the quantities that can be scientifically measured in an investigation.<br>• Can distinguish between the change and measured variables in simple experiments.<br>• Can recognise when comparisons are being made between two tests but is unable to articulate the purpose of a control. | **Acid Rain**<br>Question 5<br>(Partial)<br>Figure 2.15<br>**Sunscreens**<br>Question 3<br>Figure 2.14 |
| Level 2: 25.6% of all students across all PISA 2006 countries can perform tasks at level 2 on the Identifying Scientific Issues scale. This proportion is 26.6% for students in non-OECD countries. | | |
| Students at this level can determine if scientific measurement can be applied to a given variable in an investigation. They can recognise the variable being manipulated (changed) by the investigator. Students can appreciate the relationship between a simple model and the phenomenon it is modelling. In researching topics students can select appropriate key words for a search. | • Can identify a relevant feature being modelled in an investigation.<br>• Shows an understanding of what can and cannot be measured by 'scientific' instruments.<br>• Given several stated aims for an experiment and can select the most appropriate one.<br>• Can recognise what is being changed (the cause) in an experiment.<br>• Can select a 'best' set of internet search words on a topic from several given sets. | **Genetically Modified Crops**<br>Questions 3 and 4<br>Figure 2.13 |

**Table C.1** (concluded)

**Summary descriptions of six levels of proficiency on the competency, Identifying Scientific Issues**

| General Proficiencies Students Should Haveat Each Level | Specific Tasks a Student Should Be Able to Do | Examples from Released Items |
|---|---|---|
| Level 1: 18.2% of all students across all PISA 2006 countries can perform tasks at level 1 on the Identifying Scientific Issues scale. This proportion is 24.3% for students in non-OECD countries. | | |
| Students at this level can suggest appropriate sources of information on scientific topics. They can identify a quantity that is undergoing variation in an experiment. In specific contexts they can recognise whether that variable can be measured using familiar measuring tools or not. | • Given a number of sources of potential information on a scientific topic the student can select some appropriate sources.<br>• Given a specific but simple scenario the student can identify a quantity that is undergoing change.<br>• Within the scope of a student's familiarity with measuring devices can recognise when a device can be used to measure a variable. | |

**Notes:**
1. Results are weighted using the normalized population weights.
2. Ten per cent of students in all PISA 2006 countries scored below Level 1 on this competency. The corresponding estimate for students in non-OECD countries is 17.1 per cent.

The scientific knowledge most applicable to the competency, *Identifying scientific issues*, is that knowledge associated with an understanding of science processes and understanding the major domains of physical, life, and Earth systems. Also helpful is the ability to differentiate between scientific and non-scientific domains. In traditional, discipline-based courses teachers might introduce contemporary issues and have students identify the physics, chemistry, biology, or geology concepts that are fundamental to understanding the issue. Science teachers might consider questions that help students understand the basic scientific knowledge associated with genetically modified crops and acid rain, to use two examples from the released items.

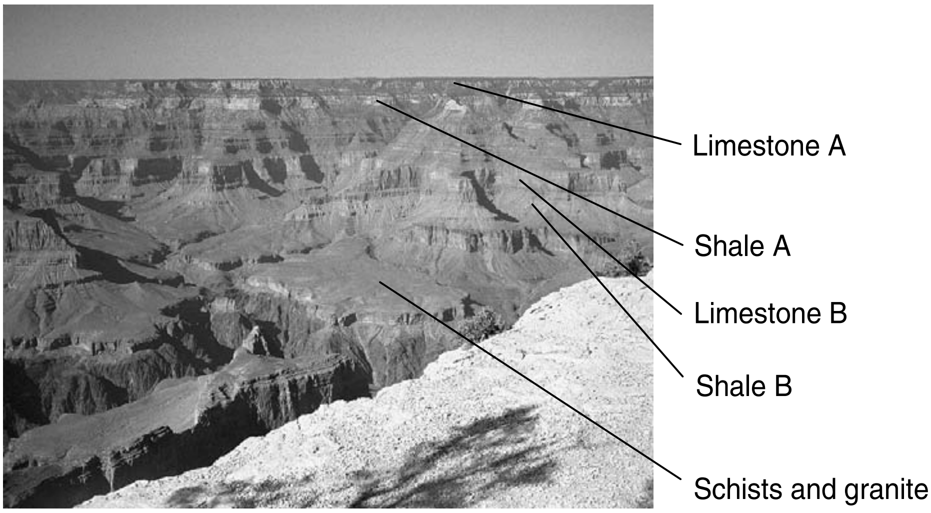
## *Explaining Phenomena Scientifically*

Approximately 46 per cent of the science tasks included in PISA were related to the competency, *Explaining phenomena scientifically*. Figures C.7 through C.10 show tasks at proficiency levels 1, 2, 3, 4, and 6.

# THE GRAND CANYON

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

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




## Question 1: THE GRAND CANYON

*S426Q01 –019*

What caused the Grand Canyon to form?

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## THE GRAND CANYON SCORING 1

***Full Credit***

Code 2: The Colorado River cut down through the layers by eroding away the rock.

- The river cut down through the layers of rock.
- Water erosion because there is a river at the bottom.
- Movement of the Earth's crust lifted these layers up and the erosion.
- The river moulded the terrain.
- The flowing water.
- Soil erosion

**Scoring Comment:** To gain Code 1, the response must refer to "water erosion" (or just "erosion"). or explicitly mention the action of water (mentioning "river" is enough).

***Full Credit***

Code 0: Other responses

- Underground canyons that collapsed.
- Wind erosion.
- By the water.
- The Grand Canyon formed because the movement of the Earth's crust uplifted the layers of rock composing the canyon wall.
- Glaciers.

## Question 7: THE GRAND CANYON

*S426Q07*

About five million people visit the Grand Canyon national park every year. There is concern about the damage that is being caused to the park by so many visitors.

Can the following questions be answered by scientific investigation? Circle "Yes" or "No" for each question.

| Can this question be answered by scientific investigation? | Yes or No? |
|---|---|
| How much erosion is caused by use of the walking tracks? | Yes / No |
| Is the park area as beautiful as it was 100 years ago? | Yes / No |

## THE GRAND CANYON SCORING 7

***Full Credit***

Code 1: Both correct Yes, No in that other.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

## Question 3: THE GRAND CANYON

S426Q03

The temperature in the Grand Canyon ranges from below 0 °C to over 40 °C
A1 though it a desert area cracks in the rocks sometimes contain water. How do these temperature changes and the water in rock cracks help to speed up the breakdown of rocks?

A Freezing water dissolves warm rocks
B Water cements rocks together
C Ice smoothes the surface of rocks
D Freezing water expands in the rock cracks.

### THE GRAND CANYON SCORING 3

***Full* Credit**

Code 1: D. Freezing water expands in tie rook cracks.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

## Question 5: THE GRAND CANYON

S426Q05

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

A In ancient times, people brought seafood to the area from the ocean.
B Oceans were once much rougher and sea water washed inland on giant waves.
C An ocean covered this area at that time aid then receded later,
D Some sea animals once lived on land before migrating to the sea.

### THE GRAND CANYON SCORING 5

***Full Credit***

Code 1: C. An ocean covered this area at that time arid then receded later.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

**translation's Note: In Question 10S, "National Parks" should be replaced with the most common term used in the country for nature or scenic reserves.**

**Question 10S: THE GRAND CANYON** *S426Q10S*

How much do you agree with the following statements?

Tick only one box in each row.

| | *Strongly Agree* | *Agree* | *Disagree* | *Strongly Disagree* |
|---|---|---|---|---|
| a) The systematic study of fossils is important. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |
| b) Action to protect National Parks from damage should be based on scientific evidence. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |
| c) Scientific investigation of geological layers is important. | ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 |

**Figure C.6 GRAND CANYON**

Competency: Explaining phenomena scientifically

Levels: 2 and 1

# PHYSICAL EXERCISE

Regular but moderate physical exercise is good for our health.

**Translation's Note: Field Trial graphic has been enhanced. It MUST be replaced with the above graphic.**

## Question 1: PHYSICAL EXERCISE

*S493Q01*

What are the advantages of regular physical exercise? Circle "Yes" or "No" for each statement.

| Is this an advantage of regular physical exercise? | Yes or No? |
|---|---|
| Physical exercise helps prevent heart and circulation illnesses. | Yes / No |
| Physical exercise leads to a healthy diet. | Yes / No |
| Physical exercise helps to avoid becoming overweight. | Yes / No |

## PHYSICAL EXERCISE SCORING 1

***Full Credit***

Code 1: All three correct: Yes, No, Yes in that or their.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

## Question 3: PHYSICAL EXERCISE

*S493Q03*

What happens when muscles are exercised? Circle “Yes” or “No” for each statement.

| Does this happen when muscles are exercised? | Yes or No? |
|---|---|
| Muscles get an increased flow of blood. | Yes / No |
| Fats are formed in the muscles. | Yes / No |

## PHYSICAL EXERCISE SCORING 3

***Full Credit***

Code 1: Both correct Yes, No in that other.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

**Question 5: PHYSICAL EXERCISE** *S493Q05 – 01 11 12 99*

Why do you have to breathe more heavily when you're doing physical exercise than when your body is resting?

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## PHYSICAL EXERCISE 5

***Full Credit***

Code 11: To remove *increased* levels of carbon dioxide from your body or to supply more oxygen to your body, but not both. *[Do not accept "air" instead of "carbon dioxide" or "oxygen".]*

- When you exercise your body needs more oxygen and produces more carbon dioxide. Breathing does this.
- Breathing faster allows more oxygen into the blood and more carbon dioxide to be removed.

Code 12: To remove *increased* levels of carbon dioxide from your body or to supply more oxygen to your body, but not both. *[Do not accept "air" instead of "carbon dioxide" or "oxygen".]*

- Because we must get rid the carbon dioxide that builds up.
- Because the muscles need oxygen. *[The implication is that you body needs <u>more</u> oxygen when you are exercising (using your muscles).]*
- Because physical exercise uses up oxygen.
- You breathe more heavily because you are taking more oxygen into your lungs. *[Poorly expressed, but recognises that you are supplied with more oxygen.]*
- Since you are using so much energy your body needs double or triple the amount of air intake. It also needs to remove the carbon dioxide in your body.

  *[Code 12 for second sentence – the implication is that more carbon dioxide that usual has to be removed from your; the first sentence is not contradictory, though by itself it would get Code 01.]*

***No Credit***

Code 0: Other responses.

- To get more air in your lungs.
- Because muscles consume more energy. *[Not specific enough.]*
- Because your heart beats faster.
- Your body needs oxygen. *[Does not refer to the need <u>more</u> oxygen.]*

Code 99: Missing.

### Figure C.7 PHYSICAL EXERCISE

Competency: Explaining phenomena scientifically

Levels: 4 and 1

# MARY MONTAGU

Read the following newspaper article and answer the questions that follow.

## THE HISTORY OF VACCINATION

Mary Montagu was a beautiful woman. She survived an attack of smallpox in 1715 but she was left covered with scars. While living in Turkey in 1717, she observed a method called inoculation that was commonly used there. This treatment involved scratching a weak type of smallpox virus into the skin of healthy young people who then became sick, but in most cases only with a mild form of the disease.

Mary Montagu was so convinced of the safety of these inoculations that she allowed her son and daughter to be inoculated.

In 1796, Edward Jenner used inoculations of a related disease, cowpox, to produce antibodies against smallpox. Compared with the inoculation of smallpox, this treatment had less side effects and the treated person could not infect others. The treatment became known as vaccination.

## Question 2: MARY MONTAGU

*S477Q02*

What kinds of diseases can people be vaccinated against?

A Inherited diseases like hemophilia.
B Diseases that are caused by viruses, like polio.
C Diseases from the malfunctioning of the body, like diabetes.
D Any sort of disease that has no cure.

## MARY MONTAGU SCORING 2

***Full Credit***

Code 1: B. Diseases that are caused by viruses, like polio.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

## Question 3: MARY MONTAGU *S477Q03*

If animals or humans become sick with an infectious bacterial disease and then recover, the type of bacteria that caused the disease does not usually make them sick again.

What is the reason for this?

A The body has killed all bacteria that may cause the same kind of disease.
B The body has made antibodies that kill this type of bacteria before they multiply.
C The red blood cells kill all bacteria that may cause the same kind of disease.
D The red blood cells capture and get rid of this type of bacteria from the body.

## MARY MONTAGU SCORING 3

***Full Credit***

Code 1: B. The body has made antibodies that kill this type of bacteria before they multiply.

***No Credit***

Code 0: Other responses.

Code 9: Missing.

## Question 4: MARY MONTAGU

*S477Q04 – 019*

Give one reason why it is recommended that young children and old people, in particular, should be vaccinated against influenza (flu).

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## MARY MONTAGU SCORING 4

***Full Credit***

Code 1: Responses referring to young and/or old people having weaker immune systems that other people, or similar.

Scoring Comment: The reason(s) given must refer to young or old people *in particular* – not to everyone in general. Also, the response must indicate, directly or indirectly., that these people have weaker immune systems that other people – not just that they are generally "weaker".

- These people have less resistance to getting sick.
- The young and old can't fight off disease as easily as others.
- They are more likely to catch the flu.
- If they get the flu the effects are worse in these people.
- Because organisms of young children and older people are weaker.
- Old people get sick more easily.

***No Credit***

Code 0: Other responses.

- So they don't get the flu.
- They are weaker.
- They need help to fight the flu.

Code 9: Missing.

## Question 10S: MARY MONTAGU

*S477Q10S*

How much do you agree with the following statements?

Tick only one box in each row.

| | Strongly Agree | Agree | Disagree | Strongly Disagree |
|---|---|---|---|---|
| a) I am in favour of research to develop vaccines for new strains of influenza. | ☐1 | ☐2 | ☐3 | ☐4 |
| b) The cause of a disease can only be identified by scientific research. | ☐1 | ☐2 | ☐3 | ☐4 |
| c) The effectiveness of unconventional treatments for diseases should be subject to scientific investigation. | ☐1 | ☐2 | ☐3 | ☐4 |

**Figure C.8 MARY MONTAGU**

Competency: Explaining phenomena scientifically

Levels: 3 and 2

## GREENHOUSE

*Read the texts and answer the questions that follow.*

### THE GREENHOUSE EFFECT: FACT OR FICTION?

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

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

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

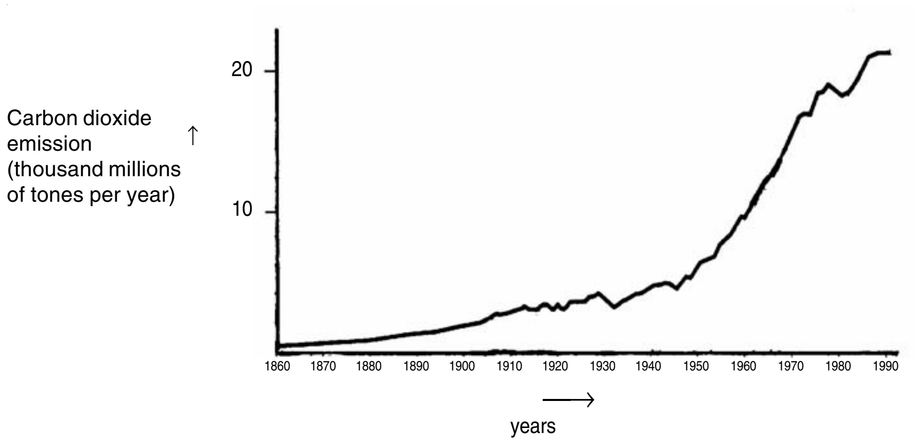
As a result of this the average temperature above the Earth's surface is higher than it would be if there were no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term *greenhouse effect.*

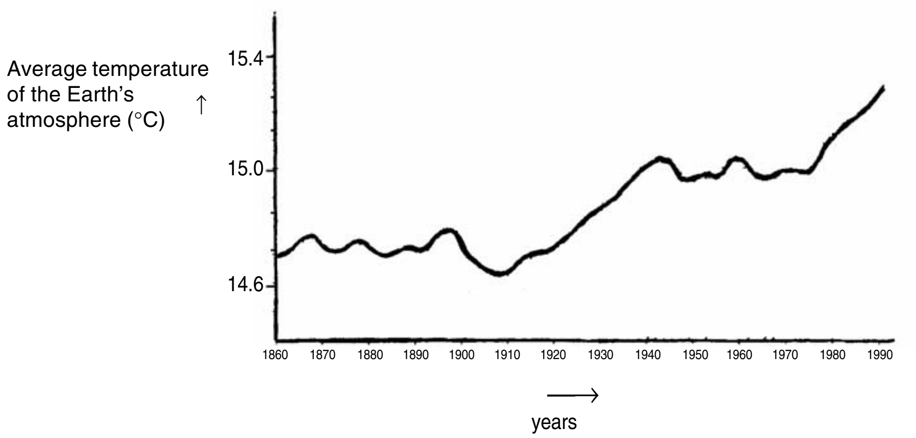
The greenhouse effect is said to have become more pronounced during the twentieth century.

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

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

In a library he comes across the following two graphs.




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

### Question 3: GREENHOUSE

*S114Q03 – 01 02 11 12 99*

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

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## GREENHOUSE SCORING 3

***Full Credit***

Code 11: Refers to the increase of both (average) temperature and cardon dioxide emission.

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

Code 12: Refers (in general terms) to a positive relationship between temperature and carbon dioxide emission.

*[Note: This code is intended to capture students' use of terminology such as 'positive relationship', 'similar shape' or 'directly proportional'; although the following sample response is not strictly correct, it shows sufficient understanding to be given credit here.]*

- The amount of $CO_2$ and average temperature of the Earth is directly proportional.
- They have a similar shape indicating a relationship.

***No Credit***

Code 01: Refers to the increase of either the (average) temperature or the carbon dioxide emission.

- The temperature has gone up.
- $CO_2$ is increasing.
- It shows the dramatic change in the temperatures.

Code 2: Refers to temperature and carbon dioxide emission without being clear about the nature of the relationship.

- The carbon dioxide emission (graph 1) has an affect on the earth's rising temperature (graph 2).
- The carbon dioxide is the main cause of the increase in the earth's temperature.

or

Other responses.

- The carbon dioxide emission is greatly rising more than the average Earth's temperature. *[Note: This answer is incorrect because the extent to which the $CO_2$ emission and the temperature are rising is seen as the answer, rather than that they are both increasing.]*
- The rise of $CO_2$ over the years is due to the rise of the temperature of the Earth's atmosphere.
- The way the graph goes up.
- There is a rise.

Code 99: Missing.

## Question 4: GREENHOUSE

*S114Q04 – 0129*

Another student, Leena, disagrees with Kaled's conclusion. She compares the two graphs and says that some parts of the graphs do not support his conclusion. Give an example of a part of the graphs that does not support Kaled's conclusion. Explain your answer.

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## GREENHOUSE SCORING 4

***Full Credit***

Code 2: Refers to one particular part of the graphs in which the curves are not both descending or both climbing and gives the corresponding explanation.

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

***Partial Credit***

Code 1: Mentions a correct period, without any explanation.

- 1930-1933.
- before 1910.

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

- in 1980 the emissions went down but the temperature still rose.

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

- Between 1950 and 1980 the temperature decreased and the carbon dioxide emission increased.

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

- At some places the temperature rises even if the emission decreases.
- Earlier there was little emission but nevertheless high temperature.
- When there is a steady increase in graph 1. 5 there isn't an increase in graph 2. It stays constant. *[Note: It stays constant "overall".]*
- Because at the start the temperature is still high where the cardon dioxide was very low.

Refers to an irregularity in one of the graphs.

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

Indicates difference in the graphs, but explanation is poor.

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

***No Credit***

Code 0: Refers to an irregularity in a curve without referring specifically to the two graphs.

- It goes a little up and down.
- It went down in 1930
- Fossil fuels.

Refers to a poorly defined period or year without any explanation.

- The middle part.
- 1910.

Other responses

- In 1940 the average temperature increased, but not the carbon dioxide emission.
- Around 1910 the temperature has increased but not the emission.

Code 9: Missing

## Question 5: GREENHOUSE *S114Q05 - 01 02 03 11 12 99*

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

Name one of the factors that Jeanne means.

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## GREENHOUSE SCORING 5

***Full Credit***

Code 11: Gives a factor referring to the energy/irradiation coming from the Sun.

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

Code 12: Gives a factor referring to a natural component or a potential pollutant.

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

***No Credit***

Code 01: Refers to a cause that influences the carbon dioxide concentration.

- Cleaning of rain forest
- The amount of $CO_2$ being let off.
- Fossil fuels.

Code 02: Refers to a non-specific factor**.**

- Fertilisers.
- Sprays.
- How the weather has been.

Code 03: Other incorrect factors or other responses.

- Amount of oxygen.
- Nitrogen.
- The hole in the ozone layer is also getting bigger.

Code 99: Missing.

## Figure C.9 GREENHOUSE

Competencies: Explaining phenomena scientifically and using scientific evidence

Levels: 6, 5, 4 and 3

Table C.2 describes examples of competencies required to attain proficiency levels for the science competency, *Explaining phenomena scientifically*.

## Table C.2

## Summary descriptions of six levels of proficiency on the competency, Explaining Phenomena Scientifically

| General Proficiencies Students Should Have at Each Level | Specific Tasks a Student Should Be Able to Do | Examples from Released Items |
|---|---|---|
| Level 6: 1.4% of all students across all PISA 2006 countries can perform tasks at level 6 on the Explaining Phenomena Scientifically scale. This proportion is 0.8% for students in non-OECD countries. | | |
| Students at this level draw on a range of abstract scientific knowledge and concepts and the relationships between these in developing explanations of processes within systems. | • Demonstrates an understanding of a variety of complex, abstract physical, biological or environmental systems.<br>• In explaining processes can articulate the relationships between a number of discrete elements or concepts. | **Greenhouse**<br>Question 5<br>Figure 2.21 |
| Level 5: 6.2% of all students across all PISA 2006 countries can perform tasks at level 5 on the Explaining Phenomena Scientifically scale. This proportion is 4.0% for students in non-OECD countries. | | |
| Students at this level draw on knowledge of two or three scientific concepts and identify the relationship between them in developing an explanation of a contextual phenomenon. | • Is able to take a scenario, identify its major component features, whether conceptual or factual, and use the relationships between these features in providing an explanation of a phenomenon.<br>• Can synthesise two or three central scientific ideas in a given context in developing an explanation for, or a prediction of, an outcome. | |
| Level 4: 15.6% of all students across all PISA 2006 countries can perform tasks at level 4 on the Explaining Phenomena Scientifically scale. This proportion is 10.8% for students in non-OECD countries. | | |
| Students at this level have an understanding of scientific ideas, including scientific models, with a significant level of abstraction. They can apply a general, scientific concept containing such ideas in the development of an explanation of a phenomenon. | • Understands a number of abstract scientific models and can select an appropriate one from which to draw inferences in explaining a phenomenon in a specific context, e.g. the particle model, planetary models, models of biological systems.<br>• Is able to link two or more pieces of very specific knowledge (including from an abstract source) in an explanation, e.g. increased exercise leads to increased metabolism in muscle cells, this is turn requires and increased exchange of gases in the blood supply which is achieved by an increased rate of breathing. | **Physical Exercise**<br>Question 5<br>Figure 2.19 |
| Level 3: 23.3% of all students across all PISA 2006 countries can perform tasks at level 3 on the Explaining Phenomena Scientifically scale. This proportion is 19.1% for students in non-OECD countries. | | |
| Students at this level can apply one or more concrete or tangible scientific ideas or concepts in the development of an explanation of a phenomenon. This is enhanced when there are specific cues given or options available from which to choose. When developing an explanation, cause and effect relationships are recognised and simple, explicit scientific models may be drawn upon. | • Understands the central feature(s) of a scientific system and, in concrete terms, can predict outcomes from changes in that system, e.g. the effect of a weakening of the immune system in a human.<br>• In a simple and clearly defined context can recall several relevant, tangible facts and apply these in developing an explanation of the phenomenon. | **Mary Montagu**<br>Question 4<br>Figure 2.20<br>**Acid Rain**<br>Question 2<br>Figure 2.15 |
| Level 2: 24.8% of all students across all PISA 2006 countries can perform tasks at level 2 on the Explaining Phenomena Scientifically scale. This proportion is 25.5% for students in non-OECD countries. | | |
| Students at this level can recall an appropriate, tangible, scientific fact applicable in a simple and straightforward context and can use it to explain or predict an outcome. | • Given a specific outcome in a simple context can, in a number of cases and with appropriate cues, indicate the scientific fact or process that has caused that outcome, e.g. water expands when it freezes and opens cracks in rocks, land containing marine fossils was once under the sea.<br>• Can recall specific scientific facts with general currency in the public domain, e.g. vaccination provides protection against viruses that cause disease. | **Grand Canyon**<br>Question 3<br>Figure 2.18<br>**Mary Montagu**<br>Questions 2 and 3<br>Figure 2.20 |

**Table C.2** (concluded)

**Summary descriptions of six levels of proficiency on the competency, Explaining Phenomena Scientifically**

| General Proficiencies Students Should Have at Each Level | Specific Tasks a Student Should Be Able to Do | Examples from Released Items |
|---|---|---|
| Level 1: 18.8% of all students across all PISA 2006 countries can perform tasks at level 1 on the Explaining Phenomena Scientifically scale. This proportion is 24.2% for students in non-OECD countries. | | |
| Students at this level can recognise simple cause and effect relationships given relevant cues. The knowledge drawn upon is a singular scientific fact that is drawn from experience or has widespread popular currency. | • Can choose a suitable response from among several responses given the context is a simple one and that re call of a single scientific fact is involved, e.g. ammeters are used to measure electric current.<br>• Given sufficient cues, simple cause and effect relations hips are recognised, e.g. Do muscles get an increased flow of blood during exercise? Yes or No. | **Physical Exercise**<br>Question 3<br>Figure 2.19<br>**Clothes**<br>Question 2<br>Figure 2.16<br>**Grand Canyon**<br>Question 5<br>Figure 2.18 |

Notes:

1. Results are weighted using the normalized population weights.
2. 9.9 per cent of students in all PISA 2006 countries scored below Level 1 on this competency. The corresponding estimate for students in non-OECD countries is 15.6 per cent.

The competency, explaining phenomena scientifically, is directly related to the aims of traditional science courses such as physics and biology. In PISA 2006, this critical aspect of scientific literacy centered on basic scientific concepts such as those described in Figure 2.4. What this means for teachers in countries with traditional science courses is a combined emphasis on major concepts fundamental to science disciplines complemented with facts and information associated with the basic concepts.

## Using Scientific Evidence

Approximately 32 per cent of science tasks presented to students in PISA related to the science competency, *Using scientific evidence*. Sample tasks for this competency are included in units on Acid Rain, Greenhouse, and Sunscreens. The figures describe sample tasks at levels 2, 3, 4, and 5.

The precise competencies required to perform at different levels of proficiency are described in Table C.3. This competency requires students to synthesize knowledge of science and knowledge about science as they apply both of these to a life situation or contemporary social problem. Although addressing this competency can be done in traditional science classes, it will require a contextual issue related to physics, chemistry, biology, or geology. Presenting students with issues in contexts such as those used in PISA 2006, provides the opportunity for students to identify the science discipline, clarify the concepts basic to the instruction, and then combine their understanding of science processes and content to articulate a decision or solution.

## Table C.3

## Summary descriptions of six levels of proficiency on the competency, Using Scientific Evidence

| General Proficiencies Students Should Have at Each Level | Specific Tasks a Student Should Be Able to Do | Examples from Released Items |
|---|---|---|
| Level 6: 1.6% of all students across all PISA 2006 countries can perform tasks at level 6 on the Using Scientific Evidence scale. This proportion is 0.7% for students in non-OECD countries. | | |
| Students at this level demonstrate an ability to compare and differentiate among competing explanations by examining supporting evidence. They can formulate arguments by synthesising evidence from multiple sources. | • Can recognise that alternative hypotheses can be formed from the same set of evidence.<br>• Is able to test competing hypotheses against available evidence.<br>• Can construct a logical argument for a hypo thesis by using data from a number of sources. | |
| Level 5: 6.9% of all students across all PISA 2006 countries can perform tasks at level 5 on the Using Scientific Evidence scale. This proportion is 4.0% for students in non-OECD countries. | | |
| Students at this level are able to interpret data from related datasets presented in various formats. They can identify and explain differences and similarities in the datasets and draw conclusions based on the combined evidence presented in those datasets. | • Can compare and discuss the characteristics of different datasets graphed on the one set of axes.<br>• Can recognise and discuss relationships between datasets (graphical and otherwise) in which the measured variable differs.<br>• Based on an analysis of the sufficiency of the data, is able to make judgements about the validity of conclusions. | **Greenhouse**<br>Question 4<br>Figure 2.21 |
| Level 4: 16.0% of all students across all PISA 2006 countries can perform tasks at level 4 on the Using Scientific Evidence scale. This proportion is 11.1% for students in non-OECD countries. | | |
| Students at this level can interpret a dataset expressed in a number of formats, such as tabular, graphic and diagrammatic, by summarising the data and explaining relevant patterns. They can use the data to draw relevant conclusions. Students can also determine whether the data supports assertions about a phenomenon. | • Can locate relevant parts of graphs and compare these in response to specific questions.<br>• Understands how to use a control in analysing the results of an investigation and developing a conclusion.<br>• Is able to interpret a table that contains two measured variables and suggest credible relationships between those variables.<br>• Can identify the characteristics of a straightforward technical device by reference to diagrammatic representations and general scientific concepts and thus form conclusions about its method of operation. | **Sunscreens**<br>Question 5<br>Figure 2.14<br>**Greenhouse**<br>Question 4<br>(Partial)<br>Figure 2.21 |
| Level 3: 22.0% of all students across all PISA 2006 countries can perform tasks at level 3 on the Using Scientific Evidence scale. This proportion is 18.4% for students in non-OECD countries. | | |
| Students at this level are able to select a piece of relevant information from data in answering a question or in providing support for or against a given conclusion. They can draw a conclusion from an uncomplicated or simple pattern in a dataset. Students can also determine, in simple cases, if enough information is present to support a given conclusion. | • Given a specific question is able to locate relevant scientific information in a body of text.<br>• Given specific evidence or data can choose between appropriate and inappropriate conclusions.<br>• Can apply a simple set of criteria in a given context in order to draw a conclusion or make a prediction about an outcome.<br>• Given a set of functions is able to determine if they are applicable to a specific machine. | **Greenhouse**<br>Question 3<br>Figure 2.21 |
| Level 2: 22.3% of all students across all PISA 2006 countries can perform tasks at level 2 on the Using Scientific Evidence scale. This proportion is 22.5% for students in non-OECD countries. | | |
| Students at this level are able to recognise the general features of a graph if they are given appropriate cues and can point to an obvious feature in a graph or simple table in support of a given statement. They are able to recognise if a set of given characteristics apply to the function of everyday artifacts in making choices about their use. | • Can compare two columns in a simple table of measurements and indicate differences.<br>• Is able to state a trend in a set of measurements or simple line or bar graph.<br>• Given a common artifact can determine some characteristics or properties pertaining to the artifact from among a list of properties. | **Acid Rain**<br>Question 3<br>Figure 2.15 |

## Table C.3 (concluded)

## Summary descriptions of six levels of proficiency on the competency, Using Scientific Evidence

| General Proficiencies Students Should Have at Each Level | Specific Tasks a Student Should Be Able to Do | Examples from Released Items |
|---|---|---|
| Level 1: 17.5% of all students across all PISA 2006 countries can perform tasks at level 1 on the Using Scientific Evidence scale. This proportion is 21.6% for students in non-OECD countries. | | |
| In response to a question, students at this level can extract information from a fact sheet or diagram pertinent to a common everyday context. They can extract information from bar graphs where the requirement is simple comparisons of bar heights. In common, experienced contexts students at this level can attribute an effect to a cause. | • In response to a specific question pertaining to a bar graph is able to make comparisons of the height of bars and give meaning to the difference observed.<br>• Given variation in a natural phenomenon can, in some cases, indicate an appropriate cause e.g. fluctuations in the output of wind turbines may be attributed to changes in wind strength. | |

Notes:

1. Results are weighted using the normalized population weights.
2. 13.7 per cent of students in all PISA 2006 countries scored below Level 1 on this competency. The corresponding estimate for students in non-OECD countries is 21.7 per cent.

# Appendix D

## References


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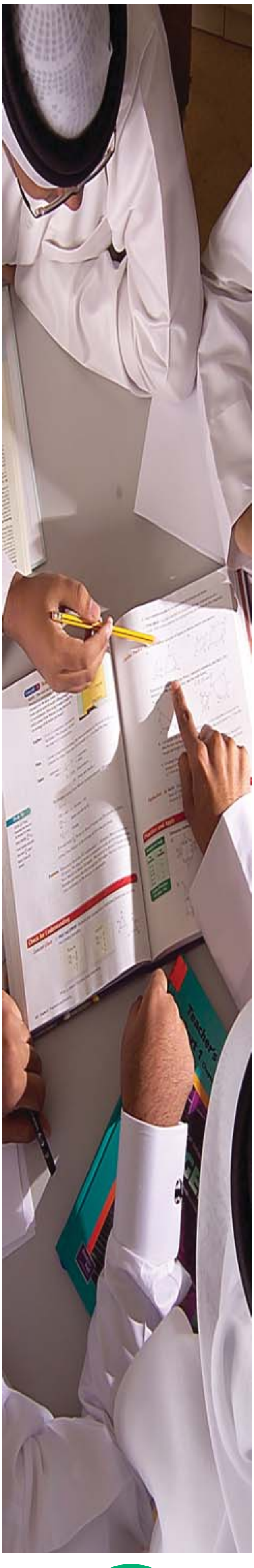
# Appendix E

## Acknowledgements



The authors of this report cannot take full credit for its production. Many persons have contributed to making this study possible, and the authors wish to thank all those who have assisted with various aspects of PISA 2006, including national management and oversight, survey design, data collection, data cleaning and analysis, drafting and editing of the report, technical reviews, translation, and finally, production design and printing. Thanks are also owed to members of the PISA international management team, especially the secretariat of the Organisation for Economic Co-operation and Development (OECD) and the Australian Council for Educational Research (ACER). In particular, the contributions of the following members of the Qatar PISA 2006 project team are gratefully acknowledged:

### Supreme Education Council

His Highness, the Heir Apparent, Sheikh Tamim Bin Hamad Bin Khalifa Al-Thani, Chair

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# Knowledge and Skills for the New Millennium:

## Results from PISA 2006 for Qatar

Ensuring that all children and youth in Qatar are equipped with the knowledge and skills they need to fully participate in society and the increasingly global and competitive world of work are among the key objectives pursued by the Supreme Education Council. This eminent Council was installed by Emiri decree of 2002, calling upon Qatar's educators to realise the "Education for a New Era" initiative – probably one of the most comprehensive and ambitious education reform programmes the world has seen to date.

The results presented in this report place the reading, mathematic and scientific literacy proficiencies of Qatar's 15-year-olds in an international context. Whilst performance is comparatively low by OECD standards, the findings presented do offer reason for optimism. Provided the political will to effect improvement, and the financial means invested in education in Qatar, are sustained at present levels, the reading literacy proficiency of students attending school in the country will, in time, be raised to a world-class standard of competence. In this scenario, the relationships revealed by the data analyses presented in this report hold the promise of concomitant improvement in the mathematics and science scores attained by future cohorts of students in Qatar.