PISA 2015 Assessment and Analytical Framework

SCIENCE, READING, MATHEMATIC, FINANCIAL LITERACY AND COLLABORATIVE PROBLEM SOLVING

Revised edition

Programme for International Student Assessment

OECD

PISA

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OECD
BETTER POLICIES FOR BETTER LIVES

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Foreword

The OECD Programme for International Student Assessment (PISA), created in 1997, represents a commitment by the governments of OECD countries to monitor the outcomes of education systems, in terms of student achievement, within a common, internationally agreed framework. PISA is a collaborative effort, bringing together scientific expertise from the participating countries/economies and steered jointly by their governments on the basis of shared policy interests. Experts from participating countries also serve on working groups that are charged with linking the PISA policy objectives with the best available substantive and technical expertise in the field of internationally comparable assessments. Through involvement in these expert groups, countries ensure that the PISA assessment instruments are internationally valid and take into account the cultural and curricular context of the PISA-participating countries and economies.

PISA 2015 is the sixth cycle of the triennial assessment. For the first time, PISA 2015 delivers the assessments of all subjects – science, reading, mathematics, financial literacy and the additional domain, collaborative problem solving – via computer. However a paper-based assessment instrument, consisting only of trend items, is provided for countries/economies that choose not to test their students on computer.

As in 2006, scientific literacy is the main focus of this survey. The framework for assessing science was fully revised for the PISA 2015 assessment and introduces a refined notion of "knowledge about science" that has been split into two components – procedural knowledge and epistemic knowledge. In addition, the construct "Support for scientific enquiry" has been changed to "Valuing scientific approaches to enquiry", which is essentially a change in terminology to better reflect what is measured. In addition, the contexts in PISA 2015 have been changed from "personal, social and global" in the 2006 assessment to "personal, local/national and global" to make the headings more coherent across the domains.

The framework for assessing reading was revised for PISA 2009 while the frameworks for assessing mathematics and financial literacy were revised for PISA 2012. These frameworks remained unchanged in PISA 2015. The analytic framework on which the development of the various questionnaires was based was also redeveloped for PISA 2015. This revised edition includes the framework that was developed for assessing collaborative problem solving for the first time in PISA 2015.

This publication presents the guiding principles behind the PISA 2015 assessment, and the framework for assessing collaborative problem solving was developed by the collaborative problem solving expert group, which are described in terms of the knowledge and competencies students need to acquire and use to solve scientific problems, the contexts in which knowledge and competencies are applied, and students' attitudes towards science. Sample tasks are also included.

The framework for assessing science was developed by the scientific literacy expert group with the guidance of John de Jong, Rose Clesham, Christine Rozunick, Peter Foltz, Mark Robeck and Catherine Hayes from Pearson. The scientific literacy expert group was chaired by Jonathan Osborne from Stanford University. The collaborative problem solving expert group was chaired by Art Graesser, University of Memphis.

The framework for the PISA 2015 questionnaires was developed by the questionnaire expert group with the guidance of Eckhard Klieme from the German Institute for International Educational Research (DIPF) in Germany. The questionnaire expert group was chaired by David Kaplan from the University of Wisconsin, United States. Other experts who contributed to the development of the questionnaire framework are Sonja Bayer, Jonas Bertling, Bieke de Fraine, Art Graesser, Silke Hertel, Nina Jude, Franz Klingebiel, Susanne Kuger Patrick Kyllonen, Leonidas Kyriakides, Katharina Müller, Manfred Prenzel, Christine Sälzer, Tina Seide, Anja Schiepe-Tiska, Svenja Vieluf and Nadine Zeidler.

The frameworks have also been reviewed by expert panels in each of the participating countries. The chapters were drafted by the respective expert groups under the direction of their chairs. The members of the expert groups are listed in Annex B.

The publication was prepared by the OECD Secretariat, principally by Sophie Vayssettes, Marilyn Achiron, Sophie Limoges and Hélène Guillou. Miyako Ikeda and Jeffrey Mo were responsible for the additional framework for collaborative problem solving. Rose Bolognini oversaw the production of this revised edition and Fung Kwan Tam designed the publication.

The report is published under the responsibility of the Secretary-General of the OECD.

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What is PISA?

"What is important for citizens to know and be able to do?" In response to that question and to the need for cross-nationally comparable evidence on student performance, the Organisation for Economic Co-operation and Development (OECD) launched the Programme for International Student Assessment (PISA) in 1997. PISA assesses the extent to which 15-year-old students, near the end of their compulsory education, have acquired key knowledge and skills that are essential for full participation in modern societies.

The triennial assessment focuses on the core school subjects of science, reading and mathematics. Students' proficiency in an innovative domain is also assessed (in 2015, this domain is collaborative problem solving). The assessment does not just ascertain whether students can reproduce knowledge; it also examines how well students can extrapolate from what they have learned and can apply that knowledge in unfamiliar settings, both in and outside of school. This approach reflects the fact that modern economies reward individuals not for what they know, but for what they can do with what they know.

PISA is an ongoing programme that, over the longer term, will lead to the development of a body of information for monitoring trends in the knowledge and skills of students in various countries as well as in different demographic subgroups of each country. In each round of PISA, one of the core domains is tested in detail, taking up nearly two-thirds of the total testing time. The major domain in 2015 is science, as it was in 2006. Reading was the major domain in 2000 and 2009, and mathematics was the major domain in 2003 and 2012.

Through questionnaires distributed to students, parents, school principals and teachers, PISA also gathers information about students' home background, their approaches to learning and their learning environments.

With this alternating schedule of major domains, a thorough analysis of achievement in each of the three core areas is presented every nine years; an analysis of trends is offered every three years. Combined with the information gathered through the various questionnaires, the PISA assessment provides three main types of outcomes:

- Basic indicators that provide a baseline profile of the knowledge and skills of students.
- Indicators derived from the questionnaires that show how such skills relate to various demographic, social, economic and educational variables.
- Indicators on trends that show changes in outcome levels and distributions, and in relationships between student-level, school-level and system-level background variables and outcomes.

Policy makers around the world use PISA findings to gauge the knowledge and skills of students in their own country/economy in comparison with those in other participating countries/economies, establish benchmarks for improvements in the education provided and/or in learning outcomes, and understand the relative strengths and weaknesses of their own education systems.

This publication presents the theory underlying the PISA 2015 assessment – the sixth since the programme's inception. It includes frameworks for assessing the three core subjects – science, reading and mathematics (Chapters 2, 3 and 4, respectively) – and the framework for an assessment of students' financial literacy (Chapter 5). This revised edition includes the framework for assessing collaborative problem solving, outlined in Chapter 7. The chapters outline the knowledge content that students need to acquire in each domain, the processes that students need to be able to perform, and the contexts in which this knowledge and these skills are applied. They also discuss how each domain is assessed. Chapter 6 explains the theory underlying the context questionnaires distributed to students, their parents, school principals and teachers.

WHAT MAKES PISA UNIQUE

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

PISA's unique features include its:

- **Policy orientation,** which connects data on student learning outcomes with data on students' backgrounds and attitudes towards learning, and on key factors that shape their learning in and outside school, in order to highlight differences in performance patterns and identify the characteristics of schools and education systems that perform well.
- **Innovative concept of "literacy",** which refers to students' capacity to apply knowledge and skills in key subjects, and to analyse, reason and communicate effectively as they identify, interpret and solve problems in a variety of situations.
- **Relevance to lifelong learning,** as PISA asks students to report on their motivation to learn, their beliefs about themselves and their learning strategies.
- **Regularity,** which enables countries to monitor their progress in meeting key learning objectives.
- **Breadth of coverage,** which, in PISA 2015, encompasses the 34 OECD countries and 38 partner countries and economies.

Box 1.1 **Key features of PISA 2015**

The content

The PISA 2015 survey focused on science, with reading, mathematics and collaborative problem solving as minor areas of assessment. PISA 2015 also included an assessment of young people's financial literacy, which was optional for countries and economies.

PISA assesses not only whether students can reproduce knowledge, but also whether they can extrapolate from what they have learned and apply their knowledge in new situations. It emphasises the mastery of processes, the understanding of concepts, and the ability to function in various types of situations.

The students

Approximately 540 000 students completed the assessment in 2015, representing about 29 million 15-year-olds in the schools of the 72 participating countries and economies.

The assessment

Computer-based tests were used, with assessments lasting a total of two hours for each student, in a range of countries and economies.

Test items were a mixture of multiple-choice questions and questions requiring students to construct their own responses. The items were organised in groups based on a passage setting out a real-life situation. About 810 minutes of test items for science, reading, mathematics and collaborative problem solving were covered, with different students taking different combinations of test items.

Students also answered a background questionnaire, which took 35 minutes to complete. The questionnaire sought information about the students themselves, their homes, and the school and learning experiences. School principals completed a questionnaire that covered the school system and the learning environment. For additional information, some countries/economies decided to distribute a questionnaire to their teachers. It was the first time that this optional teacher questionnaire was offered to PISA-participating countries/economies. In some countries/economies optional questionnaires were distributed to parents, who were asked to provide information on their perceptions of and involvement in their child's school, their support for learning in the home, and their child's career expectations, particularly in science. Countries could choose two other optional questionnaires for students: one asked students about their familiarity with and use of information and communication technologies (ICT); and the second sought information about their education to date, including any interruptions in their schooling, and whether and how they are preparing for a future career.

The relevance of PISA results is confirmed by studies tracking young people in the years following the assessment. Studies in Australia, Canada and Denmark show a strong relationship between 15-year-old students' performance in reading in the PISA 2000 assessment and the likelihood of a student completing secondary school and continuing with post-secondary studies at age of 19. For example, Canadian students who had attained reading proficiency Level 5 at the age of 15 were 16 times more likely to be enrolled in post-secondary studies when they were 19 years old than those who had not attained Level 1 in reading proficiency.

THE PISA 2015 TEST

For the first time, PISA 2015 delivers the assessments of all subjects via computer. Paper-based assessment instruments were provided for countries that choose not to test their students by computer, but the paper-based assessment was limited to reading, mathematics and science trends items only. New items were developed only for the computer-based assessment. A field trial was used to study the effect of the change of mode of delivery. Data were collected and analysed to establish equivalence between the computer- and paper-based assessments.

Box 1.2 **2015 mode study**

A study similar to the mode study for the OECD Programme for the International Assessment of Adult Competencies (PIAAC) was planned for the PISA 2015 field trial. Students were randomly assigned to either a computer-based or paper-based assessment of reading, mathematical and scientific literacy. Each domain included six clusters of paper-based trend items that were used in previous cycles of PISA. These items were adapted for computer delivery so that countries opting to take the computer-based assessment would be able to link back to previous cycles and would be comparable with countries choosing the paper-based option. Some two-thirds of the items from PISA use objective scoring, such as multiple-choice, true false, and simple open-ended response formats that are easily adapted and reliably scored by computer; the rest are scored by expert coders within each country. These more complex open-ended items were retained and scored in a similar fashion for PISA 2015. Analyses of the PISA field trial were used to determine the comparability between the two modes of presentation across all trend items. Results were presented to and agreed with the PISA Technical Advisory Group, the OECD and all participating countries in 2014.

The 2015 computer-based assessment was designed as a two-hour test. Each test form allocated to students comprised four 30-minute clusters of test material. This test design included six intact clusters from each of the domains of science, reading and mathematics to measure trends. For the major subject of science, an additional six clusters of items were developed to reflect the new features of the 2015 framework. In addition, three clusters of collaborative problem-solving items were developed for the countries that decided to participate in this assessment.

There were 66 different test forms, Students spent one hour on the science assessment (one cluster each of trends and new science items) plus one hour on another subject – reading, mathematics or collaborative problem solving. For the countries/economies that chose not to participate in the collaborative problem-solving assessment, 36 test forms were prepared.

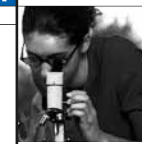
Countries that chose paper-based delivery for the main survey measured student performance with 30 paper-and-pencil forms containing trends items from two of the three core PISA domains.

Each test form was completed by a sufficient number of students for appropriate estimates to be made of the achievement levels on all items by students in each country and in relevant subgroups within a country (such as boys and girls, and students from different social and economic contexts).

The assessment of financial literacy is offered as an option in PISA 2015 based on the same framework as the one developed for PISA 2012. The financial literacy assessment was developed as a one-hour exercise, comprising two clusters distributed to a subsample of students in combination with the science, mathematics and reading assessments.

AN OVERVIEW OF WHAT IS ASSESSED IN EACH DOMAIN

Box 1.3 presents definitions of the three core domains assessed in PISA 2015. The definitions all emphasise functional knowledge and skills that allow one to participate fully in society. Such participation requires more than just being able to carry out tasks imposed externally by, for example, an employer; it also means being able to participate in decision making. The more complex tasks in PISA require students to reflect on and evaluate material, not just to answer questions that have one correct answer.



Box 1.3 **Definitions of the domains**

Scientific literacy: The ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to:

- Explain phenomena scientifically – recognise, offer and evaluate explanations for a range of natural and technological phenomena.
- Evaluate and design scientific enquiry – describe and appraise scientific investigations and propose ways of addressing questions scientifically.
- Interpret data and evidence scientifically – analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

Reading literacy: An individual's capacity to understand, use, reflect on and engage with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society.

Mathematical literacy: An individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens.

Scientific literacy (Chapter 2) is defined as the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.

PISA assesses students' performance in science through questions related to:

Contexts: Personal, local/national and global issues, both current and historical, which demand some understanding of science and technology. The contexts in PISA 2015 were changed from "personal, social and global" in the 2006 assessment to "personal, local/national and global" to make the headings more coherent.

Knowledge: An understanding of the major facts, concepts and explanatory theories that form the basis of scientific knowledge. Such knowledge includes knowledge of both the natural world and technological artefacts (content knowledge), knowledge of how such ideas are produced (procedural knowledge), and an understanding of the underlying rationale for these procedures and the justification for their use (epistemic knowledge). The major difference from PISA 2006 is that the notion of "knowledge about science" has been specified more clearly and split into two components: procedural knowledge and epistemic knowledge.

Competencies: The ability to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.

Attitudes: A set of attitudes towards science indicated by an interest in science and technology, valuing scientific approaches to enquiry, where appropriate, and a perception and awareness of environmental issues. The second, "support for scientific enquiry" in the previous cycles, was changed to a measure of "valuing scientific approaches to enquiry", which is essentially a change in terminology to better reflect what is measured.

Reading literacy (Chapter 3) is defined as students' ability to understand, use and reflect on written text to achieve their purposes.

PISA assesses students' performance in reading through questions related to:

Text format: PISA uses continuous texts or prose organised in sentences and paragraphs, and non-continuous texts that present information in other ways, such as in lists, forms, graphs or diagrams. The test uses a range of prose forms, such as narration, exposition and argumentation.

Processes (aspects): Students are not assessed on the most basic reading skills, as it is assumed that most 15-year-old students will have acquired these. Rather, students are expected to demonstrate their proficiency in accessing and retrieving information, forming a broad general understanding of the text, interpreting it, reflecting on its content, and reflecting on its form and features.

Situations: These are defined by the use for which the text was constructed. For example, a novel, personal letter or biography is written for people's personal use; official documents or announcements for public use; a manual or report for occupational use; and a textbook or worksheet for educational use. Since some groups may perform better in one reading situation than in another, a range of types of reading is included in the test.

Mathematical literacy (Chapter 4) is defined as students' ability to analyse, reason and communicate ideas effectively as they pose, formulate, solve and interpret solutions to mathematical problems in a variety of situations.

PISA assesses students' performance in mathematics through questions related to:

Processes: These are defined in terms of three categories: formulating situations mathematically; employing mathematical concepts, facts, procedures and reasoning; and interpreting, applying and evaluating mathematical outcomes (herein referred to as "formulate", "employ" and "interpret"). They describe what students do to connect the context of a problem with the mathematics involved and thus solve the problem. These three processes each draw on seven fundamental mathematical capabilities: communicating; mathematising; representing; reasoning and argument; devising strategies for solving problems; using symbolic, formal and technical language and operations; and using mathematical tools. All of these capabilities are based on the problem solver's detailed mathematical knowledge about individual topics.

Content: These are four ideas (quantity, space and shape, change and relationships, and uncertainty and data) that are related to familiar curricular subjects, such as numbers, algebra and geometry, in overlapping and complex ways.

Contexts: These are the settings in a student's world in which the problems are placed. The framework identifies four contexts: personal, educational, societal and scientific.

THE EVOLUTION OF REPORTING STUDENT PERFORMANCE IN PISA

Results from PISA are reported using scales. Initially, the OECD average score for all three subjects was 500 with a standard deviation of 100, which meant that two-thirds of students across OECD countries scored between 400 and 600 points. These scores represent degrees of proficiency in a particular domain. In subsequent cycles of PISA, the OECD average score has fluctuated slightly around the original.

Reading literacy was the major domain in 2000, and the reading scales were divided into five levels of knowledge and skills. The main advantage of this approach is that it is useful for describing what substantial numbers of students can do with tasks at different levels of difficulty. Results were also presented through three "aspect" subscales of reading: accessing and retrieving information; integrating and interpreting texts; and reflecting and evaluating texts. A proficiency scale was also available for mathematics and science, though without described levels.

PISA 2003 built upon this approach by specifying six proficiency levels for the mathematics scale. There were four "content" subscales in mathematics*:* space and shape, change and relationships, quantity, and uncertainty.

Similarly, the reporting of science in PISA 2006 specified six proficiency levels. The three "competency" subscales in science related to identifying scientific issues, explaining phenomena scientifically and using scientific evidence. Country performance was compared on the bases of knowledge about science and knowledge of science. The three main areas of knowledge of science were physical systems, living systems, and earth and space systems.

PISA 2009 marked the first time that reading literacy was re-assessed as a major domain. Trend results were reported for all three domains. PISA 2009 added a Level 6 to the reading scale to describe very high levels of reading proficiency. The bottom level of proficiency, Level 1, was relabelled as Level 1a. Another level, Level 1b, was introduced to describe the performance of students who would previously have been rated as "below Level 1", but who show proficiency in relation to new items that are easier than those included in previous PISA assessments. These changes allow countries to know more about what kinds of tasks students with very high and very low reading proficiency are capable of completing.

Mathematics was re-assessed as a major domain in PISA 2012. In addition to the "content" subscales (with the "uncertainty" scale re-named as "uncertainty and data" for improved clarity), three new subscales were developed to assess the three processes in which students, as active problem solvers, engage. These three "process" subscales are: formulating situations mathematically; employing mathematical concepts, facts, procedures and reasoning; and interpreting, applying and evaluating mathematical outcomes (known as "formulating", "employing" and "interpreting").

Science, which was the main subject of assessment in PISA 2006, is again the main domain in PISA 2015. The assessment measures students' ability to: explain phenomena scientifically; evaluate and design scientific enquiry; and interpret data and evidence scientifically. The science scale has also been extended by the addition of a Level "1b" to better describe the proficiency of students at the lowest level of ability who demonstrate minimal scientific literacy and who would previously not have been included in the reporting scales.

THE CONTEXT QUESTIONNAIRES

To gather contextual information, PISA asks students and the principals of their schools to respond to questionnaires. These take about 35 and 45 minutes, respectively, to complete. The responses to the questionnaires are analysed with the assessment results to provide at once a broader and more nuanced picture of student, school and system performance. Chapter 6 presents the questionnaire framework in detail. The questionnaires from all assessments since PISA's inception are available on the PISA website: www.pisa.oecd.org.

The questionnaires seek information about:

- Students and their family backgrounds, including their economic, social and cultural capital.
- Aspects of students' lives, such as their attitudes towards learning, their habits and life in and outside of school, and their family environment.
- Aspects of schools, such as the quality of the schools' human and material resources, public and private management and funding, decision-making processes, staffing practices and the school's curricular emphasis and extracurricular activities offered.
- Context of instruction, including institutional structures and types, class size, classroom and school climate, and science activities in class.
- Aspects of learning, including students' interest, motivation and engagement.

Four additional questionnaires are offered as options:

- A *computer familiarity questionnaire*, focusing on the availability and use of information and communications technology (ICT) and on students' ability to carry out computer tasks and their attitudes towards computer use.
- An *educational career questionnaire*, which collects additional information on interruptions in schooling, on preparation for students' future career, and on support with science learning.
- A *parent questionnaire*, focusing on parents' perceptions of and involvement in their child's school, their support for learning at home, school choice, their child's career expectations, and their background (immigrant/non-immigrant).
- A *teacher questionnaire*, which is new to PISA, will help illustrate the similarities and differences between groups of teachers in order to better establish the context for students' test results. The level of analysis of data gathered from the optional teacher questionnaire is the school level. Science teachers are asked to describe their teaching practices through a parallel questionnaire that also focuses on teacher-directed teaching and learning activities in science lessons, and a selected set of inquiry-based activities. The teacher questionnaire asks about the content of a school's science curriculum and how it is communicated to parents too. The new optional teacher questionnaire gathers information on transformational leadership as well.

The contextual information collected through the student, school and optional questionnaires comprises only a part of the information available to PISA. Indicators describing the general structure of the education systems (their demographic and economic contexts – for example, costs, enrolments, school and teacher characteristics, and some classroom processes) and their effect on labour market outcomes are routinely developed and applied by the OECD (e.g. in the annual OECD publication, *Education at a Glance*).

A COLLABORATIVE PROJECT

PISA is the result of a collaborative effort among OECD and partner governments. The assessments are developed co-operatively, agreed by participating countries/economies, and implemented by national organisations. The co-operation of students, teachers and principals in participating schools has been crucial to the success of PISA during all stages of development and implementation.

The PISA Governing Board (PGB), representing all countries/economies at senior policy levels, determines the policy priorities for PISA in the context of OECD objectives and oversees adherence to these priorities during the implementation of the programme. The PGB sets priorities for developing indicators, for establishing assessment instruments and for reporting results. Experts from participating countries/economies also serve on working groups tasked with linking PISA policy objectives with the best available technical expertise in the different assessment domains. By participating in these expert groups, countries/economies ensure that the instruments are internationally valid and take into account differences in the cultures and education systems.

Participating countries/economies implement PISA at the national level, through National Centres managed by National Project Managers, subject to the agreed administration procedures. National Project Managers play a vital role in ensuring that implementation is of high quality. They also verify and evaluate the survey results, analyses, reports and publications.

The development of the science and collaborative problem-solving frameworks and the adaptation of the frameworks for reading and mathematics are the responsibility of Pearson, while the design and development of the questionnaires are the responsibility of the Deutsches Institut für Pädagogische Forschung (DIPF). Management and oversight of this survey, the development of the instruments, scaling, and analysis are the responsibility of the Educational Testing Service (ETS) as is the development of the electronic platform. Other partners or subcontractors involved with ETS include cApStAn Linguistic Quality Control and the Department of Experimental and Theoretical Pedagogy at the University of Liège (SPe) in Belgium; the Center for Educational Technology (CET) in Israel; the Public Research Centre (CRP) Henri Tudor and the Educational Measurement and Research Center (EMACS) of the University of Luxembourg in Luxembourg; and GESIS – Leibniz-Institute for the Social Sciences in Germany. Westat assumed responsibility for survey operations and sampling with the subcontractor, the Australian Council for Educational Research (ACER).

The OECD Secretariat has overall managerial responsibility for the programme, monitors its implementation on a day-to-day basis, acts as the secretariat for the PGB, builds consensus among countries, and serves as the interlocutor between the PGB and the contractors charged with implementation. The OECD Secretariat is also responsible for the production of the indicators, and the analysis and preparation of the international reports and publications in co-operation with the contractors and in close consultation with member countries both at the policy level (PGB) and at the implementation level (National Project Managers).

2

PISA 2015 science framework

Science is the main subject of assessment in the Programme for International Student Assessment (PISA) in 2015. This chapter defines "scientific literacy" as assessed in PISA. It describes the types of contexts, knowledge, competencies and attitudes towards science that are reflected in the assessment's science problems and provides several sample items. The chapter also discusses how student performance in science is measured and reported.

This document provides a description of and rationale for the framework that forms the basis of the instrument to assess scientific literacy – the major domain in PISA 2015. Previous PISA frameworks for the science assessment (OECD, 2006, 2004, 1999) have elaborated a conception of scientific literacy as the central construct for science assessment. These documents have established a broad consensus among science educators of the concept of scientific literacy. This framework for PISA 2015 refines and extends the previous construct, in particular by drawing on the PISA 2006 framework that was used as the basis for assessment in 2006, 2009 and 2012.

Scientific literacy matters at both the national and international levels as humanity faces major challenges in providing sufficient water and food, controlling diseases, generating sufficient energy and adapting to climate change (UNEP, 2012). Many of these issues arise, however, at the local level where individuals may be faced with decisions about practices that affect their own health and food supplies, the appropriate use of materials and new technologies, and decisions about energy use. Dealing with all of these challenges will require a major contribution from science and technology. Yet, as argued by the European Commission, the solutions to political and ethical dilemmas involving science and technology "cannot be the subject of informed debate unless young people possess certain scientific awareness" (European Commission, 1995: 28). Moreover, "this does not mean turning everyone into a scientific expert, but enabling them to fulfil an enlightened role in making choices which affect their environment and to understand in broad terms the social implications of debates between experts" (ibid.: 28). Given that knowledge of science and science-based technology contributes significantly to individuals' personal, social, and professional lives, an understanding of science and technology is thus central to a young person's "preparedness for life".

The concept of scientific literacy in this framework *refers to a knowledge of both science and science-based technology*, even though science and technology do differ in their purposes, processes and products. Technology seeks the optimal solution to a human problem, and there may be more than one optimal solution. In contrast, science seeks the answer to a specific question about the natural, material world. Nevertheless, the two are closely related. For instance, new scientific knowledge leads to the development of new technologies (think of the advances in material science that led to the development of the transistor in 1948). Likewise, new technologies can lead to new scientific knowledge (think of how knowledge of the universe has been transformed through the development of better telescopes). Individuals make decisions and choices that influence the directions of new technologies (consider the decision to drive a smaller, more fuel-efficient car). Scientifically literate individuals should therefore be able to make more informed choices. They should also be able to recognise that, while science and technology are often a source of solutions, paradoxically, they can also be seen as a source of risk, generating new problems that can only be solved through the use of science and technology. Therefore, individuals need to be able to weigh the potential benefits and risks of applying scientific knowledge to themselves and society.

Scientific literacy also requires not just knowledge of the concepts and theories of science but also knowledge of the common procedures and practices associated with scientific enquiry and how these enable science to advance. Therefore, individuals who are scientifically literate have a knowledge of the major concepts and ideas that form the foundation of scientific and technological thought; how such knowledge has been derived; and the degree to which such knowledge is proved by evidence or theoretical explanations.

Undoubtedly, many of the challenges of the 21st century will require innovative solutions that have a basis in scientific thinking and scientific discovery. Societies will require a cadre of well-educated scientists to undertake the research and nurture the innovation that will be essential to meet the economic, social and environmental challenges that the world faces.

For all of these reasons, scientific literacy is perceived to be a key competency (Rychen and Salganik, 2003) and defined in terms of the ability to use knowledge and information interactively – that is "an understanding of how it [a knowledge of science] changes the way one can interact with the world and how it can be used to accomplish broader goals" (ibid.: 10). As such, it represents a major goal for science education for all students. Therefore, the view of scientific literacy that forms the basis for the 2015 international assessment of 15-year-old students is a response to the question: What is important for young people to know, value and be able to do in situations involving science and technology?

DEFINING SCIENTIFIC LITERACY

Current thinking about the desired outcomes of science education is rooted strongly in a belief that an understanding of science is so important that it should be a feature of every young person's education (American Association for the Advancement of Science, 1989; Confederacion de Sociedades Cientificas de España, 2011; Fensham, 1985; Millar and Osborne, 1998; National Research Council, 2012; Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [KMK], 2005; Taiwan Ministry of Education, 1999). Indeed, in many countries science is an obligatory element of the school curriculum from kindergarten until the completion of compulsory education.

Many of the documents and policy statements cited above give pre-eminence to an education for citizenship. However, many of the curricula for school science across the world are based on a view that the primary goal of science education should be the preparation of the next generation of scientists (Millar and Osborne, 1998). These two goals are not always compatible. Attempts to resolve the tension between the needs of the majority of students who will not become scientists and the needs of the minority who will have led to an emphasis on teaching science through enquiry (National Academy of Science, 1995; National Research Council, 2000), and new curriculum models (Millar, 2006) that address the needs of both groups. The emphasis in these frameworks and their associated curricula lies not on producing individuals who will be "producers" of scientific knowledge, i.e. the future scientists; rather, it is on educating all young people to become informed, critical users of scientific knowledge.

To understand and engage in critical discussions about issues that involve science and technology requires three domain-specific competencies. The first is the ability to provide explanatory accounts of natural phenomena, technical artefacts and technologies, and their implications for society. Such an ability requires a knowledge of the fundamental ideas of science and the questions that frame the practice and goals of science. The second is the knowledge and understanding of scientific enquiry to: identify questions that can be answered by scientific enquiry; identify whether appropriate procedures have been used; and propose ways in which such questions might be answered. The third is the competency to interpret and evaluate data and evidence scientifically and evaluate whether the conclusions are justified. Thus, scientific literacy in PISA 2015 is defined by the three competencies to:

- explain phenomena scientifically
- evaluate and design scientific enquiry
- interpret data and evidence scientifically.

All of these competencies require knowledge. Explaining scientific and technological phenomena, for instance, demands a knowledge of the content of science (hereafter, content knowledge). The second and third competencies, however, require more than a knowledge of what is known; they depend on an understanding of how scientific knowledge is established and the degree of confidence with which it is held. Some have argued for teaching what has variously been called "the nature of science" (Lederman, 2006), "ideas about science" (Millar and Osborne, 1998) or "scientific practices" (National Research Council, 2012). Recognising and identifying the features that characterise scientific enquiry requires a knowledge of the standard procedures that underlie the diverse methods and practices used to establish scientific knowledge (hereafter, procedural knowledge). Finally, the competencies require epistemic knowledge – an understanding of the rationale for the common practices of scientific enquiry, the status of the knowledge claims that are generated, and the meaning of foundational terms, such as theory, hypothesis and data.

Box 2.1 **Scientific knowledge: PISA 2015 terminology**

This document is based upon a view of scientific knowledge as consisting of three distinguishable but related elements. The first of these and the most familiar is a knowledge of the facts, concepts, ideas and theories about the natural world that science has established. For instance, how plants synthesise complex molecules using light and carbon dioxide or the particulate nature of matter. This kind of knowledge is referred to as "**content knowledge**" or "knowledge of the content of science".

Knowledge of the procedures that scientists use to establish scientific knowledge is referred to as "**procedural knowledge**". This is a knowledge of the practices and concepts on which empirical enquiry is based such as repeating measurements to minimise error and reduce uncertainty, the control of variables, and standard procedures for representing and communicating data (Millar, Lubben, Gott and Duggan, 1995). More recently these have been elaborated as a set of "concepts of evidence" (Gott, Duggan and Roberts, 2008).

Furthermore, understanding science as a practice also requires "**epistemic knowledge**" which refers to an understanding of the role of specific constructs and defining features essential to the process of knowledge-building in science (Duschl, 2007). Epistemic knowledge includes an understanding of the function that questions, observations, theories, hypotheses, models and arguments play in science; a recognition of the variety of forms of scientific enquiry; and the role peer review plays in establishing knowledge that can be trusted.

A more detailed discussion of these three forms of knowledge is provided in the later section on scientific knowledge and in Figures 2.5, 2.6 and 2.7.

Both procedural and epistemic knowledge are necessary to identify questions that are amenable to scientific enquiry, to judge whether appropriate procedures have been used to ensure that the claims are justified, and to distinguish scientific issues from matters of values or economic considerations. This definition of scientific literacy assumes that, throughout their lives, individuals will need to acquire knowledge, not through scientific investigations, but through the use of resources such as libraries and the Internet. Procedural and epistemic knowledge are essential to decide whether the many claims of knowledge and understanding that pervade contemporary media are based on the use of appropriate procedures and are justified.

People need all three forms of scientific knowledge to perform the three competencies of scientific literacy. PISA 2015 focuses on assessing the extent to which 15-year-olds are capable of displaying the three aforementioned competencies appropriately within in a range of personal, local/national (grouped in one category) and global contexts. (For the purposes of the PISA assessment, these competencies are only tested using the knowledge that 15-year-old students can reasonably be expected to have already acquired.) This perspective differs from that of many school science programmes that are dominated by content knowledge. Instead, the framework is based on a broader view of the kind of knowledge of science required of fully engaged citizens.

In addition, the competency-based perspective also recognises that there is an affective element to a student's display of these competencies: students' attitudes or disposition towards science will determine their level of interest, sustain their engagement, and may motivate them to take action (Schibeci, 1984). Thus, the scientifically literate person would typically have an interest in scientific topics; engage with science-related issues; have a concern for issues of technology, resources and the environment; and reflect on the importance of science from a personal and social perspective. This requirement does not mean that such individuals are necessarily disposed towards becoming scientists themselves, rather such individuals recognise that science, technology and research in this domain are an essential element of contemporary culture that frames much of our thinking.

These considerations led to the definition of scientific literacy used in PISA 2015 (see Box 2.2). The use of the term "scientific literacy", rather than "science", underscores the importance that the PISA science assessment places on the application of scientific knowledge in the context of real-life situations.

Box 2.2 **The 2015 definition of scientific literacy**

Scientific literacy is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen.

A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to:

- **Explain phenomena scientifically** – recognise, offer and evaluate explanations for a range of natural and technological phenomena.
- **Evaluate and design scientific enquiry** – describe and appraise scientific investigations and propose ways of addressing questions scientifically.
- **Interpret data and evidence scientifically** – analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

The competencies required for scientific literacy

Competency 1: Explain phenomena scientifically

The cultural achievement of science has been to develop a set of explanatory theories that have transformed our understanding of the natural world (in this document, "natural world" refers to phenomena associated with any object or activity occurring in the living or the material world), such as the idea that day and night is caused by a rotating Earth, or the idea that diseases can be caused by invisible micro-organisms. Moreover, such knowledge has enabled us to develop technologies that support human life by, for example, preventing disease or enabling rapid human communication across the globe. The competency to explain scientific and technological phenomena is thus dependent on a knowledge of these major explanatory ideas of science.

Explaining scientific phenomena, however, requires more than the ability to recall and use theories, explanatory ideas, information and facts (content knowledge). Offering scientific explanations also requires an understanding of how such knowledge has been derived and the level of confidence we might hold about any scientific claims. For this competency, the individual requires a knowledge of the standard forms and procedures used in scientific enquiry to obtain such knowledge (procedural knowledge) and an understanding of their role and function in justifying the knowledge produced by science (epistemic knowledge).

Competency 2: Evaluate and design scientific enquiry

Scientific literacy implies that students have some understanding of the goal of scientific enquiry, which is to generate reliable knowledge about the natural world (Ziman, 1979). Data collected and obtained by observation and experiment, either in the laboratory or in the field, lead to the development of models and explanatory hypotheses that enable predictions that can then be tested experimentally. New ideas, however, commonly build on previous knowledge. Scientists themselves rarely work in isolation; they are members of research groups or teams that engage, nationally and internationally, in extensive collaboration with colleagues. New knowledge claims are always perceived to be provisional and may lack justification when subjected to critical peer review – the mechanism through which the scientific community ensures the objectivity of scientific knowledge (Longino, 1990). Hence, scientists have a commitment to publish or report their findings and the methods used in obtaining their evidence. Doing so enables empirical studies, at least in principle, to be replicated and results confirmed or challenged. However, measurements can never be absolutely precise; they all contain a degree of error. Much of the work of the experimental scientist is thus devoted to resolving uncertainty by repeating measurements, collecting larger samples, building instruments that are more accurate and using statistical techniques that assess the degree of confidence in any result.

In addition, science has well-established procedures that are the foundations of any experiment to establish cause and effect. The use of controls enables the scientist to claim that any change in a perceived outcome can be attributed to a change in one specific feature. Failure to use such techniques leads to results where effects are confounded and cannot be trusted. Likewise, double-blind trials enable scientists to claim that the results have not been influenced either by the subjects of the experiment, or by the experimenter themselves. Other scientists, such as taxonomists and ecologists, are engaged in the process of identifying underlying patterns and interactions in the natural world that warrant a search for an explanation. In other cases, such as evolution, plate tectonics or climate change, scientists examine a range of hypotheses and eliminate those that do not fit with the evidence.

Facility with this competency draws on content knowledge, a knowledge of the common procedures used in science (procedural knowledge), and the function of these procedures in justifying any claims advanced by science (epistemic knowledge). Procedural and epistemic knowledge serve two functions. First, such knowledge is required by individuals to appraise scientific investigations and decide whether they have followed appropriate procedures and whether the conclusions are justified. Second, individuals who have this knowledge should be able to propose, at least in broad terms, how a scientific question might be investigated appropriately.

Competency 3: Interpret data and evidence scientifically

Interpreting data is such a core activity of all scientists that some rudimentary understanding of the process is essential for scientific literacy. Initially, data interpretation begins with looking for patterns, constructing simple tables and graphical visualisations, such as pie charts, bar graphs, scatterplots or Venn diagrams. At a higher level, it requires the use of more complex data sets and the use of the analytical tools offered by spreadsheets and statistical packages. It would be wrong, however, to look at this competency as merely an ability to use these tools. A substantial body of knowledge is required to recognise what constitutes reliable and valid evidence and how to present data appropriately.

Scientists make choices about how to represent the data in graphs, charts or, increasingly, in complex simulations or 3D visualisations. Any relationships or patterns must then be read using a knowledge of standard patterns. Whether uncertainty has been minimised by standard statistical techniques must also be considered. All of this draws on a body of procedural knowledge. The scientifically literate individual can also be expected to understand that uncertainty is an inherent feature of all measurement, and that one criterion for expressing confidence in a finding is determining the probability that the finding might have occurred by chance.

It is not sufficient, however, to understand the procedures that have been applied to obtain any data set. The scientifically literate individual needs to be able to judge whether they are appropriate and the ensuing claims are justified (epistemic knowledge). For instance, many sets of data can be interpreted in multiple ways. Argumentation and critique are essential to determining which is the most appropriate conclusion.

Whether it is new theories, novel ways of collecting data or fresh interpretations of old data, argumentation is the means that scientists and technologists use to make their case for new ideas. Disagreement among scientists is normal, not extraordinary. Determining which interpretation is the best requires a knowledge of science (content knowledge). Consensus on key scientific ideas and concepts has been achieved through this process of critique and argumentation (Longino, 1990). Indeed, it is a critical and sceptical disposition towards all empirical evidence that many would see as the hallmark of the professional scientist. The scientifically literate individual understands the function and purpose of argument and critique and why they are essential to the construction of knowledge in science. In addition, they should be able both to construct claims that are justified by data and to identify any flaws in the arguments of others.

The evolution of the definition of scientific literacy in PISA

In PISA 2000 and 2003, scientific literacy was defined as:

> "…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." (OECD, 2004, 2000)

In 2000 and 2003, the definition embedded knowledge *of* science and understandings *about* science within the one term "scientific knowledge". The 2006 definition separated and elaborated the term "scientific knowledge" by dividing it into two components: "knowledge *of* science" and "knowledge *about* science" (OECD, 2006). Both definitions referred to the application of scientific knowledge to understanding and making informed decisions about the natural world. In PISA 2006, the definition was enhanced by the addition of knowledge of the relationship between science and technology – an aspect that was assumed but not elaborated in the 2003 definition.

> "For the purposes of PISA, scientific literacy refers to 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.
> - Willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen." (OECD, 2006).

These ideas have evolved further in the PISA 2015 definition of scientific literacy. The major difference is that the notion of "knowledge *about* science" has been specified more clearly and split into two components – procedural knowledge and epistemic knowledge.

In 2006, the PISA framework was also expanded to include attitudinal aspects of students' responses to scientific and technological issues within the construct of scientific literacy. In 2006, attitudes were measured in two ways: through the student questionnaire and through items embedded in the student test. Discrepancies were found between the results from the embedded questions and those from the background questionnaire with respect to "interest in science" for all students and gender differences in these issues (OECD, 2009; see also Drechsel, Carstensen and Prenzel, 2011). More important, embedded items extended the length of the test. Hence, in PISA 2015, attitudinal aspects are only measured through the student questionnaire; there are no embedded attitudinal items.

As for the constructs measured within this domain, the first ("interest in science") and third ("environmental awareness") remain the same as in 2006. The second ("support for scientific enquiry") has been changed to a measure of "valuing scientific approaches to enquiry", which is essentially a change in terminology to better reflect what is measured.

In addition, the contexts in PISA 2015 have been changed from "personal, social and global" in the 2006 assessment to "personal, local/national and global" to make the headings more coherent.

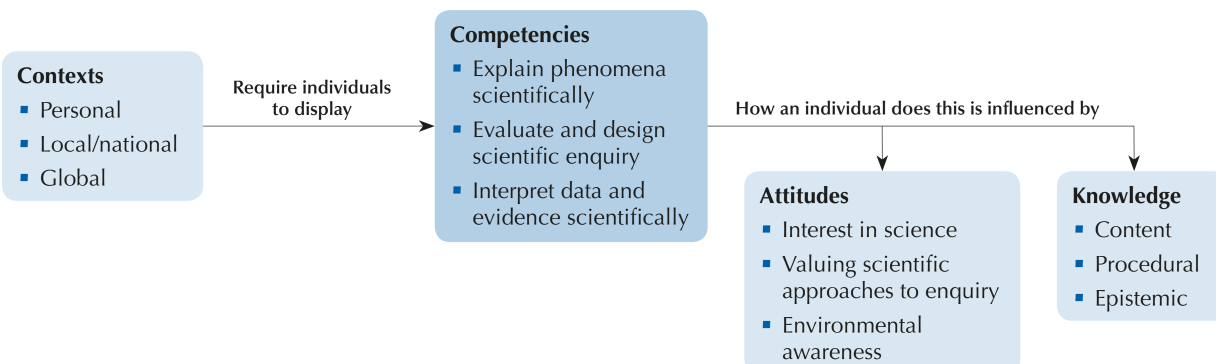
ORGANISING THE DOMAIN OF SCIENCE

The PISA 2015 definition of scientific literacy consists of four interrelated aspects (see Figures 2.1 and 2.2).

Figure 2.1 ■ **Aspects of the scientific literacy assessment framework for PISA 2015**

Contexts	Personal, local/national and global issues, both current and historical, which demand some understanding of science and technology.
Knowledge	An understanding of the major facts, concepts and explanatory theories that form the basis of scientific knowledge. Such knowledge includes knowledge of both the natural world and technological artefacts (content knowledge), knowledge of how such ideas are produced (procedural knowledge), and an understanding of the underlying rationale for these procedures and the justification for their use (epistemic knowledge).
Competencies	The ability to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.
Attitudes	A set of attitudes towards science indicated by an interest in science and technology, valuing scientific approaches to enquiry where appropriate, and a perception and awareness of environmental issues.

Figure 2.2 ■ **Inter-relations between the four aspects**



Contexts of assessment items

PISA 2015 assesses scientific knowledge in contexts that are relevant to the science curricula of participating countries. Such contexts are not, however, restricted to the common aspects of participants' national curricula. Rather, the assessment requires evidence of the successful use of the three competencies required for scientific literacy in situations set in personal, local/national and global contexts.

Assessment items are not limited to school science contexts. In the PISA 2015 scientific literacy assessment, the items focus on situations relating to the self, family and peer groups (personal), to the community (local and national), and to life across the world (global). Technology-based topics may be used as a common context. Some topics may be set in historical contexts, which are used to assess students' understanding of the processes and practices involved in advancing scientific knowledge.

Figure 2.3 shows how science and technology issues are applied within personal, local/national and global settings. The contexts are chosen in light of their relevance to students' interests and lives. The areas of application are: health and disease, natural resources, environmental quality, hazards, and the frontiers of science and technology. They are the areas in which scientific literacy has particular value for individuals and communities in enhancing and sustaining quality of life, and in developing public policy.

The PISA science assessment is *not* an assessment of contexts. Rather, it assesses competencies and knowledge *in* specific contexts. These contexts are chosen on the basis of the knowledge and understanding that students are likely to have acquired by the age of 15.

Sensitivity to linguistic and cultural differences is a priority in item development and selection, not only for the sake of the validity of the assessment, but also to respect these differences among participating countries.

Figure 2.3 ▪ **Contexts in the PISA 2015 scientific literacy assessment**

	Personal	Local/National	Global
Health and disease	Maintenance of health, accidents, nutrition	Control of disease, social transmission, food choices, community health	Epidemics, spread of infectious diseases
Natural resources	Personal consumption of materials and energy	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply	Renewable and non-renewable natural systems, population growth, sustainable use of species
Environmental quality	Environmentally friendly actions, use and disposal of materials and devices	Population distribution, disposal of waste, environmental impact	Biodiversity, ecological sustainability, control of pollution, production and loss of soil/biomass
Hazards	Risk assessments of lifestyle choices	Rapid changes (e.g. earthquakes, severe weather), slow and progressive changes (e.g. coastal erosion, sedimentation), risk assessment	Climate change, impact of modern communication
Frontiers of science and technology	Scientific aspects of hobbies, personal technology, music and sporting activities	New materials, devices and processes, genetic modifications, health technology, transport	Extinction of species, exploration of space, origin and structure of the universe

Scientific competencies

Figures 2.4a, 2.4b and 2.4c provide a detailed description of how students may display the three competencies required for scientific literacy. The set of scientific competencies in Figures 2.4a, 2.4b and 2.4c reflects a view that science is best seen as an ensemble of social and epistemic practices that are common across all sciences (National Research Council, 2012). Hence, all these competencies are framed as actions. They are written in this manner to convey the idea of what the scientifically literate person both understands and is capable of doing. Fluency with these practices is, in part, what distinguishes the expert scientist from the novice. While it would be unreasonable to expect a 15-year-old student to have the expertise of a scientist, a scientifically literate student can be expected to appreciate the role and significance of these practices and try to use them.

Figure 2.4a ▪ **PISA 2015 scientific competencies: Explain phenomena scientifically**

Explain phenomena scientifically
Recognise, offer and evaluate explanations for a range of natural and technological phenomena demonstrating the ability to: ▪ Recall and apply appropriate scientific knowledge. ▪ Identify, use and generate explanatory models and representations. ▪ Make and justify appropriate predictions. ▪ Offer explanatory hypotheses. ▪ Explain the potential implications of scientific knowledge for society.

Demonstrating the competency of *explaining phenomena scientifically* requires students to recall the appropriate content knowledge in a given situation and use it to interpret and explain the phenomenon of interest. Such knowledge can also be used to generate tentative explanatory hypotheses in contexts where there is a lack of knowledge or data. A scientifically literate person is expected to be able to draw on standard scientific models to construct simple representations to explain everyday phenomena, such as why antibiotics do not kill viruses, how a microwave oven works, or why gases are compressible but liquids are not, and use these to make predictions. This competency includes the ability to describe or interpret phenomena and predict possible changes. In addition, it may involve recognising or identifying appropriate descriptions, explanations and predictions.

Figure 2.4b ▪ **PISA 2015 scientific competencies : Evaluate and design scientific enquiry**

Evaluate and design scientific enquiry

Describe and appraise scientific investigations and propose ways of addressing questions scientifically demonstrating the ability to:

- Identify the question explored in a given scientific study.
- Distinguish questions that could be investigated scientifically.
- Propose a way of exploring a given question scientifically.
- Evaluate ways of exploring a given question scientifically.
- Describe and evaluate how scientists ensure the reliability of data, and the objectivity and generalisability of explanations.

The competency of *evaluating and designing scientific enquiry* is required to evaluate reports of scientific findings and investigations critically. It relies on the ability to distinguish scientific questions from other forms of enquiry or recognise questions that could be investigated scientifically in a given context. This competency requires a knowledge of the key features of a scientific investigation – for example, what things should be measured, what variables should be changed or controlled, or what action should be taken so that accurate and precise data can be collected. It requires an ability to evaluate the quality of data, which, in turn, depends on recognising that data are not always completely accurate. It also requires the ability to determine whether an investigation is driven by an underlying theoretical premise or, alternatively, whether it seeks to determine patterns.

A scientifically literate person should also be able to recognise the significance of previous research when judging the value of any given scientific enquiry. Such knowledge is needed to situate the work and judge the importance of any possible outcomes. For example, knowing that the search for a malaria vaccine has been an ongoing programme of scientific research for several decades, and given the number of people who are killed by malarial infections, any findings that suggested a vaccine would be achievable would be of substantial significance.

Moreover, students need to understand the importance of developing a sceptical attitude towards all media reports in science. They need to recognise that all research builds on previous work, that the findings of any one study are always subject to uncertainty, and that the study may be biased by the sources of funding. This competency requires students to possess both procedural and epistemic knowledge but may also draw on their content knowledge of science, to varying degrees.

Figure 2.4c ▪ **PISA 2015 scientific competencies: Interpret data and evidence scientifically**

Interpret data and evidence scientifically

Analyse and evaluate scientific data, claims and arguments in a variety of representations and draw appropriate conclusions, demonstrating the ability to:

- Transform data from one representation to another.
- Analyse and interpret data and draw appropriate conclusions.
- Identify the assumptions, evidence and reasoning in science-related texts.
- Distinguish between arguments that are based on scientific evidence and theory and those based on other considerations.
- Evaluate scientific arguments and evidence from different sources (e.g. newspapers, the Internet, journals).

A scientifically literate person should be able to interpret and make sense of basic forms of scientific data and evidence that are used to make claims and draw conclusions. Displaying this competency may require all three forms of scientific knowledge.

Those who possess this competency should be able to interpret the meaning of scientific evidence and its implications to a specified audience in their own words, using diagrams or other representations as appropriate. This competency requires the use of mathematical tools to analyse or summarise data, and the ability to use standard methods to transform data into different representations.

This competency also includes accessing scientific information and producing and evaluating arguments and conclusions based on scientific evidence (Kuhn, 2010; Osborne, 2010). It may also involve evaluating alternative conclusions using

evidence; giving reasons for or against a given conclusion using procedural or epistemic knowledge; and identifying the assumptions made in reaching a conclusion. In short, the scientifically literate individual should be able to identify logical or flawed connections between evidence and conclusions.

Table 2.1 shows the desired distribution of items, by competency, in the PISA 2015 science assessment.

Table 2.1 Desired distribution of items, by competency

Competency	Percentage of total items
Explain phenomena scientifically	40-50
Evaluate and design scientific enquiry	20-30
Interpret data and evidence scientifically	30-40

Scientific knowledge

Content knowledge

Given that only a sample of the content domain of science can be assessed in the PISA 2015 scientific literacy assessment, clear criteria are used to guide the selection of the knowledge that is assessed. The criteria are applied to knowledge from the major fields of physics, chemistry, biology, earth and space sciences, and require that the knowledge:

- has relevance to real-life situations
- represents an important scientific concept or major explanatory theory that has enduring utility
- is appropriate to the developmental level of 15-year-olds.

It is thus assumed that students have some knowledge and understanding of the major explanatory ideas and theories of science, including an understanding of the history and scale of the universe, the particle model of matter, and the theory of evolution by natural selection. These examples of major explanatory ideas are provided for illustrative purposes; there has been no attempt to list comprehensively all the ideas and theories that might be considered fundamental for a scientifically literate individual.

Figure 2.5 ▪ **Knowledge of the content of science**

Physical systems that require knowledge of:

- Structure of matter (e.g. particle model, bonds)
- Properties of matter (e.g. changes of state, thermal and electrical conductivity)
- Chemical changes of matter (e.g. chemical reactions, energy transfer, acids/bases)
- Motion and forces (e.g. velocity, friction) and action at a distance (e.g. magnetic, gravitational and electrostatic forces)
- Energy and its transformation (e.g. conservation, dissipation, chemical reactions)
- Interactions between energy and matter (e.g. light and radio waves, sound and seismic waves)

Living systems that require knowledge of:

- Cells (e.g. structures and function, DNA, plant and animal)
- The concept of an organism (e.g. unicellular and multicellular)
- Humans (e.g. health, nutrition, subsystems such as digestion, respiration, circulation, excretion, reproduction and their relationship)
- Populations (e.g. species, evolution, biodiversity, genetic variation)
- Ecosystems (e.g. food chains, matter and energy flow)
- Biosphere (e.g. ecosystem services, sustainability)

Earth and space systems that require knowledge of:

- Structures of the Earth systems (e.g. lithosphere, atmosphere, hydrosphere)
- Energy in the Earth systems (e.g. sources, global climate)
- Change in Earth systems (e.g. plate tectonics, geochemical cycles, constructive and destructive forces)
- Earth's history (e.g. fossils, origin and evolution)
- Earth in space (e.g. gravity, solar systems, galaxies)
- The history and scale of the universe and its history (e.g. light year, Big Bang theory)

Figure 2.5 shows the content knowledge categories and examples selected by applying these criteria. Such knowledge is required for understanding the natural world and for making sense of experiences in personal, local/national and global contexts. The framework uses the term "systems" instead of "sciences" in the descriptors of content knowledge. The intention is to convey the idea that citizens have to understand concepts from the physical and life sciences, and earth and space sciences, and how they apply in contexts where the elements of knowledge are interdependent or interdisciplinary. Things viewed as subsystems at one scale may be viewed as whole systems at a smaller scale. For example, the circulatory system can be seen as an entity in itself or as a subsystem of the human body; a molecule can be studied as a stable configuration of atoms but also as a subsystem of a cell or a gas. Thus, applying scientific knowledge and exhibiting scientific competencies requires a determination of which system and which boundaries apply in any particular context.

Table 2.2 shows the desired distribution of items, by content of science.

Table 2.2 Desired distribution of items, by content

System	Percentage of total items
Physical	36
Living	36
Earth and space	28
Total	100

Procedural knowledge

A fundamental goal of science is to generate explanatory accounts of the material world. Tentative explanatory accounts are first developed and then tested through empirical enquiry. Empirical enquiry relies on certain well-established concepts, such as the notion of dependent and independent variables, the control of variables, types of measurement, forms of error, methods of minimising error, common patterns observed in data, and methods of presenting data.

It is this knowledge of the concepts and procedures that are essential for scientific enquiry that underpins the collection, analysis and interpretation of scientific data. Such ideas form a body of procedural knowledge that has also been called "concepts of evidence" (Gott, Duggan and Roberts, 2008; Millar et al., 1995). One can think of procedural knowledge as knowledge of the standard procedures scientists use to obtain reliable and valid data. Such knowledge is needed both to undertake scientific enquiry and engage in critical reviews of the evidence that might be used to support particular claims. It is expected, for instance, that students will know that scientific knowledge has differing degrees of certainty associated with it, and so can explain why there is a difference between the confidence associated with measurements of the speed of light (which has been measured many times with ever more accurate instrumentation) and measurements of fish stocks in the North Atlantic or the mountain lion population in California. The examples listed in Figure 2.6 convey the general features of procedural knowledge that may be tested.

Figure 2.6 ▪ **PISA 2015 procedural knowledge**

Procedural knowledge

- The concept of variables, including dependent, independent and control variables.
- Concepts of measurement, e.g. quantitative (measurements), qualitative (observations), the use of a scale, categorical and continuous variables.
- Ways of assessing and minimising uncertainty, such as repeating and averaging measurements.
- Mechanisms to ensure the replicability (closeness of agreement between repeated measures of the same quantity) and accuracy of data (the closeness of agreement between a measured quantity and a true value of the measure).
- Common ways of abstracting and representing data using tables, graphs and charts, and using them appropriately.
- The control-of-variables strategy and its role in experimental design or the use of randomised controlled trials to avoid confounded findings and identify possible causal mechanisms.
- The nature of an appropriate design for a given scientific question, e.g. experimental, field-based or pattern-seeking.

Epistemic knowledge

Epistemic knowledge refers to an understanding of the role of specific constructs and defining features essential to the process of knowledge building in science (Duschl, 2007). Those who have such knowledge can explain, with examples, the distinction between a scientific theory and a hypothesis or a scientific fact and an observation. They know that models, whether representational, abstract or mathematical, are a key feature of science, and that such models are

like maps rather than accurate pictures of the material world. These students can recognise that any particle model of matter is an idealised representation of matter and can explain how the Bohr model is a limited model of what we know about the atom and its constituent parts. They recognise that the concept of a “theory” as used in science is not the same as the notion of a “theory” in everyday language, where it is used as a synonym for a “guess” or a “hunch”. Procedural knowledge is required to explain what is meant by the control-of-variables strategy; epistemic knowledge is required to explain *why* the use of the control-of-variables strategy or the replication of measurements is central to establishing knowledge in science.

Scientifically literate individuals also understand that scientists draw on data to advance claims to knowledge, and that argument is a commonplace feature of science. In particular, they know that some arguments in science are hypothetico-deductive (e.g. Copernicus’ argument for the heliocentric system), some are inductive (the conservation of energy), and some are an inference to the best explanation (Darwin’s theory of evolution or Wegener’s argument for moving continents). They also understand the role and significance of peer review as the mechanism that the scientific community has established for testing claims to new knowledge. As such, epistemic knowledge provides a rationale for the procedures and practices in which scientists engage, a knowledge of the structures and defining features that guide scientific enquiry, and the foundation for the basis of belief in the claims that science makes about the natural world.

Figure 2.7 represents what are considered to be the major features of epistemic knowledge necessary for scientific literacy.

Figure 2.7 ▪ **PISA 2015 epistemic knowledge**

Epistemic knowledge

The constructs and defining features of science. That is:

- The nature of scientific observations, facts, hypotheses, models and theories.
- The purpose and goals of science (to produce explanations of the natural world) as distinguished from technology (to produce an optimal solution to human need), and what constitutes a scientific or technological question and appropriate data.
- The values of science, e.g. a commitment to publication, objectivity and the elimination of bias.
- The nature of reasoning used in science, e.g. deductive, inductive, inference to the best explanation (abductive), analogical, and model-based.

The role of these constructs and features in justifying the knowledge produced by science. That is:

- How scientific claims are supported by data and reasoning in science.
- The function of different forms of empirical enquiry in establishing knowledge, their goal (to test explanatory hypotheses or identify patterns) and their design (observation, controlled experiments, correlational studies).
- How measurement error affects the degree of confidence in scientific knowledge.
- The use and role of physical, system and abstract models and their limits.
- The role of collaboration and critique, and how peer review helps to establish confidence in scientific claims.
- The role of scientific knowledge, along with other forms of knowledge, in identifying and addressing societal and technological issues.

Epistemic knowledge is most likely to be tested pragmatically in a context where a student is required to interpret and answer a question that requires some of this type of knowledge rather than assessing directly whether they understand the features detailed in Figure 2.7. For example, students may be asked to identify whether the conclusions are justified by the data, or what piece of evidence best supports the hypothesis advanced in an item and explain why.

Table 2.3 describes the desired distribution of items by type of knowledge.

Table 2.3 **Desired distribution of items, by type of knowledge**

Knowledge	Percentage of total items
Content	54-66
Procedural	19-31
Epistemic	10-22

The desired balance, by percentage of items, among the three knowledge components – content, procedural and epistemic – is shown in Table 2.4. These weightings are broadly consistent with the previous framework and reflect a consensus view among the experts consulted during the drafting of this framework.

Table 2.4 Desired distribution of items for knowledge

Knowledge types	Systems			
	Physical	Living	Earth and space	Total over systems
Content	20-24	20-24	14-18	54-66
Procedural	7-11	7-11	5-9	19- 31
Epistemic	4-8	4-8	2-6	10-22
Total over knowledge types	36	36	28	100

Sample items

In this section, three examples of science units are presented. The first is from PISA 2006 and is included to demonstrate the linkage between the 2006 and the 2015 frameworks. Questions from the unit are shown in the original paper-based format and also how they might be transposed and presented on screen. The second example is a new onscreen unit illustrating the 2015 scientific literacy framework. The third example illustrates an interactive, simulated scientific-enquiry environment which allows for assessing students' proficiency in science within a real world setting.

Other examples of science items are available on the PISA website (www.oecd.org/pisa/), including interactive examples (November 2016).

Science example 1: GREENHOUSE

Science example 1 is entitled GREENHOUSE and deals with the increase in the average temperature of the Earth's atmosphere. The stimulus material consists of a short text introducing the term "Greenhouse effect" and includes graphical information on the average temperature of the Earth's atmosphere and carbon dioxide emissions on Earth over time.

The area of application is Environment Quality within a global setting.

Read the texts and answer the questions that follow.

THE GREENHOUSE EFFECT: FACT OR FICTION?

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

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

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

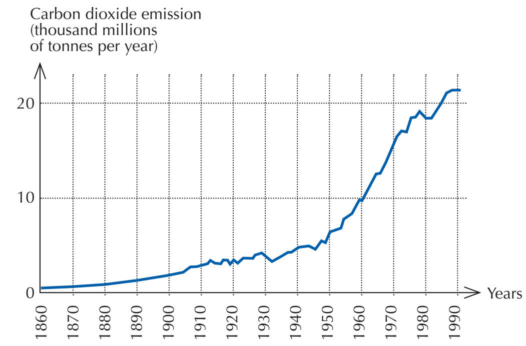
As a result of this the average temperature above the Earth's surface is higher than it would be if there were no atmosphere. The Earth's atmosphere has the same effect as a greenhouse, hence the term greenhouse effect.

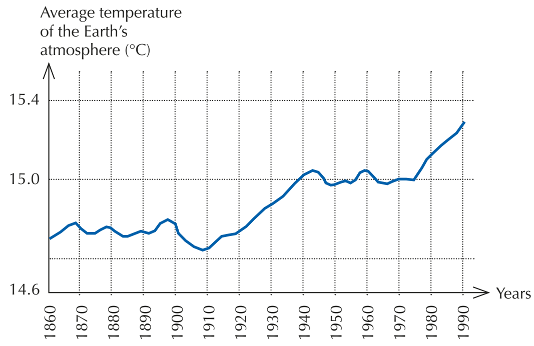
The greenhouse effect is said to have become more pronounced during the twentieth century.

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

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

In a library he comes across the following two graphs.





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

GREENHOUSE – *QUESTION 1*

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

Figure 2.8 ▪ **Framework categorisation for GREENHOUSE question 1**

Framework categories	2006 Framework	2015 Framework
Knowledge type	Knowledge about science	Epistemic
Competency	Explaining phenomena scientifically	Explaining phenomena scientifically
Context	Environmental, global	Environmental, global
Cognitive demand	Not applicable	Medium

Question 1 demonstrates how the 2015 framework largely maps onto the same categories as the 2006 framework, using the same competency and context categorisations. The 2006 framework included two categorisations of scientific knowledge: knowledge *of* science (referring to knowledge of the natural world across the major fields of science) and knowledge *about* science (referring to the means and goals of science). The 2015 framework elaborates on these two aspects, subdividing knowledge *about* science into procedural and epistemic knowledge. Question 1 requires students not only to understand how the data is represented in the two graphs, but also to consider whether this evidence scientifically justifies a given conclusion. This is one of the features of epistemic knowledge in the 2015 framework. The context categorisation is "environmental, global". A new feature of the 2015 framework is consideration of cognitive demand (see Figure 2.23). This question requires an interpretation of graphs involving a few linked steps; thus, according to the framework, it is categorised as medium cognitive demand.

GREENHOUSE – *QUESTION 2*

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

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

....

Figure 2.9 ▪ **Framework categorisation for GREENHOUSE question 2**

Framework categories	2006 Framework	2015 Framework
Knowledge type	Knowledge about science	Epistemic
Competency	Explaining phenomena scientifically	Explaining phenomena scientifically
Context	Environmental, global	Environmental, global
Cognitive demand	Not applicable	Medium

Question 2 requires students to study the two graphs in detail. The knowledge, competency, context and cognitive demand are in the same categories as question 1.

GREENHOUSE – *QUESTION 3*

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

Name one of the factors that Jeanne means.

....

Figure 2.10 ▪ **Framework categorisation for GREENHOUSE question 3**

Framework categories	2006 Framework	2015 Framework
Knowledge type	Knowledge about science	Procedural
Competency	Explaining phenomena scientifically	Explaining phenomena scientifically
Context	Environmental, global	Environmental, global
Cognitive demand	Not applicable	Medium

Question 3 requires students to consider control variables in terms of the critical review of evidence used to support claims. This is categorised as "procedural knowledge" in the 2015 framework.

The screenshots below illustrate how the GREENHOUSE question would be presented in an onscreen environment. The text and graphs are essentially unchanged, with students using page turners on the top right of the screen to view graphs and text as required. As the original questions were open responses, the onscreen version also necessitates an open-response format in order to replicate the paper version as closely as possible, ensuring comparability between delivery modes and therefore protecting comparability of data over time.

Figure 2.11 ▪ **GREENHOUSE presented onscreen: Stimulus page 1**

PISA 2015 ? ⇦ ⇨

Greenhouse effect
Introduction

2

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.

Figure 2.12 ▪ **GREENHOUSE presented onscreen: Stimulus page 2**

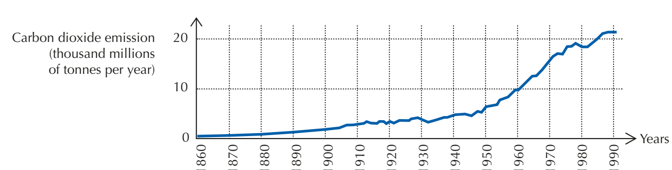
PISA 2015 ? ⇦ ⇨

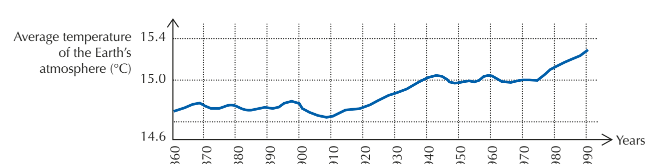
Greenhouse effect
Introduction

*Now click on **Next** to view the first question.*

1 2

A student named André becomes interested in the possible relationship between the average temperature of the Earth's atmosphere and the carbon dioxide emission on the Earth.
In a library he comes across the following two graphs.





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

Figure 2.13 ▪ **GREENHOUSE presented onscreen: Question 1**

PISA 2015

Greenhouse effect
Question 1/3

Type your answer to the question below.

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

2

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.

Figure 2.14 ▪ **GREENHOUSE presented onscreen: Question 2**

PISA 2015

Greenhouse effect
Question 2/3

Type your answer to the question below.

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

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

2

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.

Figure 2.15 ▪ **GREENHOUSE presented onscreen: Question 3**

PISA 2015 ?

Greenhouse effect
Question 3/3

Type your answer to the question below.

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

Name one of the factors that Jeanne means.

2

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 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.

Science example 2: SMOKING

This new 2015 exemplar unit explores various forms of evidence linked to the harmful effects of smoking and the methods used to help people to stop smoking. New scientific literacy items for 2015 are only developed for computer-based delivery and therefore this exemplar is only shown in an onscreen format.

All onscreen standard question types in the PISA 2015 computer platform have a vertical split screen with the stimuli presented on the right side and the questions and answer mechanisms on the left side.

Figure 2.16 ▪ **SMOKING: Question 1**

PISA 2015 Unit Name: SMOKING

Question 1/9

John and Rose are researching cigarette smoking for a school project.

Read John's research on the right.
Then respond to the question below.

Select **two** reasons from the list below that suggest why cigarette companies could claim there was **no** evidence that tar from cigarette smoke caused cancer in humains.

- ☐ Humans are immune to tar
- ☐ Experiments were carried out with mice
- ☐ Chemicals from smoking decreased the effects of tar
- ☐ Humans may react differently from mice
- ☐ Filter-tip cigarettes remove all tar from smoke

John's research

In the 1950s research studies found that tar from cigarette smoke caused cancer in mice. Tobacco companies claimed there was no evidence that smoking caused cancer in humains. They also began to produce filter-tip cigarettes.

SMOKING – *QUESTION 1*

This question requires students to interpret given evidence using their knowledge of scientific concepts. They need to read the information in the stimulus about early research into the potential harmful effects of smoking, and then select two options from the menu to answer the question.

In this question, students have to apply content knowledge using the competency of "explaining phenomena scientifically". The context is categorised as "health and disease" in a local/national setting. The cognitive demand requires the use and application of conceptual knowledge and is therefore categorised as a medium level of demand.

Figure 2.17 ▪ **Framework categorisation for SMOKING question 1**

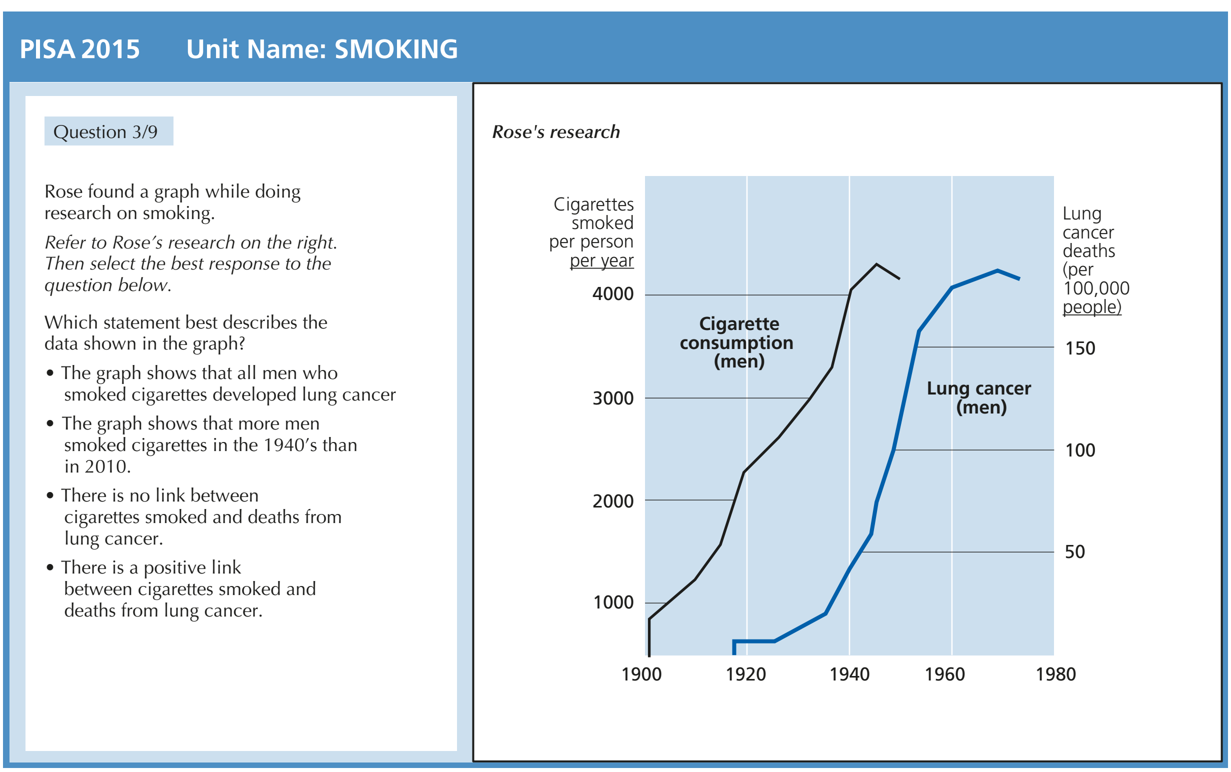
Framework categories	2015 Framework
Knowledge type	Content
Competency	Explaining phenomena scientifically
Context	Health and disease, local and national
Cognitive demand	Medium

SMOKING – *QUESTION 2*

This question explores students' understanding of data.

The right side of the screen shows authentic data of cigarette consumption and deaths from lung cancer in men over an extended period of time. Students are asked to select the best descriptor of the data by clicking on one of the radio buttons next to answer statements on the left side of the screen.

Figure 2.18 ▪ **SMOKING: Question 2**



This unit tests content knowledge using the competency of "interpreting data and evidence scientifically".

The context is "health and disease" applied to a local/national setting. As students need to interpret the relationship between two graphs, the cognitive demand is categorised as medium.

Figure 2.19 ▪ **Framework categorisation for SMOKING question 2**

Framework categories	2015 Framework
Knowledge type	Content
Competency	Interpret data and evidence scientifically
Context	Health and disease, local and national
Cognitive demand	Medium

Science example 3: ZEER POT

This new 2015 exemplar unit features the use of interactive tasks using simulations of scientific enquiry to explore and assess scientific literacy knowledge and competencies.

This unit focuses on an authentic low-cost cooling container called a Zeer pot, developed for local use in Africa, using readily available local resources. Cost and lack of electricity limit the use of refrigerators in these regions, even though the hot climate requires that people keep food cool so that it can be kept for a longer time before bacterial growth renders it a risk to health.

The first screen shot of this simulation introduces what a Zeer pot looks like and how it works. Students are not expected to have an understanding of how the process of evaporation causes cooling, just that it does.

Using this simulation, students are asked to investigate the conditions that will produce the most effective cooling effects (4˚C) for keeping food fresh in the Zeer pot. The simulator keeps certain conditions constant (the air temperature and the humidity), but includes this information to enhance the authentic contextual setting. In the first question, students are asked to investigate the optimum conditions to keep the maximum amount of food fresh in the Zeer pot by altering the thickness of the sand layer and the moisture conditions.

Figure 2.20 ▪ **ZEER POT: Stimulus**

PISA 2015 Unit name: ZEER POT

Introduction

A zeer pot refrigeration is an invention to keep food cool without electricity, usually found in African countries.

A small clay pot sits inside a larger clay pot with a clay or fabric lid. The space between the two pots is filled with sand.This creates an insulating layer around the inner pot. The sand is kept damp by adding water at regular intervals. When the water evaporates, the temperature in the inner pot is reduced.

Local people make zeer pots out of clay, a locally available resource.

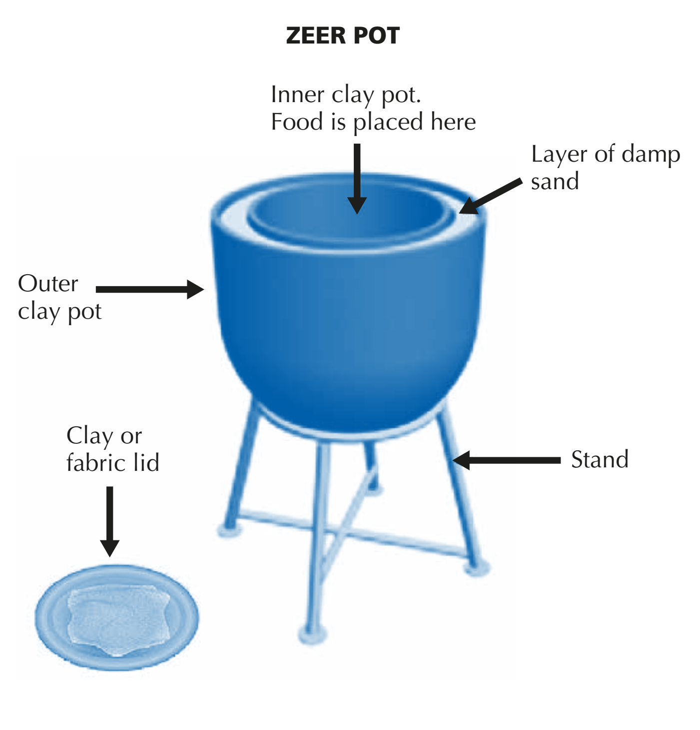
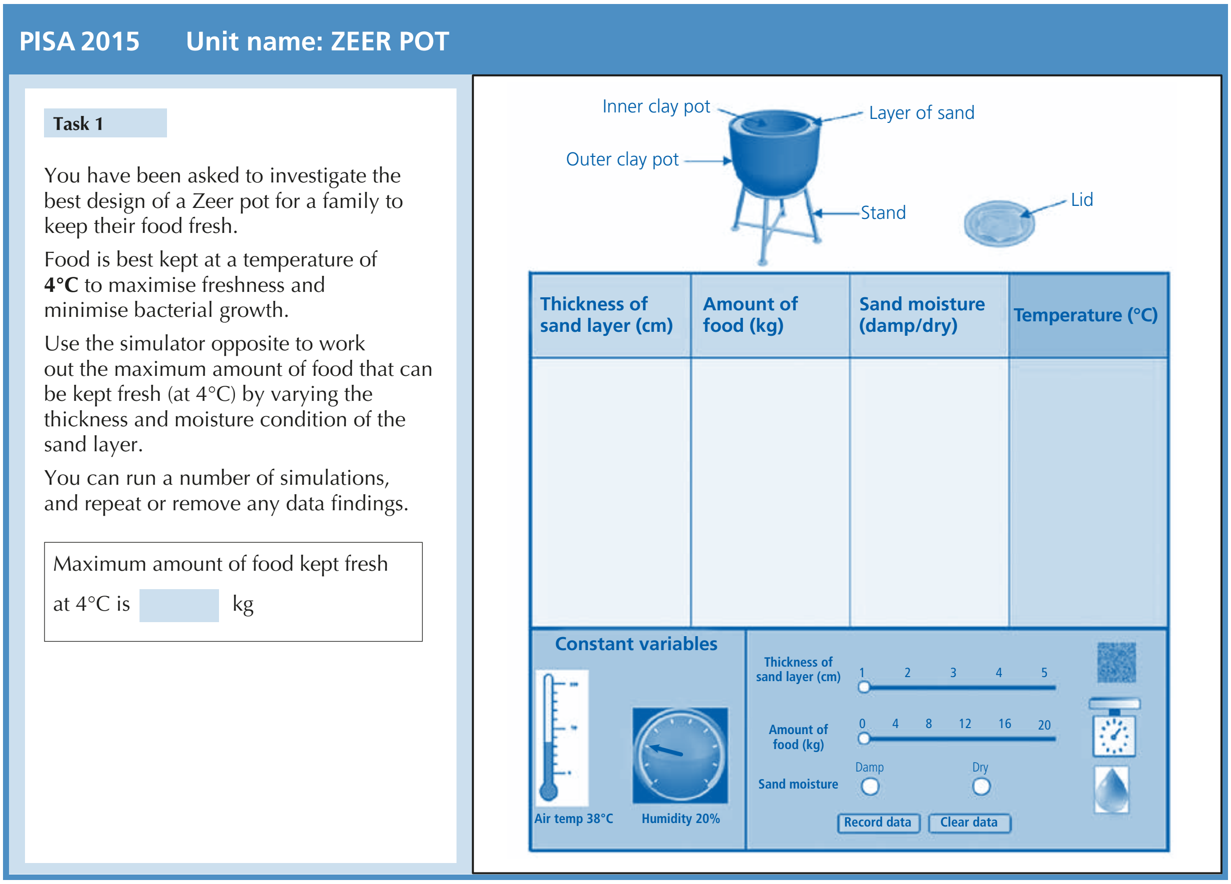


Figure 2.21 ▪ **ZEER POT: Question 1**



When students have set their conditions (which also alter the visual display of the on screen Zeer pot), they press the record-data button, which then runs the simulation and populates the data chart. They need to run a number of data simulations, and can remove data or repeat any simulations as required. This screen then records their response to the maximum amount of food kept fresh at 4ºC. Their approaches to the design and evaluation of this form of scientific enquiry can be assessed in subsequent questions.

The knowledge categorisation for this item is "procedural", and the competence is "evaluate and design scientific enquiry". The context categorisation is "natural resources", although it also has links to "health and disease". The cognitive demand of this question is categorised as high because students are given a complex situation, and they need to develop a systematic sequence of investigations to answer the question.

Figure 2.22 ▪ **Framework categorisation for ZEERPOT question 1**

Framework categories	2015 Framework
Knowledge type	Procedural
Competency	Evaluate and design scientific enquiry
Context	Natural resources
Cognitive demand	High

Attitudes

Why attitudes matter

Peoples' attitudes towards science play a significant role in their interest, attention and response to science and technology, and to issues that affect them specifically. One goal of science education is to develop attitudes that lead students to engage with scientific issues. Such attitudes also support the subsequent acquisition and application of scientific and technological knowledge for personal, local/national and global benefit, and lead to the development of self-efficacy (Bandura, 1997).

Attitudes form part of the construct of scientific literacy. That is, a person's scientific literacy includes certain attitudes, beliefs, motivational orientations, self-efficacy and values. The construct of attitudes used in PISA draws upon Klopfer's (1976) structure for the affective domain in science education and reviews of attitudinal research (Gardner, 1975; Osborne, Simon and Collins, 2003; Schibeci, 1984). A major distinction made in these reviews is between attitudes towards science and scientific attitudes. While the former is measured by the level of interest displayed in scientific issues and activities, the latter is a measure of a disposition to value empirical evidence as the basis of belief.

Defining attitudes towards science in PISA 2015

The PISA 2015 assessment evaluates students' attitudes towards science in three areas: interest in science and technology, environmental awareness, and valuing scientific approaches to enquiry (see Figure 2.23), which are considered core to the construct of scientific literacy. These three areas were selected for measurement because a positive attitude towards science, a concern for the environment and an environmentally sustainable way of life, and a disposition to value the scientific approach to enquiry are characteristics of a scientifically literate individual. Thus, the extent to which individual students are, or are not interested in science and recognise its value and implications is considered an important measure of the outcome of compulsory education. Moreover, in 52 of the countries (including all OECD countries) that participated in PISA 2006, students with a higher general interest in science performed better in science (OECD, 2007:143).

Interest in science and technology was selected because of its established relationships with achievement, course selection, career choice and lifelong learning. For instance, there is a considerable body of literature which shows that interest in science is established by age 14 for the majority of students (Ormerod and Duckworth, 1975; Tai et al., 2006). Moreover, students with such an interest are more likely to pursue scientific careers. Policy concerns in many OECD countries about the number of students, particularly girls, who choose to pursue the study of science make the measurement of attitudes towards science an important aspect of the PISA assessment. The results may provide information about a perceived declining interest in the study of science among young people (Bøe et al., 2011). This measure, when correlated with the large body of other information collected by PISA through the student, teacher and school questionnaires, may provide insights into the causes of any decline in interest.

Valuing scientific approaches to enquiry was chosen because scientific approaches to enquiry have been highly successful at generating new knowledge – not only within science itself, but also in the social sciences, and even finance and sports. Moreover, the core value of scientific enquiry and the Enlightenment is the belief in empirical evidence as the basis of rational belief. Recognising the *value of the scientific approach to enquiry* is, therefore, widely regarded as a fundamental objective of science education that warrants assessing.

Appreciation of, and support for, scientific enquiry implies that students can identify and also value scientific ways of gathering evidence, thinking creatively, reasoning rationally, responding critically and communicating conclusions as they confront life situations related to science and technology. Students should understand how scientific approaches to enquiry function, and why they have been more successful than other methods in most cases. Valuing scientific approaches to enquiry, however, does not mean that an individual has to be positively disposed towards all aspects of science or even use such methods themselves. Thus, the construct is a measure of students' attitudes towards the use of a scientific method to investigate material and social phenomenon and the insights that are derived from such methods.

Environmental awareness is of international concern, as well as being of economic relevance. Attitudes in this area have been the subject of extensive research since the 1970s (see, for example, Bogner and Wiseman, 1999; Eagles and Demare, 1999; Rickinson, 2001; Weaver, 2002). In December 2002, the United Nations approved resolution 57/254 declaring the ten-year period beginning on 1 January 2005 to be the United Nations Decade of Education for Sustainable Development (UNESCO, 2003). The International Implementation Scheme (UNESCO, 2005) identifies the environment as one of the three spheres of sustainability (along with society, including culture, and economy) that should be included in all education programmes for sustainable development.

Given the importance of environmental issues to the continuation of life on Earth and the survival of humanity, young people today need to understand the basic principles of ecology and the need to organise their lives accordingly. This means that developing environmental awareness and a responsible disposition towards the environment is an important element of contemporary science education.

In PISA 2015 these specific attitudes towards science are measured through the student questionnaire. Further detail of these constructs can be found in the Questionnaire framework, Chapter 5.

ASSESSING SCIENTIFIC LITERACY

Cognitive demand

A key new feature of the PISA 2015 framework is the definition of levels of cognitive demand within the assessment of scientific literacy and across all three competencies of the framework. In assessment frameworks, item difficulty, which is empirically derived, is often confused with cognitive demand. Empirical item difficulty is estimated from the proportion of test-takers who solve the item correctly, and thus assesses the amount of knowledge held by the test-taker population, whereas cognitive demand refers to the type of mental processes required (Davis and Buckendahl, 2011). Care needs to be taken to ensure that the depth of knowledge required, i.e. the cognitive demand test items, is understood explicitly by the item developers and users of the PISA framework. For instance, an item can have high difficulty because the knowledge it is testing is not well known, but the cognitive demand is simply recall. Conversely, an item can be cognitively demanding because it requires the individual to relate and evaluate many items of knowledge – each of which is easily recalled. Thus, not only should the PISA test instrument discriminate in terms of performance between easier and harder test items, the test also needs to provide information on how students across the ability range can deal with problems at different levels of cognitive demand (Brookhart and Nitko, 2011).

The competencies are articulated using a range of terms defining cognitive demand through the use of verbs such as "recognise", "interpret", "analyse" and "evaluate". However, in themselves these verbs do not necessarily indicate a hierarchical order of difficulty that is dependent on the level of knowledge required to answer any item. Various classifications of cognitive demand schemes have been developed and evaluated since Bloom's Taxonomy was first published (Bloom, 1956). These have been largely based on categorisations of knowledge types and associated cognitive processes that are used to describe educational objectives or assessment tasks.

Bloom's revised Taxonomy (Anderson and Krathwohl, 2001) identifies four categories of knowledge – factual, conceptual, procedural and meta-cognitive. This categorisation considers these forms of knowledge to be hierarchical and distinct from the six categories of performance used in Bloom's first taxonomy – remembering, understanding, applying, analysing, evaluating and creating. In Anderson and Krathwohl's framework, these two dimensions are now seen to be independent of each other, allowing for lower levels of knowledge to be crossed with higher order skills, and vice versa.

A similar framework is offered by Marzano and Kendall's Taxonomy (2007), which also provides a two-dimensional framework based on the relationship between how mental processes are ordered and the type of knowledge required. The use of mental processes is seen as a consequence of a need to engage with a task with meta-cognitive strategies that define potential approaches to solving problems. The cognitive system then uses either retrieval, comprehension, analysis or knowledge utilisation. Marzano and Kendall divide the knowledge domain into three types of knowledge, information, mental procedures and psychomotor, compared to the four categories in Bloom's revised Taxonomy. Marzano and Kendall argue that their taxonomy is an improvement upon Bloom's Taxonomy because it offers a model of how humans actually think rather than simply an organising framework.

A different approach is offered by Ford and Wargo (2012), who offer a framework for scaffolding dialogue as a way of considering cognitive demand. Their framework uses four levels that build on each other: recall, explain, juxtapose and evaluate. Although this framework has not been specifically designed for assessment purposes, it has many similarities to the PISA 2015 definition of scientific literacy and the need to make more explicit references to such demands in the knowledge and competencies.

Another schema can be found in the framework based on Depth of Knowledge developed by Webb (1997) specifically to address the disparity between assessments and the expectations of student learning. For Webb, levels of depth can be determined by taking into account the complexity of both the content and the task required. His schema consists of four major categories: level 1 (recall), level 2 (using skills and/or conceptual knowledge), level 3 (strategic thinking) and level 4 (extended thinking). Each category is populated with a large number of verbs that can be used to describe cognitive processes. Some of these appear at more than one level. This framework offers a more holistic view of learning and assessment tasks, and requires an analysis of both the content and cognitive process demanded by any task. Webb's Depth of Knowledge (DOK) approach is a simpler but more operational version of the SOLO Taxonomy (Biggs and Collis, 1982) which describes a continuum of student understanding through five distinct stages of pre-structural, unistructural, multistructural, relational and extended abstract understanding.

All the frameworks described briefly above have served to develop the knowledge and competencies in the PISA 2015 Framework. In drawing up such a framework, it is recognised that there are challenges in developing test items based on a cognitive hierarchy. The three main challenges are that:

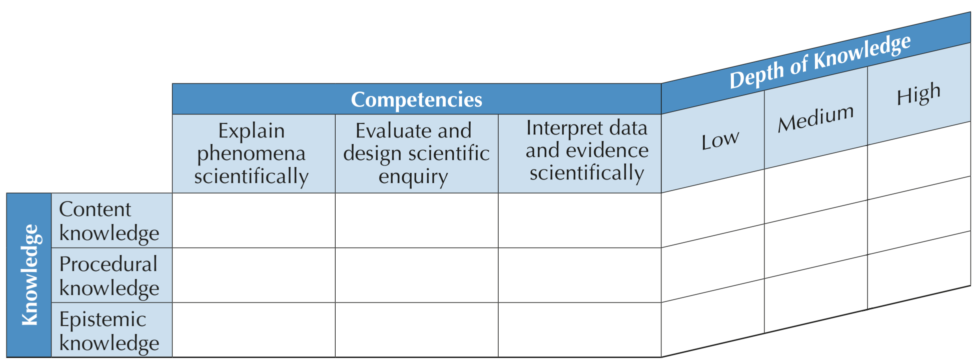
a) Too much effort is made to fit test items into particular cognitive frameworks, which can lead to poorly developed items.

b) Intended items (with frameworks defining rigorous, cognitively demanding goals) may differ from actual items (which may operationalise the standard in a much less cognitively demanding way).

c) Without a well-defined and understood cognitive framework, item writing and development often focuses on item difficulty and uses a limited range of cognitive processes and knowledge types, which are then only described and interpreted post hoc, rather than building from a theory of increasing competency.

The approach taken in this framework is to use an adapted version of Webb's Depth of Knowledge grid (Webb, 1997) alongside the desired knowledge and competencies. As the competencies are the central feature of the framework, the cognitive framework needs to assess and report on them across the student ability range. Webb's Depth of Knowledge Levels offer a taxonomy for cognitive demand that requires items to identify both the cognitive demand from the verbal cues that are used, e.g. analyse, arrange, compare, and the expectations of the depth of knowledge required.

Figure 2.23 ▪ **PISA 2015 Framework for Cognitive Demand**



The grid in Figure 2.23 provides a framework for mapping items against the two dimensions of knowledge and competencies. In addition, each item can also be mapped using a third dimension based on a depth-of-knowledge taxonomy. This provides a means of operationalising cognitive demand as each item can be categorised as making demands that are:

- **Low**
  Carry out a one-step procedure, for example recall a fact, term, principle or concept, or locate a single point of information from a graph or table.
- **Medium**
  Use and apply conceptual knowledge to describe or explain phenomena, select appropriate procedures involving two or more steps, organise/display data, interpret or use simple data sets or graphs.
- **High**
  Analyse complex information or data; synthesise or evaluate evidence; justify; reason, given various sources; develop a plan or sequence of steps to approach a problem.

The distribution of items by depth of knowledge is described in Table 2.5.

Table 2.5 Distribution of items by depth of knowledge

Depth of knowledge	Percentage of items
Low	8
Medium	30
High	61
Total	**100**

Items that merely require recall of one piece of information make low cognitive demands, even if the knowledge itself might be quite complex. In contrast, items that require recall of more than one piece of knowledge, and require a comparison and evaluation of the competing merits of their relevance would be seen as having high cognitive demand. The difficulty of any item, therefore, is a combination both of the degree of complexity and range of knowledge it requires, and the cognitive operations that are required to process the item.

Therefore, the factors that determine the demand of items assessing science achievement include:

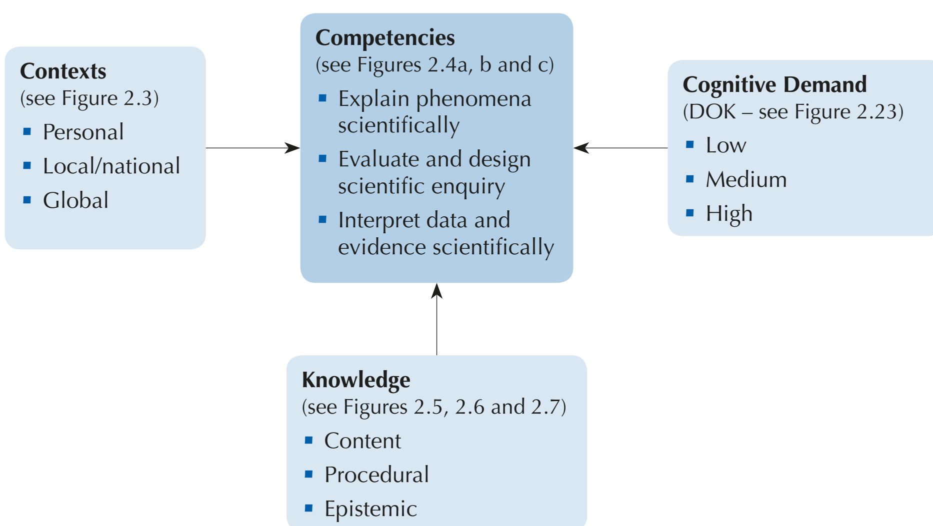
- The number and degree of complexity of elements of knowledge demanded by the item.
- The level of familiarity and prior knowledge that students may have of the content, procedural and epistemic knowledge involved.
- The cognitive operation required by the item, e.g. recall, analysis, evaluation.
- The extent to which forming a response is dependent on models or abstract scientific ideas.

This four-factor approach allows for a broader measure of scientific literacy across a wider range of student ability. Categorising the cognitive processes required for the competencies that form the basis of scientific literacy together with a consideration of the depth of knowledge required offers a model for assessing the level of demand of individual items. In addition, the relative simplicity of the approach offers a way to minimise the problems encountered in applying such frameworks. The use of this cognitive framework also facilitates the development of an a priori definition of the descriptive parameters of the reporting proficiency scales (see Figure 2.25).

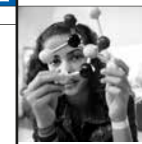
Test characteristics

Figure 2.24 is a variation of Figure 2.2 that presents the basic components of the PISA framework for the 2015 scientific literacy assessment in a way that can be used to relate the framework with the structure and the content of assessment units. This may be used as a tool both to plan assessment exercises and to study the results of standard assessment exercises. As a starting point to construct assessment units, it shows the need to consider the contexts that will serve as stimulus material, the competencies required to respond to the questions or issues, the knowledge central to the exercise, and the cognitive demand.

Figure 2.24 ▪ **A tool for constructing and analysing assessment units and items**



A test unit is defined by specific stimulus material, which may be a brief written passage, or text accompanying a table, chart, graph or diagram. In units created for PISA 2015, the stimulus material may also include non-static stimulus material, such as animations and interactive simulations. The items are a set of independently scored questions of various types, as illustrated by the examples already discussed. Further examples can be found at the PISA website (www.oecd.org/pisa/) (November 2016).



PISA uses this unit structure to facilitate the use of contexts that are as realistic as possible, reflecting the complexity of real-life situations, while making efficient use of testing time. Using situations about which several questions can be posed, rather than asking separate questions about a larger number of different situations, reduces the overall time required for a student to become familiar with the material in each question. However, the need to make each score point independent of others within a unit needs to be taken into account. It is also necessary to recognise that, because this approach reduces the number of different assessment contexts, it is important to ensure that there is an adequate range of contexts so that bias due to the choice of contexts is minimised.

PISA 2015 test units require the use of all three scientific competencies and draw on all three forms of science knowledge. In most cases, each test unit assesses multiple competencies and knowledge categories. Individual items, however, assess only one form of knowledge and one competency.

The need for students to read texts in order to understand and answer written questions on scientific literacy raises an issue of the level of reading literacy that are required. Stimulus material and questions use language that is as clear, simple and brief, and as syntactically simplified as possible while still conveying the appropriate meaning. The number of concepts introduced per paragraph is limited. Questions within the domain of science that assess reading or mathematical literacy are avoided.

Response formats

Three classes of items are used to assess the competencies and scientific knowledge identified in the framework. About one-third of the items are in each of the three classes:

- simple multiple choice: items calling for
  - selection of a single response from four options
  - selection of a "hot spot", an answer that is a selectable element within a graphic or text
- complex multiple choice: items calling for
  - responses to a series of related "Yes/No" questions that are treated for scoring as a single item (the typical format in 2006)
  - selection of more than one response from a list
  - completion of a sentence by selecting drop-down choices to fill multiple blanks
  - "drag-and-drop" responses, allowing students to move elements on screen to complete a task of matching, ordering or categorising
- constructed response: items calling for written or drawn responses
  - Constructed-response items in scientific literacy typically call for a written response ranging from a phrase to a short paragraph (e.g. two to four sentences of explanation). A small number of constructed-response items call for drawing (e.g. a graph or diagram). In a computer-based assessment, any such item is supported by simple drawing editors that are specific to the response required.

In 2015, some responses are captured by interactive tasks, for example, a student's choices for manipulating variables in a simulated scientific enquiry. Responses to these interactive tasks are likely scored as complex multiple-choice items. Some kinds of responses to interactive tasks may be sufficiently open-ended that they are treated as constructed response.

Assessment structure

Computer is the primary mode of delivery for all domains, including scientific literacy, in PISA 2015. All new science literacy items are only available on computer. However a paper-based assessment instrument, consisting only of the trend items, is provided for countries choosing not to test their students by computer. (The PISA 2015 field trial studied the effect on student performance of the change in mode of delivery. For further details see Box 1.2.)

Scientific literacy items are organised into 30-minute sections called "clusters". Each cluster includes either only new units or only trend units. Overall for 2015, the target number of clusters included in the main survey is:

- six clusters of trend units in 2015 main survey
- six clusters of new units in 2015 main survey.

Each student is assigned one two-hour test form. A test form is composed of four clusters, with each cluster designed to occupy thirty minutes of testing time. The clusters are placed in multiple computer-based test forms, according to a rotated test design.

Each student spends one hour on scientific literacy, with the remaining time assigned to either one or two of the additional domains of reading, mathematics and collaborative problem solving. For any countries taking the paper-based assessment instrument, intact clusters of 2006 units are formed into a number of test booklets. The paper-based assessment is limited to trend items and does not include any newly developed material. In contrast, the computer-based instrument includes newly developed items as well as trend items. When transposing paper-based trend items to an onscreen format, the presentation, response format and cognitive demand remain comparable.

Item contexts are spread across personal, local/national and global settings roughly in the ratio 1:2:1, as was the case in 2006. A wide selection of areas of application are used for units, subject to satisfying as far as possible the various constraints imposed by the distribution of items shown in Tables 2.1 and 2.4.

Reporting proficiency in science

To achieve the aims of PISA, scales must be developed to measure student proficiency. A descriptive scale of levels of competence needs to be based on a theory of how the competence develops, not just on a post-hoc interpretation of what items of increasing difficulty seem to be measuring. The 2015 draft framework therefore defined explicitly the parameters of increasing competence and progression, allowing item developers to design items representing this growth in ability (Kane, 2006; Mislevy and Haertel, 2006). Initial draft descriptions of the scales are offered below, though it is recognised that these may need to be updated after the main survey. Although comparability with the 2006 scale descriptors (OECD, 2007) has been maximised in order to enable trend analyses, the new elements of the 2015 framework, such as depth of knowledge, have also been incorporated. The scales have also been extended by the addition of a level "1b" to specifically address and provide a description of students at the lowest level of ability who demonstrate minimal scientific literacy and would previously not have been included in the reporting scales. The initial draft scales for 2015 Framework therefore propose more detailed and more specific descriptors of the levels of scientific literacy, and not an entirely different model as shown in Figure 2.25.

Figure 2.25 ■ **Initial draft of proficiency scale descriptions for science**

Level	Descriptor
6	At Level 6, students are able to use content, procedural and epistemic knowledge to consistently provide explanations, evaluate and design scientific enquiries, and interpret data in a variety of complex life situations that require a high level of cognitive demand. They can draw appropriate inferences from a range of different complex data sources, in a variety of contexts and provide explanations of multi-step causal relationships. They can consistently distinguish scientific and non-scientific questions, explain the purposes of enquiry, and control relevant variables in a given scientific enquiry or any experimental design of their own. They can transform data representations, interpret complex data and demonstrate an ability to make appropriate judgments about the reliability and accuracy of any scientific claims. Level 6 students consistently demonstrate advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations. They can develop arguments to critique and evaluate explanations, models, interpretations of data and proposed experimental designs in a range of personal, local and global contexts.
5	At Level 5, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of life situations in some but not all cases of high cognitive demand. They draw inferences from complex data sources, in a variety of contexts and can explain some multi-step causal relationships. Generally, they can distinguish scientific and non-scientific questions, explain the purposes of enquiry, and control relevant variables in a given scientific enquiry or any experimental design of their own. They can transform some data representations, interpret complex data and demonstrate an ability to make appropriate judgments about the reliability and accuracy of any scientific claims. Level 5 students show evidence of advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations. They can develop arguments to critique and evaluate explanations, models, interpretations of data and proposed experimental designs in some but not all personal, local and global contexts.

...

Figure 2.25 [continued] ▪ **Initial draft of proficiency scale descriptions for science**

4	At Level 4, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of given life situations that require mostly a medium level of cognitive demand. They can draw inferences from different data sources, in a variety of contexts and can explain causal relationships. They can distinguish scientific and non-scientific questions, and control variables in some but not all scientific enquiry or in an experimental design of their own. They can transform and interpret data and have some understanding about the confidence held about any scientific claims. Level 4 students show evidence of linked scientific thinking and reasoning and can apply this to unfamiliar situations. Students can also develop simple arguments to question and critically analyse explanations, models, interpretations of data and proposed experimental designs in some personal, local and global contexts.
3	At Level 3, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some given life situations that require at most a medium level of cognitive demand. They are able to draw a few inferences from different data sources, in a variety of contexts, and can describe and partially explain simple causal relationships. They can distinguish some scientific and non-scientific questions, and control some variables in a given scientific enquiry or in an experimental design of their own. They can transform and interpret simple data and are able to comment on the confidence of scientific claims. Level 3 students show some evidence of linked scientific thinking and reasoning, usually applied to familiar situations. Students can develop partial arguments to question and critically analyse explanations, models, interpretations of data and proposed experimental designs in some personal, local and global contexts.
2	At Level 2, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some given familiar life situations that require mostly a low level of cognitive demand. They are able to make a few inferences from different sources of data, in few contexts, and can describe simple causal relationships. They can distinguish some simple scientific and non-scientific questions, and distinguish between independent and dependent variables in a given scientific enquiry or in a simple experimental design of their own. They can transform and describe simple data, identify straightforward errors, and make some valid comments on the trustworthiness of scientific claims. Students can develop partial arguments to question and comment on the merits of competing explanations, interpretations of data and proposed experimental designs in some personal, local and global contexts.
1a	At Level 1a, students are able to use a little content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low level of cognitive demand. They are able to use a few simple sources of data, in a few contexts and can describe some very simple causal relationships. They can distinguish some simple scientific and non-scientific questions, and identify the independent variable in a given scientific enquiry or in a simple experimental design of their own. They can partially transform and describe simple data and apply them directly to a few familiar situations. Students can comment on the merits of competing explanations, interpretations of data and proposed experimental designs in some very familiar personal, local and global contexts.
1b	At Level 1b, students demonstrate a little evidence to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low level of cognitive demand. They are able to identify straightforward patterns in simple sources of data in a few familiar contexts and can offer attempts at describing simple causal relationships. They can identify the independent variable in a given scientific enquiry or in a simple design of their own. They attempt to transform and describe simple data and apply them directly to a few familiar situations.

The proposed level descriptors are based on the 2015 Framework described in this document and offer a qualitative description of the differences between levels of performance. The factors used to determine the demand of items assessing science achievement that have been incorporated into this outline of the proficiency scales include:

- the number and degree of complexity of elements of knowledge demanded by the item
- the level of familiarity and prior knowledge that students may have of the content, procedural and epistemic knowledge involved
- the cognitive operation required by the item, e.g. recall, analysis, evaluation
- the extent to which forming a response is dependent on models or abstract scientific ideas.

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3

PISA 2015 reading framework

This chapter defines "reading literacy" as assessed in the Programme for International Student Assessment (PISA) in 2015 and the competencies required for reading literacy. It describes the cognitive processes (aspects) involved in reading that are assessed, the types of texts and response formats used in the assessment, and how student performance in reading is measured and reported.

In PISA 2015, reading literacy is assessed as a minor domain, providing an opportunity to make comparisons in student performance over time. This framework uses the same description and illustrations of the PISA reading assessment as included in the 2009 framework, when reading was re-examined and updated for use as the major domain in that cycle. The framework does not, however, cover digital reading (also referred to as electronic reading in 2009). This is because the 2009 report provided separate scales for print reading and digital reading. Since reading is a minor domain in PISA 2015, and since digital reading was not assessed in all participating countries in 2009 or in 2012, there are no separate data on digital reading, nor was digital reading included as part of the overall concept of reading literacy.

For PISA 2015, the computer is the primary mode of delivery for all domains, including reading literacy. However, paper-based assessment instruments are provided for countries that choose not to test their students by computer. The reading literacy component of both the computer-based and paper-based instruments is composed of the same clusters of reading trend items. The number of trend items in the minor domains are increased compared with previous PISA assessments, thereby increasing the construct coverage while reducing the number of students responding to each question. This design is intended to reduce potential bias while stabilising and improving the measurement of trends.

With the move to computer-based delivery for 2015, the 2012 text classification "medium: print and digital" is a potential source of confusion. For 2015, the terminology has been updated to "fixed text" and "dynamic text" to distinguish between delivery mode and the space in which the text is displayed (hereafter referred to as "text display space"), regardless of whether it is printed or on screen. It is important to note, however, that the constructs of the 2009 framework remain unchanged.

2015 reading literacy terminology

Mode: refers only to the delivery channel. The following distinctions are made:

Paper-based: items delivered on paper

Computer-based: items delivered on computer

Text display space: In 2009, a broad classification, "medium", was used to describe the features of print and digital texts. For 2015, the classification remains, but is renamed "text display space".

Fixed text: what was previously called "print-medium text". As this type of text is presented on a screen in PISA 2015, the term "print" no longer applies.

Dynamic text: what was previously called "digital-medium text". As "print-medium" texts are also presented on a screen in PISA 2015, the term "digital" applies to both text display spaces.

Digital reading: The term "digital reading assessment" is retained for historical purposes to refer specifically to the 2009/2012 optional domain.

Note: This new terminology is intended to be provisional, for use only in 2015 when items previously delivered on paper and classified as "print" are delivered on a screen. The purpose is to make a clearer distinction between the mode of delivery and the features of the classification previously known as "medium". In 2018, when reading literacy will once again become the major domain, both the framework and these terms will be revisited and updated.

In 2015, only fixed-text items are used in the assessment, and these are delivered primarily in a computer-based mode. This is shown in Table 3.1 below.

Table 3.1 Relationship between mode and text display space for 2015

Mode/Text display space	Fixed text	Dynamic text
Paper-based mode	✔	✘
Computer-based mode	✔	✔ (but not assessed in 2015)

Reading literacy was the major domain assessed in 2000, for the first PISA cycle and in 2009, for the fourth PISA cycle. For the sixth PISA cycle (PISA 2015), reading is a minor domain and its framework has not changed from the PISA 2009 cycle (OECD, 2010). There were two major modifications to the PISA 2009 version of the reading framework: the incorporation of an assessment of digital reading and the elaboration of the constructs of reading engagement and metacognition. However, reading is a minor domain in PISA 2015. The reading of digital texts is not included and no data on engagement or metacognition in reading are collected.

The PISA framework for assessing the reading literacy of students towards the end of compulsory education, therefore, must focus on skills that include finding, selecting, interpreting and evaluating information from a full range of texts, including those encountered both inside and outside the classroom.

DEFINING READING LITERACY

Definitions of reading and reading literacy have changed over time in parallel with changes in society, economy and culture. The concept of learning, particularly the concept of lifelong learning, has expanded the perception of reading literacy. Literacy is no longer considered to be an ability acquired only in childhood during the early years of schooling. Instead, it is viewed as an expanding set of knowledge, skills and strategies that individuals build on throughout life in various contexts, through interaction with their peers and the wider community.

Cognitive-based theories of reading literacy emphasise the interactive nature of reading and the constructive nature of comprehension, in the print medium (Binkley and Linnakylä, 1997; Bruner, 1990; Dole et al., 1991) and to an even greater extent in the digital medium (Fastrez, 2001; Legros and Crinon, 2002; Leu, 2007; Reinking, 1994). The reader generates meaning in response to text by using previous knowledge and a range of text and situational cues that are often socially and culturally derived. While constructing meaning, the reader uses various processes, skills and strategies to foster, monitor and maintain understanding. These processes and strategies are expected to vary with context and purpose as readers interact with a variety of continuous and non-continuous texts in the print medium and (typically) with multiple texts in the digital medium.

The PISA 2015 definition of reading literacy, the same as used in PISA 2009, as shown in Box 3.1:

Box 3.1 **The 2015 definition of reading literacy**

Reading literacy is understanding, using, reflecting on and engaging with written texts, in order to achieve one's goals, develop one's knowledge and potential, and participate in society.

Reading literacy…

The term "reading literacy" is preferred to "reading" because it is likely to convey to a non-expert audience more precisely what the survey is measuring. "Reading" is often understood as simply decoding, or even reading aloud, whereas the intention of this survey is to measure something broader and deeper. Reading literacy includes a wide range of cognitive competencies, from basic decoding, to knowledge of words, grammar and larger linguistic and textual structures and features, to knowledge about the world.

In this study, "reading literacy" is intended to express the active, purposeful and functional application of reading in a range of situations and for various purposes. According to Holloway (1999), reading skills are essential to the academic achievement of middle- and high school students. PISA assesses a wide range of students. Some will go on to university; some will pursue further studies in preparation for joining the labour force; some will enter the workforce directly after completing compulsory education. Achievement in reading literacy is not only a foundation for achievement in other subject areas within the education system, but also a prerequisite for successful participation in most areas of adult life (Cunningham and Stanovich, 1998; Smith et al., 2000). Indeed, regardless of their academic or labour-force aspirations, students' reading literacy is important for their active participation in their community and economic and personal life.

Reading literacy skills matter not just for individuals, but for economies as a whole. Policy makers and others are coming to recognise that in modern societies, human capital – the sum of what the individuals in an economy know and can do – may be the most important form of capital. Economists have for many years developed models showing generally that a country's education levels are a predictor of its economic growth potential (Coulombe et al., 2004).

…is understanding, using, reflecting on…

The word "understanding" is readily connected with "reading comprehension", a well-accepted element of reading. The word "using" refers to the notions of application and function – doing something with what we read. "Reflecting on" is added to "understanding" and "using" to emphasise the notion that reading is interactive: readers draw on their own thoughts and experiences when engaging with a text. Of course, every act of reading requires some reflection, drawing on information from outside the text. Even at the earliest stages, readers draw on symbolic knowledge to decode a text and require a knowledge of vocabulary to construct meaning. As readers develop their stores of information, experience and beliefs, they constantly, often unconsciously, test what they read against outside knowledge, thereby continually reviewing and revising their sense of the text.

…and engaging with…

A reading literate person not only has the skills and knowledge to read well, but also values and uses reading for a variety of purposes. It is therefore a goal of education to cultivate not only proficiency but also engagement in reading. Engagement in this context implies the motivation to read and comprises a cluster of affective and behavioural characteristics that include an interest in and enjoyment of reading, a sense of control over what one reads, involvement in the social dimension of reading, and diverse and frequent reading practices.

…written texts…

The term "written texts" is meant to include all those coherent texts in which language is used in its graphic form, whether printed or digital. Instead of the word "information", which is used in some other definitions of reading, the term "texts" was chosen because of its association with written language and because it more readily connotes literary as well as information-focused reading.

These texts do not include aural language artefacts, such as voice recordings; nor do they include film, TV, animated visuals or pictures without words. They do include visual displays, such as diagrams, pictures, maps, tables, graphs and comic strips that include some written language (for example, captions). These visual texts can exist either independently or they can be embedded in larger texts. Digital texts are distinguished from printed texts in a number of respects, including physical readability; the amount of text visible to the reader at any one time; the way different parts of a text and different texts are connected with one another through hypertext links; and, given these text characteristics, the way that readers typically engage with digital texts. To a much greater extent than with printed or hand-written texts, readers need to construct their own pathways to complete any reading activity associated with a digital text.

…in order to achieve one's goals, develop one's knowledge and potential, and participate in society.

This phrase is meant to capture the full scope of situations in which reading literacy plays a role, from private to public, from school to work, from formal education to lifelong learning and active citizenship. "To achieve one's goals and to develop one's knowledge and potential" spells out the idea that reading literacy enables the fulfilment of individual aspirations – both defined ones, such as graduating or getting a job, and those less defined and less immediate that enrich and extend personal life and lifelong education. The word "participate" is used because it implies that reading literacy allows people to contribute to society as well as to meet their own needs. "Participating" includes social, cultural and political engagement.

ORGANISING THE DOMAIN OF READING

This section describes how the domain is represented, a vital issue because the organisation and representation of the domain determines the test design and, ultimately, the evidence about student proficiencies that can be collected and reported.

Reading is a multidimensional domain. While many elements are part of the construct, not all can be taken into account in building the PISA assessment. Only those considered most important were selected.

The PISA reading literacy assessment is built on three major task characteristics to ensure a broad coverage of the domain:

- *situation*, which refers to the range of broad contexts or purposes for which reading takes place
- *text*, which refers to the range of material that is read
- *aspect*, which refers to the cognitive approach that determines how readers engage with a text.

In PISA, features of the text and aspect variables (but not of the situation variable) are also manipulated to influence the difficulty of a task.

Reading is a complex activity. The elements of reading do not exist independently of one another in neat compartments. The assignment of texts and tasks to framework categories does not imply that the categories are strictly partitioned or that the materials exist in atomised cells determined by a theoretical structure. The framework scheme is provided to ensure coverage, to guide the development of the assessment and to set parameters for reporting, based on what are considered the marked features of each task.

Examples of reading items are available in the *PISA 2012 Assessment and Analytical Framework* (OECD, 2013) and on the PISA website (www.oecd.org/pisa/).

Situation

The PISA situation variables were adapted from the Common European Framework of Reference (CEFR) developed for the Council of Europe (Council of Europe, 1996). The four situation variables – personal, public, educational and occupational – are described in the following paragraphs.

The *personal* situation relates to texts that are intended to satisfy an individual's personal interests, both practical and intellectual. This category also includes texts that are intended to maintain or develop personal connections with other people. It includes personal letters, fiction, biography, and informational texts that are intended to be read to satisfy curiosity, as a part of leisure or recreational activities. In the digital medium it includes personal e-mails, instant messages and diary-style blogs.

The *public* category describes the reading of texts that relate to activities and concerns of the larger society. The category includes official documents and information about public events. In general, the texts associated with this category assume a more or less anonymous contact with others; they also therefore include forum-style blogs, news websites and public notices that are encountered both on line and in print.

The content of *educational* texts is usually designed specifically for the purpose of instruction. Printed text books and interactive learning software are typical examples of material generated for this kind of reading. Educational reading normally involves acquiring information as part of a larger learning task. The materials are often not chosen by the reader, but instead assigned by an instructor. The model tasks are those usually identified as "reading to learn" (Sticht, 1975; Stiggins, 1982).

Many 15-year-olds will move from school into the labour force within one to two years. A typical *occupational* reading task is one that involves the accomplishment of some immediate task. It might include searching for a job, either in a print newspaper's classified advertisement section, or on line; or following workplace directions. The model tasks of this type are often referred to as "reading to do" (Sticht, 1975; Stiggins, 1982).

Situation is used in PISA reading literacy to define texts and their associated tasks, and refers to the contexts and uses for which the author constructed the text. The manner in which the situation variable is specified is therefore about supposed audience and purpose, and is not simply based on the place where the reading activity is carried out. Many texts used in classrooms are not specifically designed for classroom use. For example, a piece of literary text may typically be read by a 15-year-old in a mother-tongue language or literature class, yet the text was written (presumably) for readers' personal enjoyment and appreciation. Given its original purpose, such a text is classified as *personal* in PISA. As Hubbard (1989) has shown, some kinds of reading usually associated with out-of-school settings for children, such as rules for clubs and records of games, often take place unofficially at school as well. These texts are classified as *public* in PISA. Conversely, textbooks are read both in schools and in homes, and the process and purpose probably differ little from one setting to another. Such texts are classified as *educational* in PISA.

The four categories overlap. In practice, for example, a text may be intended both to delight and to instruct (personal and educational); or to provide professional advice that is also general information (occupational and public). While content is not a variable that is specifically manipulated in this study, by sampling texts across a variety of situations the intent is to maximise the diversity of content that is included in the PISA reading literacy survey.

Table 3.2 shows the desired distribution of items by situation for reading tasks.

Table 3.2 Desired distribution of reading items, by situation

Situation	Percentage of total items
Personal	30
Educational	25
Occupational	15
Public	30
Total	**100**

Text

Reading requires material for the reader to read. In an assessment, that material – a text (or a set of texts) related to a particular task – must be coherent within itself. That is, the text must be able to stand alone without requiring additional material to make sense to the proficient reader.[1] While it is obvious that there are many different kinds of texts and that any assessment should include a broad range, it is not so obvious that there is an ideal categorisation of kinds of texts.

PISA 2009 and PISA 2012

In PISA 2009 and PISA 2012, the addition of digital reading to the framework made this issue still more complex. There were four main text classifications, because of the print and digital reading assessments proposed in these surveys:

- medium: print and digital
- environment: authored, message-based and mixed (only applicable to digital medium)
- text format: continuous, non-continuous, mixed and multiple
- text type: description, narration, exposition, argumentation, instruction and transaction.

PISA 2015

As explained above, in PISA 2015 only the items used previously for the "print reading assessment" are delivered on computer or paper, and there are only two text classifications:

- text format
- text type.

Text display space is a third classification of text with two categories, fixed texts and dynamic text. It is not used in PISA 2015 but will be integrated into the PISA 2018 survey.

In PISA 2015, the term 'text display space" is used to describe the features of the space – fixed or dynamic – and not the mode in which the text is presented.

Fixed texts usually appear on paper in forms such as single sheets, brochures, magazines and books, but tend to appear more and more on a screen as PDFs and on e-readers. This development results in further blurring the distinction between what was labelled "print reading" and "digital reading" in the PISA 2009 framework. As PISA 2015 uses only what was labelled "print reading" in 2009 there are no conceptual change in this aspect for PISA 2015. The physical status of the fixed text encourages (though it may not compel) the reader to approach the content of the text in a particular sequence. In essence, such texts have a fixed or static existence. In real life and in the assessment context, the extent or amount of the text is immediately visible to the reader.

When moving the fixed-text "print" reading trend items from paper to computer-based delivery in the 2015 assessment, care needed to be taken to use navigation tools typical of dynamic texts sparingly and only the most obvious among them. Effects of presenting the original paper-based items on the computer were examined during the mode-effect study in the field trial.

Dynamic texts only appear on a screen. Dynamic text is synonymous with *hypertext*: a text or texts with navigation tools and features that make possible and indeed even require non-sequential reading. Each reader constructs a "customised" text from the information encountered at the links he or she follows. In essence, such texts have an unfixed, dynamic existence. In dynamic texts, typically only a fraction of the available text can be seen at any one time, and often the extent of text available is unknown. No dynamic texts are included in PISA 2015.

The *environment* classification was a new variable for the PISA 2009 reading framework. Since it applies only to dynamic texts it is not discussed in the 2015 PISA framework.

Text format

An important classification of texts is the distinction between continuous and non-continuous texts.

Texts in *continuous* and *non-continuous* format appear in both the print and digital media. *Mixed* and *multiple* format texts are also prevalent in both media, particularly so in the digital medium. Each of these four formats is elaborated as follow:

Continuous texts are formed by sentences organised into paragraphs. These may fit into even larger structures, such as sections, chapters, and books (e.g. newspaper reports, essays, novels, short stories, reviews and letters including on e-book readers).

Non-continuous are most frequently organised in matrix format, composed of a number of lists (Kirsch and Mosenthal, 1990) (e.g. lists, tables, graphs, diagrams, advertisements, schedules, catalogues, indexes and forms). They thus require a different approach to reading than *continuous* texts do.

Many texts are single, coherent artefacts consisting of a set of elements in both a *continuous* and *non-continuous* format. In well-constructed *mixed* texts, the constituents (e.g. a prose explanation, along with a graph or table) are mutually supportive, with coherence and cohesion links throughout. *Mixed* text in the print medium is a common format in magazines, reference books and reports. In the digital medium, authored web pages are typically mixed texts, with combinations of lists, paragraphs of prose, and often graphics. Message-based texts, such as online forms, e-mail messages and forums, also combine texts that are *continuous* and *non-continuous* in format.

Multiple texts are defined as those that have been generated independently, and make sense independently; they are juxtaposed for a particular occasion or may be loosely linked together for the purposes of the assessment. The relationship between the texts may not be obvious; they may be complementary or may contradict one another. For example, a set of websites from different companies providing travel advice may or may not provide similar directions to tourists. Multiple texts may have a single "pure" format (for example, continuous), or may include both continuous and non-continuous texts.

Table 3.3 shows the desired distribution of items by text format.

Table 3.3 Desired distribution of reading items, by text format

Text format	Percentage of total items
Continuous	60
Non-continuous	30
Mixed	5
Multiple	5
Total	**100**

Text type

A different categorisation of text is by text type: description, narration, exposition, argumentation, instruction and transaction.

Texts, as they are found in the world, typically resist categorisation; they are usually not written with rules in mind, and tend to cut across categories. In order to ensure that the reading instrument represents different types of reading, PISA categorises texts based on their predominant characteristics.

The following classification of texts used in PISA is adapted from the work of Werlich (1976).

Description is the type of text in which the information refers to properties of objects in space. The typical questions that descriptive texts answer are "what" questions (e.g. a depiction of a particular place in a travelogue or diary, a catalogue, a geographical map, an online flight schedule or a description of a feature, function or process in a technical manual).

Narration is the type of text in which the information refers to properties of objects in time. Narration typically answers questions relating to "when", or "in what sequence". "Why characters in stories behave as they do" is another question that narration typically answers (e.g. a novel, a short story, a play, a biography, a comic strip, fictional texts and a newspaper report of an event).

Exposition is the type of text in which the information is presented as composite concepts or mental constructs, or those elements into which concepts or mental constructs can be analysed. The text provides an explanation of how the different elements interrelate in a meaningful whole, and often answers questions about "how" (e.g. a scholarly essay, a diagram showing a model of memory, a graph of population trends, a concept map and an entry in an online encyclopaedia).

Argumentation is the type of text that presents the relationship among concepts or propositions. Argument texts often answer "why" questions. An important sub-classification of argument texts is persuasive and opinionative texts, referring to opinions and points of view. Examples of text in the text type category *argumentation* are a letter to the editor, a poster advertisement, the posts in an online forum and a web-based review of a book or film.

Instruction is the type of text that provides directions on what to do. The text presents directions for certain behaviours in order to complete a task (e.g. a recipe, a series of diagrams showing a procedure for giving first aid, and guidelines for operating digital software).

Transaction is the kind of text that aims to achieve a specific purpose outlined in the text, such as requesting that something is done, organising a meeting or making a social engagement with a friend. Before the spread of digital communication, this kind of text was a significant component of some kinds of letters and, as an oral exchange, the principal purpose of many phone calls. This text type was not included in Werlich's (1976) categorisation. It was used for the first time in the PISA 2009 framework because of its prevalence in the digital medium (e.g. everyday e-mail and text message exchanges between colleagues or friends that request and confirm arrangements).

Aspect

Whereas navigation tools and features are the visible or physical features that allow readers to negotiate their way into, around and between texts, *aspects* are the mental strategies, approaches or purposes that readers use to negotiate their way into, around and between texts.

Five aspects guide the development of the reading literacy assessment tasks:

- retrieving information
- forming a broad understanding
- developing an interpretation
- reflecting on and evaluating the content of a text
- reflecting on and evaluating the form of a text.

As it is not possible to include sufficient items in the PISA assessment to report on each of the five aspects as a separate subscale, these five aspects are organised into three broad aspect categories for reporting on reading literacy:

- access and retrieve
- integrate and interpret
- reflect and evaluate.

Retrieving information tasks, which focus the reader on separate pieces of information within the text, are assigned to the *access and retrieve* scale.

Forming a broad understanding and *developing an interpretation* tasks focus the reader on relationships within a text. Tasks that focus on the whole text require readers to form a broad understanding; tasks that focus on relationships between parts of the text require developing an interpretation. The two are grouped together under *integrate and interpret*.

Tasks addressing the last two aspects, *reflecting on and evaluating the content of a text* and *reflecting on and evaluating the form of a text*, are grouped together into a single *reflect and evaluate* aspect category. Both require the reader to draw primarily on knowledge outside the text and relate it to what is being read. *Reflecting on and evaluating content* tasks are concerned with the notional substance of a text; *reflecting on and evaluating form* tasks are concerned with its structure or formal features.

Figure 3.1 ▪ **Relationship between the reading framework and the aspect subscales**

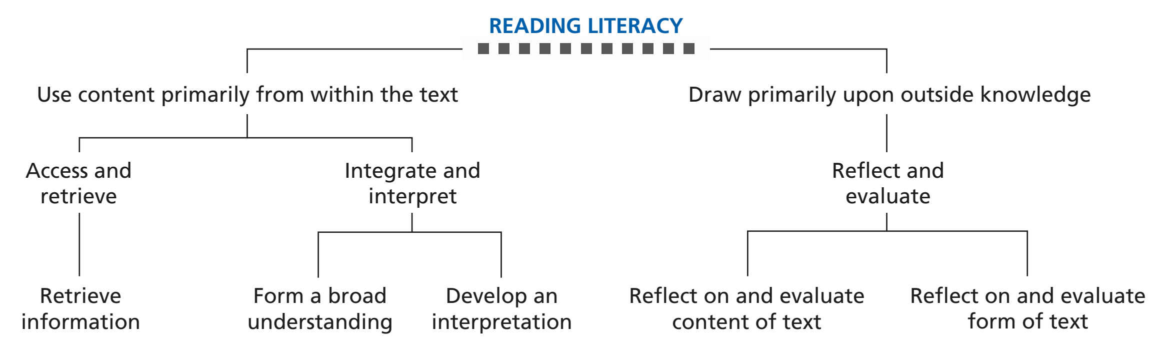

Figure 3.1 shows the relationship between the five aspects targeted in the test development and the three broad reporting aspects.

An elaboration of the three broad aspect categories is given below.

Access and retrieve

Accessing and retrieving involves going to the information space provided and navigating in that space to locate and retrieve one or more distinct pieces of information. Access and retrieve tasks can range from locating the details required by an employer from a job advertisement, to finding a telephone number with several prefix codes, to finding a particular fact to support or disprove a claim someone has made.

While *retrieving* describes the process of selecting the required information, *accessing* describes the process of getting to the place, the information space, where the required information is located. Some items may require retrieving information only, especially in fixed texts where the information is immediately visible and where the reader only has to select what is appropriate in a clearly specified information space. On the other hand, some items in the dynamic space require little more than accessing (for example, clicking to select an item in a list of search results). However, only the former processes are involved in the *access and retrieve* tasks in PISA 2015 as the digital reading assessment is not offered. Such *access and retrieve* items in the fixed-text display space might require readers to use navigation features, such as headings or captions, to find their way to the appropriate section of the text before locating the relevant information. The process of accessing and retrieving information involves skills associated with selecting, collecting and retrieving information.

Integrate and interpret

Integrating and interpreting involves processing what is read to make internal sense of a text.

Integrating focuses on demonstrating an understanding of the coherence of the text. *Integrating* involves connecting various pieces of information to make meaning, whether it be identifying similarities and differences, making comparisons of degree, or understanding cause-and-effect relationships.

Interpreting refers to the process of making meaning from something that is not stated. When interpreting, a reader is identifying the underlying assumptions or implications of part or all of the text.

Both *integrating* and *interpreting* are required to *form a broad understanding*. A reader must consider the text as a whole or in a broad perspective. Students may demonstrate initial understanding by identifying the main topic or message or by identifying the general purpose or use of the text.

Both *integrating* and *interpreting* are also involved in *developing an interpretation*, which requires readers to extend their initial broad impressions so that they develop a deeper, more specific or more complete understanding of what they have read. *Integrating* tasks include identifying and listing supporting evidence, and comparing and contrasting information in which the requirement is to draw together two or more pieces of information from the text. In order to process either explicit or implicit information from one or more sources in such tasks, the reader must often infer an intended relationship or category. *Interpreting* tasks may involve drawing an inference from a local context, for example, interpreting the meaning of a word or phrase that gives a particular nuance to the text. This process of comprehension is also assessed in tasks that require the student to make inferences about the author's intention, and to identify the evidence used to infer that intention.

The relationship between the processes of integration and interpretation may therefore be seen as intimate and interactive. Integrating involves first inferring a relationship within the text (a kind of interpretation), and then bringing pieces of information together, therefore allowing an interpretation to be made that forms a new integrated whole.

Reflect and evaluate

Reflecting and evaluating involves drawing upon knowledge, ideas or attitudes beyond the text in order to relate the information provided within the text to one's own conceptual and experiential frames of reference.

Reflect items may be thought of as those that require readers to consult their own experience or knowledge to compare, contrast or hypothesise. *Evaluate* items are those that ask readers to make a judgement drawing on standards beyond the text.

Reflecting on and evaluating the content of a text requires the reader to connect information in a text to knowledge from outside sources. Readers must also assess the claims made in the text against their own knowledge of the world.

Often readers are asked to articulate and defend their own points of view. To do so, readers must be able to develop an understanding of what is said and intended in a text. They must then test that mental representation against what they know and believe on the basis of either prior information, or information found in other texts. Readers must call on supporting evidence from within the text and contrast it with other sources of information, using both general and specific knowledge as well as the ability to reason abstractly.

Reflecting on and evaluating the form of a text requires readers to stand apart from the text, to consider it objectively and to evaluate its quality and appropriateness. Implicit knowledge of text structure, the style typical of different kinds of texts and register play an important role in these tasks. Evaluating how successful an author is in portraying some characteristic or persuading a reader depends not only on substantive knowledge but also on the ability to detect subtleties in language.

Some examples of assessment tasks characteristic of reflecting on and evaluating the form of a text include determining the usefulness of a particular text for a specified purpose and evaluating an author's use of particular textual features in accomplishing a particular goal. The student may also be called upon to describe or comment on the author's use of style and to identify the author's purpose and attitude. To some extent, every critical judgement requires the reader to consult his or her own experience; some kinds of reflection, on the other hand, do not require evaluation (for example, comparing personal experience with something described in a text). Thus evaluation might be seen as a subset of reflection.

Inter-relation and interdependence of the three aspects

The three broad aspects defined for PISA reading literacy are not conceived of as entirely separate and independent, but rather as interrelated and interdependent. Indeed, from a cognitive-processing perspective, they can be considered semi-hierarchical: it is not possible to interpret or integrate information without having first retrieved it; and it is not possible to reflect on or evaluate information without having made some sort of interpretation. In PISA, however, the framework description of reading aspects distinguishes approaches to reading that are demanded for different contexts and purposes; these are then reflected in assessment tasks that emphasise one or other aspect. Table 3.4 shows the desired distribution of items by aspect.

Table 3.4 Desired distribution of reading items, by aspect

Aspect	Percentage of total items
Access and retrieve	25
Integrate and interpret	50
Reflect and evaluate	25
Total	**100**

ASSESSING READING LITERACY

The previous section outlined the conceptual framework for reading literacy. The concepts in the framework must, in turn, be represented in tasks and questions in order to collect evidence of students' proficiency in reading literacy.

The distribution of tasks across the major framework variables of situation, text and aspect was discussed in the previous section. In this section some of the other major issues in constructing and operationalising the assessment are considered: factors affecting item difficulty, and how difficulty can be manipulated; the choice of response formats; and some issues around coding and scoring. Considerations of moving the fixed-text "print-medium" trend items to computer-based delivery in 2015 are also discussed further in this section.

Factors affecting item difficulty

The difficulty of any reading literacy task depends on an interaction among several variables. Drawing on Kirsch and Mosenthal's work (see, for example, Kirsch, 2001; Kirsch and Mosenthal, 1990), we can manipulate the difficulty of items by applying knowledge of the following aspect and text format variables.

In *access and retrieve* tasks, difficulty depends on the number of pieces of information that the reader needs to locate, the amount of inference required, the amount and prominence of competing information, and the length and complexity of the text.

In *integrate and interpret* tasks, difficulty is affected by the type of interpretation required (for example, making a comparison is easier than finding a contrast); the number of pieces of information to be considered; the degree and prominence of competing information in the text; and by the nature of the text: the less familiar and the more abstract the content, and the longer and more complex the text, the more difficult the task is likely to be.

In *reflect and evaluate* tasks, difficulty is affected by the type of reflection or evaluation required (from least to most difficult, the types of reflection are: connecting; explaining and comparing; hypothesising and evaluating); the nature of the knowledge that the reader needs to bring to the text (a task is more difficult if the reader needs to draw on narrow, specialised knowledge rather than broad and common knowledge); the relative abstraction and length of the text; and by the depth of understanding of the text required to complete the task.

In tasks relating to *continuous texts*, difficulty is influenced by the length of the text, the explicitness and transparency of its structure, how clearly the parts are related to the general theme, and whether there are text features, such as paragraphs or headings, and discourse markers, such as sequencing words.

In tasks relating to *non-continuous texts*, difficulty is influenced by the amount of information in the text; the list structure (simple lists are easier to negotiate than more complex lists); whether the components are ordered and explicitly organised, for example with labels or special formatting; and whether the information required is in the body of the text or in a separate part, such as a footnote.

Response formats

The form in which the evidence is collected – the *response format* – varies according to what is considered appropriate given the kind of evidence that is being collected, and also according to the pragmatic constraints of a large-scale assessment. As in any large-scale assessments the range of feasible item formats is limited, with multiple-choice (simple and complex) and constructed response items (where students write their own answer) being the most manageable formats.

Students in different countries are more or less familiar with various response formats. Including items in a variety of formats is likely to provide some balance between more and less familiar formats for all students, regardless of nationality.

To ensure proper coverage of the ability ranges in different countries, to ensure fairness given the inter-country and gender differences observed, and to ensure a valid assessment of the reflect and evaluate aspect, both multiple choice and open constructed response items continue to be used in PISA reading literacy assessments regardless of the change in delivery mode. Any major change in the distribution of item types in print reading might also impact on the measurement of trends.

Table 3.5 shows target coding requirements for PISA reading tasks. The distribution is shown in relation to the three aspects of reading literacy assessment. Items that require expert judgement consist of open constructed responses. Items that do not require coder judgement consist of simple multiple-choice, complex-multiple choice and closed constructed-response items. The closed constructed response items are those that require the student to generate a response, but require minimal judgement on the part of a coder. For example, a task in which a student is asked to copy a single word from the text, where only one word is acceptable, would be classified as a closed constructed response item. Such items impose a minor cost burden in operational terms and therefore from a pragmatic perspective, these closed constructed response items can be grouped with multiple choice items.

Table 3.5 Approximate distribution of tasks, by coding requirement for PISA 2015

Aspect	% of tasks requiring expert judgement in coding	% of tasks not requiring expert judgement in coding	% of test
Access and retrieve	11	14	25
Integrate and interpret	14	36	50
Reflect and evaluate	18	7	25
Total	**43**	**57**	**100**

Table 3.5 indicates that while there is some distribution of items that require coder judgement and those that do not across the aspects, they are not distributed evenly. The reflection and evaluation aspect tasks are assessed through a larger percentage of constructed response items, which require expert coder judgement.

Given that the delivery of the 2015 assessment is computer-based, it may be possible to use computer coding for some responses not requiring expert judgement without affecting the construct or attributes of the items.

Coding and scoring

Codes are applied to test items, either by a more or less automated process of capturing the alternative chosen by the student for a multiple-choice answer, or by a human judge (expert coder) selecting a code that best captures the kind of response given by a student to an item that requires a constructed response. The code is then converted to a score for the item.

For multiple-choice or closed-response format items, the student has either chosen the designated correct answer or not, so the item is scored as 1 (full credit) or 0 (no credit), respectively. For more complex scoring of constructed response items, some answers, even though incomplete, indicate a higher level of reading literacy than inaccurate or incorrect answers, and thus receive partial credit.

Transition from paper-based to computer-based delivery

The main mode of delivery for the previous PISA assessments was paper. In moving to computer-based delivery in 2015, care must be taken to maintain comparability between the assessments. Some of the factors considered when transposing items from paper to computer mode are discussed below.

- ***Item types***: The computer provides a range of opportunities for designers of test items, including new item formats (e.g. drag-and-drop, hotspots). Since the purpose of the 2015 assessment is to study trends, there is less opportunity to exploit innovative item types. The majority of response formats remains unchanged in 2015, although some drop-down or hotspot items may be used to enable computer coding of items that were previously scored by experts, but only where no expert judgement is required and the item construct is not affected.
- ***Stimulus presentation***: A feature of fixed texts defined in the construct is that "the extent or amount of the text is immediately visible to the reader". Clearly, it is impossible, both on paper and on a screen, to have long texts displayed on a single page or screen. To allow for this and still satisfy the construct of fixed texts, pagination is used for texts rather than scrolling. Texts that cover more than one page are presented in their entirety before the student sees the first question.
- ***IT skills***: Just as paper-based assessments rely on a set of fundamental skills for working with printed materials, so computer-based assessments rely on a set of fundamental skills for using computers. These include knowledge of basic hardware (e.g. keyboard and mouse) and basic conventions (e.g. arrows to move forward and specific buttons to press to execute commands). The intention is to keep such skills to a minimal core level.

There is research evidence that a computer-based testing environment can influence students' performance in reading. Some early studies indicated that reading speed was slower in a computer-based environment (Dillon, 1994) and less accurate (Muter et al., 1982), although these studies were conducted on proofreading tasks, not in an assessment situation.

There is a large body of more recent literature on paper- and computer-based tests' equivalency (see e.g. Macedo-Rouet et al., 2009; Paek, 2005); however these still reveal conflicting findings. A meta-analysis of studies looking at K-12 students' mathematics and reading achievement (Wang et al, 2008) indicated that, overall, administration mode has no statistically significant effect on scores.

A mode-effects study was conducted as part of the OECD Programme for the International Assessment of Adult Competencies (PIAAC) field trial. In this study, adults were randomly assigned to either a computer-based or paper-based assessment of literacy and numeracy skills. The majority of the items used in the paper-delivery mode was adapted for computer delivery and used in this study. Analyses of these data revealed that almost all of the item parameters were stable across the two modes, thus showing that responses could be measured along the same literacy and numeracy scales. This study, along with the results, was written up as part of the *Technical Report of the Survey of Adult Skills* (OECD, 2014). Given this evidence, it was hypothesised that 2009 reading items could be transposed onto a screen without affecting trend data. (The PISA 2015 field trial studied the effect on student performance of the change in mode of delivery. For further details see Box 1.2.)

Reporting proficiency in reading

PISA reports results in terms of proficiency scales that are interpretable for the purposes of policy. In PISA 2015, reading is a minor domain, and fewer reading items are administered to participating students. A single reading literacy scale is reported based upon the overall combined scale for reading.

To capture the progression of complexity and difficulty in PISA 2015, this reading literacy scale is based on the PISA 2009 combined print reading literacy scale and is divided into seven levels. Figure 3.2 describes these seven levels of reading proficiency. Level 6 is the highest described level of proficiency (Level 5 was the highest level before PISA 2009). The bottom level of measured proficiency is Level 1b (for the PISA 2009 and all subsequent PISA reading assessments, Level 1 was re-labelled as Level 1a and a new level was added, Level 1b, that describes students who would previously have been rated as "below Level 1"). These different levels of proficiency allow countries to know more about the kinds of tasks students with very high and very low reading proficiency are capable of performing. Levels 2, 3, 4 and 5 remain the same in PISA 2015 as in PISA 2000.

Figure 3.2 ▪ **Summary description of the seven levels of reading proficiency in PISA 2015**

Level	Lower score limit	Characteristics of tasks
6	698	Tasks at this level typically require the reader to make multiple inferences, comparisons and contrasts that are both detailed and precise. They require demonstration of a full and detailed understanding of one or more texts and may involve integrating information from more than one text. Tasks may require the reader to deal with unfamiliar ideas, in the presence of prominent competing information, and to generate abstract categories for interpretations. *Reflect and evaluate* tasks may require the reader to hypothesise about or critically evaluate a complex text on an unfamiliar topic, taking into account multiple criteria or perspectives, and applying sophisticated understandings from beyond the text. A salient condition for access and retrieve tasks at this level is precision of analysis and fine attention to detail that is inconspicuous in the texts.
5	626	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of deeply embedded information, inferring which information in the text is relevant. Reflective tasks require critical evaluation or hypothesis, drawing on specialised knowledge. Both interpretative and reflective tasks require a full and detailed understanding of a text whose content or form is unfamiliar. For all aspects of reading, tasks at this level typically involve dealing with concepts that are contrary to expectations.
4	553	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of embedded information. Some tasks at this level require interpreting the meaning of nuances of language in a section of text by taking into account the text as a whole. Other interpretative tasks require understanding and applying categories in an unfamiliar context. Reflective tasks at this level require readers to use formal or public knowledge to hypothesise about or critically evaluate a text. Readers must demonstrate an accurate understanding of long or complex texts whose content or form may be unfamiliar.
3	480	Tasks at this level require the reader to locate, and in some cases recognise the relationship between, several pieces of information that must meet multiple conditions. Interpretative tasks at this level require the reader to integrate several parts of a text in order to identify a main idea, understand a relationship or construe the meaning of a word or phrase. They need to take into account many features in comparing, contrasting or categorising. Often the required information is not prominent or there is much competing information; or there are other text obstacles, such as ideas that are contrary to expectation or negatively worded. Reflective tasks at this level may require connections, comparisons and explanations, or they may require the reader to evaluate a feature of the text. Some reflective tasks require readers to demonstrate a fine understanding of the text in relation to familiar, everyday knowledge. Other tasks do not require detailed text comprehension but require the reader to draw on less common knowledge.
2	407	Some tasks at this level require the reader to locate one or more pieces of information, which may need to be inferred and may need to meet several conditions. Others require recognising the main idea in a text, understanding relationships, or construing meaning within a limited part of the text when the information is not prominent and the reader must make low level inferences. Tasks at this level may involve comparisons or contrasts based on a single feature in the text. Typical reflective tasks at this level require readers to make a comparison or several connections between the text and outside knowledge, by drawing on personal experience and attitudes.
1a	335	Tasks at this level require the reader to locate one or more independent pieces of explicitly stated information; to recognise the main theme or author's purpose in a text about a familiar topic, or to make a simple connection between information in the text and common, everyday knowledge. Typically the required information in the text is prominent and there is little, if any, competing information. The reader is explicitly directed to consider relevant factors in the task and in the text.
1b	262	Tasks at this level require the reader to locate a single piece of explicitly stated information in a prominent position in a short, syntactically simple text with a familiar context and text type, such as a narrative or a simple list. The text typically provides support to the reader, such as repetition of information, pictures or familiar symbols. There is minimal competing information. In tasks requiring interpretation the reader may need to make simple connections between adjacent pieces of information.

Note

1. This does not preclude the use of several texts in a single task, but each of the texts should be coherent in itself.

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4

PISA 2015 mathematics framework

This chapter defines "mathematical literacy" as assessed in the Programme for International Student Assessment (PISA) in 2015 and the competencies required for mathematical literacy. It explains the processes, content knowledge and contexts reflected in the assessment's mathematics problems, and how student performance in mathematics is measured and reported.

In PISA 2015, mathematics is assessed as a minor domain, providing an opportunity to make comparisons of student performance over time. This framework continues the description and illustration of the PISA mathematics assessment as set out in the 2012 framework, when mathematics was re-examined and updated for use as the major domain in that cycle.

For PISA 2015, the computer is the primary mode of delivery for all domains, including mathematical literacy. However, paper-based assessment instruments are provided for countries that choose not to test their students by computer. The mathematical literacy component for both the computer-based and paper-based instruments are composed of the same clusters of mathematics trend items. The number of trend items in minor domains are increased, compared with previous PISA assessments, therefore increasing the construct coverage while reducing the number of students responding to each question. This design is intended to reduce potential bias while stabilising and improving the measurement of trends.

In PISA 2012, as the computer-based assessment of mathematics (CBAM) was an optional domain and was not taken by all countries, it is not part of the mathematical literacy trend. Therefore, CBAM items developed for PISA 2012 are not included in the 2015 assessment where mathematical literacy is a minor domain, despite the change in delivery mode.

The framework has been updated to reflect the change in delivery mode, and includes a discussion of the considerations of transposing paper items to a screen and examples of what the results look like. The definition and constructs of mathematical literacy however, remain unchanged and consistent with those used in 2012.

The PISA 2015 mathematics framework is organised into several major sections. The first section, "Defining Mathematical Literacy," explains the theoretical underpinnings of the PISA mathematics assessment, including the formal definition of the mathematical literacy construct. The second section, "Organising the Domain of Mathematics," describes three aspects: a) the mathematical *processes* and the *fundamental mathematical capabilities* (in previous frameworks the "*competencies*") underlying those processes; b) the way mathematical *content* knowledge is organised in the PISA 2015 framework, and the content knowledge that is relevant to an assessment of 15-year-old students; and c) the *contexts* in which students face mathematical challenges. The third section, "Assessing Mathematical Literacy", outlines the approach taken to apply the elements of the framework previously described, including the structure of the survey, the transfer to a computer-based assessment and reporting proficiency. The 2012 framework was written under the guidance of the 2012 Mathematics Expert Group (MEG), a body appointed by the main PISA contractors with the approval of the PISA Governing Board (PGB). The ten MEG members included mathematicians, mathematics educators, and experts in assessment, technology, and education research from a range of countries. In addition, to secure more extensive input and review, a draft of the PISA 2012 mathematics framework was circulated for feedback to over 170 mathematics experts from over 40 countries. Achieve and the Australian Council for Educational Research (ACER), the two organisations contracted by the Organisation for Economic Co-operation and Development (OECD) to manage framework development, also conducted various research efforts to inform and support development work. Framework development and the PISA programme generally have been supported and informed by the ongoing work of participating countries (e.g. the research described in OECD, 2010). This PISA 2015 Framework is an update written under the guidance of the 2015 Mathematics Expert Group (MEG), a body appointed by the Core 1 contractor with the approval of the PISA Governing Board (PGB).

DEFINING MATHEMATICAL LITERACY

An understanding of mathematics is central to a young person's preparedness for life in modern society. A growing proportion of problems and situations encountered in daily life, including in professional contexts, require some level of understanding of mathematics, mathematical reasoning and mathematical tools, before they can be fully understood and addressed. Mathematics is a critical tool for young people as they confront issues and challenges in personal, occupational, societal, and scientific aspects of their lives. It is thus important to have an understanding of the degree to which young people emerging from school are adequately prepared to apply mathematics to understanding important issues and solving meaningful problems. An assessment at age 15 provides an early indication of how individuals may respond in later life to the diverse array of situations they will encounter that involve mathematics.

The construct of mathematical literacy used in this report is intended to describe the capacities of individuals to reason mathematically and use mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. This conception of mathematical literacy supports the importance of students developing a strong understanding of concepts of pure mathematics and the benefits of being engaged in explorations in the abstract world of mathematics. The construct of mathematical literacy, as defined for PISA, strongly emphasises the need to develop students' capacity to use mathematics in context, and it is important that they have rich experiences in their mathematics classrooms to accomplish this. For the purposes of PISA 2012, mathematical literacy was defined as shown in Box 4.1.

Box 4.1 **The 2015 definition of mathematical literacy**

Mathematical literacy is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens.

This definition is also used in the PISA 2012 assessment.

The focus of the language in the definition of mathematical literacy is on active engagement in mathematics, and is intended to encompass reasoning mathematically and using mathematical concepts, procedures, facts and tools in describing, explaining and predicting phenomena. In particular, the verbs "formulate", "employ", and "interpret" point to the three processes in which students as active problem solvers will engage.

The language of the definition is also intended to integrate the notion of mathematical modelling, which has historically been a cornerstone of the PISA framework for mathematics (e.g. OECD, 2004), into the PISA 2015 definition of mathematical literacy. As individuals use mathematics and mathematical tools to solve problems in contexts, their work progresses through a series of stages (individually developed later in the document).

The modelling cycle is a central aspect of the PISA conception of students as active problem solvers; however, it is often not necessary to engage in every stage of the modelling cycle, especially in the context of an assessment (Niss et al., 2007). The problem solver frequently carries out some steps of the modelling cycle but not all of them (e.g. when using graphs), or goes around the cycle several times to modify earlier decisions and assumptions.

The definition also acknowledges that mathematical literacy helps individuals to recognise the role that mathematics plays in the world and in helping them make the kinds of well-founded judgements and decisions required of constructive, engaged and reflective citizens.

Mathematical tools mentioned in the definition refer to a variety of physical and digital equipment, software and calculation devices. The 2015 computer-based survey includes an online calculator as part of the computer-based test material provided for some questions.

ORGANISING THE DOMAIN OF MATHEMATICS

The PISA mathematics framework defines the domain of mathematics for the PISA survey and describes an approach to assessing the mathematical literacy of 15-year-olds. That is, PISA assesses the extent to which 15-year-old students can handle mathematics adeptly when confronted with situations and problems – the majority of which are presented in real-world contexts.

For purposes of the assessment, the PISA 2015 definition of mathematical literacy can be analysed in terms of three interrelated aspects:

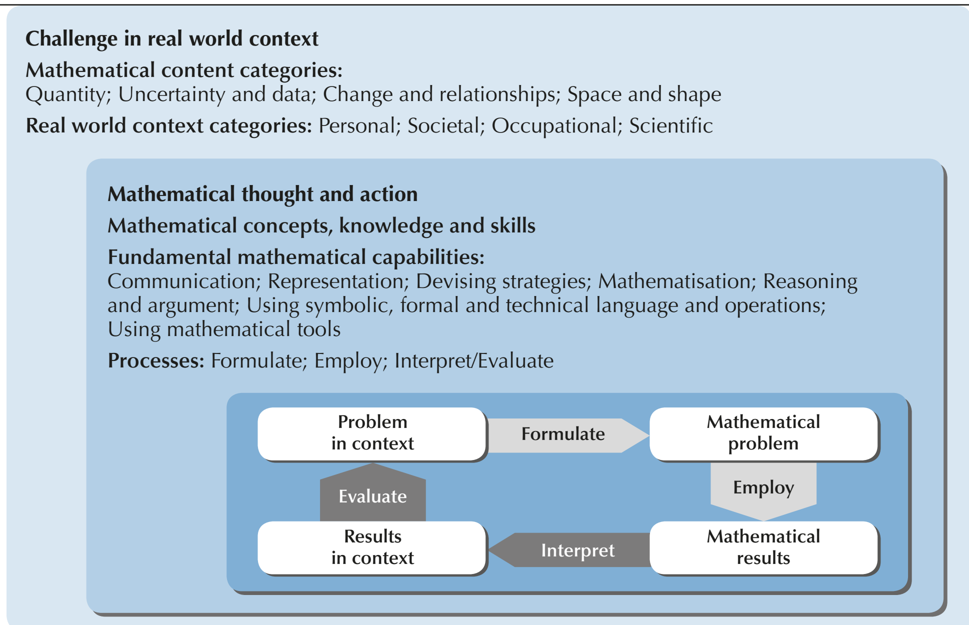
- the mathematical processes that describe what individuals do to connect the context of the problem with mathematics and thus solve the problem, and the capabilities that underlie those processes
- the mathematical content that is targeted for use in the assessment items
- the contexts in which the assessment items are located.

The following sections elaborate these aspects. In highlighting these aspects of the domain, the PISA 2012 mathematics framework, which is also used in PISA 2015, helps to ensure that assessment items developed for the survey reflect a range of processes, content and contexts, so that, considered as a whole, the set of assessment items effectively operationalises what this framework defines as mathematical literacy. To illustrate the aspects of mathematic literacy, examples are available in the PISA 2012 Assessment and Analytical Framework (OECD, 2013) and on the PISA website (www.oecd.org/pisa/).

Several questions, based on the PISA 2015 definition of mathematical literacy, lie behind the organisation of this section of the framework. They are:

- What processes do individuals engage in when solving contextual mathematics problems, and what capabilities do we expect individuals to be able to demonstrate as their mathematical literacy grows?
- What mathematical content knowledge can we expect of individuals – and of 15-year-old students in particular?
- In what contexts can mathematical literacy be observed and assessed?

Figure 4.1 ■ **A model of mathematical literacy in practice**



Mathematical processes and the underlying mathematical capabilities

Mathematical processes

The definition of mathematical literacy refers to an individual's capacity to formulate, employ and interpret mathematics. These three words – formulate, employ and interpret – provide a useful and meaningful structure for organising the mathematical processes that describe what individuals do to connect the context of a problem with the mathematics and thus solve the problem. Items in the 2015 PISA mathematics survey are assigned to one of three mathematical processes:

- formulating situations mathematically
- employing mathematical concepts, facts, procedures and reasoning
- interpreting, applying and evaluating mathematical outcomes.

It is important for both policy makers and those engaged more closely in the day-to-day education of students to know how effectively students are able to engage in each of these processes. The *formulating* process indicates how effectively students are able to recognise and identify opportunities to use mathematics in problem situations and then provide the necessary mathematical structure needed to formulate that contextualised problem into a mathematical form. The *employing* process indicates how well students are able to perform computations and manipulations and apply the concepts and facts that they know to arrive at a mathematical solution to a problem formulated mathematically. The *interpreting* process indicates how effectively students are able to reflect upon mathematical solutions or conclusions, interpret them in the context of a real-world problem, and determine whether the results or conclusions are reasonable. Students' facility in applying mathematics to problems and situations is dependent on skills inherent in all three of these processes, and an understanding of their effectiveness in each category can help inform both policy-level discussions and decisions being made closer to the classroom level.

Formulating situations mathematically

The word *formulate* in the definition of mathematical literacy refers to individuals being able to recognise and identify opportunities to use mathematics and then provide mathematical structure to a problem presented in some contextualised form. In the process of formulating situations mathematically, individuals determine where they can extract the essential mathematics to analyse, set up and solve the problem. They translate from a real-world setting to the domain of mathematics and provide the real-world problem with mathematical structure, representations and specificity. They reason about and make sense of constraints and assumptions in the problem. Specifically, this process of formulating situations mathematically includes activities such as the following:

- identifying the mathematical aspects of a problem situated in a real-world context and identifying the significant variables
- recognising mathematical structure (including regularities, relationships and patterns) in problems or situations
- simplifying a situation or problem in order to make it amenable to mathematical analysis
- identifying constraints and assumptions behind any mathematical modelling and simplifications gleaned from the context
- representing a situation mathematically, using appropriate variables, symbols, diagrams and standard models
- representing a problem in a different way, including organising it according to mathematical concepts and making appropriate assumptions
- understanding and explaining the relationships between the context-specific language of a problem and the symbolic and formal language needed to represent it mathematically
- translating a problem into mathematical language or a representation
- recognising aspects of a problem that correspond with known problems or mathematical concepts, facts or procedures
- using technology (such as a spreadsheet or the list facility on a graphing calculator) to portray a mathematical relationship inherent in a contextualised problem.

Employing mathematical concepts, facts, procedures and reasoning

The word *employ* in the definition of mathematical literacy refers to individuals being able to apply mathematical concepts, facts, procedures and reasoning to solve mathematically formulated problems to obtain mathematical conclusions. In the process of employing mathematical concepts, facts, procedures and reasoning to solve problems, individuals perform the mathematical procedures needed to derive results and find a mathematical solution (e.g. performing arithmetic computations, solving equations, making logical deductions from mathematical assumptions, performing symbolic manipulations, extracting mathematical information from tables and graphs, representing and manipulating shapes in space, and analysing data). They work on a model of the problem situation, establish regularities, identify connections between mathematical entities, and create mathematical arguments. Specifically, this process of employing mathematical concepts, facts, procedures and reasoning includes activities such as:

- devising and implementing strategies for finding mathematical solutions
- using mathematical tools[1], including technology, to help find exact or approximate solutions
- applying mathematical facts, rules, algorithms and structures when finding solutions
- manipulating numbers, graphical and statistical data and information, algebraic expressions and equations, and geometric representations
- making mathematical diagrams, graphs and constructions, and extracting mathematical information from them
- using and switching between different representations in the process of finding solutions
- making generalisations based on the results of applying mathematical procedures to find solutions
- reflecting on mathematical arguments and explaining and justifying mathematical results.

Interpreting, applying and evaluating mathematical outcomes

The word *interpret* used in the definition of mathematical literacy focuses on the abilities of individuals to reflect upon mathematical solutions, results, or conclusions and interpret them in the context of real-life problems. This involves translating mathematical solutions or reasoning back into the context of a problem and determining whether the results are reasonable and make sense in the context of the problem. This mathematical process category encompasses both the “interpret” and “evaluate” arrows noted in the previously defined model of *mathematical literacy* in practice (see Figure 4.1).

Individuals engaged in this process may be called upon to construct and communicate explanations and arguments in the context of the problem, reflecting on both the modelling process and its results. Specifically, this process of interpreting, applying and evaluating mathematical outcomes includes activities such as:

- interpreting a mathematical result back into the real-world context
- evaluating the reasonableness of a mathematical solution in the context of a real-world problem
- understanding how the real world impacts the outcomes and calculations of a mathematical procedure or model in order to make contextual judgements about how the results should be adjusted or applied
- explaining why a mathematical result or conclusion does, or does not, make sense given the context of a problem
- understanding the extent and limits of mathematical concepts and mathematical solutions
- critiquing and identifying the limits of the model used to solve a problem.

Desired distribution of items by mathematical process

The goal in constructing the assessment is to achieve a balance that provides approximately equal weighting between the two processes that involve making a connection between the real world and the mathematical world and the process that calls for students to be able to work on a mathematically formulated problem. Table 4.1 shows the desired distribution of items by process.

Table 4.1 Desired distribution of mathematics items, by process category

Process category	Percentage of items
Formulating situations mathematically	25
Employing mathematical concepts, facts, procedures and reasoning	50
Interpreting, applying and evaluating mathematical outcomes	25
Total	**100**

Fundamental mathematical capabilities underlying the mathematical processes

A decade of experience in developing PISA items and analysing the ways in which students respond to items has revealed that there is a set of fundamental mathematical capabilities that underpins each of these reported processes and mathematical literacy in practice. The work of Mogens Niss and his Danish colleagues (Niss, 2003; Niss and Jensen, 2002; Niss and Højgaard, 2011) identified eight capabilities – referred to as "competencies" by Niss and in the PISA 2003 framework (OECD, 2004) – that are instrumental to mathematical behaviour.

The PISA 2015 framework uses a modified formulation of this set of capabilities, which condenses the number from eight to seven based on an investigation of the operation of the competencies through previously administered PISA items (Turner et al., 2013). These cognitive capabilities are available to or learnable by individuals in order to understand and engage with the world in a mathematical way, or to solve problems. As the level of mathematical literacy possessed by an individual increases, that individual is able to draw to an increasing degree on the fundamental mathematical capabilities (Turner and Adams, 2012). Thus, increasing activation of fundamental mathematical capabilities is associated with increasing item difficulty. This observation has been used as the basis of the descriptions of different proficiency levels of mathematical literacy reported in previous PISA surveys and discussed later in this framework.

The seven fundamental mathematical capabilities used in this framework are as follows:

- ***Communication:*** Mathematical literacy involves communication. The individual perceives the existence of some challenge and is stimulated to recognise and understand a problem situation. Reading, decoding and interpreting statements, questions, tasks or objects enables the individual to form a mental model of the situation, which is an important step in understanding, clarifying and formulating a problem. During the solution process, intermediate results may need to be summarised and presented. Later on, once a solution has been found, the problem solver may need to present the solution, and perhaps an explanation or justification, to others.
- ***Mathematising:*** Mathematical literacy can involve transforming a problem defined in the real world to a strictly mathematical form (which can include structuring, conceptualising, making assumptions, and/or formulating a model), or interpreting or evaluating a mathematical outcome or a mathematical model in relation to the original problem. The term mathematising is used to describe the fundamental mathematical activities involved.

- ***Representation:*** Mathematical literacy frequently involves representations of mathematical objects and situations. This can entail selecting, interpreting, translating between, and using a variety of representations to capture a situation, interact with a problem, or to present one's work. The representations referred to include graphs, tables, diagrams, pictures, equations, formulae and concrete materials.
- ***Reasoning and argument:*** This capability involves logically rooted thought processes that explore and link problem elements so as to make inferences from them, check a justification that is given, or provide a justification of statements or solutions to problems.
- ***Devising strategies for solving problems:*** Mathematical literacy frequently requires devising strategies for solving problems mathematically. This involves a set of critical control processes that guide an individual to effectively recognise, formulate and solve problems. This skill is characterised as selecting or devising a plan or strategy to use mathematics to solve problems arising from a task or context, as well as guiding its implementation. This mathematical capability can be demanded at any of the stages of the problem-solving process.
- ***Using symbolic, formal and technical language and operations:*** Mathematical literacy requires using symbolic, formal and technical language and operations. This involves understanding, interpreting, manipulating, and making use of symbolic expressions within a mathematical context (including arithmetic expressions and operations) governed by mathematical conventions and rules. It also involves understanding and utilising formal constructs based on definitions, rules and formal systems and also using algorithms with these entities. The symbols, rules and systems used vary according to what particular mathematical content knowledge is needed for a specific task to formulate, solve or interpret the mathematics.
- ***Using mathematical tools[1]:*** Mathematical tools include physical tools, such as measuring instruments, as well as calculators and computer-based tools that are becoming more widely available. In addition to knowing how to use these tools to assist them in completing mathematical tasks, students need to know about the limitations of such tools. Mathematical tools can also have an important role in communicating results.

Figure 4.2 ▪ **Relationship between mathematical processes (top row) and fundamental mathematical capabilities (left-most column)**

	Formulating **situations mathematically**	***Employing*** **mathematical concepts, facts, procedures and reasoning**	***Interpreting*****, applying and evaluating mathematical outcomes**
Communicating	Read, decode, and make sense of statements, questions, tasks, objects or images, in order to form a mental model of the situation	Articulate a solution, show the work involved in reaching a solution and/or summarise and present intermediate mathematical results	Construct and communicate explanations and arguments in the context of the problem
Mathematising	Identify the underlying mathematical variables and structures in the real world problem, and make assumptions so that they can be used	Use an understanding of the context to guide or expedite the mathematical solving process, e.g. working to a context- appropriate level of accuracy	Understand the extent and limits of a mathematical solution that are a consequence of the mathematical model employed
Representation	Create a mathematical representation of real-world information	Make sense of, relate and use a variety of representations when interacting with a problem	Interpret mathematical outcomes in a variety of formats in relation to a situation or use; compare or evaluate two or more representations in relation to a situation
Reasoning and argument	Explain, defend or provide a justification for the identified or devised representation of a real-world situation	Explain, defend or provide a justification for the processes and procedures used to determine a mathematical result or solution Connect pieces of information to arrive at a mathematical solution, make generalisations or create a multi-step argument	Reflect on mathematical solutions and create explanations and arguments that support, refute or qualify a mathematical solution to a contextualised problem
Devising strategies for solving problems	Select or devise a plan or strategy to mathematically reframe contextualised problems	Activate effective and sustained control mechanisms across a multi-step procedure leading to a mathematical solution, conclusion or generalisation	Devise and implement a strategy in order to interpret, evaluate and validate a mathematical solution to a contextualised problem

...

Figure 4.2 [continued] ■ **Relationship between mathematical processes (top row) and fundamental mathematical capabilities (left-most column)**

	Formulating situations mathematically	*Employing* mathematical concepts, facts, procedures and reasoning	*Interpreting*, applying and evaluating mathematical outcomes
Using symbolic, formal and technical language and operations	Use appropriate variables, symbols, diagrams and standard models in order to represent a real-world problem using symbolic/formal language	Understand and utilise formal constructs based on definitions, rules and formal systems as well as employing algorithms	Understand the relationship between the context of the problem and representation of the mathematical solution. Use this understanding to help interpret the solution in context and gauge the feasibility and possible limitations of the solution
Using mathematical tools	Use mathematical tools in order to recognise mathematical structures or to portray mathematical relationships	Know about and be able to make appropriate use of various tools that may assist in implementing processes and procedures for determining mathematical solutions	Use mathematical tools to ascertain the reasonableness of a mathematical solution and any limits and constraints on that solution, given the context of the problem

These capabilities are evident to varying degrees in each of the three mathematical processes. The ways in which these capabilities manifest themselves within the three processes are described in Figure 4.1.

A good guide to the empirical difficulty of items can be obtained by considering which aspects of the fundamental mathematical capabilities are required for planning and executing a solution (Turner, 2012, Turner and Adams, 2012; Turner et al., 2013). The easiest items will require the activation of few capabilities and in a relatively straightforward way. The hardest items require complex activation of several capabilities. Predicting difficulty requires consideration of both the number of capabilities and the complexity of activation required.

Mathematical content knowledge

An understanding of mathematical content – and the ability to apply that knowledge to the solution of meaningful contextualised problems – is important for citizens in the modern world. That is, to solve problems and interpret situations in personal, occupational, societal and scientific contexts, there is a need to draw upon certain mathematical knowledge and understandings.

Mathematical structures have been developed over time as a means to understand and interpret natural and social phenomena. In schools, the mathematics curriculum is typically organised around content strands (e.g. number, algebra and geometry) and detailed topic lists that reflect historically well-established branches of mathematics and that help in defining a structured curriculum. However, outside the mathematics classroom, a challenge or situation that arises is usually not accompanied by a set of rules and prescriptions that shows how the challenge can be met. Rather, it typically requires some creative thought in seeing the possibilities of bringing mathematics to bear on the situation and in formulating it mathematically. Often a situation can be addressed in different ways drawing on different mathematical concepts, procedures, facts or tools.

Since the goal of PISA is to assess mathematical literacy, an organisational structure for mathematical content knowledge is proposed based on the mathematical phenomena that underlie broad classes of problems and which have motivated the development of specific mathematical concepts and procedures. Because national mathematics curricula are typically designed to equip students with knowledge and skills that address these same underlying mathematical phenomena, the outcome is that the range of content arising from organising content this way is closely aligned with that typically found in national mathematics curricula. This framework lists some content topics appropriate for assessing the mathematical literacy of 15-year-old students, based on analyses of national standards from eleven countries.

To organise the domain of mathematics for purposes of assessing mathematical literacy, it is important to select a structure that grows out of historical developments in mathematics, that encompasses sufficient variety and depth to reveal the essentials of mathematics, and that also represents, or includes, the conventional mathematical strands in an acceptable way. Thus, a set of content categories that reflects the range of underlying mathematical phenomena was selected for the PISA 2015 framework, consistent with the categories used for previous PISA surveys.

The following list of content categories, therefore, is used in PISA 2015 to meet the requirements of historical development, coverage of the domain of mathematics and the underlying phenomena which motivate its development, and reflection of the major strands of school curricula. These four categories characterise the range of mathematical content that is central to the discipline and illustrate the broad areas of content used in the test items for PISA 2015:

- *change and relationships*
- *space and shape*
- *quantity*
- *uncertainty and dat*a.

With these four categories, the mathematical domain can be organised in a way that ensures a spread of items across the domain and focuses on important mathematical phenomena, but at the same time, avoids a too fine division that would work against a focus on rich and challenging mathematical problems based on real situations. While categorisation by content category is important for item development and selection, and for reporting of assessment results, it is important to note that some specific content topics may materialise in more than one content category. Connections between aspects of content that span these four content categories contribute to the coherence of mathematics as a discipline and are apparent in some of the assessment items selected for the PISA 2015 assessment.

The broad mathematical content categories and the more specific content topics appropriate for 15-year-old students described later in this section reflect the level and breadth of content that is eligible for inclusion on the PISA 2015 survey. Narrative descriptions of each content category and the relevance of each to solving meaningful problems are provided first, followed by more specific definitions of the kinds of content that are appropriate for inclusion in an assessment of mathematical literacy of 15-year-old students. These specific topics reflect commonalities found in the expectations set by a range of countries and education jurisdictions. The standards examined to identify these content topics are viewed as evidence not only of what is taught in mathematics classrooms in these countries but also as indicators of what countries view as important knowledge and skills for preparing students of this age to become constructive, engaged and reflective citizens.

Descriptions of the mathematical content knowledge that characterise each of the four categories – *change and relationships, space and shape, quantity, and uncertainty and data* – are provided below.

Change and relationships

The natural and designed worlds display a multitude of temporary and permanent relationships among objects and circumstances, where changes occur within systems of inter-related objects or in circumstances where the elements influence one another. In many cases these changes occur over time, and in other cases changes in one object or quantity are related to changes in another. Some of these situations involve discrete change; others change continuously. Some relationships are of a permanent, or invariant, nature. Being more literate about change and relationships involves understanding fundamental types of change and recognising when they occur in order to use suitable mathematical models to describe and predict change. Mathematically this means modelling the change and the relationships with appropriate functions and equations, as well as creating, interpreting, and translating among symbolic and graphical representations of relationships.

Change and relationships is evident in such diverse settings as growth of organisms, music, and the cycle of seasons, weather patterns, employment levels and economic conditions. Aspects of the traditional mathematical content of functions and algebra, including algebraic expressions, equations and inequalities, tabular and graphical representations, are central in describing, modelling and interpreting change phenomena. Representations of data and relationships described using statistics also are often used to portray and interpret change and relationships, and a firm grounding in the basics of number and units is also essential to defining and interpreting *change and relationships*. Some interesting relationships arise from geometric measurement, such as the way that changes in perimeter of a family of shapes might relate to changes in area, or the relationships among lengths of the sides of triangles.

Space and shape

Space and shape encompasses a wide range of phenomena that are encountered everywhere in our visual and physical world: patterns, properties of objects, positions and orientations, representations of objects, decoding and encoding of visual information, navigation and dynamic interaction with real shapes as well as with representations. Geometry serves as an essential foundation for *space and shape*, but the category extends beyond traditional geometry in content, meaning and method, drawing on elements of other mathematical areas such as spatial visualisation, measurement and algebra.

For instance, shapes can change, and a point can move along a locus, thus requiring function concepts. Measurement formulas are central in this area. The manipulation and interpretation of shapes in settings that call for tools ranging from dynamic geometry software to Global Positioning System (GPS) software are included in this content category.

PISA assumes that the understanding of a set of core concepts and skills is important to mathematical literacy relative to *space and shape*. Mathematical literacy in the area of *space and shape* involves a range of activities such as understanding perspective (for example in paintings), creating and reading maps, transforming shapes with and without technology, interpreting views of three-dimensional scenes from various perspectives and constructing representations of shapes.

Quantity

The notion of *Quantity* may be the most pervasive and essential mathematical aspect of engaging with, and functioning in, our world. It incorporates the quantification of attributes of objects, relationships, situations and entities in the world, understanding various representations of those quantifications, and judging interpretations and arguments based on quantity. To engage with the quantification of the world involves understanding measurements, counts, magnitudes, units, indicators, relative size, and numerical trends and patterns. Aspects of quantitative reasoning – such as number sense, multiple representations of numbers, elegance in computation, mental calculation, estimation and assessment of reasonableness of results – are the essence of mathematical literacy relative to *quantity*.

Quantification is a primary method for describing and measuring a vast set of attributes of aspects of the world. It allows for the modelling of situations, for the examination of change and relationships, for the description and manipulation of space and shape, for organising and interpreting data, and for the measurement and assessment of uncertainty. Thus mathematical literacy in the area of *quantity* applies knowledge of number and number operations in a wide variety of settings.

Uncertainty and data

In science, technology and everyday life, uncertainty is a given. Uncertainty is therefore a phenomenon at the heart of the mathematical analysis of many problem situations, and the theory of probability and statistics as well as techniques of data representation and description have been established to deal with it. The *uncertainty and data* content category includes recognising the place of variation in processes, having a sense of the quantification of that variation, acknowledging uncertainty and error in measurement, and knowing about chance. It also includes forming, interpreting and evaluating conclusions drawn in situations where uncertainty is central. The presentation and interpretation of data are key concepts in this category (Moore, 1997).

There is uncertainty in scientific predictions, poll results, weather forecasts and economic models. There is variation in manufacturing processes, test scores and survey findings, and chance is fundamental to many recreational activities enjoyed by individuals. The traditional curricular areas of probability and statistics provide formal means of describing, modelling and interpreting a certain class of uncertainty phenomena, and for making inferences. In addition, knowledge of number and of aspects of algebra, such as graphs and symbolic representation, contribute to facility in engaging in problems in this content category. The focus on the interpretation and presentation of data is an important aspect of the *uncertainty and data category*.

Desired distribution of items by content category

The trend items selected for PISA 2015 are distributed across the four content categories, as shown in Table 4.2. The goal in constructing the survey is a balanced distribution of items with respect to content category, since all of these domains are important for constructive, engaged and reflective citizens.

Table 4.2 Desired distribution of mathematics items, by content category

Content category	Percentage of items
Change and relationships	25
Space and shape	25
Quantity	25
Uncertainty and data	25
Total	**100**

Content topics for guiding the assessment of mathematical literacy

To effectively understand and solve contextualised problems involving *change and relationships, space and shape, quantity* and *uncertainty and data* requires drawing upon a variety of mathematical concepts, procedures, facts, and tools at an appropriate level of depth and sophistication. As an assessment of mathematical literacy, PISA strives to assess the levels and types of mathematics that are appropriate for 15-year-old students on a trajectory to become constructive, engaged and reflective citizens able to make well-founded judgements and decisions. It is also the case that PISA, while not designed or intended to be a curriculum-driven assessment, strives to reflect the mathematics that students have likely had the opportunity to learn by the time they are 15 years old.

The content included in PISA 2015 is the same as that developed in PISA 2012. The four content categories of *change and relationships, space and shape, quantity* and *uncertainty and data* serve as the foundation for identifying this range of content, yet there is not a one-to-one mapping of content topics to these categories. The following content is intended to reflect the centrality of many of these concepts to all four content categories and reinforce the coherence of mathematics as a discipline. It intends to be illustrative of the content topics included in PISA 2015, rather than an exhaustive listing:

- ***Functions:*** the concept of function, emphasising but not limited to linear functions, their properties, and a variety of descriptions and representations of them. Commonly used representations are verbal, symbolic, tabular and graphical.
- ***Algebraic expressions:*** verbal interpretation of and manipulation with algebraic expressions, involving numbers, symbols, arithmetic operations, powers and simple roots.
- ***Equations and inequalities:*** linear and related equations and inequalities, simple second-degree equations, and analytic and non-analytic solution methods.
- ***Co-ordinate systems:*** representation and description of data, position and relationships.
- ***Relationships within and among geometrical objects in two and three dimensions:*** static relationships such as algebraic connections among elements of figures (e.g. the Pythagorean theorem as defining the relationship between the lengths of the sides of a right triangle), relative position, similarity and congruence, and dynamic relationships involving transformation and motion of objects, as well as correspondences between two- and three-dimensional objects.
- ***Measurement:*** quantification of features of and among shapes and objects, such as angle measures, distance, length, perimeter, circumference, area and volume.
- ***Numbers and units:*** concepts, representations of numbers and number systems, including properties of integer and rational numbers, relevant aspects of irrational numbers, as well as quantities and units referring to phenomena such as time, money, weight, temperature, distance, area and volume, and derived quantities and their numerical description.
- ***Arithmetic operations:*** the nature and properties of these operations and related notational conventions.
- ***Percents, ratios and proportions:*** numerical description of relative magnitude and the application of proportions and proportional reasoning to solve problems.
- ***Counting principles:*** simple combinations and permutations.
- ***Estimation:*** purpose-driven approximation of quantities and numerical expressions, including significant digits and rounding.
- ***Data collection, representation and interpretation:*** nature, genesis and collection of various types of data, and the different ways to represent and interpret them.
- ***Data variability and its description:*** concepts such as variability, distribution and central tendency of data sets, and ways to describe and interpret these in quantitative terms.
- ***Samples and sampling:*** concepts of sampling and sampling from data populations, including simple inferences based on properties of samples.
- ***Chance and probability:*** notion of random events, random variation and its representation, chance and frequency of events, and basic aspects of the concept of probability.

Contexts

The choice of appropriate mathematical strategies and representations is often dependent on the context in which a mathematics problem arises. Context is widely regarded as an aspect of problem solving that imposes additional demands on the problem solver (see Watson and Callingham, 2003, for findings about statistics). For the PISA survey, it is important that a wide variety of contexts is used. This offers the possibility of connecting with the broadest possible range of individual interests and with the range of situations in which individuals operate in the 21st century.

For purposes of the PISA 2015 mathematics framework, four context categories have been defined and are used to classify assessment items developed for the PISA survey:

- ***Personal*** – Problems classified in the personal context category focus on activities of one's self, one's family or one's peer group. The kinds of contexts that may be considered personal include (but are not limited to) those involving food preparation, shopping, games, personal health, personal transportation, sports, travel, personal scheduling and personal finance.
- ***Occupational*** – Problems classified in the occupational context category are centred on the world of work. Items categorised as occupational may involve (but are not limited to) such things as measuring, costing and ordering materials for building, payroll/accounting, quality control, scheduling/inventory, design/architecture and job-related decision making. Occupational contexts may relate to any level of the workforce, from unskilled work to the highest levels of professional work, although items in the PISA survey must be accessible to 15-year-old students.
- ***Societal*** – Problems classified in the societal context category focus on one's community (whether local, national or global). They may involve (but are not limited to) such things as voting systems, public transport, government, public policies, demographics, advertising, national statistics and economics. Although individuals are involved in all of these things in a personal way, in the societal context category the focus of problems is on the community perspective.
- ***Scientific*** – Problems classified in the scientific category relate to the application of mathematics to the natural world and issues and topics related to science and technology. Particular contexts might include (but are not limited to) such areas as weather or climate, ecology, medicine, space science, genetics, measurement and the world of mathematics itself. Items that are intramathematical, where all the elements involved belong in the world of mathematics, fall within the scientific context.

PISA assessment items are arranged in units that share stimulus material. It is therefore usually the case that all items in the same unit belong to the same context category. Exceptions do arise; for example stimulus material may be examined from a personal point of view in one item and a societal point of view in another. When an item involves only mathematical constructs without reference to the contextual elements of the unit within which it is located, it is allocated to the context category of the unit. In the unusual case of a unit involving only mathematical constructs and being without reference to any context outside of mathematics, the unit is assigned to the scientific context category.

Using these context categories provides the basis for selecting a mix of item contexts and ensures that the assessment reflects a broad range of uses of mathematics, ranging from everyday personal uses to the scientific demands of global problems. Moreover, it is important that each context category be populated with assessment items having a broad range of item difficulties. Given that the major purpose of these context categories is to challenge students in a broad range of problem contexts, each category should contribute substantially to the measurement of mathematical literacy. It should not be the case that the difficulty level of assessment items representing one context category is systematically higher or lower than the difficulty level of assessment items in another category.

In identifying contexts that may be relevant, it is critical to keep in mind that a purpose of the assessment is to gauge the use of mathematical content knowledge, processes and capabilities that students have acquired by the age of 15. Contexts for assessment items, therefore, are selected in light of relevance to students' interests and lives, and the demands that will be placed upon them as they enter society as constructive, engaged and reflective citizens. National project managers from countries participating in the PISA survey are involved in judging the degree of such relevance.

Desired distribution of items by context category

The trend items selected for the PISA 2015 mathematics survey represent a spread across these context categories, as described in Table 4.3. With this balanced distribution, no single context type is allowed to dominate, providing students with items that span a broad range of individual interests and a range of situations that they might expect to encounter in their lives.

Table 4.3 Desired distribution of mathematics items, by context

Content category	Percentage of items
Personal	25
Occupational	25
Societal	25
Scientific	25
Total	**100**

ASSESSING MATHEMATICAL LITERACY

This section outlines the approach taken to apply the elements of the framework described in previous sections to PISA 2015. This includes the structure of the mathematics component of the PISA survey, arrangements for transferring the paper-based trend items to a computer-based delivery, and reporting mathematical proficiency.

Structure of the survey instrument

In 2012, when mathematical literacy was the major domain, the paper-based instrument contained a total of 270 minutes of mathematics material. The material was arranged in nine clusters of items, with each cluster representing 30 minutes of testing time. The item clusters were placed in test booklets according to a rotated design, they also contained linked materials.

Mathematical literacy is a minor domain in 2015 and students are asked to complete fewer clusters. However the item clusters are similarly constructed and rotated. Six mathematics clusters from previous cycles, including one "easy" and one "hard", are used in one of three designs, depending on whether countries take the Collaborative Problem Solving option or not, or whether they take the test on paper. Using six clusters rather than three as was customary for the minor domains in previous cycles results in a larger number of trend items, therefore the construct coverage is increased. However, the number of students responding to each question is lower. This design is intended to reduce potential bias, thus stabilising and improving the measurement of trends. The field trial was used to perform a mode-effect study and to establish equivalence between the computer- and paper-based forms.

Response formats

Three types of response format are used to assess mathematical literacy in PISA 2015: open constructed-response, closed constructed-response and selected-response (simple and complex multiple-choice) items. Open constructed-response items require a somewhat extended written response from a student. Such items also may ask the student to show the steps taken or to explain how the answer was reached. These items require trained experts to manually code student responses.

Closed constructed-response items provide a more structured setting for presenting problem solutions, and they produce a student response that can be easily judged to be either correct or incorrect. Often student responses to questions of this type can be keyed into data-capture software, and coded automatically, but some must be manually coded by trained experts. The most frequent closed constructed-responses are single numbers.

Selected- response items require students to choose one or more responses from a number of response options. Responses to these questions can usually be automatically processed. About equal numbers of each of these response formats is used to construct the survey instruments.

Item scoring

Although most of the items are dichotomously scored (that is, responses are awarded either credit or no credit), the open constructed-response items can sometimes involve partial credit scoring, which allows responses to be assigned credit according to differing degrees of "correctness" of responses. For each such item, a detailed coding guide that allows for full credit, partial credit or no credit is provided to persons trained in the coding of student responses across the range of participating countries to ensure coding of responses is done in a consistent and reliable way. To maximise the comparability between the paper-based and computer-based assessments, careful attention is given to the scoring guides in order to ensure that the important elements are included.

Computer-based assessment of mathematics

The main mode of delivery for the PISA 2012 assessment was paper-based. In moving to computer-based delivery for 2015, care is taken to maximise comparability between the two assessments. The following section describes some of the features intrinsic to a computer-based assessment. Although these features provide the opportunities outlined below, to ensure comparability the PISA 2015 survey consists solely of items from the 2012 paper-based assessment. The features described here, however, will be used in future PISA assessments when their introduction can be controlled to ensure comparability with prior assessments.

Increasingly, mathematics tasks at work involve some kind of electronic technology, so that mathematical literacy and computer use are melded together (Hoyles et al., 2002). For employees at all levels of the workplace, there is now an interdependency between mathematical literacy and the use of computer technology. Solving PISA items on a computer rather than on paper moves PISA into the reality and the demands of the 21st century.

There is a great deal of research evidence into paper- and computer-based test performance, but findings are mixed. Some research suggests that a computer-based testing environment can influence students' performance. Richardson et al. (2002) reported that students found computer-based problem-solving tasks engaging and motivating, often despite the unfamiliarity of the problem types and the challenging nature of the items. They were sometimes distracted by attractive graphics, and sometime used poor heuristics when attempting tasks.

In one of the largest comparisons of paper-based and computer-based testing, Sandene et al. (2008) found that eighth-grade students' mean score was four points higher on a computer-based mathematics test than on an equivalent paper-based test. Bennett et al. (2008) concluded from his research that computer familiarity affects performance on computer-based mathematics tests, while others have found that the range of functions available through computer-based tests can affect performance. For example, Mason (2001) found that students' performance was negatively affected in computer-based tests compared to paper-based tests when there was no opportunity on the computer version to review and check responses. Bennett (2003) found that screen size affected scores on verbal-reasoning tests, possibly because smaller computer screens require scrolling.

By contrast, Wang et al (2008) conducted a meta-analysis of studies pertaining to K-12 students' mathematics achievements which indicated that administration mode has no statistically significant effect on scores. Moreover, recent mode studies that were part of the Programme for the International Assessment of Adult Competencies (PIAAC) suggested that equality can be achieved (OECD, 2014). In this study, adults were randomly assigned to either a computer-based or paper-based assessment of literacy and numeracy skills. The majority of the items used in the paper delivery mode were adapted for computer delivery and used in this study. Analyses of these data revealed that almost all of the item parameters were stable across the two modes, thus demonstrating the ability to place respondents on the same literacy and numeracy scale. Given this, it is hypothesised that mathematics items used in PISA 2012 can be transposed onto a screen without affecting trend data. (The PISA 2015 field trial studied the effect on student performance of the change in mode of delivery. For further details see Box 1.2.)

Just as paper-based assessments rely on a set of fundamental skills for working with printed materials, computer-based assessments rely on a set of fundamental information and communications technology (ICT) skills for using computers. These include knowledge of basic hardware (e.g. keyboard and mouse) and basic conventions (e.g. arrows to move forward and specific buttons to press to execute commands). The intention is to keep such skills to a minimal, core level in the computer-based assessment.

Reporting proficiency in mathematics

The outcomes of the PISA mathematics survey are reported in a number of ways. Estimates of overall mathematical proficiency are obtained for sampled students in each participating country, and a number of proficiency levels are defined. Descriptions of the degree of mathematical literacy typical of students in each level are also developed. For PISA 2003, scales based on the four broad content categories were developed. In Figure 4.3, descriptions of the six proficiency levels reported for the overall PISA mathematics scale in 2012 are presented. These form the basis of the PISA 2015 mathematics scale. The finalised 2012 scale is used to report the PISA 2015 outcomes. As *mathematical literacy* is a minor domain in 2015, only the overall proficiency scale is reported.

Fundamental mathematical capabilities play a central role in defining what it means to be at different levels of the scales for mathematical literacy overall and for each of the reported processes. For example, in the proficiency scale description for Level 4 (see Figure 4.3), the second sentence highlights aspects of mathematising and representation that are evident at this level. The final sentence highlights the characteristic communication, reasoning and argument of Level 4, providing a contrast with the short communications and lack of argument of Level 3 and the additional reflection of Level 5. In an earlier section of this framework and in Figure 4.2, each of the mathematical processes was described in terms of the fundamental mathematical capabilities that individuals might activate when engaging in that process.

Figure 4.3 ▪ **Summary description of the six levels of mathematics proficiency in PISA 2015**

Level	What students can typically do
6	At Level 6, students can conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation.
5	At Level 5, students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterisations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning.
4	At Level 4, students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Students at this level can utilise their limited range of skills and can reason with some insight, in straightforward contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
3	At Level 3, students can execute clearly described procedures, including those that require sequential decisions. Their interpretations are sufficiently sound to be a base for building a simple model or for selecting and applying simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They typically show some ability to handle percentages, fractions and decimal numbers, and to work with proportional relationships. Their solutions reflect that they have engaged in basic interpretation and reasoning.
2	At Level 2, students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results.
1	At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli.

Note

1. In some countries, “mathematical tools” can also refer to established mathematical procedures, such as algorithms. For the purposes of the PISA framework, “mathematical tools” refers only to the physical and digital tools described in this section.

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PISA 2015 financial literacy framework

This chapter describes the rationale behind measuring 15-year-olds' financial literacy in the Programme for International Student Assessment (PISA) and defines the term. It explains the content, processes and contexts that are reflected in the financial literacy problems used in the assessment, and describes how student proficiency in financial literacy is measured and reported.

PISA 2012 was the first large-scale international study to assess the financial literacy of young people. The assessment found wide variations in levels of financial literacy within and across countries. The PISA 2015 assessment provides information about trends and data from countries that have not previously participated in this optional assessment.

This framework is based on that developed for the 2012 assessment. It discusses how the items and the language used to measure and describe financial literacy were designed and developed. It also contains a definition of financial literacy and organises the domain around the content, processes and contexts that are relevant to 15-year-old students. Content areas include *money and transactions, planning and managing finances, risk and reward* and *the financial landscape*. The framework covers some of the processes through which students exhibit their financial literary, such as *identify financial information, analyse information in a financial context, evaluate financial issues,* and *apply financial knowledge and understanding*. Items are set in the *education and work*, *home and family*, *individual* and *societal* contexts. In addition, the framework discusses the relationship between financial literacy and non-cognitive skills and between both mathematics and reading literacy. It also discusses how students' financial behaviour and experience are measured.

POLICY INTEREST IN FINANCIAL LITERACY

In recent years, developed and emerging countries and economies have become increasingly concerned about the level of financial literacy among their citizens. This has stemmed, in particular, from shrinking public and private support systems, shifting demographic profiles, including the ageing of the population, and wide-ranging developments in the financial marketplace. A lack of financial literacy contributes to ill-informed financial decisions, and these decisions could, in turn, have tremendous adverse effects on both personal and, ultimately, global finance (OECD/INFE, 2009; OECD, 2009a; see also Gerardi et al., 2010, for empirical analysis of financial literacy and mortgage delinquency). As a result, financial literacy is now acknowledged as an important element of economic and financial stability and development. This is reflected in the G20 endorsement of the OECD/INFE (International Network on Financial Education) High-level Principles on National Strategies for Financial Education (G20, 2012; OECD/INFE, 2012), the OECD/INFE policy handbook on national strategies for financial education and core competencies on financial literacy for youth, and its statement supporting the widespread use of instruments to measure financial literacy, including the PISA financial literacy assessment (G20, 2013; OECD INFE, 2015b; OECD INFE, 2015c).

Demographic and cultural shifts

In most countries, longevity is increasing, and in many the birth rate is falling. At the same time, women's participation in the labour force and the proportion of people entering higher education are both increasing, and grown-up children are less likely to continue to live in close proximity to older family members than in previous generations. The likely outcome of these shifts will be a greater need for financial security in retirement and professional care in old age, resulting in additional government expenditure (Colombo et al., 2011). Working-age adults may be expected to shoulder the tax burden to finance this expenditure while at the same time also saving for their own retirement, potentially repaying their own student loans, and managing increasingly varied working-life trajectories, which may include periods of inactivity, self-employment and/or retraining.

Risk shift and increased individual responsibility

There has been a widespread transfer of risk from both governments and employers to individuals, meaning that now many people face the financial risks associated with longevity, investment, credit, out-of-pocket healthcare and long-term care. The number of financial decisions that individuals have to make, and the significance of these decisions, is increasing as a consequence of changes in the market and the economy. For instance, longer life expectancy means individuals need to ensure that they accumulate savings to cover much longer periods of retirement than previous generations, despite the steadily rising age of retirement in many countries. Traditional pay-as-you-go (PAYG) public pension schemes are supplemented by privately funded schemes in which the individual may be responsible for making investment decisions, including the contribution rate, the investment allocation and the type of pay-out product. Moreover, defined-contribution pension plans are quickly replacing defined-benefit pension plans for new entrants, shifting onto workers the risks of uncertain investment performance and of longer life expectancy.

Even when individuals use the services of financial intermediaries and advisors, they need to be financially literate in order to understand what is being offered or advised, and to manage the products they choose. They should also be aware that some advisors may face a conflict of interest. Depending on the national legal framework for financial advice, individuals may be fully responsible for the financial product they decide to purchase, facing all the direct consequences of their choice.

Surveys show that a majority of workers are unaware of the risks they now have to face, and have neither sufficient financial knowledge nor the skills to manage such risks adequately, even if they are aware of them (OECD, 2008; Money and Pensions Panel, 2013; Barrett et al., 2013).

Greater supply of a wide range of financial products and services

In addition, in all countries, growing numbers of consumers have access to a wide range of financial products and services from a variety of providers, delivered through various channels.[1] Greater financial inclusion in emerging economies, as well as worldwide developments in technology and deregulation have resulted in widening access to all kinds of financial products, from current accounts and remittances products to revolving credit and equity portfolios. The products available are also becoming more complex, and individuals are required to compare these products in a number of ways, such as the fees charged, interest rates paid or received, length of contract and exposure to risk. Individuals must also identify appropriate providers and delivery channels from the vast array of possibilities, including community groups, traditional financial institutions, online banks and mobile phone companies.

Increased demand for financial products and services

Economic and technological developments have brought greater global connectedness and massive changes in both the methods and frequency of communications and financial transactions, as well as in social interactions and consumer behaviour. Such changes have made it more important that individuals are able to interact with financial providers and their intermediaries. In particular, consumers often need access to financial services (including banks and other providers, such as post offices) in order to make and receive electronic payments, like income, remittances and online transactions, and even to conduct face-to-face transactions when cash or cheques are no longer favoured. Together, these trends have transferred the responsibility of major financial decisions to individuals, enlarged the options for the majority of the population (including new financial consumers) and increased the level of complexity they face. Against this backdrop, individuals are expected to be sufficiently financially literate to take the necessary steps to protect themselves and their relatives and ensure their financial well-being.

Expected benefits of financial education and improved levels of financial literacy

Existing empirical evidence shows that young people and adults in both developed and emerging economies who have been exposed to good-quality financial education are subsequently more likely than others to plan ahead, save and engage in other responsible financial behaviours (Bernheim et al., 2001; Cole et al., 2011; Lusardi, 2009; Atkinson et al. 2015; Bruhn et al. 2013; Miller et al. 2014). This evidence suggests a possible causal link between financial education and outcomes, and indicates that improved levels of financial literacy can lead to positive behaviour change.

Other research indicates a number of potential benefits of being financially literate. There is mounting evidence that in developed countries those with higher financial literacy are better able to manage their money, participate in the stock market and perform better on their portfolio choice, and that they are more likely to choose mutual funds with lower fees (Hastings and Tejeda-Ashton, 2008; Hilgert et al., 2003; Lusardi and Mitchell, 2008, 2011; Stango and Zinman, 2009; van Rooij et al., 2011; Yoong, 2011). In emerging economies, financial literacy is shown to be correlated with holding basic financial products, like bank accounts, and buying insurance (OECD/INFE, 2013; Xu and Zia, 2012). Similarly, 15-year-old students with bank accounts have higher levels of financial literacy than those without, on average across the OECD countries participating in the 2012 PISA exercise (OECD, 2014c). Moreover, adults who have greater financial knowledge are more likely to accumulate more wealth (Lusardi and Mitchell, 2011).

Higher levels of financial literacy have been found to be related not only to asset building but also to debt and debt management, with more financially literate individuals opting for less costly mortgages and avoiding high interest payments and additional fees (Gerardi et al., 2010; Lusardi and Tufano, 2009a, 2009b; Moore et al., 2003).

In addition to the benefits identified for individuals, large-scale financial literacy can be expected to improve economic and financial stability for a number of reasons (OECD, 2005). Financially literate consumers can make more informed decisions and demand higher-quality services, which can, in turn, encourage competition and innovation in the market. As individuals can protect themselves to a greater extent against income or expenditure shocks and are less likely to default on credit commitments, macro-level shocks are likely to have a lower impact on financially literate populations. Financially literate consumers are also less likely to react to market conditions in unpredictable ways, less likely to make unfounded complaints and more likely to take appropriate steps to manage the risks transferred to them. All of these factors can lead to a more efficient financial services sector. They can also ultimately help to reduce government aid (and taxation) aimed at assisting those who have taken unwise financial decisions – or no decision at all.

Box 5.1 OECD activities in relation to financial education

In 2002, the OECD initiated a far-reaching financial education project to address governments' emerging concerns about the potential consequences of low levels of financial literacy. This project is serviced by the OECD Committee on Financial Markets and the Insurance and Private Pensions Committee in co-ordination with other relevant bodies, including the Education Policy Committee, on issues related to schools. The project takes a holistic approach to financial-consumer issues that highlights how, alongside improved financial access, adequate consumer protection and regulatory frameworks, financial education has a complementary role to play in promoting the outcome of financial literacy.

One of the first milestones of the financial education project was the adoption of the *Recommendation on Principles and Good Practices for Financial Education and Awareness* by the OECD Council (OECD, 2005a). Alongside these recommendations, the publication, *Improving Financial Literacy: Analysis of Issues and Policies*, details the reasons for focusing on financial education, and provides a first international overview of financial education work being undertaken in various countries (OECD, 2005b). The book also includes principles and good practices for policy makers and other stakeholders seeking to improve levels of financial literacy in their country. It is complemented by a global clearinghouse on financial education, the OECD International Gateway for Financial Education (www.financial-education.org/home.html), which gathers data, resources, research and news on financial education issues and programmes from around the world.

Recognising the increasingly global nature of financial literacy and education issues, in 2008 the OECD created the International Network on Financial Education (INFE) to benefit from and encompass the experience and expertise of developed and emerging economies. More than 240 public institutions from more than 110 countries and economies are members of the INFE (2015 figures). Members meet twice a year to discuss the latest developments in their country, share their expertise, and collect evidence, as well as to develop analytical and comparative studies, methodologies, good practice, policy instruments and practical guidance on key priority areas.

Financial education for youth and in schools

The 2005 OECD Recommendation advised that "financial education should start at school. People should be educated about financial matters as early as possible in their lives" (OECD, 2005a). Two main reasons underpin the OECD recommendation: the importance of focusing on youth in order to provide them with key life skills before they start to become active financial consumers; and the relative efficiency of providing financial education in schools rather than attempting remedial actions in adulthood.

At the time the OECD Recommendation was published, there was a lack of guidance on ways to implement financial education initiatives for youth and in schools. The OECD/INFE subsequently created a dedicated expert subgroup to develop policy and practical tools. The resulting publication was welcomed by G20 leaders in September 2013 (OECD, 2014b). The publication includes guidelines for financial education in schools and guidance on financial education learning frameworks, which were also supported by the Ministers of Finance of the Asia-Pacific Economic Cooperation in August 2012.

Young people are increasingly seen as an important target group for financial education. A survey of individual financial literacy schemes supported by the European Commission (Habschick et al., 2007) found that most were directed at children and young people; and stock-taking exercises launched by the OECD/INFE demonstrated that many OECD and non-OECD countries have developed or are developing programmes in schools to varying extents (OECD 2014b; Messy and Monticone, 2016a, 2016b).

Note: The Joint Ministerial Statement from the 2012 APEC Finance Ministerial Meeting is available at http://mddb.apec.org.

Focus on youth

People form habits and behaviours from a young age, learning from their parents and others around them. This shows how important it is to intervene early to help shape beneficial behaviours and attitudes (Whitebread and Bingham, 2013). Young people need to understand basic financial principles and practices from an early age in order to operate within the complex financial landscape they are likely to find themselves, often before reaching adulthood. Younger generations are

not only likely to face ever-increasing complexity in financial products, services and markets, but, as noted above, they are more likely to have to bear more financial risks in adulthood than their parents. In particular, they are likely to bear more responsibility for planning their own retirement savings and investments, and covering their healthcare needs; and they will have to deal with more sophisticated and diverse financial products.

Young people may learn beneficial behaviours from their friends and family, such as prioritising their expenditure or putting money aside "for a rainy day"; but the recent changes in the financial marketplace and social welfare systems make it unlikely that they can gain adequate knowledge or information about these systems unless they work in related fields.[2] The majority of young people will have to apply their skills to search for information and solve problems, and know when to make informed use of professional financial advice. Efforts to improve financial knowledge in the workplace or in other settings can be severely limited by a lack of early exposure to financial education and by a lack of awareness of the benefits of continuing financial education. It is therefore important to provide early opportunities for establishing the foundations of financial literacy.

In addition to preparing young people for their adult life, financial education for youth and in schools can also address the immediate financial issues facing young people. Children are often consumers of financial services from a young age. The results of the PISA 2012 financial literacy assessment revealed that, on average across the 13 participating OECD countries and economies, almost 60% of 15-year-old students have a bank account (OECD, 2014c). Moreover, it is not uncommon for them to have accounts with access to online payment facilities or to use mobile phones (with various payment options) even before they become teenagers. Clearly, they would benefit from improved financial literacy skills. Before leaving school, they may also need to make decisions about issues such as scooter or car insurance, savings products and overdrafts.

In many countries, adolescents (around the age of 15 to 18) and their parents face one of their most important financial decisions: that is, whether or not to invest in tertiary education. The gap in wages between university-educated workers and those who had not attended university has widened in many economies (OECD, 2014a). At the same time, the education costs borne by students and their families have increased, often resulting in large student loans to repay, and potentially leading towards a reliance on credit (Bradley, 2012; OECD, 2014b; Ratcliffe and McKernan, 2013; Smithers, 2010).

Efficiency of providing financial education in schools

Research suggests that there is a link between financial literacy and a family's economic and educational background: those who are more financially literate disproportionately come from highly educated families that hold a wide range of financial products (Lusardi et al., 2010). Results of the 2012 PISA financial literacy assessment show that, on average across OECD countries and economies, 14% of the variation in student performance in financial literacy within each country and economy is associated with the student's socio-economic status, and that students with at least one parent who has tertiary-level education score higher, on average, than other students (OECD, 2014c). In order to provide equal opportunities to all students, it is important to offer financial education to those who would not otherwise have access to it. Schools are well-positioned to advance financial literacy among all demographic groups and reduce gaps and inequalities in financial literacy, including across generations.

Recognising both the importance of financial literacy for youth and the unique potential to create more skilled and knowledgeable future generations, an increasing number of countries have begun to develop financial education programmes for children and young people. These are either dedicated to youth generally or to (some part of) the school population, and include programmes at the national, regional and local levels as well as pilot exercises.

The need for data

Policy makers, educators and researchers need high-quality data on levels of financial literacy in order to inform financial education strategies and the implementation of financial education programmes in schools by identifying priorities and measuring change across time.

Several countries have undertaken national surveys of financial literacy across their adult population; and the OECD has developed a questionnaire designed to capture levels of financial literacy among adults at an international level, which was first piloted in 2010 and is now being used for a second international comparative study (Atkinson and Messy, 2012; OECD/INFE, 2011; OECD/INFE, 2015a). However, until financial literacy was included in the 2012 PISA assessment, there were few efforts to collect data on the levels of financial literacy among young people under the age of 18, and none that could be compared across countries.

A robust measure of financial literacy among young people provides information at the national level that can indicate whether the current approach to financial education is effective. In particular, it can help to identify issues that need addressing through schools or extracurricular activities or programmes that will enable young people to be properly and equitably equipped to make financial decisions in adulthood. Such a measure can also be used as a baseline against which the success of school and other programmes can be assessed and reviewed in the future.

An international study provides additional benefits to policy makers and other stakeholders. Comparing levels of financial literacy across countries makes it possible to see which countries have the highest levels of financial literacy and begin to identify particularly effective national strategies and good practices. It also makes it possible to recognise common challenges and explore the possibility of finding international solutions to the issues faced.

Thus, collecting robust and internationally comparable financial literacy data in the student population provides policy makers, educators, curriculum and resource developers, researchers and others with:

- international evidence on how young people are distributed across the financial literacy proficiency scale, which can be used to develop more targeted programmes and policies
- an opportunity to compare financial education strategies across countries and explore good practice
- comparable data over time to track trends in financial literacy and potentially assess the association between financial literacy and the availability of financial education in schools.

In addition, developing a financial literacy assessment framework that is applicable across countries provides national authorities with detailed guidance about the scope and operational definition of financial literacy without having to fund national studies. As noted in the article, "Financial Literacy and Education Research Priorities", there has been a gap in the research on financial literacy related to the lack of consistency in defining and measuring programme success. There is a need for researchers to develop a clear understanding of what it means to be 'financially educated'" (Schuchardt et al., 2009).

Measuring financial literacy in PISA

PISA 2012 was the first large-scale international study to assess the financial literacy of young people. PISA assesses the readiness of students for their life beyond compulsory schooling – and, in particular, their capacity to use knowledge and skills – by collecting and analysing cognitive and other information from 15-year-olds in countries and economies.

PISA financial literacy data provides a rich set of comparative data that policy makers and other stakeholders can use to make evidence-based decisions. International comparative data on financial literacy can answer questions such as, "How well are young people prepared for the new financial systems that are becoming more global and more complex?" and "In which countries/economies do students show high levels of financial literacy?".

As with the core PISA domains of reading, mathematics and science, the main focus of the financial literacy assessment in PISA is on measuring the proficiency of 15-year-old students in demonstrating and applying knowledge and skills. And like the other PISA domains, financial literacy is assessed using an instrument designed to provide data that are valid, reliable and comparable.

The PISA financial literacy assessment framework developed in 2012 (OECD, 2013a) provided the first step in constructing an assessment that satisfies these three broad criteria. The main benefit of constructing an assessment framework is improved measurement, as it provides an articulated plan for developing the individual items and designing the instrument that will be used to assess the domain. A further benefit is that it provides a common language for discussion of the domain, thereby improving understanding of what is being measured. It also promotes an analysis of the kinds of knowledge and skills associated with competency in the domain, thus providing the groundwork for building a described proficiency scale or scales that can be used to interpret the results.

The development of the PISA frameworks can be described as a sequence of the following six steps:

- Develop a definition for the domain and a description of the assumptions that underlie that definition.
- Identify a set of key characteristics that should be taken into account when constructing assessment tasks for international use.
- Operationalise the set of key characteristics that will be used in test construction, with definitions based on existing literature and experience in conducting other large-scale assessments.

- Evaluate how to organise the set of tasks constructed in order to report to policy makers and researchers on achievement in each assessment domain for 15-year-old students in participating countries.
- Validate the variables and assess the contribution each makes to understanding task difficulty across the various participating countries.
- Prepare a described proficiency scale for the results.

The 2015 framework maintains the definition of the domain used in 2012 while updating the operationalisation of the domain to ensure that it is in line with recent developments in financial markets and the latest research findings.

DEFINING FINANCIAL LITERACY

In developing a working definition of financial literacy that can be used as the basis for designing an international financial literacy assessment, the Financial Literacy Expert Group (FEG) looked both to existing PISA domain definitions of literacies and to articulations of the nature of financial education.

PISA conceives of literacy as students' capacity to apply knowledge and skills in key subject areas and to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations. PISA is forward-looking, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered specific curricular content (OECD, 2010a).

In its *Recommendation on Principles and Good Practices for Financial Education and Awareness*, the OECD defined financial education as "the process by which financial consumers/investors improve their understanding of financial products, concepts and risks and, through information, instruction and/or objective advice, develop the skills and confidence to become more aware of financial risks and opportunities, to make informed choices, to know where to go for help, and to take other effective actions to improve their financial well-being" (OECD, 2005a).

The FEG agreed that "understanding", "skills" and the notion of applying understanding and skills ("effective actions") were key elements of this definition. It was recognised, however, that the definition of financial education describes a process – education – rather than an outcome. What was required for the assessment framework was a definition encapsulating the outcome of that process in terms of competency or literacy.

The definition of financial literacy for PISA is as shown in Box 5.2.

Box 5.2 **The 2015 definition of financial literacy**

Financial literacy is knowledge and understanding of financial concepts and risks, and the skills, motivation and confidence to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts, to improve the financial well-being of individuals and society, and to enable participation in economic life.

This definition, like other PISA domain definitions, has two parts. The first part refers to the kind of thinking and behaviour that characterises the domain. The second part refers to the purposes for developing the particular literacy.

In the following paragraphs, each part of the definition of financial literacy is considered in turn to help clarify its meaning in relation to the assessment.

Financial literacy…

Literacy is viewed as an expanding set of knowledge, skills and strategies, which individuals build on throughout life, rather than as a fixed quantity, a line to be crossed, with illiteracy on one side and literacy on the other. Literacy involves more than the reproduction of accumulated knowledge, although measuring prior financial knowledge is an important element in the assessment. It also involves a mobilisation of cognitive and practical skills, and other resources, such as attitudes, motivation and values. The PISA assessment of financial literacy draws on a range of knowledge and skills associated with the capacity to deal with the financial demands of everyday life and uncertain futures within contemporary society.

…is knowledge and understanding of financial concepts and risks…

Financial literacy is thus contingent on some knowledge and understanding of fundamental elements of the financial world, including key financial concepts as well as the purpose and basic features of financial products. This also includes risks that may threaten financial well-being as well as insurance policies and pensions. It can be assumed that 15-year-olds

are beginning to acquire this knowledge and gain experience of the financial environment that they and their families inhabit and the main risks they face. All of them are likely to have been shopping to buy household goods or personal items; some will have taken part in family discussions about money and whether what is wanted is actually needed or affordable; and a sizeable proportion of students will have already begun to earn and save money. Some students already have experience of financial products and commitments through a bank account or a mobile phone contract. A grasp of concepts such as interest, inflation, and value for money are soon going to be, if they are not already, important for their financial well-being.

…and the skills,…

These skills include generic cognitive processes, such as accessing information, comparing and contrasting, extrapolating and evaluating, applied in a financial context. They include basic skills in mathematical literacy, such as the ability to calculate a percentage, undertake basic mathematical operations or convert from one currency to another, and language skills, such as the capacity to read and interpret advertising and contractual texts.

…motivation and confidence…

Financial literacy involves not only the knowledge, understanding and skills to deal with financial issues, but also non-cognitive attributes: the motivation to seek information and advice in order to engage in financial activities, the confidence to do so, and the ability to manage emotional and psychological factors that influence financial decision making. These attributes are considered as a goal of financial education, as well as being instrumental in building financial knowledge and skills.

…to apply such knowledge and understanding in order to make effective decisions…

PISA focuses on the ability to activate and apply knowledge and understanding in real-life situations rather than on the ability to reproduce knowledge. In assessing financial literacy, this translates into a measure of young people's ability to transfer and apply what they have learned about personal finance into effective decision making. The term "effective decisions" refers to informed and responsible decisions that satisfy a given need.

…across a range of financial contexts…

Effective financial decisions apply to a range of financial contexts that relate to young people's present daily life and experience, but also to steps they are likely to take in the near future as adults. For example, young people may currently make relatively simple decisions such as how they will use their pocket money or, at most, which mobile phone contract they will choose; but they may soon be faced with major decisions about education and work options with long-term financial consequences.

…to improve the financial well-being of individuals and society…

Financial literacy in PISA is primarily conceived of as literacy around personal or household finance, distinguished from economic literacy, which includes concepts such as the theories of demand and supply, market structures and so on. Financial literacy is concerned with the way individuals understand, manage and plan their own and their households' – which often means their families' – financial affairs. It is recognised, however, that good financial understanding, management and planning on the part of individuals has some collective impact on the wider society, in contributing to national and even global stability, productivity and development.

…and to enable participation in economic life.

Like the other PISA literacy definitions, the definition of financial literacy implies the importance of the individual's role as a thoughtful and engaged member of society. Individuals with a high level of financial literacy are better equipped to make decisions that are of benefit to themselves, and also to constructively support and critique the economic world in which they live.

ORGANISING THE DOMAIN OF FINANCIAL LITERACY

How the domain is represented and organised determines the assessment design, including item development and, ultimately, the evidence about student proficiencies that can be collected and reported. Many elements are part of the concept of financial literacy, not all of which can be taken into account in an assessment like PISA. It is necessary to select the elements that will best ensure construction of an assessment comprising tasks with an appropriate range of difficulty and a broad coverage of the domain.

A review of approaches and rationales adopted in previous large-scale studies, and particularly in PISA, shows that most consider the relevant content, processes and contexts for assessment as they specify what they wish to assess. Content, processes and contexts can be thought of as three different perspectives on the area to be assessed.

- ***Content*** comprises the knowledge and understanding that are essential in the area of literacy in question.
- ***Processes*** describes the mental strategies or approaches that are called upon to negotiate the material.
- ***Contexts*** refers to the situations in which the domain knowledge, skills and understandings are applied, ranging from the personal to the global.

To construct the assessment, the different categories within each perspective are identified and weighted, and then a set of tasks is developed to reflect these categories. The three perspectives are also helpful in thinking about how achievement in the area is to be reported.

The following section examines each of the three perspectives and the framework categories into which they are divided. Examples of items drawn from the PISA 2012 field trial to illustrate these three different perspectives are available in the PISA 2012 Assessment and Analytical Framework (OECD, 2013b) and on the PISA website (www.oecd.org/pisa/). While they are representative of those used in the main survey, these particular items are not used in the assessment instrument; only secure, unpublished items are used to protect the integrity of the data that is collected to measure student proficiency.

Content

The content of financial literacy is conceived of as the areas of knowledge and understanding that must be drawn upon in order to perform a particular task. A review of the content of existing financial literacy learning frameworks from Australia, Brazil, England, Japan, Malaysia, the Netherlands, New Zealand, Northern Ireland, Scotland, South Africa and the United States indicates that there is some consensus on financial literacy content areas (OECD, 2014b). The review shows that the content of financial education in schools was similar, albeit with some cultural differences, and that it was possible to identify a series of topics commonly included in these frameworks. These topics form the four content areas of the PISA financial literacy assessment: *money and transactions, planning and managing finances, risk and reward,* and *financial landscape*. Further work undertaken by the OECD/INFE to develop a core-competencies framework on financial literacy for young people provides additional guidance on how these content areas are mapped to desired outcomes (OECD/INFE, 2015c).

Money and transactions

This content area includes awareness of the different forms and purposes of money and managing monetary transactions, which may include spending or making payments, taking into account value for money, and using bank cards, cheques, bank accounts and currencies. It also covers practices such as taking care of cash and other valuables, calculating value for money, and filing documents and receipts.

Tasks in this content area can ask students to show that they are:

- Aware of the different forms and purposes of money. Students can:
  - Recognise bank notes and coins.
  - Understand that money can be exchanged for goods and services.
  - Identify different ways to pay for items purchased in person or at a distance (from a catalogue or on line, for example).
  - Recognise that there are various ways of receiving money from other people and transferring money between people or organisations, such as cash, cheques, card payments in person or on line, or electronic transfers on line or via SMS.
  - Understand that money can be borrowed or lent, and the purpose of interest (taking into account that the payment and receipt of interest is forbidden in some religions).
- Confident and capable of handling and monitoring transactions. Students can:
  - Use cash, cards and other payment methods to purchase items.
  - Use cash machines to withdraw cash or to get an account balance.
  - Calculate the correct change.
  - Work out which of two consumer items of different sizes would give better value for money, taking into account the individual's specific needs and circumstances.
  - Check transactions listed on a bank statement and note any irregularities.

Planning and managing finances

Income, expenditure and wealth need planning and managing over both the short term and long term. This content area reflects the process of managing, planning and monitoring income and expenses and understanding ways of enhancing wealth and financial well-being. It includes content related to credit use as well as savings and wealth creation.

Tasks in this content area can ask students to show that they know about and can:

- Monitor and control income and expenses. Students can:
  - Identify various types of income (e.g. allowances, salary, commission, benefits,) and ways of discussing income (such as hourly wage and gross or net annual income).
  - Draw up a budget to plan regular spending and saving and live within it.

- Use income and other available resources in the short and long term to enhance financial well-being. Students can:
  - Understand how to manipulate various elements of a budget, such as identifying priorities if income does not meet planned expenses, or finding ways to increase savings, such as reducing expenses or increasing income.
  - Assess the impact of different spending plans and be able to set spending priorities in the short and long term.
  - Plan ahead to pay future expenses: for example, working out how much money needs to be saved each month to make a particular purchase or pay a bill.
  - Understand the purposes of accessing credit and the ways in which expenditure can be smoothed over time through borrowing or saving.
  - Understand the idea of building wealth, the impact of compound interest on savings, and the pros and cons of investment products.
  - Understand the benefits of saving for long-term goals or anticipated changes in circumstance, such as living independently.
  - Understand how government taxes and benefits affect personal and household finances.

Risk and reward

Risk and reward is a key area of financial literacy. It incorporates the ability to identify ways of balancing and covering risks and managing finances in uncertainty with an understanding of the potential for financial gains or losses across a range of financial contexts. There are two types of risk of particular importance in this domain. The first relates to financial losses that an individual cannot bear, such as those caused by catastrophic or repeated costs. The second is the risk inherent in financial products, such as credit agreements with variable interest rates, or investment products. This content area therefore includes knowledge of the types of products that may help people to protect themselves from the consequences of negative outcomes, such as insurance and savings, as well as the ability to assess the level of risk and reward related to different products, purchases, behaviours or external factors.

Tasks in this content area can ask students to show that they:

- Recognise that certain financial products, including insurance, and processes, such as saving, can be used to manage and offset various risks, depending on different needs and circumstances. Students know how to assess whether certain insurance policies may be of benefit.
- Understand the benefits of contingency planning, diversification and the dangers of default on payment of bills and credit agreements. Students can apply this knowledge to decisions about:
  - limiting the risk to personal capital
  - various types of investment and savings vehicles, including formal financial products and insurance products, where relevant
  - various forms of credit, including informal and formal credit, unsecured and secured, rotating and fixed term, and those with fixed or variable interest rates.
- Know about and can manage risks and rewards associated with life events, the economy and other external factors, such as the potential impact of:
  - theft or loss of personal items, job loss, birth or adoption of a child, deteriorating health or mobility
  - fluctuations in interest rates and exchange rates
  - other market changes.

- Know about the risks and rewards associated with substitutes for financial products, particularly:
  - saving in cash, or buying property, livestock or gold as a store of wealth
  - taking credit or borrowing money from informal lenders.
- Know that there may be unidentified risks and rewards associated with new financial products (examples may include innovative digital finance or "crowd funding", but, by definition, such a list will change over time).

Financial landscape

This content area relates to the character and features of the financial world. It covers awareness of the role of regulation and consumer protection, knowing the rights and responsibilities of consumers in the financial marketplace and within the general financial environment, and the main implications of financial contracts. Information resources are also topics relevant to this content area. In its broadest sense, *financial landscape* also incorporates an understanding of the consequences of changes in economic conditions and public policies, such as changes in interest rates, inflation, taxation or welfare benefits for individuals, households and society.

Tasks in this content area can ask students to show that they:

- Are aware of the role of regulation and consumer protection.
- Know about rights and responsibilities. Students can:
  - understand that buyers and sellers have rights, such as being able to apply for redress
  - understand that buyers and sellers have responsibilities, such as giving accurate information when applying for financial products (consumers and investors), disclosing all material facts (providers); and being aware of the implications of one of the parties not doing so (consumers and investors)
  - recognise the importance of the legal documentation provided when purchasing financial products or services and the importance of understanding the content.
- Know and understand the financial environment. Students:
  - can identify which providers are trustworthy, and which products and services are protected through regulation or consumer-protection laws
  - can identify whom to ask for advice when choosing financial products, and where to go for help or guidance in relation to financial matters
  - are aware of existing financial crimes, such as identity theft and scams, knowledge of how to take appropriate precautions to protect personal data and avoid other scams, and knowledge of their rights and responsibilities in the event that they are a victim
  - are aware of the potential for new forms of financial crime and awareness of the risks.
- Know and understand the impact of their own financial decisions on themselves and others. Students:
  - understand that individuals have choices in spending and saving, and each action can have consequences for the individual and for society
  - recognise how personal financial habits, actions and decisions have an impact at an individual, community, national and international level.
- Understand the influence of economic and external factors. Students:
  - are aware of the economic climate and understand the impact of policy changes, such as reforms related to the funding of post-school training or compulsory savings for retirement
  - understand how the ability to build wealth or access credit depends on economic factors, such as interest rates, inflation and credit scores
  - understand that a range of external factors, such as advertising and peer pressure, can affect individuals' financial choices and outcomes.

Processes

The process categories relate to cognitive processes. They are used to describe students' ability to recognise and apply concepts relevant to the domain, and to understand, analyse, reason about, evaluate and suggest solutions. PISA defines four process categories for financial literacy: *identify financial information, analyse information in a financial context,*

evaluate financial issues and *apply financial knowledge and understanding*. While the verbs used here bear some resemblance to those in Bloom's taxonomy of educational objectives (Bloom, 1956), an important distinction is that the processes in the financial literacy construct are not operationalised as a hierarchy of skills. They are, instead, parallel essential cognitive approaches, all of which are part of the financially literate individual's repertoire. The order in which the processes are presented here relates to a typical sequence of thought processes and actions, rather than to an order of difficulty or challenge. At the same time, it is recognised that financial thinking, decisions and actions are most often dependent on a recursive and interactive blend of the processes described in this section. For the purposes of the assessment, each task is identified with the process that is judged most central to its completion.

Identify financial information

This process is engaged when the individual searches and accesses sources of financial information, and identifies or recognises its relevance. In PISA 2015 the information is in the form of texts, such as contracts, advertisements, charts, tables, forms and instructions displayed on a screen. A typical task might ask students to identify the features of a purchase invoice, or recognise the balance on a bank statement. A more difficult task might involve searching through a contract that uses complex legal language to locate information that explains the consequences of defaulting on loan repayments. This process category is also reflected in tasks that involve recognising financial terminology, such as identifying "inflation" as the term used to describe increasing prices over time.

Analyse information in a financial context

This process covers a wide range of cognitive activities undertaken in financial contexts, including interpreting, comparing and contrasting, synthesising, and extrapolating from information that is provided. Essentially, it involves recognising something that is not explicit: identifying the underlying assumptions or implications of an issue in a financial context. For example, a task may involve comparing the terms offered by different mobile phone contracts, or working out whether an advertisement for a loan is likely to include unstated conditions. An example in this process category is provided below, in the unit *SHARES*.

Evaluate financial issues

In this process, the focus is on recognising or constructing financial justifications and explanations, drawing on financial knowledge and understanding applied in specified contexts. It involves such cognitive activities as explaining, assessing and generalising. Critical thinking is brought into play in this process, when students must draw on knowledge, logic and plausible reasoning to make sense of and form a view about a finance-related problem. The information that is required to deal with such a problem may be partly provided in the stimulus of the task, but students will need to connect such information with their own prior financial knowledge and understanding.

In the PISA context, any information that is required to understand the problem is intended to be within the expected range of experiences of a 15-year-old – either direct experiences or those that can be readily imagined and understood. For example, it is assumed that 15-year-olds are likely to be able to identify with the experience of wanting something that is not essential, such as a music player or games console. A task based on this scenario could ask about the factors that might be considered in determining the relative financial merits of making a purchase or deferring it, given specified financial circumstances.

Apply financial knowledge and understanding

The fourth process picks up a term from the definition of financial literacy: "to apply such [financial] knowledge and understanding". It focuses on taking effective action in a financial setting by using knowledge of financial products and contexts, and understanding of financial concepts. This process is reflected in tasks that involve performing calculations and solving problems, often taking into account multiple conditions. An example of this kind of task is calculating the interest on a loan over two years. This process is also reflected in tasks that require recognition of the relevance of prior knowledge in a specific context. For example, a task might require the student to work out whether purchasing power will decline or increase over time when prices are changing at a given rate. In this case, knowledge about inflation needs to be applied.

Contexts

Decisions about financial issues are often dependent on the contexts or situations in which they are presented. By situating tasks in a variety of contexts, the assessment offers the possibility of connecting with the broadest possible range of individual interests across a variety of situations in which individuals need to function in the 21st century.

Certain situations will be more familiar to 15-year-olds than others. In PISA, assessment tasks are framed in situations of general life, which may include but are not confined to school contexts. The focus may be on the individual, family or peer group, on the wider community, or even on a global scale.

As a starting point, the Financial Literacy Expert Group (FEG) looked at the contexts used in the Programme for the International Assessment of Adult Competencies (PIAAC) literacy framework: *education and work, home and family, leisure and recreation,* and *community and citizenship* (PIAAC Literacy Expert Group, 2009). For the purposes of the financial literacy domain, the heading *leisure and recreation* was replaced by *individual* to reflect the fact that many of the financial interactions that young people have are related to themselves as individual consumers. Such interactions may include leisure and recreation, but are not limited to these. It was further decided to replace *community and citizenship* with *societal*. While *community and citizenship* captures the idea of a perspective wider than the personal, it was felt that the term *community* was not wide enough.

Societal, by contrast, implicitly encompasses national and global situations as well as the more local, thus better fitting the potential reach of financial literacy. The contexts identified for the PISA financial literacy assessment are, then, *education and work, home and family, individual* and *societal*.

Education and work

The context of *education and work* is of great importance to young people. Virtually all 15-year-olds will be starting to think about financial matters related to both education and work, whether they are spending existing earnings, considering future education options or planning their working life.

The educational context is obviously relevant to PISA students, since they are, by definition, a sample of the school-based population; indeed, many of them will continue in education or training for some time. However, many 15-year-old students are also already engaged in some form of paid work outside school hours making the work context equally valid. In addition, many will move from education into some form of employment, including self-employment, before reaching their 20s.

Typical tasks within this context could include understanding payslips, planning to save for tertiary education, investigating the benefits and risks of taking out a student loan, and participating in workplace savings schemes.

Home and family

*Home and famil*y includes financial issues relating to the costs involved in running a household. Family is the most likely household circumstance for 15-year-olds; however, this category also encompasses households that are not based on family relationships, such as the kind of shared accommodation that young people often use shortly after leaving the family home. Tasks within this context may include buying household items or family groceries, keeping records of family spending, and making plans for family events. Decisions about budgeting and prioritising spending may also be framed within this context.

Individual

The context of the *individual* is important within personal finance since there are many decisions that a person takes entirely for personal benefit or gratification, and many risks and responsibilities that must be borne by individuals. These decisions span essential personal needs as well as leisure and recreation. They include choosing personal products and services, such as clothing, toiletries or haircuts, buying consumer goods, such as electronic or sports equipment, and more long-term commitments, such as season tickets or a gym membership. They also cover the process of making personal decisions and the importance of ensuring individual financial security, such as keeping personal information safe and being cautious about unfamiliar products.

Although the decisions made by an individual may be influenced by the family and society (and may ultimately affect society), when it comes to opening a bank account, buying shares or getting a loan, it is typically the individual who has the legal responsibility and ownership. The context *individual* therefore includes contractual issues around events such as opening a bank account, purchasing consumer goods, paying for recreational activities, and dealing with relevant financial services that are often associated with larger consumption items, such as credit and insurance.

Societal

The environment young people are living in is characterised by change, complexity and interdependence. Globalisation is creating new forms of interdependence where actions are subject to economic influences and consequences that stretch well beyond the individual and the local community. While the core of the financial literacy domain is focused on personal finances, the *societal* context recognises that individual financial well-being cannot be entirely separated from the rest of society. Personal financial well-being affects and is affected by the local community, the nation and even global activities. Financial literacy within this context includes such matters as being informed about consumer rights and responsibilities, understanding the purpose of taxes and local government charges, being aware of business interests, and taking into account the role of consumer purchasing power. It also extends to considering financial choices, such as donating to non-profit organisations and charities.

Non-cognitive factors

The PISA working definition of financial literacy includes the non-cognitive terms *motivation* and *confidence*, attitudes which, according to some, have an influence on money-management behaviour (Johnson and Staten, 2010). PISA conceives of both financial attitudes and behaviour as aspects of financial literacy in their own right. Attitudes and behaviour are also of interest in terms of their interactions with the cognitive elements of financial literacy. Information collected about the financial attitudes and behaviour of 15-year-olds could also constitute useful baseline data for any longitudinal study of the financial literacy of adults, including their financial behaviours.

The Financial Literacy Expert Group identified four non-cognitive factors to include in the framework: *access to information and education, access to money and financial products, attitudes towards and confidence about financial matters,* and *spending and saving behaviour.*

Access to information and education

There are various sources of financial information and education that may be available to students, including informal discussion with friends, parents or other family members, information from the financial sector, as well as formal school education. The literature in this area often refers to the process of "financial socialisation", which can be seen as the process of acquiring financial literacy. Parents have a major role in the financial socialisation of children but, as discussed above, they may not have been exposed to all the financial contexts and decisions that their children face (Gudmondson and Danes, 2011; Otto, 2013). Copying and discussing financial behaviours with friends can be another important source of socialisation, but this also may vary in terms of quality and reliability, with recent research from the UK indicating that money is rarely talked about honestly (Money Advice Service, 2014). In addition, the amount and quality of formal education and training about money and personal finance received by students varies within and across countries (OECD, 2014b, 2014c).

Data about students' access to financial information and education can be collected through both the student questionnaire and the questionnaire for school principals. In the student questionnaire, students can be asked about their typical sources of information in order to analyse the extent to which each source is correlated with financial literacy. This is intended to provide a description of students' main sources of financial socialisation, rather than assessing whether they understand the importance of using appropriate sources of information or advice, which is covered in the cognitive assessment. Students can also be asked about the types of tasks that they face and the financial concepts they are exposed to during curricular classes. The school questionnaire can ask principals about the availability and quality of financial education in their schools. Evidence about the extent to which there is a link between levels of financial literacy and financial education inside and outside schools is likely to be particularly useful in shaping education programmes for improving financial literacy.

Access to money and financial products

The results of the 2012 PISA financial literacy exercise showed that, in the Flemish Community of Belgium, Estonia, New Zealand and Slovenia, students with a bank account scored higher in financial literacy than students with similar socio-economic status who did not hold a bank account (OECD, 2014c). While this does not indicate a causal relationship, it is plausible to assume that real-life experiences of financial products may influence young people's financial literacy and vice versa. Personal experience may come, for example, from using financial products, such as payment cards, from dealing with the banking system, or from occasional working activities outside of school hours.

Students who have had more personal experience in dealing with financial matters from earning money or receiving an allowance might also be expected to perform better on the cognitive assessment than those without such experience. However, a recent review suggests that the key factor may not be experience, but the extent to which parents are involved in the spending decisions made by young people, with higher financial literacy associated with more involved parents (Drever et al., 2015). The 2015 framework recognises the importance of knowing whether students have access to money and financial products.

Attitudes towards and confidence about financial matters

The PISA definition of financial literacy highlights the important role of attitudes. Individual preferences can determine financial behaviour and affect the ways in which financial knowledge is used. PISA 2012 showed that students' perseverance and openness to problem solving were strongly associated with their financial literacy scores (OECD, 2014c). In addition, the extent to which students believe that they are in control of their future, and their preference for current consumption may influence their financial decisions, their independence, and their propensity to learn how to make plans for their own financial security (Golsteyn et al., 2013; Lee and Mortimer, 2009; Meier and Sprenger, 2013).

Confidence in one's own ability to make a financial decision may also be a key driver in explaining who will work through complex financial problems or make choices across several possible products. At the same time, however, confidence may turn into overconfidence, leading to a tendency to mistakes and overly risky decisions. The 2015 framework recognises the importance of a student's perception of his or her own financial knowledge and skills.

Spending and saving behaviour

While items in the cognitive assessment test students' ability to make particular spending and savings decisions, it is also useful to have some measure of what their actual (reported) behaviour is: that is, how students save and spend in practice. The PISA financial literacy assessment provides the opportunity to look at the potential relationship between 15-year-olds' spending and saving behaviour and their results on the cognitive financial literacy assessment.

ASSESSING FINANCIAL LITERACY

The structure of the assessment

In 2012, the PISA financial literacy assessment was developed as a one-hour, paper-based exercise to be completed in addition to one hour of material from other cognitive domains. The financial literacy assessment was composed of 40 items divided into two clusters, chosen from 75 tasks that were used in the field trial. The selection of items was made based on their psychometric properties, such as ensuring that each item distinguished between high- and low-scoring students.

In 2015, items are transferred to a computer-based platform. Additional items were developed for this form of delivery in order to replace items that had been released in the report of the 2012 results. The 2015 financial literacy assessment was developed as a one-hour exercise, comprising 43 items divided into two clusters.

As with other PISA assessment domains, computer-based financial literacy items are grouped in units composed of one or two items based around a common stimulus. The selection includes financially-focused stimulus material in diverse formats, including prose, diagrams, tables, charts and illustrations. All financial literacy assessments include a broad sample of items covering a range of difficulty that allows for measuring and describing the strengths and weaknesses of students and key subgroups of students.

Response formats and coding

Some PISA items require short descriptive responses; others require more direct responses of one or two sentences or a calculation, while some can be answered by checking a box. Decisions about the form in which the data are collected – the response formats of the items – are based on what is considered appropriate given the kind of evidence that is being collected, and also on technical and pragmatic considerations. In the financial literacy assessment as in other PISA assessments, two broad types of items are used: constructed-response items and selected-response items.

Constructed-response items require students to generate their own answers. The format of the answer may be a single word or figure, or may be longer – a few sentences or a worked calculation. Constructed-response items that require a more extended answer are ideal for collecting information about students' capacity to explain decisions or demonstrate a process of analysis.

The second broad type of item in terms of format and coding is selected response. This kind of item requires students to choose one or more alternatives from a given set of options. The most common type in this category is the simple multiple-choice item, which requires the selection of one from a set of (usually) four options.

A second type of selected-response item is complex multiple choice, in which students respond to a series of "Yes/No"-type questions. Selected-response items are typically regarded as most suitable for assessing items associated with identifying and recognising information, but they are also a useful way of measuring students' understanding of higher-order concepts that they themselves may not easily be able to express.

Although particular item formats lend themselves to specific types of questions, the format of the item should not affect the interpretation of the results. Research suggests that different groups (for example, boys and girls, and students in different countries) respond differentially to the various item formats. Several research studies on response-format effects based on PISA data suggest that there are strong arguments for retaining a mixture of multiple-choice and constructed-response items. In their study of PISA reading literacy compared with the IEA Reading Literacy Study (IEARLS), Lafontaine and Monseur (2006) found that response format had a significant impact on gender performance. In another study, countries were found to show differential equivalence of item difficulties in PISA reading on items in different formats (Grisay and Monseur, 2007). This finding may relate to the fact that students in different countries are more or less familiar with the particular formats. The PISA financial literacy option includes items in a variety of formats to minimise the possibility that item format affects student performance. Such an influence would be extrinsic to the intended object of measurement – in this case, financial literacy.

When considering the distribution of item formats, the question of resources must be weighed as well as the equity issues discussed in the preceding paragraphs. All except the most simple of constructed-response items are coded by expert judges who must be trained and monitored. Selected-response and short "closed" constructed-response items do not require expert coding and therefore demand fewer resources.

The proportions of constructed- and selected-response items are determined taking of all these considerations into account. Most of the items selected for the PISA 2015 main survey do not require expert judgement.

Most items are coded dichotomously (full credit or no credit), but where appropriate an item's coding scheme allows for partial credit. Partial credit makes possible more nuanced scoring of items. Some answers, even though incomplete, are better than others. If incomplete answers for a particular question indicate a higher level of financial literacy than inaccurate or incorrect answers, a scoring scheme has been devised that allows partial credit for that question. Such "partial credit" items yield more than one score point.

Distribution of score points

While each PISA financial literacy item is categorised according to a single content, a single process and a single context category, it is recognised that, since PISA aims to reflect real-life situations and problems, often elements of more than one category are present in a task. In such cases, the item is identified with the category judged most integral to responding successfully to the task.

The target distribution of score points according to financial literacy content areas is shown in Table 5.1. The term "score points" is used in preference to "items", as some partial credit items are included. The distributions are expressed in terms of ranges, indicating the approximate weighting of the various categories. They contain a mix of original items, developed for the 2012 and 2015 assessments.

The distribution reflects that *money and transactions* is considered to be to the most immediately relevant content area for 15-year-olds.

Table 5.2 shows the target distribution of score points among the four processes.

The weighting shows that greater importance is attributed to evaluating financial issues and applying financial knowledge and understanding.

Table 5.3 shows the target distribution of score points among the four contexts.

Table 5.1 Approximate distribution of score points in financial literacy, by content

Money and transactions	Planning and managing finances	Risk and reward	Financial landscape	Total
30% – 40%	25% – 35%	15% – 25%	10% – 20%	100%

Table 5.2 Approximate distribution of score points in financial literacy, by process

Identify financial information	Analyse information in a financial context	Evaluate financial issues	Apply financial knowledge and understanding	Total
15% – 25%	15% – 25%	25% – 35%	25% – 35%	100%

Table 5.3 Approximate distribution of score points in financial literacy, by context

Education and work	Home and family	Individual	Societal	Total
10% – 20%	30% – 40%	35% – 45%	5% – 15%	100%

Consistent with an assessment of personal financial literacy of 15-year-olds, there is a clear emphasis on *individual*, but also a weighting towards the financial interests of the household or family unit. *Education and work* and *societal* contexts are given less emphasis, but included in the scheme as they are important elements of financial experience.

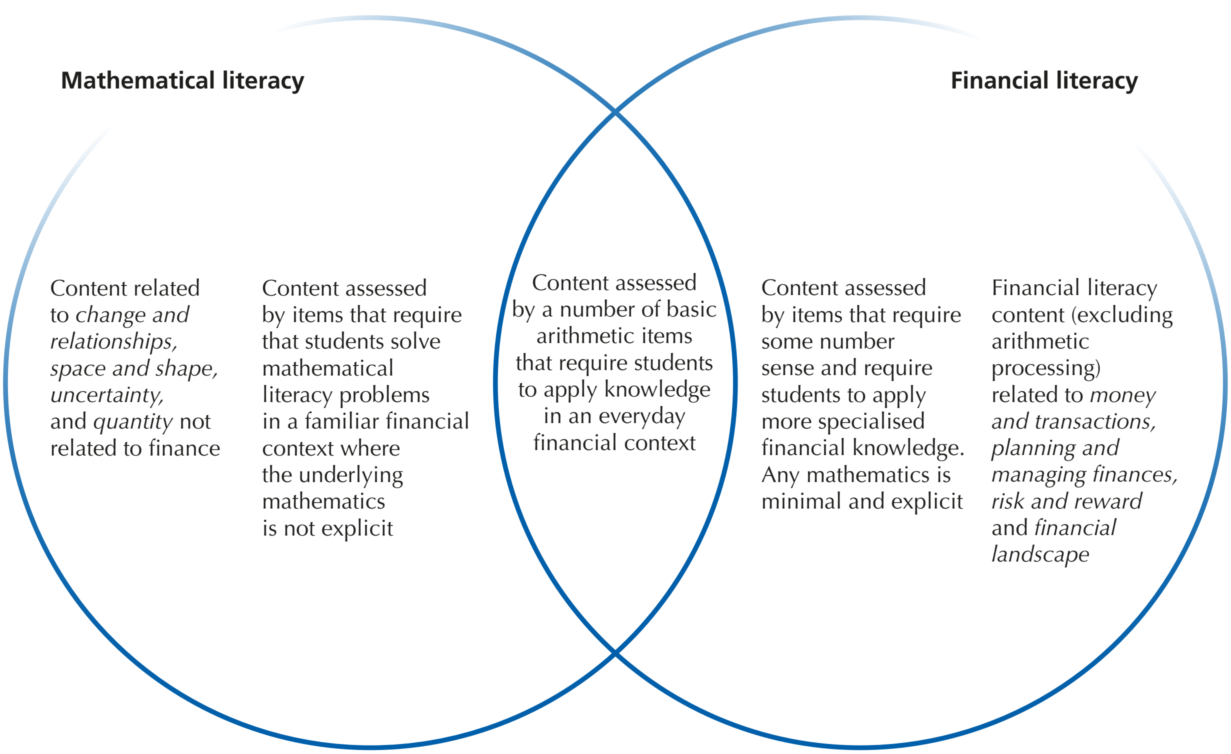
THE IMPACT OF OTHER DOMAIN KNOWLEDGE AND SKILLS ON FINANCIAL LITERACY

A certain level of numeracy (or mathematical literacy) is regarded as a prerequisite for financial literacy. Huston (2010) argues that "if an individual struggles with arithmetic skills, this will certainly impact his/her financial literacy. However, available tools (e.g. calculators) can compensate for these deficiencies; thus, information directly related to successfully navigating personal finances is a more appropriate focus than numeracy skills for a financial literacy measure". Mathematically-related proficiencies, such as number sense, familiarity with multiple representations of numbers, and skills in mental calculation, estimation and the assessment of reasonableness of results, are intrinsic to some aspects of financial literacy.

On the other hand, there are large areas where the content of mathematical literacy and financial literacy do not intersect. As defined in the PISA 2012 mathematics literacy framework, mathematical literacy incorporates four content areas: *change and relationships, space and shape, quantity* and *uncertainty*. Of these, only *quantity* directly intersects with the content of the PISA financial literacy assessment. Unlike the mathematical literacy content area *uncertainty*, which requires students to apply probability measures and statistics, the financial literacy content area *risk and reward* requires an understanding of the features of a particular situation or product that indicate a that there will be a risk of losing money and (sometimes) a possibility of gains. This is a non-numeric appreciation of the way financial well-being can be affected by chance and an awareness of the related products and actions to protect against loss.

In the financial literacy assessment, the quantity-related proficiencies described above are applied to problems requiring more financial knowledge than can be expected in the mathematical literacy assessment. Similarly, knowledge about financial matters and the ability to apply such knowledge and reasoning in financial contexts (in the absence of any specifically mathematical content) characterise much of all four content areas of financial literacy: *money and transactions, planning and managing finances, risk and reward* and *financial landscape*. Figure 5.1 represents the relationship between the content of mathematical literacy and financial literacy in PISA.

Figure 5.1 ▪ **Relationship between the content of financial literacy and mathematical literacy in PISA**



Operationally, there are few items populating the portion of the diagram where the two circles intersect. In the financial literacy assessment, the nature of the mathematical literacy expected is basic arithmetic: the four operations (addition, subtraction, multiplication and division) with whole numbers, decimals and common percentages. Such arithmetic occurs as an intrinsic part of the financial literacy context and enables financial literacy knowledge to be applied and demonstrated.

Items that require such arithmetic skills involve basic mathematics of a level within the reach of most 15-year-olds. Use of financial formulae (requiring knowledge of algebra) is not considered appropriate. Dependence on calculation is minimised in the assessment; tasks are framed in such a way as to avoid the need for substantial or repetitive calculation. The calculators used by students in their classrooms and on the PISA mathematics assessment are also available in the financial literacy assessment, but success in the items will not depend on their use.

A similar reasoning holds for reading skills. It is assumed that all students taking part in the financial literacy assessment will have some basic reading proficiency, even while it is known from previous PISA surveys that reading skill varies widely both within and across countries (OECD, 2010b). To minimise the level of reading literacy required, stimulus material and task statements are generally designed to be as clear, simple and brief as possible. In some cases, however, the stimulus may deliberately present complex or somewhat technical language. The capacity to read and interpret the language of financial documents or pseudo financial documents is regarded as part of financial literacy.

Highly technical terminology relating to financial matters is avoided. The Financial Literacy Expert Group has advised on terms that it judges reasonable to expect 15-year-olds to understand. Some of these terms may be the focus of assessment tasks.

In practice, the results of the 2012 PISA financial literacy assessment gave a more precise measure of students' performance in financial literacy in comparison with reading and mathematics performance. The results indicated that around 25% of the financial literacy score reflected factors that are uniquely captured by the financial literacy assessment, while the remaining 75% of the financial literacy score reflected skills measured in the mathematics and/or reading assessments.

The association between financial literacy and other domains indicates that, in general, students who perform at higher levels in mathematics and/or reading also perform well in financial literacy. There were, however, wide variations in financial literacy performance for any given level of performance in mathematics and reading, meaning that the skills measured by the financial literacy assessment went beyond or fell short of the ability to use the knowledge that students acquired from subjects taught in compulsory education. For instance, in Australia, the Flemish Community of Belgium, the Czech Republic, Estonia, New Zealand and the Russian Federation, students performed better in financial literacy than students in other countries with similar performance in mathematics and reading, while, by contrast, in France, Italy and Slovenia, students' performance in financial literacy was lower, on average, when compared to that of students in the other participating countries and economies who displayed the same level of proficiency in reading and mathematics (OECD, 2014c).

REPORTING FINANCIAL LITERACY

The data from the 2012 financial literacy assessment is held in a database separate from the main PISA database. In 2015, the data from all domains is presented together. The databases include, for the sampled students, their financial literacy, mathematics and reading cognitive results, the behaviour data from the short questionnaire on financial literacy, and data from the general student questionnaire and school questionnaire.

In each PISA cycle, financial literacy is reported as an independent result, and in relation to performance in other domains, financial behaviour, and to some background variables, such as socio-economic status and immigrant background. The data also allow for the development of further work under the aegis of the OECD Project on Financial Education.

The financial literacy cognitive data is scaled similarly to the other PISA data. A comprehensive description of the modelling technique used for scaling can be found in the *PISA 2012 Technical Report* (OECD, 2014d).

Each item is associated with a particular point on the PISA financial literacy scale that indicates its difficulty, and each student's performance is associated with a particular point on the same scale that indicates the student's estimated proficiency.

As with the other PISA domains, the relative difficulty of tasks in a test is estimated by considering the proportion of test takers answering each question correctly. The relative proficiency of students taking a particular test is estimated by considering the proportion of test items that they answer correctly. A single continuous scale showing the relationship between the difficulty of items and the proficiency of students is constructed.

Starting from the 2012 assessment, the scale was divided into levels, according to a set of statistical principles, and then descriptions were generated based on the tasks located within each level, to encapsulate the kinds of skills and knowledge needed to complete those tasks successfully. The scale and set of descriptions are known as a described proficiency scale.

By calibrating the difficulty of each item, it is possible to locate the degree of financial literacy that the item represents. By showing the proficiency of each student on the same scale, it is possible to describe the degree of financial literacy that the student possesses. The described proficiency scale helps to interpret what students' financial literacy scores mean in substantive terms.

Following PISA practice, a scale is constructed (based on participating OECD countries) having a mean of 500 and a standard deviation of 100. Five levels of proficiency in financial literacy are described in the assessment, as a first step in reporting how financial literacy develops, and to compare student performance between and within participating countries and economies (see OECD, 2014c, Chapter 2).

Notes

1. Financial inclusion increased from 51% of the adult population with an account at a financial institution or mobile money service in 2011, to 62% in 2014. However, two billion adults have no bank account at all (Demirguc-Kunt et al., 2015).

2. PISA 2012 indicates that students with a parent working in the financial services sector have higher levels of financial literacy, on average, although data are only available for a limited number of countries.

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6

PISA 2015 context questionnaires framework

This chapter describes the core content of the Programme for International Student Assessment (PISA) 2015 and PISA's interest in measuring student's engagement at school, dispositions towards school and their self-beliefs, and in gathering information about students' backgrounds and the learning environment at school. The chapter discusses the content and aims of the Student Questionnaire, the School Questionnaire (completed by school principals), the optional Parent Questionnaire (completed by parents of students who sat the PISA test), the optional Educational Career Questionnaire (completed by students, concerning their educational and career aspirations), the optional ICT Familiarity Questionnaire (completed by students, concerning their attitudes towards and experience with computers) and the optional Teacher Questionnaire (completed by teachers, and introduced in PISA 2015).

Providing indicators on the effectiveness, equity and efficiency of education systems, setting benchmarks for international comparison, and monitoring trends over time are the most important goals of the Programme for International Student Assessment (PISA). In addition, PISA builds a sustainable database that allows researchers worldwide to study basic and policy-oriented questions on education, including its relation to society and the economy.

In order to reach these goals, PISA not only needs reliable and valid measures for assessing cognitive student achievement (in reading, mathematics, science literacy and other "life skills"), but also information on non-cognitive outcomes (e.g. students' motivation to learn), individual conditions (e.g. students' cultural, ethnic and socio-economic background), and the structural and process characteristics of the institutional context (e.g. teaching practices and learning opportunities in classrooms, leadership and school policies for professional development, vertical and horizontal differentiation of the school system). It is this diverse set of constructs that is measured through questioning various stakeholders, namely students and school principals, and (on an optional basis) parents and teachers.

PISA 2015 is the sixth wave of the programme. Since 2000, the so-called "Background Questionnaires" have gained substantially in importance. Meanwhile, questionnaires are of interest in their own right, beyond providing the "background" for reporting test results. PISA 2015 is a combination of student assessment in selected areas of achievement and context assessment on different policy-related issues. One reason for this change of perspective is that policy makers wanted the programme to report on a variety of issues that are relevant to professional practice, governance and policy making in education. Thus, the scope of issues to be covered has gradually expanded since PISA 2000. In addition to student achievement and its relation to individual background, learning opportunities and non-cognitive outcomes, educational policies and practices are monitored through indicators. Also, data analysis and reporting have become more complex, allowing for more in-depth reporting. In addition to providing tables of indicators, patterns of input, process and outcome variables are identified within and across countries; trends are reported, relations are explored, impact is estimated. These analyses require more sophisticated modelling approaches, and detailed data on contextual factors regarding students, schools and education systems.

Probably the most important characteristic of PISA, after 15 years of existence, is the availability of system-level trend data. PISA allows for the description of change in a country's performance level over time, but also for the description of changes in non-cognitive outcomes, living conditions of adolescents and their families, professional practices and organisational structures for schooling. The more PISA moves towards repeated cycles of measurement, the more can be learned from examining the stability and variability of conditions, processes, outcomes and their relations: policy makers can use trend data for constant diagnosis and feedback; the explanatory power of the study will increase because changes in performance can be interpreted and explained more substantively, taking changes in input and process into account (Gustafsson, 2008; Hanushek and Wößmann, 2011); and trend analyses are less likely to be biased by cultural issues.

Quite often, policy makers and researchers have been reluctant to interpret "soft" constructs, such as school climate, students' motivation, teachers' job satisfaction or parents' self-reported engagement, fearing that they are not sufficiently comparable across countries. Now that trends are available, the focus is on change rates within countries rather than on cross-sectional comparisons of status. For example, the question of whether well-being in schools is increasing or decreasing will be a relevant indicator within countries, and this indicator is not affected by response styles differing between countries. However, trend analyses require PISA to define a general set of constructs that will remain constant over several cycles in the future. This set of constructs will be referred to as "core content" in this chapter.[1]

This framework intends to explain the goals and the rationale for choosing appropriate questionnaire content, guiding both questionnaire development and the forthcoming reports. The document is organised into two main parts: a definition of the core content of the PISA questionnaires, and a description of the modular structure for broader coverage of policy issues.

The first part of this document links the current framework to the overarching (cross-cycle) structure of PISA context assessment set out in the PISA 2012 Framework (OECD 2013: 168 ff.). The constructs that need to be covered for monitoring trends in education are revisited, with reference to the general background of Educational Effectiveness Research. Measures that have been used previously for initial reporting, for international indicators and for secondary analyses are overviewed, culminating in an outline of core content that should be assessed in all cycles, for all participants.

The second and larger part of this document explores the full breadth of policy issues to be covered, structured in 19 modules, and explains how the most important modules – i.e. those judged as high priority modules by the PISA Governing Board – have been implemented in PISA 2015. Here, detailed references to current research are provided.

The development of questionnaire content for PISA 2015 has been challenged not only by the intention of covering a broad array of policy issues, but also by the introduction of Computer-Based Assessment (CBA) as the preferred mode of administration for both cognitive tests and questionnaires. In addition to developing new questions, all content from previous cycles had to be revisited, sometimes transformed into a CBA-friendly format (like using a "slider" that can be manipulated interactively instead of having the test-taker fill in numeric information), and field trialled anew. Finally, the analysis of process data based on logfile recording will deepen the understanding of response behaviour.

Based on careful analysis of the field trial data and thoughtful discussion of priorities among experts and policy makers, constructs, questions and items were selected for inclusion in the PISA 2015 main survey. The Student Questionnaire was targeted to last 35 minutes, on average.

DEFINING THE CORE OF CONTEXT ASSESSMENT IN PISA

Choosing from the many measures that might be incorporated in the PISA study design is a complex process, directed by the priorities that countries have set for the study, but also informed by education research. One of the major forces that drive the PISA design in general is the rhythmic change of focus in the cognitive assessment: reading literacy has been or will be the major domain of assessment in PISA 2000, 2009 and 2018; mathematics is the focus of PISA 2003, 2012 and 2021; science takes the lead in PISA 2006, 2015 and 2024. Whatever serves as the major domain of cognitive assessment shall also be a major focus of "domain-specific" context assessment. However, there is a need for some stability in measurement to understand trends in education.

The Questionnaire Framework for PISA 2012 established an overarching structure that delineated core questionnaire content that should be kept comparable across cycles (OECD 2013: 189 ff.) to allow for continuous monitoring of education systems. The overarching framework refers to domain-specific as well as domain-general measures assessing conditions, processes and outcomes of education for both individual students and schools. Finding an appropriate balance among these facets of the design is crucial for the long-term success of the PISA programme. In order to establish valid and reliable trends at the country level, it is important to implement a stable set of variables, which will be used as major reporting variables across PISA cycles.[2]

This overarching framework is discussed below, along with specifying the constructs and measures in more detail and providing arguments that support the choice of core content for PISA 2015.

Outline of core content: Constructs to be covered

Taking into account the goals of context assessment in PISA as stated in the introduction, strategic decisions made by the PISA Governing Board, the overarching framework developed for PISA 2012, and recommendations from the research literature, the current framework assumes that education policy makers in participating countries need to be informed in four broad areas: outcomes, student background, teaching and learning processes, and school policies and educational governance. These areas are described below. As stated above, the following sections elaborate in more detail what has already been established in the Questionnaire Framework for PISA 2012.

Non-cognitive outcomes

The main challenge of PISA concerns measuring and documenting the outcomes of education that have been reached up to the age of 15 years. Educating a person basically means fostering his or her individual development as a unique, self-determined, knowledgeable person who gradually gains in ability to participate in society. As each PISA assessment is a cross-sectional study, PISA cannot capture developmental processes; but PISA serves as a snapshot of development status at the age of 15.

This snapshot includes an assessment of literacy and life skills, but in addition to these cognitive outcomes, other factors are important, too. Success in school – and in life – depends on being committed, sharing values and beliefs, respecting and understanding others, being motivated to learn and to collaborate, and being able to regulate one's own learning behaviour. These constructs can be perceived as prerequisites of cognitive learning, but may also themselves be judged as goals of education, as the OECD project *Defining and Selecting Key Competencies* (DeSeCo) has elaborated (Rychen and Salganik, 2003). Education research and econometric analyses have shown that non-cognitive factors are most important for individual development as well as for success in life and well-being, and thus have an impact on individuals and society alike (Heckman, Stixrud and Urzua, 2006; Almlund et al., 2011).

Therefore, PISA addresses non-cognitive outcomes like attitudes, beliefs, motivation and aspirations, and learning-related behaviour, such as invested learning time. These non-cognitive outcomes are measured within the Student Questionnaire (StQ), but also in the ICT Familiarity Questionnaire (ICTQ). They may be of a general nature, such as achievement

motivation and well-being of students, or related to the domains of the cognitive assessment, such as reading engagement, interest in mathematics or enjoyment of science. Domain-specific non-cognitive outcomes are also mentioned in the respective definitions of literacy, so this array of constructs serves as a link between test frameworks and context framework. Students' self-efficacy beliefs – i.e. the strength of their belief in being able to solve tasks similar to the ones tested in the cognitive PISA tests – have been shown to be a strong correlate of student achievement both within and between countries.

Student background

In order to understand education careers and to study equity issues within and across countries, family background variables, such as socio-economic status and immigrant background, have to be taken into account. The distribution of education opportunities and outcomes depending on these background variables shows whether countries succeed in providing equal opportunities.

PISA has become famous for its detailed, theory-based assessment of family background, socio-economic status and immigration background. A lot of effort went into the definition and operationalisation of individual student background indicators, finally leading to the establishment of a powerful, integrated indicator for students' economic, social and cultural status (ESCS; Willms, 2006). The components of this indicator need to be assessed in as stable a way as possible across the PISA cycles. In addition, information on parental support helps understanding of how formal education and family background interact in promoting student learning.

Furthermore, PISA gathers retrospective and prospective information about education pathways and careers across the lifespan. In recent years, researchers and others have stressed the importance of early childhood education (Blau and Curie, 2006; Cunha et al., 2006). Therefore, PISA intends to capture at least some information on primary and pre-primary education.

On top of individual student background, the social, ethnic and academic composition of the school he or she attends has an impact on learning processes and outcomes. Therefore, PISA uses aggregated student data to characterise background factors on the school level in addition to structural factors, such as school location, school type and school size.

Teaching and learning

School-based instruction is the core process of formal, systematic education. Therefore, policy makers need information on teaching, learning and the organisation of schools. To increase the explanatory power of the study, assessment of teaching and learning focuses on the major domain of assessment, which, in 2015, is science. The knowledge base of educational effectiveness research (Scheerens and Bosker, 1997; Creemers and Kyriakides, 2008) allows for the identification of core factors: teachers' qualifications, teaching practices and classroom climate, learning time and learning opportunities provided both within and out of school. For teaching processes, the focus should be on three basic dimensions (Klieme, Pauli and Reusser, 2009): structure and classroom management; teacher support; and cognitive challenge. Addressing teacher- and teaching-related factors in PISA is a challenge, because sampling is by age rather than by grade or class. Nevertheless, aggregated student data and School Questionnaires can serve to describe the learning environment offered by schools.

School policies and governance

As policy makers have limited direct impact on teaching and learning processes, information on school-level factors that help to improve schools, and thus indirectly improve student learning, have high priority. As with teacher and teaching variables, school-effectiveness research has built a strong knowledge base showing that "essential supports" promote school effectiveness (Bryk et al., 2010; see also Creemers and Reezigt, 1997; Scheerens and Bosker, 1997): professional capacity, with a focus on professional development; a well-organised curriculum; leadership and school management; parental involvement; school climate (truthful interactions between stakeholders, clear norms and shared values, high achievement expectations); and the use of assessment and evaluation for improvement. These factors are addressed in the PISA questionnaires as domain-general processes on the school level. Also covered is school-level support for teaching the major domain, such as the provision of laboratory space, information and communication technology (ICT), and a school curriculum for science education.

To meet policy requests directly, PISA also needs to address issues related to governance on the system level (Hanushek and Wößmann 2011; Wößmann et al., 2007). "Locus of decision making" measures and accountability practices describe main aspects of governance, namely the distribution of power and control between central and local stakeholders. Allocation, selection, and assessment and evaluation are the basic processes that policy makers and/or school administrators use to control school quality, and to monitor and foster school improvement. Some of this information can be gained from other sources (as documented in *Education at a Glance*), some can be assessed through the PISA School Questionnaire.

Previous use of PISA context data: Measures that were important for analysis and reporting

In order to evaluate the importance of questionnaire content for PISA, it is worthwhile to look at previous cycles and how their data fed into analysis and reporting. Thus, the relevance of specific measures for policy making and research can be taken into account, in addition to the more abstract constructs mentioned before.

PISA questionnaire data have been used for several types of analyses and reports in addition to OECD reports, for instance to construct education indicators (e.g. *Education at a Glance*) and in scientific research papers. Box 6.1 presents the questionnaire material used in the PISA 2009 report, including non-cognitive outcomes and the impact of background variables, individual and school characteristics, processes and policies as well as system-level factors.

Box 6.1 **Measures based on questionnaires used in *PISA 2009 Results: What Students Know and Can Do***

Volume I: *Student Performance in Reading, Mathematics and Science*

Student background: Gender

Volume II: *Overcoming Social Background: Equity in Learning Opportunities and Outcome*

Student background: ESCS, gender, immigration status, language spoken at home, age of arrival, country of origin

Individual support assessed through Parent Questionnaire: Parental support (at beginning of primary education/at age 15), pre-primary education (attendance, quality)

Volume III: *Learning to Learn: Student Engagement, Strategies and Practice*

Student background: ESCS, gender, immigration status, language spoken at home

Outcomes: Enjoyment of reading, time and material used for reading, metacognition (awareness of strategies), self-reported use of reading strategies (memorisation, elaboration, control)

Volume IV: *What Makes a School Successful? Resources, Policies and Practices*

Student background: socio-economic status, age of school entry, grade repetition

Student-reported processes: learning time (previous education, learning time at school, enrichment/remedial education, after-school lessons), teacher-student relations, disciplinary climate, teacher's stimulation of reading engagement

School input, policies and processes (reported by the principal): type of school (public/private), number of programmes, class size, educational resources (e.g. ICT, library), school responsibility for assessment and curriculum/for resource allocation, extracurricular activities provided, school admittance/grouping/transfer policies, assessment practices/purposes, use of achievement data, school accountability, methods for monitoring teachers, teacher and student behaviour, parent involvement and expectations, leadership.

Source: OECD, 2010a, 2010b, 2010d and 2010e.

The initial report on PISA 2006 studied the impact of schools on student outcomes, while many papers listed on the Education Resources Information Center (ERIC) international data base discuss non-cognitive, domain-specific outcomes using PISA 2006 data. Seventeen of the publications that used multivariate analyses are listed in Appendix 1.

Selecting and organising the core content

Addressing policy needs, and covering measures that have been used for reporting in previous cycles, a selection of core questionnaire content for PISA 2015 and beyond can be proposed. Figure 6.1 organises the suggested content according to the model that has informed the design of international large-scale assessments for a long time (see e.g. Purves, 1987; OECD 2013: 173 ff.). The model allocates background, process and outcome characteristics of education at respective levels of action (i.e. the system level, the school level, including instruction/class/teacher factors, and the individual student level).

Figure 6.1 ■ **Measures to be included in the core context assessment for PISA**

	Student and school background	Processes	Non-cognitive outcomes
System level		**Governance:** Decision making, horizontal and vertical differentiation	(aggregated student data)
School level	School location, type and size of school, amount and source of resources (incl. ICT) Social/ethnic/academic composition Class size, teacher qualification	**School policies:** Programmes offered, admission and grouping policies, allocated learning time, additional learning time and study support, *extracurricular activities*, professional development, leadership, parental involvement, assessment/evaluation/accountability policies, school climate (teacher and student behaviour) **Teaching and learning:** Disciplinary climate, teacher support, *cognitive challenge*	(aggregated student data)
Student level	Gender, socio-economic status (parents' education and occupation, home possessions, number of books at home), language and migration background, grade level, pre-primary education, age at school entry	Grade repetition, programme attended, learning time at school (mandatory lessons and additional instruction), *out-of-school learning*	Domain-general non-cognitive outcomes (e.g. achievement motivation, well-being in school) Domain-specific non-cognitive outcomes (*motivation, domain-related beliefs and strategies, self-related beliefs, domain-related behaviour*)

Note: Measures in italics are adapted to the respective major domain, e.g. science in PISA 2015.

The set of measures included in Figure 6.1 comprises a core context design that covers all construct areas mentioned above, i.e. non-cognitive outcomes, student background, teaching and learning, school policies and governance; and allows for reporting all the analyses that have been included in initial reports, conducting all the research mentioned in Appendix 1, and calculating all indicators that have been developed for *Education at a Glance* (see above)[3]. Figure 6.1 includes all questionnaire indices that have been shown to be strongly correlated with PISA achievement measures (e.g. number of books at home, socio-economic status, self-efficacy, and disciplinary climate), and thus will be instrumental in estimating test scores in PISA ("plausible values"). Therefore, this set of measures is considered for use in further PISA cycles including and beyond PISA 2015. Keeping this core design stable across cycles will enable trend analyses and complex modelling of system-level changes.

Most of the measures mentioned in Figure 6.1 have already been used in previous cycles, mainly in PISA 2006 or PISA 2012, and thus they represent "trend" content that may be kept constant in the future. This includes the science-specific measures from PISA 2006. When reading and mathematics were the major domain of assessment (PISA 2009 and 2012, respectively), different measures were used to represent the same overarching constructs:

- **Cognitive challenge** in classrooms has been represented by teachers' stimulation of reading engagement (2009), opportunities-to-learn (OTL) question types and experience with applied mathematical tasks (2012), and inquiry-based teaching and learning (2006, 2015).
- **Student motivation** has been operationalised by enjoyment of reading (2009), interest in mathematics (2012), and enjoyment of science (2006, 2015).
- **Domain-related behaviour** has been represented by reading for school and diversity of reading material (2009), mathematics work ethics and math behaviour (2012), and media-related science activities (2006, 2015).
- **Domain-related beliefs and strategies** have been represented by subjective norms on mathematics (2012) and environmental awareness and optimism (2006, 2015); self-related beliefs have been represented by mathematics self-efficacy (2012) and science self-efficacy (2015). PISA 2009 introduced a measure of metacognition instead of reading-related beliefs.

EXPANDING THE FRAMEWORK FOR BROADER COVERAGE OF POLICY ISSUES

Modular approach to the PISA design

When the contractor for questionnaire development in PISA 2015 and the Questionnaire Expert Group started their work, they revisited the content areas described above – non-cognitive outcomes, student background, teaching and learning, school policies and governance – and further differentiated them into 19 more fine-graded "modules", which were approved by the PISA Governing Board (PGB) at its meeting in October 2011 – as the building blocks of the PISA 2015 design for context assessment. Figure 6.2 provides a schematic overview of this modular structure, positioning the modules within the overarching structure of background, process and outcome characteristics.

Figure 6.2 ▪ **Modular structure of the PISA 2015 context assessment design**

	Student background		Processes			Non-cognitive outcomes
	Family	Education	Actors	Core processes	Resource allocation	
Science-related topics		5. Out-of-school science experience	1. Teacher qualification and professional knowledge	2. Science teaching practices	12. Learning time and curriculum	4. Science-related outcomes: motivation, interest, beliefs…
				Teaching and learning		
				3. School-level learning environment for science		
General topics	7. Student SES and family 8. Ethnicity and immigration	9. Educational pathways in early childhood	14. Parental involvement 15. Leardership and school management	13. School climate: interpersonal relations, trust, expectations	16. Resources	6. Career aspirations 10. General behaviour and attitudes 11. Dispositions for collaborative problem solving
				School policies		
			17. Locus of decision making within the school system	19. Assessment evaluation and accountability	18. Allocation, selection and choice	
				Governance		

Columns one and two summarise student background characteristics related to their family and the education they received, the three columns in the middle refer to education processes at different levels (system governance, school policies, teaching and learning), and the columns on the right list various outcomes of education. In Figure 6.2, the lower part deals with domain-general topics, while the upper part includes modules that mainly deal with domain-specific (in this case: science-related) topics, including the learning environment at the school level that specifically supports science education (Module 3), such as laboratories, science-related school curricula, collaboration among science staff, and the value attributed to science within the school community. Thus, Figure 6.2 illustrates the combination of domain-general and domain-specific approaches to international large-scale assessment that is typical for all PISA cycles, with either science, reading or mathematics as the major focus of assessment. As PISA integrates cross-curricular achievement measures, like problem solving (in 2012) or collaborative problem solving (in 2015), appropriate non-cognitive outcomes are added (Module 11).

Traditionally, PISA treats the standard questionnaires (School Questionnaire and Student Questionnaire) separately from optional questionnaires that countries may choose to implement or not. PISA 2015 also keeps these questionnaires separate from an operational and reporting point of view, but the Questionnaire Expert Group intended to make the connections between standard and optional questionnaires as transparent as possible. All modules are included in the standard questionnaires to some extent, while the optional questionnaires are used to treat some modules in depth: Educational Career questions address Modules 2, 9, 12 and 14, while the ICT Familiarity Questionnaire contributes to Modules 7, 10 and 16, and the Parent Questionnaire provides content for Modules 5, 8, 9 and 14. The Teacher Questionnaire, which has been added to the design for PISA 2015, is relevant for Modules 1, 2, 11, 12, 15, 16 and 19. Thus, countries opting for any of these additional questionnaires will have additional information available for in-depth analysis of respective policy issues.

The expanded model will guide analysis and reporting in a systematic way:

- Each of the modules can be conceived as a thematic focus for analysis, as will be shown below. Based on a comprehensive review of the corresponding research literature, each module covers main components that are relevant for a specific field of education practice or policy making. Information gathered from students, school leaders and – for countries choosing those options – parents and teachers can be combined to understand patterns and relations within countries and to compare between systems.
- Equity issues in education can be researched by studying outcomes in relation to background factors. (Un-)equal opportunities can be researched by studying schooling offered to various subgroups of students, while efficiency can be described as the relation between outcomes and resources.
- Models of educational effectiveness can be specified and tested by linking schooling to education outcomes, controlling for background factors.

Every module represents a focus of policy making. Thus, the set of 19 modules covers a wide array of policy issues that are relevant across countries. This set is comprehensive, as can be seen by comparing the modular structure with literature on education policy. For example, most topics treated by Sykes, Schneider and Plank (2009) in their state-of-the-art review of education policy research are covered here.

To sum up, the modular approach to context assessment in PISA 2015 allows for a broad coverage of policy issues and related research questions. However, the PISA design sets strict limits on the length of questionnaires; to cover the requested breath of concepts, only some modules or constructs within modules can be focused in more detail. To find relevant points of interest, PGB members were asked to indicate the top priority modules for further development work, based on policy relevance and the need for improvement from previous cycles. More emphasis has been devoted to those areas identified as priorities.

The areas receiving the highest votes for high policy relevance and need of further development work included non-cognitive outcomes (Modules 4 and 10), teaching and learning (Modules 2, 12 and 1), and school policies (Modules 19 and 15). These modules will be discussed in detail in the following sections. Considerable efforts have been made to include measures for those modules in the PISA 2015 field trial and main survey. Other modules will be discussed in a less detailed manner, as their content was drawn from previous cycles with little change.

Assessing non-cognitive outcomes[4]

This section summarises the conceptual foundations for high-priority Modules 10 (domain-general student behaviour and attitudes) and 4 (science-related outcomes: motivation, attitudes, beliefs) as well as those of lower-priority Modules 6 (science career) and 11 (dispositions for collaborative problem solving).

Traditionally, PISA assessed student outcomes in terms of achievement tests. Students' motivations, attitudes, beliefs and behaviours were seen as important precursors of and predictors for scholastic performance, educational attainment and labour-market success. But education policy and labour-market policy are increasingly concerned about these "non-cognitive outcomes" because they are instrumental for personal growth, individual success and the success of society as a whole.

Research has shown the predictive power of non-cognitive outcomes for success in secondary education, higher education and the workforce in general (e.g. Heckman, Stixrud and Urzua, 2006; Lindqvist and Vestman, 2011; Poropat, 2009; Richardson et al., 2012; Roberts et al., 2007). Also, professional and public debates often question the purely achievement-oriented approach of past student assessments. There is more to education than knowledge and cognitive skills; thus non-cognitive outcomes have become increasingly interesting as stand-alone outcomes in their own right. Non-cognitive dispositions are important goals, and they often function as moderators and mediators for relations of other constructs in the assessment. PISA offers a unique opportunity to investigate complex relations between non-cognitive outcomes and achievement at the individual, school and country levels.

Previous PISA cycles have focused on domain-specific student attitudes and behaviours, for instance measuring attitudes towards reading and mathematics, mathematics self-concept, or maths anxiety. Most of these scales display robust relations with student proficiency scores. This tradition is continued with Module 4 (science-related outcomes) in PISA 2015. In addition, the current framework includes a set of domain-general, non-cognitive student factors to broaden the coverage of relevant constructs, increase the policy relevance of the PISA 2015 database, and acknowledge the increased interest in non-cognitive assessments in both policy and research. Questions cover, for example, general achievement motivation. As in PISA 2012, anchoring vignettes (King and Wand, 2007) are used for better measurement to identify and correct for construct-unrelated response styles. This increases the cross-cultural comparability of the derived indices.

Figure 6.3 ▪ **Measures of non-cognitive outcomes included in the PISA 2015 main survey**

Area	Science-related (Module 4)	Domain-general (Modules 6, 10, 11)
Self	**Self-efficacy**	Test anxiety Well-being in general (life satisfaction) **Well-being at school (sense of belonging)**
Interest, attitudes, and motivation	Interest in broad science topics **Enjoyment of science** **Instrumental motivation**	Achievement motivation
Beliefs and preferences	Epistemological beliefs **Environmental awareness** **Environmental optimism**	Collaboration and teamwork dispositions Career aspirations
Technology – ICT		**ICT use** Interest in ICT Perceived ICT competence Perceived Autonomy in using ICT ICT use in social interaction
Behaviour		Health: physical activities Time use: activities before/after school

Note: bold = trend measures.

Science-related outcomes (Module 4)

As science is the major domain assessed in PISA 2015, students' interest and motivation in science, technology, engineering and mathematics (STEM) subjects, plus related beliefs and behaviour are considered to be an important assessment dimension. The second column in Figure.6.3 provides an overview of the respective constructs in the broader domains of self, interest, attitudes, and motivation, beliefs and preferences.

Motivation to learn science and beliefs about oneself as a science learner are important policy and education goals in many countries. Moreover, it has been shown that they are positively associated with students' performance in science (OECD, 2007). This relationship is reciprocal: science-related beliefs and attitudes can be both a consequence and a cause of better science performance.

From a policy point of view, the shortage of skilled workers in technical and science professions – especially among women – has become a concern in recent years, and it is expected to rise in the future (European Commission, 2004, 2006; OECD, 2008). Therefore, PISA aims to identify how interested students are in science. Measures of enjoyment of science and instrumental motivation will allow for reporting trends since 2006.

In addition, environmental issues are a global concern. Threats to the environment are prominently discussed in the media, and students are challenged to understand complex environmental issues. Further, students' levels of environmental awareness and optimism affect their engagement in environmental concerns and, in turn, affect the world's global climate, the economy and society as a whole. Therefore, PISA 2015 includes two measures of environmental beliefs that were developed for PISA 2006.

The following paragraphs provide relevant research background information and the different measures included in the PISA 2015 field trial to cover these outcomes.

Self-related beliefs referring to science learning: Positive self-efficacy belief is highly related to motivation, learning behaviour, general expectations for the future and students' performance (OECD, 2007).

Motivation to learn science covers three constructs: interest in broad science topics, enjoyment of science and instrumental motivation. Motivation to learn that is based on interest and enjoyment is experienced as self-determinate and intrinsic (Krapp and Prenzel, 2011). It affects student engagement, learning activities, performance and career choices, and can be shaped by classroom instructions and parental motivation practices (Gottfried et al., 2009; Kunter, 2005; Rakoczy, Klieme

and Pauli, 2008; Ryan and Deci, 2000). In addition, instrumental motivation is an important predictor for course selection, career choices and performance (Eccles, 1994; Eccles and Wigfield, 1995; Wigfield, Eccles and Rodriguez, 1998). All three constructs have been used in previous PISA cycles, but the interest scale has been substantially revised and split into two measures.

Beliefs about science: Epistemological beliefs are closely related to students' general values of science and scientific inquiry (Fleener, 1996; Hofer and Pintrich, 2002). They include beliefs about science as an evolving and changing subject and how individuals justify knowledge (Conley et al., 2004). Epistemological beliefs have been assessed in the PISA domain of mathematics but not yet in the domain of science.

Environmental issues are a distinct area of beliefs that is covered by two constructs: environmental awareness and environmental optimism. PISA 2006 showed that students from more socio-economically advantaged backgrounds reported higher levels of awareness of environmental issues and that this construct is linked with students' science performance (OECD, 2007). In addition, students reported low levels of environmental optimism, which was negatively associated with students' performance.

Domain-general student attitudes and behaviours (Module 10)

Domain-general attitudes, beliefs and behaviours can be defined as a set of student factors or constructs that cut across curricular topics, or that are independent of curricula, but are nevertheless important for and reflective of success in education. PISA 2015 does not intend to measure global dispositional traits but behavioural tendencies and preferences that are relevant in the context of learning and that can be conceptualised as outcomes of education in general, and schooling specifically.

As shown in the right column of Figure 6.3, the content of Module 10 can be grouped into broader areas that partly parallel the science-related outcomes, widening the goal of assessment well beyond science and technology. The following paragraphs provide links to previous work at the OECD and other research, especially focusing on constructs that are new to PISA, such as well-being, health and time use.

Self-related beliefs and attitudes towards school: Generalised beliefs about one's own success or failure in academic learning have been shown to be strong predictors for further effort and success, including test scores in student assessments. PISA 2015 uses a revised (and generalised) version of a test-anxiety scale that was predictive for mathematics achievement in previous PISA cycles. In addition, a new indicator for generalised achievement motivation (e.g. "I want to be the best, whatever I do") has been introduced. A set of anchoring vignettes (King and Wand, 2007) is implemented to control for response biases and increase cross-cultural equivalence.

Subjective well-being: Subjective well-being can be defined as "good mental states, including all of the various evaluations, positive and negative, that people make of their lives and the affective reactions of people to their experiences" (OECD, 2013, p. 10). The growing recent interest in this construct among researchers and policy makers has resulted in recommendations to statistical agencies to "incorporate questions on subjective well-being in their standard surveys to capture people's life evaluations, hedonic experiences and life priorities" (Stiglitz et al., 2009: 216).

The OECD (2013) responded to this charge by providing guidelines on measuring subjective well-being. To date, 27 out of 34 OECD national statistical offices have committed to collecting at least the minimal information proposed by the OECD guidelines (the single "general life satisfaction" question), which is now included in PISA 2015. The guidelines suggest that it is appropriate to collect such information from 15-year-olds, and even younger students, because the evidence suggests that they are "capable of responding effectively to subjective well-being questions from as young as age 11 with respect to measures of life evaluation and affective state" (OECD, 2013: 152). To assess well-being specifically within the context of school, PISA 2015 uses a question that has been labelled "sense of belonging" in previous cycles.

ICT: ICT-related behavioural characteristics and motivational attributes can be regarded as domain-general student outcomes. Since ICT subsumes a broad range of devices, it may play a role across all education domains. Following the OECD's DeSeCo project and the 21st-Century Skills Initiative, students should exhibit general skills related to information, media and technology above and beyond the traditional core subjects (OECD, 2005; Partnership for 21st Century Skills, 2008). PISA 2015 assesses students' interest in ICT, (self-determined) practices of ICT use, their perceived competence and autonomy in using ICT, and a specific question on use of social media within the ICT Familiarity Questionnaire.

Health: This area addresses the practice of healthy behaviours, particularly behaviour pertaining to regular exercise, and health-related lifestyle choices. Research has shown that poverty and low socio-economic status is associated with poor health outcomes (Spurrier et al., 2003). Research has also shown that physical activity can improve academic performance due to the activity itself and to the consequent reduction of more passive activities (Salmon et al., 2005).

Physical exercise can be (positively as well as negatively) influenced by teacher behaviours and school practices. The approach to measuring physical activity in PISA 2015 is adapted from and closely aligned with the Global School-based Student Health Survey of the World Health Organization. That survey is conducted among adolescents of roughly the same age as the PISA population. Relating these data to PISA measures of student and school background will help to develop an understanding of the issues of equity and health in education.

Career aspirations (Module 6)

The PISA 2015 Student Questionnaire includes two questions about career aspirations that were used in 2006. They ask about the highest education level the student expects to complete and the job he or she expects to have at the age of 30.

Non-cognitive outcomes related to collaborative problem solving (Module 11)

In order to cover dispositions related to the new domain of assessment introduced in PISA 2015, namely Collaborative Problem Solving, a set of items on valuing team work, co-operating, guiding others and negotiating was developed based on research by Wang and colleagues (2009). The Teacher Questionnaire covers types of activities and grouping, and rewards for team work from another perspective.

Assessing teaching and learning processes[5]

This section summarises the conceptual foundations for high-priority Modules 2 (science teaching practices), 12 (learning time and curriculum) and 1 (teacher qualifications and professional knowledge) as well as those of lower-priority Module 5 (out-of-school science experience).

Teaching and learning are at the heart of schooling. Most cognitive and non-cognitive, curricular and cross-curricular goals of school education are achieved – or not – by the way students and teachers interact in classrooms. While teaching is the core process in schools, the curriculum determines its content, and professional teachers implement the curriculum, orchestrate learning activities, and thus arrange for quality learning time.

PISA has been designed as a yield study, assessing life-skills and broad areas of literacy rather than curricular domains, sampling a birth cohort rather than a grade level or intact classrooms. Thus, it might be questioned why this programme should address teaching and learning processes at all. However, there is ample evidence that teaching and learning activities are the best predictors of student competencies, whatever their character might be. So, if PISA is to inform education policy making at the system and the school levels, it must cover this important area.

Clearly, the PISA study should focus on more general and internationally comparable constructs rather than fine-grained content matter. Therefore, Module 2 describes science education by broad lists of teaching and learning activities, covering both inquiry-based teaching (which was assessed in PISA 2006) and teacher-directed practices. In addition, general dimensions of teaching quality, such as classroom disciplinary climate, teacher support, feedback and adaptability, are applied to science education. Module 12 covers learning time – including non-mandatory, additional instruction within and out of school – as well as the science curriculum. In addition, the teaching force is described in terms of initial education, beliefs and professional development (Module 1).

Science teaching practices (Module 2)

According to the PISA approach to scientific literacy, the main task of science teaching is to foster students' capacity to explain phenomena scientifically, understand scientific enquiry and interpret scientific evidence. The key topic of the framework outlined below is the extent to which schools are mastering this task.

A number of processes at the classroom level have been found to be relevant for effectiveness in science education. In this framework, both domain-specific instructional approaches and activities, and more general dimensions of instructional quality are combined, as they are equally suited to support learning activities and describe processes on the classroom level. However, in PISA 2015, all questions about teaching and learning activities are framed within the context of school science, sometimes even referring to one specific course. The aim is to describe science teaching in the classroom by country-specific profiles of teaching practices, and to investigate their relation to students' outcomes.

Analyses based on PISA 2006 show that a student's outcome can be predicted by different profiles of practices in teaching (Kobarg et al., 2011). While some teaching patterns are related to high performance, others are related to high student interest and motivation. The results indicate that the items and scales for science teaching practices are applicable to in-depth descriptions of science teaching in the classroom. Moreover, a comparison of the patterns allows for detailed analyses of both students' science performance and students' interest in science topics across countries (Kobarg et al., 2011; Prenzel, Seidel and Kobarg, 2012). The teaching-practices items are developed and chosen in order to discriminate between different patterns of teaching.

Teaching and learning activities: Research has shown that inquiry-based teaching practices, which play a significant role in science education, have a positive effect on student learning, particularly students' engagement in the cognitive dimensions of inquiry and teacher-led inquiry activities (Furtak et al., 2012). Inquiry-based instruction seems not only to improve achievement (Blanchard et al., 2010), but also attitudes towards the subject and transferable critical thinking skills (Hattie, 2009).

There is a renewed interest in embedding science teaching and learning in contexts that are real and meaningful for learners (Fensham, 2009; King and Stephen, 2012). Scientific argumentation as a central goal of science education (Osborne, 2012) needs classroom situations with sufficient opportunities for social interaction. Instruction that emphasises students' active thinking and drawing conclusions from data seems to be particularly beneficial for students' development (Minner, Levy and Century, 2010). According to these findings and the analysis of the PISA 2006 items (Kobarg et al., 2011, Taylor, Stuhlsatz and Bybee, 2009), a subset of nine items from PISA 2006 is used for this scale: six of the items are unchanged from 2006; three were slightly revised.

In addition to the inquiry-based teaching practices, teacher-directed teaching and learning activities in science focus on classroom management activities and teaching methods, and broaden the perspective of domain-specific practices. The purpose is to obtain student-reported information about their actions in school science lessons and to get a realistic picture of what is going on in science classes – including classes with little inquiry-based learning.

The student perspective on science teaching is complemented by the Teacher Questionnaire, for those countries that participate in this option. Science teachers are asked to describe their teaching practices through a parallel questionnaire that also focuses on teacher-directed teaching and learning activities in science lessons, and a selected set of inquiry-based activities. Both perspectives may be combined and compared on the school level.

Dimensions of teaching quality: Several classroom studies confirm the impact of three basic dimensions of instructional quality on students' cognitive and motivational development: clear, well-structured classroom management; supportive, student-oriented classroom climate; and cognitive activation with challenging content (Klieme, Pauli and Reusser, 2009). In previous PISA cycles, the first two dimensions were covered by questions about classroom disciplinary climate and teacher support, respectively. As a school-climate variable, the purpose of the disciplinary climate question is to gather information on the structure and efficiency of classroom management, which can be seen as a prerequisite for student learning. The teacher-support question measures how often the teacher helps students with their learning (OECD, 2004).

Research has shown that the scale is positively related to students' interest (Vieluf, Lee and Kyllonen, 2009). Concerning a measure of cognitive activation, it is assumed that the level of cognitive challenge is determined by the type of problem and the way it is presented in the lesson. Therefore, "inquiry-based science education" serves as an indicator of cognitive activation in PISA 2015. In addition to these three dimensions, PISA 2015 includes a measure of adaptability in teaching, as perceived by students.

Learning time and curriculum (Module 12), including out-of-school science experience (Module 5)

The learning time and curriculum to which students are exposed in the course of their education are closely related to student outcomes (e.g. Schmidt and Maier, 2009; Abedi et al., 2006; Scherff and Piazza, 2008).

Learning time has proven to be a central factor in student learning and achievement (Gándara et al., 2003; Patall, Cooper and Allen, 2010; Scheerens and Bosker, 1997; Seidel and Shavelson, 2007). Such positive relationships were replicated in international comparative research, pointing to the cross-cultural comparability of the construct and its effects (e.g. OECD, 2011; Martin et al., 2008; Schmidt et al., 2001). Yet although there is an overall positive relation between learning time and achievement, there are large differences within and across countries and among different groups of students and schools (Ghuman and Lloyd, 2010; OECD, 2011).

Overall it is important to distinguish among learning time that is provided by the school system, realised or implemented by the school and the teacher in the classroom, and used by the students. On this path from "gross" learning time as allocated in system-level policies to student "time-on-(the right) task", many factors, at different levels (school, classroom and student) reduce available learning time to varying degrees across countries (Gillies and Quijada, 2008; Benavot, 2004). Differences in that reduction among various subgroups of students can indicate equity – or lack thereof – in education opportunities, because research shows that relations with outcomes are stronger when learning time is more narrowly defined (e.g. time-on-task instead of allocated learning time). Therefore, PISA 2015 intends to apply a broader view of learning time (Abadzi, 2009; Berliner, 1990; Millot and Lane, 2002).

At the school level, PISA 2015 assesses provided learning time (PT), but there is loss of time due to such factors as local festivities, teachers' strikes, illness or other teacher absenteeism (see Ghuman and Lloyd, 2010; Chaudhury et al., 2006). Another proportion of time is then used in the classroom, resulting in realised learning time (rt). Time loss at the classroom level is most commonly due to non-teaching activities like classroom management, collecting homework or waiting time (e.g. MacKay, 2009; The PROBE Team, 1999), which leaves realised learning time as the fraction of time during which a class is taught.[6] The proportion of realised learning time during which a student learns course content is engaged learning time (ET). This excludes periods in which a student does not attend class due to illness, truancy, being late or being physically present but mentally disengaged. Engaged learning time is the only time during which students actually learn. Figure 6.4 provides a summary of these time-related constructs, how they are defined and how they may be estimated.

Moreover, it has been shown that next to the absolute amount of time available for learning, students' time-use patterns relate to success variables and can help explain associations between student background variables (such as socio-economic status) and performance variables (such as mediator variables, see Porterfield and Winkler, 2007). In the PISA 2015 main survey, students' time use before and after school is assessed with a set of newly designed questions that was developed in parallel to Kahneman's et al. (2004) "Day-reconstruction method".

Figure 6.4 ▪ **Assessment of learning time and loss of learning time in PISA 2015**

		Student Questionnaire	School Questionnaire	
Use	Student	+ Additional instruction and study (time use) - Truancy		Engaged time (ET) = RT – student absenteeism, truancy, mentally disengaged time
Provision	Classroom	- Disciplinary climate and loss in science classes		Realised learning time (RT) = PT – loss due to classroom management, assessment time, waiting time, etc.
	School	+ Amount of school learning time + Number and type of science classes	- Loss on school level	Provided learning time (PT) = AT – loss due to weather, holidays, teacher absenteeism, etc.

In addition to learning times for mandatory schooling, other in-school and out-of-school learning activities are also taken into account. PISA 2015 attempts to identify additional learning time in a cross-culturally valid way, incorporating, for example, different formats, location, content and purposes. Information from the School and Student Questionnaires, and from the optional Educational Career Questionnaire can be combined to get the full picture. Similarly, information on extracurricular learning activities, time use before and after school every day, and science-related experiences is gathered from students, from parents in the optional Parent Questionnaire, and from school leaders in the School Questionnaire.

Curriculum: There may be great differences between the curriculum designed at the system level, the curriculum delivered by the teacher or in the textbook, and the curriculum as understood by students. For the major domain of PISA 2015, "science", differences in the curriculum are particularly large across tracks, grades, schools and countries (Schmidt et al., 2001; Martin et al., 2008). In order to examine some of this variety, the optional PISA 2015 Science Teacher Questionnaire asks about the content of a school's science curriculum and how it is communicated to the parents.

Teacher qualification and knowledge/beliefs (Module 1)

Many studies show a clear link between teacher-related factors and student learning. In addition to teachers' professional behaviour within the classroom (see above), the age and education level of the teaching force, teachers' initial education and qualifications, their individual beliefs and competencies, and their professional practices on the school level, such as collaboration and professional development, have been core topics in education policy.

Some basic information on these topics will be available from the PISA 2015 School Questionnaire, while the optional Teacher Questionnaire, which is partly based on instruments previously established in the OECD Teaching and Learning International Survey (TALIS), features additional constructs, both science-specific and domain-general (Figure 6.5). This instrument is new to PISA, although national instruments have been added to the PISA design in Germany and Ireland in previous cycles, with broad support from the teaching force. Other large-scale studies, such as Trends in International Mathematics and Science Study (TIMSS), have implemented teacher questionnaires without any loss in participation. Thus, the new optional instrument will finally give teachers a voice in PISA.

Figure 6.5 ▪ **Teacher-related measures in the PISA 2015 field trial**

	Science-related	General
Background	Gender, age, employment status, job experience, subjects studied	
Initial education	Goal of first qualification, type of teacher education and training programme (if attended), mode of qualification Number of teachers by education level (ScQ)	
	Science-related content Number of science teachers by level of qualification (ScQ)	
Professional development	Participation in different type of activities Obligation amount of participation, school policies (ScQ)	
	Collaboration Science-related content	Co-operation General content
Beliefs	Self-efficacy (related to science content and teaching science)	Job satisfaction

Note: If not indicated otherwise, constructs are included in the optional PISA 2015 Teacher Questionnaire.

Across these topics, a distinction is adapted that Shulman (1985) suggested for research on teachers: teachers' beliefs and activities can be related either to the subject matter taught, its conceptual foundations, basic ideas, etc. (content), to teaching and learning the subject matter, including issues of student understanding, teaching practices, assessment procedures, etc. (pedagogical content), or to general concepts, such as classroom management (pedagogy).

Shulman's model has been most influential in research on teachers (e.g. Hill, Rowan and Ball, 2005; Baumert et al., 2010; Bloemeke et al., 2012). In line with this research, PISA 2015 identifies content, pedagogical content, and/or pedagogy as the foci of teacher-related constructs, including initial education and professional development. There is no attempt to measure teachers' knowledge.

Teachers' background and initial education: Understanding the multiple pathways leading to the teaching profession, including mid-life career changes, is important for education policy because there is a growing need to recruit teachers from non-traditional backgrounds. For these people, but also for novice teachers with traditional training, the induction stage is important (Portner, 2005). Teacher retention is another concern in many countries (Ingersoll and Perda, 2010). In addition to formal qualifications (tertiary/secondary education certificates and academic degrees), a major in the subject being taught, the type of teacher education and training programmes attended, and professional experience (i.e. years having taught science at school), PISA 2015 asks teachers about the representation of the three foci in their initial education.

Professional development and collaboration: Professional development refers to any activity that equips teachers with the tools and resources necessary to provide quality instruction. It includes school-based programmes as well as networking, coaching, seminars or other types of training activities that foster in-service learning and thus promote the professionalisation of teaching. Even though professional development is generally regarded as crucial for improving

teaching and student achievement, Sykes referred to the ineffectiveness of common trainings as "the most serious unsolved problem for policy and practice" (Sykes, 1996: 465). However, more recent studies report positive effects on teaching practices and classroom climate (Cuevas et al., 2005; Desimone et al., 2002; Jeanpierre, Oberhause and Freeman, 2005; Supovitz and Turner, 2000; Timperley et al., 2007), as well as on student achievement (e.g. McDowall et al., 2007; Shayer and Adhami, 2007). This apparent inconsistency may be partly resolved by accounting for different features of the programmes examined. Summarising previous studies, Buczynski and Hansen describe ineffective programmes as being "too conventionally taught, too top-down, and too isolated from school and classroom realities to have much impact on practice" (Buczynski and Hansen, 2010: 600).

As early as in the 1980s, scholars indicated the benefits of supportive networks for teachers (e.g. Darling-Hammond, 1984; Rosenholtz, 1989; Bryk and Driscoll, 1988). In the 1990s the idea of "professional learning communities" emerged. This notion refers to groups of teachers who co-operatively reflect and improve their professional practices (Hord, 1997). Research on professional learning communities is still limited, but there is some indication of positive effects on education processes and outcomes (e.g. Lomos, Hofman and Bosker, 2011). In China, for example, teachers are often organised in groups that work together studying national guidelines and defining teaching goals, that co-operate for preparing and improving teaching, and that organise observation visits to provide colleagues with feedback and involve teachers in out-of-school activities (Paine and Ma, 1993). Similarly, in Japan "lesson studies" are common practice among teachers (Stigler and Hiebert, 1999). TALIS further suggests that the pattern of activities also varies between countries (Vieluf et al., 2011).

The PISA School Questionnaire in 2000 and 2012 included a question about the proportion of teachers who had recently (within the previous three months) participated in some kind of professional development activity. In 2012, the same question was asked with a focus on mathematics teachers. However, this information did not show any substantial relation to student outcomes. Therefore, PISA 2015 intended to enhance measurement of professional development by adapting questions from TALIS and other sources (e.g. Steinert et al., 2006).

Professional beliefs: PISA uses a measure of job satisfaction also used in TALIS. Science teachers are asked to report self-efficacy beliefs regarding science content and how it is taught.

Teachers' morale and commitment was assessed in PISA cycles 2000, 2003 and 2012 in the School Questionnaire that was completed by the principal (or some other member of the school management team), aiming to assess attitudes among teaching staff. These measures are included in PISA 2015 in Module 13, "school climate".

The main level of analysis for data gathered in the optional Teacher Questionnaire is the school level. No weighting for individual teacher responses are available. All data from the Teacher Questionnaire are thus treated as school variables.

Assessing school policies and governance[7]

This section summarises the conceptual foundations of high-priority Module 19 (assessment, evaluation and accountability) as well as those of lower-priority Modules 3 (school-level learning environment for science) and 13-18.

Assessment, evaluation, and accountability (Module 19)

Assessing students and evaluating schools[8] is a common practice in most countries. Since the 1980s, policy instruments, such as performance standards, standard-based assessment, annual reports on student progress and school inspectorates, have been promoted and implemented across continents. Reporting and sharing data from assessments and evaluations with different stakeholders provides multiple opportunities for monitoring, feedback and improvement.

In recent years, there has been a growing interest in the use of assessment and evaluation results through feedback to students, parents, teachers and schools as one of the most powerful tools for quality management and improvement (OECD 2010d: 76). Accountability systems based on these instruments are increasingly common in OECD countries (Scheerens, 2002: 36). Accountability is often linked to market-oriented reforms. Rewards/penalties for good/poor assessment and evaluation results are said to change behaviours in ways that improve student achievement (Wößmann et al., 2009). However, there are huge differences in assessment and evaluation practices and purposes.[9]

Previous PISA cycles have covered aspects of assessment, evaluation and accountability in the School Questionnaire, with a strong focus on the use of standardised tests. In PISA 2015, this module asks both about standardised and less standardised practices. Internal and external evaluations address different purposes and consequences and will be dealt with separately. Teacher evaluation is also addressed as a means of quality management.

Formative assessment and feedback are increasingly popular in research and teaching practice. These types of assessment and evaluation differ with respect to their respective purposes and criteria, practices, use and consequences (Pellegrino, Chudowsky and Glaser, 2001; Scriven, 2003; Wilson, 2004) (see Figure 6.6). These aspects are covered in the PISA 2015 questionnaires as much as possible.

In the following section, relevant research on school evaluation and student assessment is summarised to provide the rationale for questionnaire development in PISA 2015.

Evaluation: The evaluation of schools is used as a means of assuring transparency, judging systems, programmes, educational resources and processes, and also guiding school development (Faubert, 2009). Evaluation criteria need to be defined and applied from the viewpoints of different stakeholders (Sanders and Davidson, 2003).

Evaluation can be either external or internal (Berkemeyer and Müller, 2010). It is called external evaluation if the process is controlled and headed by an external body and the school does not define the areas that are judged. An evaluation is called internal if it is part of a process controlled by the school and in which the school defines which areas are judged. The evaluation may be conducted by members of the school (self-evaluation) or by persons/institutions commissioned by the school. Different evaluation practices generally coexist and benefit from each other (Ryan, Chandler and Samuels, 2007).

External evaluation can expand the scope of internal evaluation, validate results and implement standards or goals; internal evaluation can improve the interpretation and increase the use of external evaluation results (Nevo, 2002). However, improvement of schools seems to be more likely when an internal evaluation is applied, compared to external evaluation. Therefore, processes and outcomes of evaluation might differ, depending on whether the evaluation is internal or external. Moreover, country- and school-specific factors may influence the implementation of evaluations as well as the conclusions and effects for schools. In many countries, individual evaluations of teachers and principals, separate from school-wide evaluation, are also common (Faubert, 2009; Santiago and Benavides, 2009); they are treated here as a separate type of evaluation.

Figure 6.6 ▪ **Measures in PISA 2015 related to assessment, evaluation and accountability**

	External evaluation	Teacher evaluation	Internal evaluation	Formative assessment
Purpose and criteria	General assessment practice (ScQ) Purpose of assessment results (ScQ)			
	Evaluation policies (ScQ)			Teacher's grading (TQG)
Practices		Teacher-evaluation methods (ScQ)		Classroom-assessment instruments (TQG/TALIS)
Use and consequences	Processes of external evaluation (ScQ) Use of achievement data for accountability (ScQ)		Consequences of internal evaluation (ScQ)	Feedback: student perception (StQ) Adaptation of instruction (StQ)

Results of evaluations may be used in a formative way (e.g. to guide the analysis and improvement of processes) or in a more summative way (e.g. for accountability). Formative evaluation aims at closing the gap between the as-is state and the target state. Here, teaching and school-based processes are to be guided to a predetermined goal. Summative evaluation focuses on student outcomes and encourages schools to meet specific standards. Formative evaluation has turned out to be more effective in school improvement than summative evaluation (Creemers and Kyriakides, 2008). Effects or consequences of evaluation may differ, depending on the focus of evaluation, the procedure chosen for the evaluation, or a school's goals and priorities.

Assessment: Communication and clarification of achievement goals within schools is essential in students' learning (Brookhart, 2007; Stiggins, 2007). National standards that have emerged in recent years define what students should know (Koeppen et al., 2008; Shepard, 2006). These education standards directly shape school policies and classroom instruction by urging schools and teachers to communicate specific aims leading to a shared understanding. To check whether these goals are met, schools follow a given assessment practice or define their own. This can be implemented in the classroom learning process by more or less standardised tests and oral examinations developed by the teacher.

In addition, mandatory and non-mandatory standardised and externally developed tests verify and compare student outcomes at the classroom, school, district, state or international level (Shepard, 2006). Irrespective of the purpose and the stakeholder administering the assessment, a test must fulfil a number of quality criteria (Scheerens, Glas and Thomas, 2003). In general, standardised tests are more reliable measures, but may be less aligned with the school curriculum, and vice versa for teacher-made assessments.

The distinction between formative and summative, internal and external approaches also holds for student assessment. In its summarising function, assessment takes place in order to grade, certify or record progress. Summative assessment, whether external or internal, thus indicates and monitors standards, but may also raise standards by encouraging students, as well as teachers and schools, to put more effort into their work (Harlen and Deakin Crick, 2002). On the other hand, summative assessment might lead to lower self-esteem and diminished effort of students at risk, and therefore can increase the gap between lower- and higher-achieving students (Black and Wiliam, 2004).

Another negative aspect of assessment may arise when teaching solely focuses on answering questions, rather than on developing skills and knowledge (Harlen and Deakin Crick, 2002). Grading is arguably the most prevalent type of classroom assessment, and an essential aspect of effective teaching (McMillan, 2001; Guskey, 2007). Grades have been shown to be unreliable and of limited validity, but there is very little comparative research on grading practices in different countries.

Formative assessment can be a significant source of improvement in student learning processes (e.g. Shepard, 2006; Black and Wiliam, 2004; McMillan, 2007; OECD, 2006b). Especially for low achievers, formative assessment can lead to sizable gains in student achievement (Abrams, 2007). Formative assessment and reciprocal feedback might not just be useful for students, but also for teachers, helping them to adapt their instruction to their students' needs. However, there is large variation in the implementation and impact of formative assessment practices (e.g. Kingston and Nash, 2011; Shute, 2008; Hattie and Timperley, 2007; Black and Wiliam, 1998). Therefore, it is worthwhile to study cross-national variation in formative assessment practices through PISA 2015.

The School Questionnaire for PISA 2015 includes several questions on general assessment practices and results, external evaluation and teacher evaluation that have been used in previous cycles, to report trends. However, in line with the research cited above, internal school evaluation and formative, classroom-based assessments are given more weight in PISA 2015 than in previous cycles.

Other school policies and approaches to educational governance

During the past two decades, research on educational effectiveness has largely been concerned with the impact of school-level factors on students' learning. Studies show that school qualities have effects on student progress, with variation in schools appearing to affect students' behaviour. It has been asserted that the environment at the school level can influence the behaviour of teachers and students and thus – mostly indirectly – their consequent success in teaching and in learning. Both "soft" factors, such as school climate and parental involvement, and "hard" factors, such as school management activities and allocation policies, vary and are related to student outcomes within and across countries.

School climate (Module 13): School climate encompasses shared norms and values, the quality of relationships and the general atmosphere of a school. An academic focus – a general consensus about the mission of the school and the value of education, shared by school leaders, staff, and parents – influences the norms in student peer groups and facilitates learning. In addition, an orderly learning atmosphere maximises the use of learning time. By contrast, disrespectfulness and an unruly environment are counterproductive for teachers and students alike and distract from the school's actual mission. As in previous PISA assessments, indicators for school climate is gathered through the School Questionnaire ("behaviour affecting school climate").

PISA 2015 adds two new measures covering aspects of school climate that are often hidden, but nevertheless highly important from both a pedagogical and a policy point of view: bullying by peers and unfair treatment by teachers, as perceived by the students. Bullying has been identified as an important factor of school culture (Ertesvag and Roland, 2015) and school climate (Wang, Berry and Swearer, 2013) that is relevant across cultures (Smith et al., 2002).

Parental involvement (Module 14): Over the past years, the involvement of parents in education has gained importance in the education debate, and to some extent it has also become relevant for education policy. Parents are not only an important audience, but powerful stakeholders in education. Thus information on parents' opinions and engagement is highly valuable for large-scale assessments like PISA. Parental involvement in education has been assessed in PISA

since 2006 when the Parent Questionnaire, which directly addresses the parents of PISA students, was administered for the first time. For PISA 2015, specific aspects of parental involvement are added to the School Questionnaire (for parent-school communication and collaboration), and to the Student Questionnaire (for parental support in learning). In particular, four items on parental support are asked in parallel of students and of their parents, so that perceptions can be compared on an individual level.

Leadership and school management (Module 15): School principals play a key role in school management. They can shape teachers' professional development, define the school's education goals, ensure that instructional practice is directed towards achieving these goals, suggest modifications to improve teaching practices, and help solve problems that may arise within the classroom or among teachers. The PISA measure of educational leadership saw a major revision in the 2012 study. This work has been reviewed, and the leadership scale could be considerably shortened. In addition, the new optional Teacher Questionnaire gathers information on transformational leadership from teachers as well, because research has shown that the teachers' perspective on leadership can differ from the positions held by school administrators.

Resources (Module 16): Information on school type (public vs. private) and class size has always been included in the School Questionnaire. In addition to these trend questions, PISA 2015 allows for distinguishing between types of private schools (religious/denominational, not-for-profit, for-profit). All PISA cycles so far have included a question on the degree of problems a school experiences due to missing resources. The different approaches over time are systematised and implemented in one coherent question in the School Questionnaire.

Locus of decision making (Module 17): Education systems have been classified by the amount of control that is left to the school (i.e. school board, staff and school leaders) when decisions on admission, curriculum, allocation of resources and personnel have to be made. These indicators are based on questions in the School Questionnaire that are left unchanged to allow for trend reporting.

Allocation, selection, choice and grade repetition (Module 18): The way students are channelled into education pathways, schools, tracks or courses is a core issue of educational governance ("stratification"). On the school level, selection and allocation procedures are important aspects of school organisation. Highly selective schools provide a learning environment that may differ from the environment offered by more comprehensive schools. For all those reasons, appropriate trend questions answered by school administrators and parents have been retained.

School learning environment for science (Module 3): Conceptually, this module overlaps to a considerable degree with other modules dealing with school-level factors, such as Module 12 (Learning time and curriculum), Module 15 (School leadership and management), and Module 19 (Assessment, evaluation and accountability). In addition to those, there are questions addressing the size and qualification level of the science teaching staff, and concerning available resources, such as laboratories and equipment for hands-on student activities.

Assessing student background (Modules 7–9)[10]

This section covers three modules that were given lower priority by the PISA Governing Board: Module 7 (student socio-economic status, family and home background), Module 8 (ethnicity and migration) and Module 9 (educational pathways in early childhood). Nevertheless, these topics, and Module 7 in particular, are important, because they contain the basic information needed for calculation of the PISA index of economic, social and cultural status (ESCS).

Student socio-economic status, family and home background (Module 7): In order to compare equity related to social and ethnic factors across PISA cycles, PISA 2015 keeps measures of socio-economic status and other background variables basically unchanged. However, some minor changes have become necessary. Due to extensive development in the ICT sector, for example, questions on technology equipment in the student's home are slightly outdated. Thus, the measures of home possessions have been updated to ensure better coverage of within and across country variation of home possessions. These changes are expected not to have any effect on the important trend measures in this module.

Ethnicity and migration (Module 8): Linguistic and cultural diversity are basic facts of life in most regions of the world. Many nations are home to several subpopulations with different languages and cultures. International migration perpetuates this diversity. In OECD countries, first- and second-generation immigrant students currently comprise 10% to 20% of the student population (OECD, 2010). At the same time, students from ethnic minority groups and immigrant students often face particular challenges. In a number of education systems, immigrant students perform at significantly lower levels than their non-immigrant peers in key school subjects (Stanat and Christensen, 2006); both groups are often faced with overt or covert discrimination with potentially detrimental consequences for their psychological development and well-being. Thus, providing students from different linguistic and cultural backgrounds with equal opportunities is often considered

one of the central challenges for education systems in the 21st century. Due to cultural concerns in some countries and time restrictions in the Student Questionnaires, however, PISA 2015 retains the questions on immigration and language background that have been used in previous cycles. This information is slightly enhanced by asking principals to estimate the percentage of minority students (language minorities, socio-economically disadvantaged and special needs) among 15-year-old students in their school.

Education pathways in early childhood (Module 9): When children enter primary school, they already differ in their language, pre-reading and early numeracy skills, and these differences are often maintained later in life. Promoting school readiness and better adjustment to school is hypothesised to be an efficient means of raising the achievement levels of all children, but especially of those children who lack parental support or who grow up in disadvantaged circumstances. It has been argued that investing in early education programmes will have large, long-term monetary and non-monetary benefits (Heckman, 2006). The importance of pre-school quality has been acknowledged and analysed by OECD reporting as well.

According to UNESCO (2006), early childhood care and education (ECCE) is defined as “programmes that, in addition to providing children with care, offer a structured and purposeful set of learning activities either in formal institutions (pre-primary) or as part of a non-formal child development programme”. The focus of the internationally comparable statistics, International Standard Classification of Education Level 0 (ISCED 0), is much narrower. Currently, at least four strands of research support the relevance of applying a broader definition of ECCE than focusing on ISCED 0 alone: brain research, studies on domain-specific development and support, evaluation studies of model programmes, and longitudinal large-scale studies all rely on the broader definition of ECCE. Thus, conclusions about the importance of early child care should be drawn with ECCE and not with ISCED 0 in mind.

However, when evaluating the body of research it becomes obvious that, in fact, a number of characteristics of the kind of ECCE provided seem to determine whether benefits can be observed or not, and whether these benefits disappear or persist. Students’ opportunities to learn in early childhood are best assessed in terms of curriculum, quantity and quality of early childhood learning experiences. For example, one of the best sources available, the British Effective Provision of Pre-School Education (EPPE) Study, did find short-term effects showing that pre-school attendance was beneficial for cognitive and socio-emotional development, particularly for children from disadvantaged backgrounds. However, in the long term only those children who attended a high-quality pre-school centre showed persistent beneficial pre-school effects (e.g. Sammons et al., 2008; Sylva et al., 2011a; see also Valenti and Tracey, 2009). A certain degree of intensity in terms of hours per week/months seems to be a precondition for beneficial effects of attendance at pre-school programmes (Logan et al., 2011; Sylva et al., 2011b).

Thus, asking about early education experience in PISA only makes sense if specific aspects of programme duration, quality and curriculum can be retrieved retrospectively, which is more than unlikely (Fivush and Hamond, 1990; Markowitsch and Welzer, 2009). As a consequence, PISA 2015, while keeping a short question on ISCED 0 attendance in the Student Questionnaire, includes a series of questions in the Parent Questionnaire, expecting parents to be a more reliable source of information. Those countries that distribute the optional Parent Questionnaire will acquire information on basic characteristics of the early childhood education and care arrangements of PISA participants, and reasons for attending or not attending early childhood education and care.

Notes

1. In the past, other, more technical notions of “core” have been used in the PISA Questionnaire Design. One approach used “core” to denote a set of variables in the Student Questionnaires that are measured for all students in a given PISA cycle – even in cases where different booklets are assigned to them. Another approach defined “core” as the set of variables used for imputing plausible values of test scores. A third approach referred to “core” as the set of domain-general variables, i.e. those not related to the major domain of assessment. Please note that in contrast to those definitions, this framework identifies “core content” as a set of conceptual constructs that defines the most basic context assessment necessary in PISA. This set of constructs (has been and) should therefore be included in all PISA cycles, albeit in some cases adapted to the major domain.

2. From a technical point of view, it is also important to note that this stable set of background variables guarantees a strong set of conditioning variables used to impute measures of student proficiencies, as explained in the PISA Technical Reports (e.g. OECD 2014: 146).

3. With the exception of optional material, such as the Parent Questionnaire, the ICT Familiarity Questionnaire, the Educational Career Questionnaire and the PISA 2000 Questionnaire on cross-curricular competencies.

4. This section is based on working papers submitted by Anja Schiepe-Tiska, Christine Sälzer and Manfred Prenzel for Module 4, Jonas Bertling and Patrick Kyllonen for Module 10. Module 11 was developed in co-operation with Core 1 and the Collaborative Problem Solving Expert Group chaired by Art Graesser.

5. This section is based on working papers submitted by Katharina Müller, Manfred Prenzel and Tina Seidel for Module 2, Susanne Kuger for Module 12, Eckhard Klieme, Franz Klingebiel and Svenja Vieluf for Module 1.

6. At least at this level, “time loss” refers to diminished learning time that focuses on curricular content and therefore on domain-specific cognitive outcomes. More overarching goals of education, such as self-regulation, interest or social competencies, might very well be stimulated during “lost” time periods.

7. This section is based on working papers submitted by Sonja Bayer, Eckhard Klieme and Nina Jude for Module 19, Leonidas Kyriakides for Module 3, Silke Hertel, Nadine Zeidler and Nina Jude for Module 14 (Parental Involvement) and Bieke de Fraine for Module 15 (School Management).

8. The terms “evaluation” and “assessment” are defined quite differently in the literature. Sometimes they are even treated as synonyms. In this section the definition used conforms to that used in current OECD literature (see e.g. Rosenkvist, 2010). The term evaluation or school evaluation is used for processes on the school and system levels. Evaluators collect evidence to judge systems, education programmes, policies and practices. This may include an evaluation of individual performance among professionals, such as teacher evaluation. Assessment or student assessment, on the other hand, directly refers to student performance or student learning processes (see also Harlen, 2007). Notably, there is a strong link between assessment and evaluation. For instance, results from student assessments may be used for school evaluation purposes.

9. See OECD’s country reviews of assessment and evaluation www.oecd.org/education/preschoolandschool/oecdreviewonevaluationandassessmentframeworksforimprovingschooloutcomescountryreviews.htm.

10. This section is based on working papers submitted by Wolfram Schulz for Module 7, Svenja Vieluf for Module 8, Susanne Kuger and Hans-Günter Roßbach for Module 9.

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Annex 6.A

Selected analytical models used in publications on the PISA 2006 data for contexts of science achievement

Publication	Research Question or Model
Nagengast and Marsh (2014)	Cross-cultural measurement invariance for motivation and engagement in science
Drechsel, Carstensen and Prenzel (2011)	Dimensionality of science interest
Olsen and Lie (2011)	Country- and culture specific profiles of interest
Ainley and Ainley (2011a)	Students' enjoyment, learning engagement, and achievement
Ainley and Ainley (2011b)	Knowledge, affect, value, and students' interest in science
Lavonen and Laaksonen (2009)	Learning activities, interest in science, self-efficacy, self-concept, and performance
Fensham (2009)	Gender, task context and science performance
Buccheri, Gruber and Bruhwiler (2011)	Gender specificity in interest and vocational choices
Mc Conney et al. (2011)	Science interests among minority students
Luu and Freeman (2011)	Scientific literacy and ICT-related variables
Kubiatko and Vlckova (2010)	
Ho (2010)	Parental involvement and students' science performance
Basl (2011)	Explaining interest in future science-related careers
Kjaernsli and Lie (2011)	
Willms (2010)	School composition, school and classroom context, and students' literacy skills
Dincer and Uysal (2010)	Effects of school programme types
Coll et al. (2010)	influence of educational context in a western vs. Asian country

7

PISA 2015 collaborative problem-solving framework

This chapter describes the rationale behind measuring 15-year-olds' collaborative problem-solving skills for the first time in the Programme for International Student Assessment (PISA). It explains the content and processes that are reflected in the collaborative problem-solving items used in the computer-based assessment, and describes how student proficiency in this domain is measured and reported.

Collaborative problem solving (CPS) is a critical and necessary skill used in education and in the workforce. While problem solving as defined in PISA 2012 (OECD, 2010) relates to individuals working alone on resolving problems where a method of solution is not immediately obvious, in CPS, individuals pool their understanding and effort and work together to solve these problems. Collaboration has distinct advantages over individual problem solving because it allows for:

- an effective division of labour
- the incorporation of information from multiple perspectives, experiences and sources of knowledge
- enhanced creativity and quality of solutions stimulated by the ideas of other group members.

Collaboration has been defined as a "co-ordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (Roschelle and Teasley, 1995, p. 70). Social interaction is a vital but insufficient condition for collaboration because some social interactions do not involve shared goals, accommodation of different perspectives or organised attempts to achieve the goals.

There is a growing emphasis in state and national education systems on project-based and inquiry-oriented learning (National Research Council, 2011a). This includes shaping curriculum and instruction around critical thinking, problem solving, self-management and collaboration skills (Darling-Hammond, 2011; Halpern, 2003). Project-based work often includes tasks that require multiple students working together to achieve a team goal, such as a final report, integrated analyses or a joint presentation. Collaborative problem solving is not typically taught as an independent skill distinct from particular subjects. Therefore, in school-based contexts, collaborative learning exercises are often integrated into specific courses of study, such as the sciences, mathematics and history.

Recent curriculum and instruction reforms have focused to a greater extent on the teaching and assessment of 21st century skills (Griffin, Care and McGaw, 2011; National Research Council, 2011a,b). These skills have included critical thinking, problem solving, self-management, information and communication technology (ICT) skills, communication and collaboration (Binkley at al., 2011; OECD, 2011). Collaboration and communication skills are central to this 21st-century skill set and are described in a number of 21st-century skills curricula and assessment reports.

For example, the focal point of Singapore's third IT Masterplan (2009-14) is to facilitate a greater level of technological integration in curriculum, assessment and pedagogy in order to equip students with critical competencies, such as self-directed learning and collaboration skills (Ministry of Education, Singapore, 2008). Similarly, the Israeli national programme, Adapting the Educational System to the 21st Century (Ministry of Education, 2011), is a multiple-year plan with the goal of introducing innovative pedagogy in schools, including communication, collaboration, and other 21st-century skills. However, many of these curricula provide only a general framework and a description of goals and curriculum standards without defining the specific collaboration skills that are to be taught (Darling-Hammond, 2011).

Students need to prepare for careers that require the ability to work effectively in groups and to apply their problem-solving skills in these social situations (Brannick and Prince, 1997; Griffin, Care and McGaw, 2011; National Research Council, 2011a; Rosen and Rimor, 2012). There has been a marked shift from manufacturing to information and knowledge services. Much of the problem-solving work carried out in the world today is performed by teams in an increasingly global and computerised economy. However, even in manufacturing, work is seldom conducted by individuals working alone. Moreover, with the greater availability of networked computers, individuals are increasingly expected to work with diverse teams spread across different locations using collaborative technology (Kanter, 1994; Salas, Cooke and Rosen, 2008).

The University of Phoenix Research Institute identified virtual collaboration, i.e. the "ability to work productively, drive engagement, and demonstrate presence as a member of a virtual team" (Davis, Fidler and Gorbis, 2011, p. 12), as one of ten key skills for the future workforce. A recent Forrester report, based on a survey of information and knowledge-management decision makers from 921 North American and European enterprises, revealed that 94% had implemented or were going to implement some form of collaboration technologies, including e-mail, web conferencing, team workspaces, instant messaging or videoconferencing (Enterprise and SMB Software Survey, North America and Europe, Q42009 Forrester report). CPS skills are also needed in civic contexts, such as social networking, volunteering, participation in community life, and transactions with administration and public services. Thus, students emerging from schools into the workforce and public life will be expected to have collaborative problem-solving skills and the ability to collaborate using appropriate technology.

Collaboration among team members is crucial to the success of groups, families, corporations, public institutions, organisations and government agencies. One uncooperative member of a team can have serious negative consequences on team success. Skilled collaboration and social communication facilitate performance in the workplace (Klein, DeRouin and Salas, 2006; Salas, Cooke and Rosen, 2008), in engineering and software development (Sonnentag and Lange, 2002), and in interdisciplinary research among scientists (Nash et al., 2003). This is clearly apparent from the trend in research publications. Wuchty, Jones and Uzzi (2007) examined 19.9 million papers over five decades and demonstrated that there has been an increase in publications by teams of authors. Moreover, papers drafted by teams of authors end up higher in citation indices than papers drafted by individual authors.

The competencies assessed in the PISA 2015 collaborative problem-solving assessment therefore need to reflect the skills found in project-based learning in schools and in collaboration in workplace and civic settings, as described above. In such settings, students are expected to be proficient in skills such as communicating, managing conflict, organising a team, building consensus and managing progress.

One major factor that contributes to the success of CPS is effective communication among team members (Dillenbourg and Traum, 2006; Fiore et al., 2010; Fiore and Schooler, 2004). Therefore, an important part of the assessment must be proficiency in communication: communicating the right information and reporting what actions have been taken to the right person at the right time. This allows students to build a shared understanding of the task. The competency includes considering the perspectives of other team members, tracking the knowledge of team members, and building and monitoring a shared understanding of the progress made on the task.

Students must also be able to establish and maintain effective team organisation. This includes understanding and assigning roles, and maintaining and adapting the organisation to be effective at achieving its goals. This includes handling disagreements, conflicts, obstacles to goals and potential negative emotions (Barth and Funke, 2010; Dillenbourg, 1999; Rosen and Rimor, 2009).

In addition, students need to understand the type of collaboration and associated rules of engagement. The ground rules are different in contexts of helping, collaborative work, consensus building, win-win negotiations, debates and hidden-profile jigsaw configurations (i.e. group members have different information that needs to be integrated to arrive at a solution).

Apart from defining the domain, the CPS framework has to propose a way to operationalise the construct through a computer-based assessment (CBA). The framework builds, in part, on the individual problem-solving framework for PISA 2012, but extends it substantially in order to cover the additional concepts that need to be incorporated in order to develop and focus on the collaborative aspects of problem solving. The main elements of these aspects are group thinking and the communication skills required for effective interaction between group and individual thinking.

The CPS framework incorporates definitions and theoretical constructs that are based on research and best practices from several areas where CPS-related skills have been assessed. These areas include computer-supported co-operative work, team-discourse analysis, knowledge sharing, individual problem solving, organisational psychology, and assessment in work contexts (e.g. military teams, corporate leadership). The framework further incorporates information from existing assessments that can inform the PISA 2015 CPS assessment, including Assessment and Teaching of 21st-Century Skills (ATC21s), problem solving in the Programme for the International Assessment of Adult Competencies (PIAAC), Partnership for 21st-Century Skills, and the PISA 2012 individual problem-solving assessment (see Annex 7.B for a review).

The operationalisation of the framework described in section four requires an understanding of the major theoretical and logistical underpinnings of an assessment. The framework cannot be developed independently of considerations of the assessment design and measurement requirements. It must take into account the types of technologies, tasks and assessment contexts in which it will be applied (Funke, 1998; Funke and Frensch, 2007). For assessment design, the framework must consider the kinds of constructs that can be reliably measured, and must provide valid inferences about the collaborative skills being measured and about their impact on success in today's world. The CPS framework must also provide a basis for the development of computer-based assessments that will be used worldwide within the logistical constraints and time limits of an international assessment.

This document is organised into four sections. Following this introductory section, the section "Defining the domain" provides a definition of collaborative problem solving. The section "Organisation of the domain" describes how the domain of CPS is organised. It explains the skills and competencies needed for successful CPS and the factors that influence these skills. The section "Assessing collaborative problem-solving competency" operationalises the construct of CPS by identifying and justifying approaches to measuring CPS competencies and the contexts in which the skills can be assessed. It also describes the levels of proficiency for CPS and how they are reported. Annex 7.A provides a summary of studies with conversational agents in tasks that involve tutoring, collaborative learning, co-construction of knowledge, and collaborative problem solving. Annex 7.B provides a literature review of the key concepts in CPS related to the definition, constructs and design decisions of PISA 2015 CPS framework. Annex 7.C provides two CPS units that were developed as preliminary samples to illustrate the assessment framework and show how it might be operationalised.

DEFINING THE DOMAIN

Collaborative problem solving

The PISA 2003 Assessment Framework: Mathematics, Reading, Science and Problem Solving Knowledge and Skills (OECD, 2003) defines problem-solving competencies as:

> *… an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the content areas or curricular areas that might be applicable are not within a single subject area of mathematics, science or reading.*

The draft framework for the individual problem-solving domain in PISA 2012 (OECD, 2010) largely reiterates the 2003 definition but adds an affective element:

> *Problem solving competency is an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen.*

In defining the domain of collaborative problem solving for PISA 2015, the aspect of collaboration is obviously the most salient addition to previous versions of the domain of problem solving in PISA. In the definition for the 2015 domain, the emphasis is therefore on this collaborative aspect. The definition identifies the main elements of the domain and the relationships among these elements.

For the purposes of the assessment, the PISA 2015 definition of CPS competency is articulated in Box 7.1.

Box 7.1. **Definition of collaborative problem solving for PISA 2015**

Collaborative problem-solving competency is the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution.

PISA 2015 CPS competency is a conjoint dimension of collaboration skills and the skills needed to solve the problem (i.e. referential problem-solving skills), while collaboration serves as a leading strand.

The following remarks are offered to clarify the meaning and use of the constituent elements of the definition given above.

The capacity of an individual…

Collaboration skills can be assessed at the individual, group, or organisational level (Campbell, 1968; Dillenbourg, 1999; Fiore et al., 2010; Stahl, 2006). An advantage of collaboration is that the output of the group in solving the problem can be greater than the sum of the outputs from individual members (Aronson and Patnoe, 1997; Dillenbourg, 1999; Schwartz, 1995) and the individual level of participants does not adequately characterise how the group as a whole produces different outcomes than individuals. Yet, for the purpose of the PISA assessment, the focus is on individual capacities *within* collaborative situations. The effectiveness of collaborative problem solving depends on the ability of group members to collaborate and to prioritise the success of the group over individual successes. At the same time, this ability is a trait in each of the individual members of the group.

…to effectively engage in a process…

Collaborative problem solving involves an individual's cognitive processing that engages both cognitive and social skills. There are individual problem-solving processes as well as communication processes that interact with the cognitive systems of the other participants in the collaboration. For example, the group must not only have the correct solution

but must also agree that it is the correct solution. As discussed later in this document, the focus of the assessment is the cognitive and social skills related to CPS to establish and maintain shared understanding, to take appropriate actions to solve the problems, and to establish and maintain group organisation.

The cognitive processes involved in CPS are internal to the individual but they are also manifested in the interactions with the problem and with others in the group. That is, cognitive processes can be inferred from the actions performed by the individual, communications made to others, intermediate and final products of the problem-solving tasks, and open-ended reflections on problem-solving representations and activities. These measures can be instantiated by examining exploration and solving strategies, the type and quality of communication generated, probes of the knowledge and representation of the problem, and indicators of an individual's representation of others in the group. In other words, measuring collaborative problem-solving skills is not only a challenge comparable to measuring individual skills, but also a great opportunity to make observable the cognitive processes engaged by team members.

...whereby two or more agents ...

Collaboration requires interactions between two or more agents. The word "agent" refers to either a human or a computer-simulated participant. In both cases, an agent has the capability of generating goals, performing actions, communicating messages, reacting to messages from other participants, sensing its environment, adapting to changing environments, and learning (Franklin and Graesser, 1996). The success of CPS skills can be observed at either an individual level or a group level. Even when observations are directed at an individual level, they refer to the individual's actions and interaction enacted in order to share a representation or common goal with at least one other agent for there to be collaboration. The definition therefore sets the requirement of a minimum of two agents.

...attempt to solve a problem...

The measurement is focused primarily on the collaborative actions the students engage in while trying to solve the problem at hand, rather than solely on the correct solution of the problem. The core construct weighs collaboration processes higher than the solutions to problems.

...by sharing the understanding and effort required to come to a solution...

Collaboration can only occur if the group members strive for building and maintaining a shared understanding of the task and its solutions. Shared understanding is achieved by constructing a common ground (Clark, 1996; Clark and Brennan, 1991; Fiore and Schooler, 2004) through communication and interaction, such as building a shared representation of the meaning of the problem, understanding each individual's role, understanding the abilities and perspectives of group members, mutual tracking of the transfer of information and feedback among group members, and mutual monitoring of progress towards the solution.

...and pooling their knowledge, skills and effort to reach that solution.

Collaboration further requires that each individual establish how their own knowledge and skills can contribute to solving the problem as well as identify and appreciate the knowledge and skills that the other participant(s) can contribute. In addition to establishing the state of the pooled knowledge and skills within the group, there are potential differences in points of view, dissension/conflict among group members, errors committed by group members in need of repair, and other challenges in the problem that require cognitive effort to handle. This additional effort of justifying, defending, arguing and reformulating is a factor that may explain why groups sometimes achieve more or are more efficient than individuals: they have to be explicit about their opinion, interpretations and suggestions requiring them to process available information more deeply, to compare more solutions, and to find out the weaknesses of each solution. If there is no effort from an individual, then that individual is not collaborating. The individual is not expending productive effort if the individual does not respond to requests or events and does not take actions that are relevant to any progress towards goals.

ORGANISATION OF THE DOMAIN

Processes and factors affecting collaborative problem solving

Collaborative problem solving is an inherently complex mechanism that incorporates the components of cognition found in individual problem solving in addition to the components of collaboration. The cognitive components of individual problem solving include understanding and representing the problem content, applying problem-solving strategies, and applying self-regulation and metacognitive processes to monitor progress towards the goal (Funke, 2010; Glaser, Linn and

Bohrnstedt, 1997; Hacker, Dunlosky and Graesser, 2009; Mayer, 1998; O'Neil, 1999). However, engaging other group members in a collaborative task requires additional cognitive and social skills to allow shared understanding, knowledge and information flow, to create and understand an appropriate team organisation, and to perform co-ordinated actions to solve the problem (Dillenbourg, 1999; Fiore et al., 2010).

For the purpose of the PISA 2015 CPS assessment, collaborative problem-solving competency is defined in Box 7.1 as the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution, and pooling their knowledge, skills and effort to reach that solution. The definition incorporates three core collaborative problem-solving competencies:

1. establishing and maintaining shared understanding
2. taking appropriate action to solve the problem
3. establishing and maintaining team organisation.

These three competencies arise from a combination of collaboration and individual problem-solving processes. The individual problem-solving processes are already defined by the PISA 2012 framework: *exploring and understanding; representing and formulating; planning and executing;* and *monitoring and reflecting*. The CPS competencies are further influenced by factors such as the task, the team composition, the medium in which the task is applied, as well as the overall background context of the problem-solving task. Below we elaborate on these components.

Problem-solving skills

Much of the basis and terminology of collaborative problem solving for PISA 2015 is consistent with that of the PISA 2012 individual problem-solving framework, which addressed problem solving by an individual working alone. It defines a *problem* as existing when a person has a goal but does not have an immediate solution as to how to achieve it. That is, "problem solving is the cognitive processing directed at transforming a given situation into a goal situation when no obvious method of solution is available" (Mayer 1990, p. 284). *Problem-solving competency* is defined as "an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen" (OECD, 2010, p. 12).

The 2012 individual problem-solving framework identifies three conceptual dimensions that provide the basis for the assessment of problem solving and are also relevant to CPS. These are the *problem context*, the *nature of the problem situation*, and the *problem-solving process* (OECD, 2010, p. 16).

The *problem context* affects how difficult a problem will be to solve for individuals who have varying familiarity with the context. The 2012 individual problem-solving framework posits two aspects of the problem-solving context, namely the *setting* (whether or not it is based on technology) and the *focus* (whether it is personal or social). When the setting is based on technology, individual problem solvers make use of a technological device as a context for their problem solving, such as a computer, cell phone or remote control. The typical problem-solving goal in this context is understanding how to control or troubleshoot the device. Other problem-solving contexts do not make use of such devices. The non-technology contexts include route planning, task scheduling, and decision making (OECD, 2010, p. 17). The focus of the problem solving is classified as personal when it relates mainly to the individual being assessed, the person's family, or the person's peers. A social focus, on the other hand, is broader in the sense that it refers to a context in the wider community or society at large.

The *nature of the problem situation* describes whether the information about the problem situation is complete or not when initially presented to the problem solver. Those problem situations that are complete in their information are referred to as *static* problem situations. When it is necessary for the problem solver to explore the problem situation in order to obtain additional information that was not provided at the onset, the problem situation is referred to as *interactive*. Problem situations may also vary with respect to the degree to which the starting state of the problem, the goal state, and the actions that can be performed to achieve the goal state are specified. Problem situations for which there are clearly specified goals, given states, and legal actions can be labelled *well-defined* problems; in contrast, problems that involve multiple goals in conflict with underspecified given states and actions are called *ill-defined* problems. The PISA 2012 problem-solving assessment and the problem solving in technology-rich environments assessment that is part of the Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC), presented both well-defined and ill-defined problems (OECD, 2010, 2009).

The PISA 2012 individual problem-solving framework identified the following four cognitive processes in individual problem solving: *exploring and understanding; representing and formulating; planning and executing;* and *monitoring and reflecting* (OECD, 2010, p. 20-21). Similar processes were also identified in the PIAAC problem solving in technology-rich environments framework, with the latter being more focused on processes related to the acquisition, use and production of information in computerised environments (OECD, 2009). The CPS framework builds on the previous assessments of individual problem solving with these cognitive processes.

The first process involves understanding the problem situation by interpreting initial information about the problem and any information that is uncovered during exploration and interactions with the problem. In the second process, this information is selected, organised, and integrated with prior knowledge. This is accomplished by representing the information using graphs, tables, symbols and words, and then formulating hypotheses by identifying the relevant factors of the problem and critically evaluating information. The third process includes planning, which consists of clarifying the goal of the problem, setting any subgoals, and developing a plan to reach the goal state. Executing the plan that was created is also a part of this process. The final process consists of monitoring steps in the plan to reach the goal state and reflecting on possible solutions and critical assumptions.

These four problem-solving processes provide a basis for the development of the cognitive strand of the conjoint dimension of the CPS framework. In collaborative problem solving, the group must perform these problem-solving processes concurrently with a set of collaborative processes.

Collaborative problem-solving skills and competencies

Three major collaborative problem-solving competencies are identified and defined for measurement in the assessment. These three major CPS *competencies* are crossed with the four major individual problem-solving *processes* to form a matrix of specific *skills*. The specific skills have associated actions, processes and strategies that define what it means for the student to be competent. Table 7.1 outlines the skills of collaborative problem solving as a matrix of these collaborative and individual processes. The matrix incorporates the individual problem-solving processes from the PISA 2012 individual problem-solving framework and illustrates how each interacts with the three collaboration processes.

The CPS skills identified in this framework are based on a review of other CPS frameworks, such as the National Center for Research on Evaluation, Standards and Student Testing (CRESST) teamwork processing model (O'Neil et al., 2010, 2003), the teamwork model of Salas and colleagues (Fiore et al., 2010, 2008; Salas et al., 2008, 1992) and ATC21s (Griffin, Care and McGaw, 2011). Annex 7.B provides a review of related frameworks and CPS research.

Table 7.1 Matrix of collaborative problem-solving skills for PISA 2015

	(1) **Establishing and maintaining shared understanding**	(2) **Taking appropriate action to solve the problem**	(3) **Establishing and maintaining team organisation**
(A) **Exploring and understanding**	**(A1)** Discovering perspectives and abilities of team members	**(A2)** Discovering the type of collaborative interaction to solve the problem, along with goals	**(A3)** Understanding roles to solve the problem
(B) **Representing and formulating**	**(B1)** Building a shared representation and negotiating the meaning of the problem (common ground)	**(B2)** Identifying and describing tasks to be completed	**(B3)** Describing roles and team organisation (communication protocol/rules of engagement)
(C) **Planning and executing**	**(C1)** Communicating with team members about the actions to be/being performed	**(C2)** Enacting plans	**(C3)** Following rules of engagement, (e.g. prompting other team members to perform their tasks)
(D) **Monitoring and reflecting**	**(D1)** Monitoring and repairing the shared understanding	**(D2)** Monitoring results of actions and evaluating success in solving the problem	**(D3)** Monitoring, providing feedback and adapting the team organisation and roles

Note: The 12 skill cells have been labelled with a letter-number combination referring to the rows and columns for ease of cross-referencing later in the document.

The three major CPS competencies are described below.

1) Establishing and **maintaining shared understanding.** Students must have an ability to identify mutual knowledge (what each other knows about the problem), identify the perspectives of other agents in the collaboration, and establish a shared vision of the problem states and activities (Cannon-Bowers and Salas, 2001; Dillenbourg, 1999; Dillenbourg and Traum, 2006; Fiore and Schooler, 2004). This includes the student's ability to monitor how his or her abilities, knowledge, and perspectives interact with those of the other agents and in relation to the task. Theories of discourse processing have emphasised the importance of establishing a common ground in order for communication to be successfully achieved (Clark, 1996; Clark and Brennan, 1996), so this is also a skill that is essential to CPS. Students must also be able to establish, monitor and maintain the shared understanding throughout the problem-solving task by responding to requests for information, sending important information about tasks completed, establishing or negotiating shared meanings, verifying what each other knows, and taking actions to repair deficits in shared knowledge. These skills involve the student's own self-awareness of proficiencies in performing the task, recognising their own strengths and weaknesses in relationship to the task (metamemory), and recognising the other agents' strengths and weaknesses (transactive memory).

2) Taking appropriate action to solve the problem. Students must be able to identify the type of CPS activities that are needed to solve the problem and to follow the appropriate steps to achieve a solution. This includes efforts to understand the problem constraints, create team goals for the solution, take action on the tasks, and monitor the results in relation to the group and problem goals. These actions may include communication acts, such as explaining, justifying, negotiating, debating and arguing in order for complex information and perspectives to be transferred and for more creative or optimal solutions to be achieved. The constraints and rules of engagement differ for the different types of CPS activities, such as jigsaw problems (where individuals have different knowledge that needs to be pooled; Aronson and Patnoe, 1997), collaborative work (Rosen and Rimor, 2009), and argumentative debates in decision making (Stewart, Setlock and Fussell, 2007). A proficient collaborative problem solver is able to recognise these constraints, follow the relevant rules of engagement, troubleshoot problems and evaluate the success of the problem-solving plan.

3) Establishing and **maintaining group organisation.** A team cannot function effectively without organising the group and adapting the structure to the problem-solving task. Students must be able to understand their own role and the roles of the other agents, based on their knowledge of who is skilled at what in the team (transactive memory), follow the rules of engagement for their role, monitor the group organisation, and facilitate changes needed to handle communication breakdowns, obstacles to the problem and performance optimisation. Some problem situations need a strong leader in the group whereas other problems require a more democratic organisation. A competent student can take steps to ensure that agents are completing tasks and communicating important information. This includes providing feedback and reflecting on the success of the group organisation in solving the problem.

Underlying these three competencies are specific skills that can be individually assessed within collaborative tasks. The assessment is developed ensuring that the skills shown in the 12 cells of the CPS matrix (Table 7.1) are all measured across different tasks. Together the assessment tasks cover the three major competencies and the four component processes.

Overview of the domain

Figure 7.1 provides a schema of the salient factors that influence collaborative problem-solving competency, as well as the cognitive and social processes that comprise the skills within collaborative problem-solving contexts, as defined for PISA 2015. The core skills are described above; additional details on the role of student background and task-context factors are provided below.

Student background

A student's prior knowledge and experiences are factors that influence collaboration and problem-solving processes. A student's knowledge of a particular domain, for example of mathematics, the sciences, reading, writing and ICT skills, as well as everyday knowledge, influences the student's capacity to collaborate to solve a problem. Available research indicates that problem-solving strategies rely on domain knowledge to some extent (Funke and Frensch, 2007; Healy et al., 2002; Lee and Pennington, 1993; Mayer, 1992; Mayer and Wittrock, 1996). The assessment uses problem situations and contexts relevant to 15-year-old students that tap generalised problem-solving skills, but do not rely on specialised knowledge. The assessment assumes basic rather than advanced abilities in reading and use of computer interfaces as well as a basic knowledge of science, mathematics and the world. This is similar to the approach adopted in the PISA 2012 individual problem-solving assessment in the selection of problem contexts.

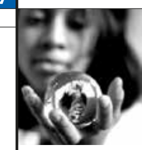
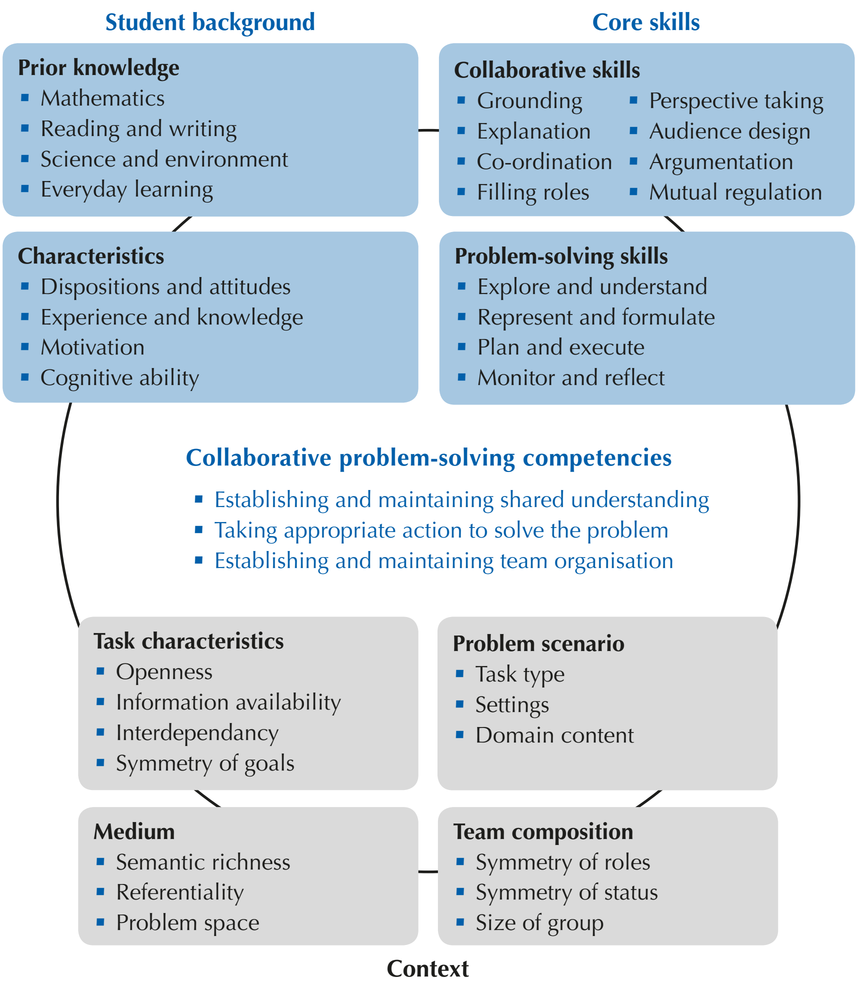


Figure 7.1 ▪ **Overview of factors and processes for collaborative problem solving in PISA 2015**



Student characteristics, such as interpersonal skills, attitudes, emotions, personality factors (e.g., the "Big Five" factors of openness, conscientiousness, extraversion, agreeableness and neuroticism) and motivation can all affect individual and collaborative problem-solving success (e.g. Avery Gomez, Wu and Passerini, 2010; Jarvenoja and Jarvela, 2010; Morgeson, Reider and Campion, 2005; O'Neill, Goffin and Gellatly, 2012). Cognitive abilities, such as working-memory capacity, logical reasoning and spatial ability similarly all contribute to CPS. While these core characteristics may influence CPS competence, the PISA 2015 CPS cognitive assessment does not specifically measure factors such as attitude, emotions, motivation or specific domain knowledge. It is, however, intended that the most critical factors are measured as part of the PISA 2015 background questionnaire (see the section "Considerations for contextual questionnaire" below).

The framework assumes that most 15-year-old students have sufficient cognitive and social abilities to complete the CPS tasks. This is a safe assumption from the perspective of research in psychological development. From the standpoint of cognitive and brain development, these students are at an age when most of them are capable of hypothetical reasoning and abstract thought (Bjorklund, forthcoming; Fischer, 1980; Piaget, 1983); from the perspective of social development, they are at an age when most students can consider the perspectives of others and have acquired a large range of socialisation skills (Bjorklund, 1997; Flavell et al., 1968). These capabilities are necessary for being able to establish and maintain a shared understanding in the group, take actions towards a joint goal, and monitor results of collaborative actions.

There is some question as to whether different cultures uniformly value students initiating actions and communications, as opposed to responding to requests and questions. However, taking initiative in appropriate contexts is an important skill at the higher level of CPS competency and therefore relevant to PISA 2015. In the assessment, team members can vary in taking on different task roles, but are not assigned a social status. The assumption is that adopting different roles in collaborative work and problem solving is acceptable in different cultures; in contrast, social status differences may limit taking initiative in some but not all cultures, thereby imposing a cultural bias. For example, in some cultures there are social customs where it is awkward for an employee to communicate with a boss by asking a question, making a request or evaluating what the boss does. These differences are avoided in the contexts of the PISA 2015 assessment. In contrast, the team members in the problem scenarios have equal status but assume different roles, which is presumed to be acceptable in all cultures and essential to CPS.

Context: Problem scenarios, team composition, task characteristics and medium

The problem scenarios and context in which the problem is solved have a number of psychological dimensions that can affect the type of collaboration and the collaborative competencies employed. These dimensions specify the context of the problem to be solved, the availability of information, the relationships among the group members, and the types of problems.

A meaningful collaborative interaction and motivating experience in assessment does not emerge spontaneously, but requires careful structuring of the collaboration to promote constructive interactions. For example, effective collaboration is characterised by a relatively symmetrical structure with respect to knowledge, status and goals (Dillenbourg, 1999), but the roles and tasks of the different group members may be very different. Symmetry of knowledge occurs when all participants have roughly the same level of knowledge, although they may have different perspectives. Symmetry of status involves collaboration among peers rather than interactions involving facilitator relationships. Finally, symmetry of goals involves common group goals rather than individual goals that may conflict (Rosen and Rimor, 2009).

Assessment items are designed so that successful performance on the task requires collaboration and interdependency among the participants. For example, in many types of problems (i.e., jigsaw, hidden profile [when the information available to the human is not complete at the beginning of the task]), each team member has a piece of information and only together can they solve the problem. These problems are dynamic rather than static because important information accrues during the course of interacting with others. Moreover, problems are designed to provide a graceful degradation of the quality of the solution, so partial or suboptimal solutions receive partial credit. Another example consists of consensus-building tasks, where there are limited resources but a group must bargain and converge on a solution that satisfies the needs of different stakeholders. Information among participants may also conflict, requiring sharing and then resolving the information in order to determine what information best solves the problem (debate).

The assessment items also consider the types of problems that groups of young people must solve, both within a formal school setting and in work contexts in order to be productive in society. A problem scenario provides the situational context in which a problem is applied. For example, within a consensus-building task, a classroom scenario may involve reaching a solution on how to prepare a PowerPoint presentation in a class when students bring different information to the group. Another scenario may be a negotiation task that involves global policies of citizens in a culture, such as a debate on where to build a new school.

The medium of a CPS item defines aspects such as its richness, referentiality and cost of grounding. For example, an item can be graphically rich, providing an immersive environment that simulates a classroom or workplace, or it could be a simple interface providing only a text description of a problem and means to communicate with the group. An item's context may have high referentiality to the outside world and real-world contexts, versus being more abstract, with little reference to external knowledge. An item can have a greater or lesser degree of cost of grounding, depending on how easy it is for members of the group to communicate with each other and find common ground. Finally, an item can have a shared problem space where the actions of each team member are explicitly apparent, such as when working on a shared document; in other scenarios, information about team members' actions might be implicit, for example, when working on separate tasks and reporting back to the group via the communication channel.

The 2012 individual problem-solving framework provides a structure for considerations of aspects of task characteristics, such as ill-defined vs. well-defined, and static vs. dynamic problems. Collaborative problem solving tends to be inherently interactive, interdependent and dynamic (Blech and Funke, 2010, 2005; Klieme, 2004; Wirth and Klieme, 2004). This provides greater challenges to assessment methods as there is much less control over the progress towards solutions, a much wider range of potential problem states, and complexities in tracking problem states. To the extent that any individual in a group depends on other individuals, there is some level of uncertainty in the control over the tasks, making it difficult for most problem types to be fully defined. Thus, a problem may be well-defined from the standpoint of the designer of the problem, but ill-defined at some points from the perspective of one or more group participants. Most or all of the problems also have different phases that can reflect variations in these context dimensions.

Table 7.2 elaborates the schematic representation of Figure 7.1 by providing an overview of the context dimensions and states that can affect the difficulty of the CPS task. In the context of a PISA assessment, it is impossible to assess all of the factors shown in Table 7.2, let alone the large number of combinations of factors; therefore the CPS assessment items constitute a sampling of the total domain by keeping many factors fixed and varying only a few. The framework identifies those factors that are most central to the definition of CPS. More specifically, PISA 2015 CPS concentrates on the collaboration skills to a greater extent than the problem-solving skills needed to solve the particular problem. Consequently, problems vary across low, medium and high difficulty with respect to collaboration skills, while problem-solving skills range from low to medium difficulty.

Table 7.2 Collabrative-problem solving context dimensions

Context	Dimension	States
Problem scenario	Task type	E.g. Jigsaw, consensus building, negotiation
	Settings	Private vs. public Technology vs. non-technology School (formal) vs. non-school (informal)
	Domain content	E.g. Math, science, reading, environment, community, politics
Team composition	Size of group	2 or more (including the student)
	Symmetry of status of team members	Symmetrical vs. asymmetrical
	Symmetry of roles: Range of actions available to each team member	Symmetrical vs. asymmetrical
Task characteristics	Openness (c.f. PISA PS 2012)	Well-defined vs. ill-defined
	Information availability: Does the student receive all necessary information at once? (c.f. PISA PS 2012)	Static vs. dynamic
	Interdependency: Student A cannot solve problem without student B's actions	Low to high
	Symmetry of goals	Group vs. individual
	Distance to solution (from beginning state to goal state)	Small, medium or large
Medium	Semantic richness	Low to high
	Referentiality to the outside world	Low to high
	Communication medium cost of grounding Interdependency: Student A cannot solve problem without student B's actions	Low to high
	Problem space: Does the student get information about other team members' actions?	Explicit vs. implicit

ASSESSING COLLABORATIVE PROBLEM-SOLVING COMPETENCY

There has been substantial research on the development of assessment methods for individual problem solving (the focus of PISA 2012), but work in assessment and training methods for collaborative problem solving is much less developed. As such, there are no established, reliable methods for large-scale assessments of individuals solving problems in a collaborative context and no existing international assessments in wide use. Although ATC21s addresses collaborative problem-solving skills, no measurement at the individual level has yet been reported (Griffin, Care and McGaw, 2011).

Given the overall matrix sampling design used in PISA, where estimates of country-level competency per domain depend on the covariance structure across the domains to be assessed, observations need to address this ability in individuals. Measurements at the individual level can only be obtained if all variables apart from the individual are controlled. Group-level measurements are highly dependent on group composition and the individual skills of the participants (Kreijns, Kirschner and Jochems, 2003; Rosen and Rimor, 2009). Fairly assigning a competency level to individuals working in a group where all group members can vary is impossible, because each individual's display of observable behaviour depends on the behaviour of the other group members.

Further, there are few well-elaborated national or international standards for training or assessing collaborative problem-solving skills. There are, however, a number of research studies, smaller-scale assessments and theoretical work that can inform the development of a reliable large-scale assessment of collaborative problem solving. Annex 7.B provides a deeper review of existing frameworks and assessment approaches.

It has therefore been decided to place each individual student in collaborative problem-solving situations, where the team member(s) with whom the student has to collaborate is/are fully controlled. This is achieved by programming computer agents.

Structure of the assessment

In the PISA 2015 main study, each student is assigned one two-hour test form composed of four 30-minute "clusters". Each form comprises one hour (two clusters) of science, the major domain, with the remaining time assigned to either one or two of the additional domains of reading, mathematics and CPS, according to a rotated test design. Three clusters of material for the CPS assessment were designed and are included in the main study.

CPS units range from 5- to 20-minute collaborative interactions within a particular problem scenario. Multiple measurements of communications, actions, products and responses to probes can be performed within each unit. These measures can be thought of as corresponding to individual items. For example, an item could be a single communication or action taken by a student at a particular point in the problem, the content of a longer sequence of communications and/or actions made by a student, or the correctness of the solution produced. Between 5 and 30 separate measurements are derived from each unit. Each of these individual items provides a score for one or more of the three CPS competencies. Additional details on scoring and weighting of items is provided below. As the CPS assessment is computer-based, the timing information automatically captured during the field trial is used to determine the actual number of items that can be included in each unit and cluster for the main study.

Measurement of collaboration skills

Collaborative problem solving is inherently an interactive, conjoint, dual-strand process that considers how the student reasons about the problem and how the student interacts with others to regulate the social processes and exchange information. These complex processes present a challenge for consistent, accurate and reliable measurement across individuals and across user populations. The complexity of the potential collaborative interactions with the environment increases when there is an attempt to create compelling problem-solving situations in more realistic environments. Computer-based assessment provides an effective means to control the assessment contexts and to collect and analyse student performance. This level of control reduces the complexity in measurement and allows the assessment to be technically implementable. This section describes the focus of what is measured and how computer-based approaches are used.

PISA 2015 CPS is an assessment of individuals in collaborative problem-solving contexts. Because overall analyses for PISA are performed at the student level, the design reflects measuring individual competencies rather than the overall performance of the group process. The PISA 2015 CPS assessment is not designed to measure individuals' cognitive problem-solving skills specifically, but it does do this to the extent that individual problem-solving skills are expressed through collaboration. As such, there is an indirect link to the 2012 individual problem-solving assessment. The 2015 measurement focuses on assessing the cognitive and social processes underlying collaborative problem-solving skills rather than specific domain knowledge.

The process of solving a problem in a collaborative situation in a computer-based assessment generates a complex data set that contains actions made by the team members, communication acts between the group members, and products generated by the individual and the group. Each can be associated with levels of proficiency for each CPS competency. Because the focus is on the individual, assessment items correspond to measures of the student's outputs, whereas outputs from the rest of the group provide contextual information about the state of the problem-solving process.

Prior research and assessments in CPS have used a number of different methods to measure the quality of the problem-solving products (i.e. outcomes) and processes. These methods use varying approaches to assessing actions, communication and products, including measures of the quality of the solutions and objects generated during the collaboration (Avouris, Dimitracopoulou and Komis, 2003), analyses of log files (files to which a computer writes a record of student activities), quality of intermediate results, paths to the solutions (Adejumo, Duimering and Zhong, 2008), team processes and structure of interactions (O'Neil, Chung and Brown, 1997), quality and type of collaborative communication (Cooke et al., 2003, Foltz and Martin, 2008; Graesser, Jeon and Dufty, 2008), and quality of situation judgements (McDaniel et al., 2001). Additional details regarding research on measurement approaches applied to CPS are provided in Annex 7.B.

Individuals working collaboratively on a problem can change the state of a problem by communicating with each other or performing certain actions. For the purpose of the assessment, actions can be defined as any explicit acts made by the individual that change the state of the collaborative problem. These actions include individual acts, such as placing

a puzzle piece, clicking on a button to start a jointly designed machine, moving a cursor on a display that the other participants can see, or editing a joint document. Each action can be mapped to measures of performance as it relates to either success (or failure) of solving the problem or to a skill identified within the framework. For example, placing a puzzle piece incorrectly indicates failure of enacting a plan (cell C2 of the skills matrix, Table 7.1). Sequences of actions provide deeper information about the problem-solving process. For example, the sequence of students' actions in first varying one part of the problem, then verifying the solution and then taking the next appropriate action, can show skills of monitoring results and evaluating success (D2).

While communication is often classified as an individual collaboration skill, the output of communication provides a window into the cognitive and social processes related to all collaborative skills. Students must communicate to collaborate, and the communication stream is captured and analysed to measure the underlying processes. The analysis of the content and structure of communication streams provides measures of the test-taker's ability to share perspectives, establish mutual goals, negotiate with other team members, and take steps to achieve these goals. For example, communication sent by the student indicating what the student sees on a screen provides an indication of building a shared representation (B1). Taking the initiative to ask other agents to manipulate parts of the problem corresponds to following rules of engagement (C3) and enacting plans (C2). Communication acts and sequences of communication acts can be classified to measure the type and quality of skills that are being enacted by the student.

The output or products of the team's problem-solving process provides a third measure of student performance. A product can be based on intermediate and final solutions to the problem-solving process or the output of a "probe item" which checks a student's understanding of a situation in a particular state. These provide a measure of the success that the actions of collaborative problem solving are being enacted properly and that the group is moving the problem state forward appropriately. The products can also be based on "probes" that are placed within the unit to assess a student's cognitive state relative to the skills in the framework. These probes would stop the simulation and ask the student either a constructed-response or multiple-choice question in order to assess knowledge states, shared understanding and the student's understanding of the other group members' skills, abilities and perspectives. The questions range from small tests of the student's state of understanding to situation judgement tasks that require students to put themselves in the context and communicate the state of the problem externally, such as writing an e-mail to a supervisor. Example probes are shown below.

Table 7.3 Example probes

Probe	Skill assessed
What does A know about what is on your screen?	**(A1)** Discovering perspectives/abilities of team members
What information do you need from B?	**(C1)** Communicating with team members about the actions being performed
Why is A not providing information to B?	**(D1)** Monitoring and repairing the shared understanding
What task will B do next?	**(B2)** Identifying and describing tasks to be completed
Who controls the factory inputs?	**(B3)** Describing roles and team organisation
Write an e-mail to your supervisor explaining whether there is consensus of your group on what to do next.	**(B1)** Building a shared representation and negotiating the meaning of the problem **(B2)** Describing tasks to be completed
Write an e-mail to your group explaining what actions the group will need to do to solve the problem.	**(B2)** Identifying and describing tasks to be completed **(C2)** Enacting plans

These explicit probes are one way of assessing students' proficiencies, but much can be inferred from the particular actions and speech acts that do not explicitly probe these knowledge states. For example, if the student does not know whether another group member is aware of what the student has on his or her screen, the student can ask the member a question that targets the uncertainty. Alternatively, another member can perform an action on the screen and observe whether the student comments on an aberration. Physical acts in a shared physical space are acts of communication, just as words and sentences are. Probes can be multiple choice (selected response) or open-ended (constructed response). However, there is no requirement that constructed response be used for such assessments if the skills can be adequately assessed through the actions, communications and products during the collaboration process. Probe items were developed for the two sample CPS units described below, but there are no probe items in the CPS units developed for the PISA 2015 assessment.

To measure performance, all actions, communications, products and response times are logged throughout the problem-solving process. Any action or communication can be thought of as a representation of a particular state of the problem-solving process. Each state of the problem-solving process can also be linked to the specific collaborative skills that need to be assessed, as defined in the framework's CPS skills matrix (Table 7.1). Therefore, items within a unit represent changes in the state performed by the student either through actions, communications or the products resulting from actions or communications.

For example, to assess "establishing and maintaining shared understanding" during the process of "representing and formulating a problem", the state of the problem has pre-determined communication acts related to establishing common ground on tasks (B1). A student initiating a communication act to establish common ground would show that he or she is performing at the highest level in that aspect of collaboration, which would be reflected in the scoring. A student who establishes common ground only after being prompted by the agent would show that he or she is at the proficient level of the skill. Students who send contextually inappropriate communications or who do not communicate any shared understanding would be scored as being below the proficient level.

Pattern-matching technology is used to process the log files and identify the key aspects of performance corresponding to the competencies. This approach permits fully automated partial-credit scoring against each of the skills from the framework. Although there are measures for skills in each cell of the framework, the scores from these skills are combined to create an overall scale for collaborative problem-solving competency.

The student's physical actions, answers to question probes, and acts of communication selected from a menu can be automatically scored. Probes requiring constructed responses, such as short e-mail communications, would require expert-coding. However, because expert-coded responses are assessed off line, the scoring rubric would need to identify the specific skills and context from the framework to be assessed, and would need to measure the quality of the communication and actions.

Conversational agents

The essence of collaborative problem solving is that team members depend on each other. Success in reaching the solution depends on what each team member brings to the collaborative effort. If one of the members in a team has nothing to offer towards solving a problem that requires contributions from all members, the problem will not be solved. Randomly pairing students with other students would therefore lead to an underestimate of the population's problem-solving skills as the weakest member in each pair would determine the probability of success, the quality of the solution, and the efficacy in dealing with the problem.

Research has shown that group composition has a significant effect on performance, in particular the balance of gender (e.g. Bear and Wooley, 2011), ability (e.g. Wildman et al., 2012), personality (e.g. McGivney, Smeaton and Lee, 2008) and what Webb (1995) terms "status characteristics", e.g. family background, popularity, attractiveness and perceived intelligence. In real life, students must be prepared to work effectively within various types of homogenous and heterogeneous groups and with a range of familiar and unfamiliar group members. However, in an assessment situation, if a student is matched with a problematic group, it can have a detrimental effect on the student's performance, and the validity of the assessment is compromised.

Similarly, some students may be highly stimulated when collaborating with one particular student but demotivated when paired with another student. The only way to obtain a full and valid estimate of an individual's collaborative problem-solving skills would therefore be to pair this individual with a number of different team members, each with a different set of characteristics relevant to collaborative problem solving. To ensure fair measurement, each individual student would need to be paired with the same number of other students displaying the same range of characteristics. As PISA is an international study, caution is needed to ensure that the same variability in student characteristics relevant to collaborative problem solving is found in each participating country.

The approach suggested in the previous paragraph is impractical in the context of a large-scale international assessment. Measurement is therefore operationalised using computer-based agents as a means to assess collaborative skills. Students collaborate with computer-based conversational agents representing team members with a range of skills and abilities. This approach allows the high degree of control and standardisation required for measurement. It further permits placing students in a number of collaborative situations and allows measurement within the time constraints of the test administration.

Students are presented with problem scenarios in designated clusters. Each scenario corresponds to an individual assessment unit. The student is asked to respond to the scenario by playing the role of problem solver alongside agents in the given context. CPS skills are measured through a number of items, where each item is linked to a task or phase in the problem-solving process, which can contain several steps.

In each CPS unit, the student works with one or two group members to solve a problem, with the group members programmed as computer agents providing input in much the same manner as fellow students would do. Across different assessment units, agents are programmed to emulate different roles, attitudes and levels of competence in order to vary the CPS situation the student is confronted with. The conversational agents interact with the student's communications and actions in pre-defined ways as the student moves through different states of the problem. Each state defines particular communication acts that can be performed by the agent or that would be expected as input from the student.

As the student progresses through the problem-solving task, the computer monitors the current states of the problem. With each state, the computer provides a changing set of choices of communication acts that a student can use to create a conversation with the agent group member(s). Differing student responses can cause different actions from the agent, both in terms of changes of the state of the simulation (e.g. an agent adding a piece to a puzzle) or conversation (e.g. an agent responding to a request from the student for a piece of information). Similarly, actions performed by the student during the problem solving, such as placing puzzle pieces or moving an object, are also monitored by the computer in order to track progress on the problem-solving process and record the type of student actions relative to the current context of the problem state.

Conversational agents can be manifested in different ways within a computer environment, ranging from simple chat interfaces to full virtual talking heads with full expressiveness. For the purposes of PISA 2015, enhanced menu-based chat interfaces, interactive simulations (e.g. moving cursors in a shared space that team members can all see and respond to) and other web-like applications provide a broad range of conversational contexts and collaborative interaction.

An adequate assessment of a student's CPS skills requires the student to work with multiple types of groups in order to cover the constructs critical for assessment. The computer environment for PISA 2015 is orchestrated so that students interact with different agents, groups and problem constraints to cover the range of aspects defined in the construct. For example, one situation may require a student to supervise the work of agents, where there is an asymmetry in roles. Other tasks may have disagreements between agents and the student, collaboratively orientated agent team members (e.g. initiates ideas, supports and praises other team members), and agent team members with low collaborative orientation (e.g. interrupts, comments negatively about work of others).

When humans collaborate together, it often takes considerable time to make introductions, discuss task properties and assign roles during the initial phases of CPS activities (e.g. "exploring and understanding" and "representing and formulating") and also to monitor and check up on team members during action phases (Marks, Mathieu and Zaccaro, 2001; Wildman et al., 2012; Zaccaro, Marks and DeChurch, 2011). There is also a danger that a group of humans will spend a lot of time pursuing an unproductive path to a solution during the action phase. Within the assessment situation, computer agents allow rigorous control over the collaborative interaction to obtain a sufficient number of assessment events within the test time constraints using strategic dialogue management and rapid immersion in the collaborative context. For example, a "rescue" agent can redirect the group's course of action when too much time has been expended on a poor solution path.

The control of the progression permits the creation of a sufficient number of observations to assess the student's proficiency in each skill specified in the cells of the framework's CPS skills matrix (Table 7.1), particularly within the exacting time constraints of the test administration.

While it is acknowledged that the PISA 2015 assessment does not directly test students working with other students, the agent-based approach permits controlled testing of the skills that are required for collaboration. By targeting these skills under controlled situations, the use of agents provides a sufficiently valid approach to measurement to allow generalisations about the critical collaboration skills. Annex 7.A provides a review of examples of how agent-based environments have been used to assess collaboration, problem solving, tutoring and group learning.

Collaborative problem-solving task types

The assessment includes different types of collaborative problem-solving tasks that elicit different types of interactions and problem-solving behaviours. A typology of the different tasks might segregate (a) group decision-making tasks (requiring argumentation, debate, negotiation or consensus to arrive at a decision); (b) group co-ordination tasks (including collaborative work or jigsaw hidden profile paradigms where unique information must be shared); and (c) group-production tasks (where a product must be created by a team, including designs for new products or written reports). It is possible to align these categories to either units or items within a unit at different phases, depending on the constraints of item development. For example, consider the following CPS activities:

Consensus building: the group needs to make a decision after considering the views, opinions and arguments of different members. A dominating leader may prevent a sufficient number of perspectives from being shared with the group, so the decision may be non-optimal. The quality of the decision may also be threatened by "group think", swift agreement among members without considering the complexities of the problem.

Jigsaw problems: a method to insure interdependence among problem solvers, which is a condition to measure collaboration. Each group member has different information or skills. The group needs to pool the information and recruit each other's skills in order to achieve the group goal. The group goal cannot be achieved by any one member alone. One social loafer who does nothing can jeopardise the achievement of the group goal.

Negotiations: group members have different amounts of information and different personal goals. Through negotiation, select information can be passed so that there can be mutual win-win optimisation that satisfies overall group goals.

Additional types of CPS tasks can be appropriate, provided they provide time-constrained collaborative activities requiring ground rules for taking actions, and they establish and maintain both shared understandings and team organisation.

Distribution of units and items

Units serve as the primary context for collaborative problem-solving activities for the assessments. Table 7.2 shows the CPS context dimensions, illustrating a range of potential contexts, problem situations and media that are part of collaborative problem solving. Manipulating all context dimensions would create a large design space of potential CPS assessment activities. To reduce the design space, a set of primary context dimensions have been identified, based on a consensus of experts, that allow for the development of units that assess the major components of CPS skills. This typology of CPS activities uses four dimensions that occur across units (e.g. a unit has only one value on the dimension) and two dimensions in which the value can change within the unit. The typology is as follows:

Across units

- Private vs. public: The context for a problem is private if the scenario is concerned only with the immediate existing problem situation and the group currently solving it – for example, a problem that involves planning a time for a party under the constraints of the participating group members. A public context involves solving a problem in which there is a larger shared context that relates to the external world – for example, a problem that involves the group deciding on the best location to build a school in an under-resourced area.
- Technological vs. non-technological: A technological problem context involves collaboratively working on solving a problem that uses machinery or computer equipment – for example, a problem that involves discovering how something works (e.g. programming an alarm) or uses technology to complete a task (e.g. operating a machine to manufacture the optimal number of shoes). A non-technological context has a referent in the problem that is not technology-related (e.g. planning a party).
- School vs. non-school: A school context involves problems that are typically encountered in a school, while non-school encompasses potential problems that are encountered outside of the school context, e.g. home, work, etc.
- Symmetrical vs. asymmetrical roles: In a problem with symmetrical roles, each group member has the same role in the problem-solving context and all participate equally. In a problem with asymmetrical roles, different roles are assigned to different people, for example, one group member can be assigned to be a scorekeeper while another is assigned the role of controlling a machine.

Within units

- Task type (for example jigsaw, consensus-building, negotiation): As described in the previous section, different types of tasks elicit different types of problem-solving behaviour and interactions among the participants. Within a particular unit, a task type can change. For example, the unit can start with a hidden profile (jigsaw) and then once all the information is shared, it can become a consensus-building task.

- Dynamic vs. static: The 2012 individual problem-solving framework distinguishes between problems that are static (e.g. information disclosed to the problem solver is complete) and those that are dynamic, in which changes in information and states of the problem are beyond the control of the problem solver. In collaborative problem solving, the start of a problem tends to be dynamic, as information about the problem context and other agents is discovered. However, in the middle of a problem, as the student and agents figure out how to execute the actions and understand the roles of the group, the problem may become static. Thus, student performance can be tracked under both static and dynamic problem-solving contexts within units.

Items and weighting for scoring

Each problem scenario (unit) contains multiple tasks. A task, e.g. consensus building, is a particular phase within the scenario, with a beginning and an end. A task consists of a number of turns (exchanges, chats, actions, etc.) between the participants in the team. A finite number of options leading onto different paths are available to the participants after each turn, some of which constitute a step towards solving the problem. The end of a task forms an appropriate point to start the next task. Whenever the participants fail to reach this point, a "rescue" is programmed to ensure that the next task can start.

From a measurement point of view, each task contains one or more items that can be scored. Each item can be coded in two (dichotomous: 0 or 1) or more (polytomous: 0, 1, ..., m) categories, according to item-coding rubrics. The rescue mentioned above ensures that items are independent. The codes reflect the matrix of skills described in Table 7.1 and the proficiencies described later in Table 7.7.

Each item addresses one of the 12 cells in Table 7.1, i.e. the cell that represents the skill that the item aims to assess. The assessment covers all 12 cells, according to weightings discussed below. For example, some items emphasise exploring common ground (A1 in Table 7.1), others require students to clarify roles (B2), others to enact plans (C2), and yet others to reflect on what went wrong in the group (D3). Therefore, each item score contributes to the score for only one cell of the matrix.

The proposed allocation of weights for item development across the 12 skill cells is shown in Table 7.4. Greatest weight is placed on column 1 and then column 3 as these competencies focus specifically on collaborative skills, while column 2 focuses more on problem-solving behaviour within a collaborative context. The overall weighting of the rows is provided as a general guideline. In the PISA 2012 individual problem-solving assessment, it was found to be difficult to distinguish performance between "exploring and understanding" and "representing and formulating" (Greiff et al., 2012). Therefore, the two rows have been combined to provide a joint total weight. Evidence of performance that would fall within either of the two rows would be allocated towards the weight for those combined skills.

Table 7.4 Target weights by target skills

	Establishing and maintaining shared understanding	Taking appropriate action to solve the problem	Establishing and maintaining team organisation	Total
Exploring and understanding				~40%
Representing and formulating				
Planning and executing				~30%
Monitoring and reflecting				~30%
Total	**40-50%**	**20-30%**	**30-35%**	**100%**

Evidence-centred design

In order to measure CPS skills, a systematic measurement methodology is required that can handle the rich data that are collected in the log files of the computer-based assessment. The evidence-centred design (ECD) framework (Mislevy and Haertel, 2006; Mislevy, Steinberg and Almond, 2003) and its computer-based extensions (Clarke-Midura et al., 2011) provides a foundation for developing computer-based performance assessments to measure CPS skills in PISA 2015.

In the OECD framework, assessment is considered a process of reasoning from imperfect evidence using claims and evidence to support the inferences being made about student proficiency. The ECD process includes (a) identifying potential claims about what constitutes student proficiency; (b) identifying evidence (what behaviours/performances elicit skills being assessed, e.g. what students might select, write, do or produce that will constitute evidence for the claims); and (c) identifying the situations (the tasks or items) that give students the optimal opportunity to produce the desired evidence. The purpose is to develop models for schema-based task authoring and for developing protocols for fitting and estimation of psychometric models.

Evidence statements could be used to (a) ground measurement of student performance in observable products elicited by tasks or items; (b) define the distinction between partial and full expressions of the collaborative problem-solving skills; and (c) serve as a basis to develop a wide variety of useful reporting aspects for researchers analysing PISA data, educators, curriculum developers and other interested stakeholders. For example, Table 7.5 lists some design patterns that can guide the development of task-model templates for collaborative problem solving based on an ECD framework.

Table 7.5 Design patterns based on an evidence-centred design framework

Attribute	Description
Rationale	How/why this design pattern provides evidence about focal skill/competency
Focal CPS skill	The primary CPS skill targeted by this design pattern (e.g. establish and maintain shared understanding)
Additional skills	Other skills that may be required by tasks under this design pattern (e.g. explore and understand)
Potential observations	What students actually do, or make, in which they might produce evidence about skills (e.g. students' argumentation in support to agent's claim)
Potential work products	Products a student might produce to demonstrate CPS skills (e.g. correct selection of a hot spot, multiple choice, constructed response)
Characteristic features of tasks	Aspects of assessment situations that are needed to evoke the desired evidence (e.g. student provided with interesting and engaging context or scenario, visible alignment with a specific CPS skill taken from 2015 CPS assessment framework)
Variable features of tasks	Aspects of assessment situations that can be varied in order to shift difficulty or focus (e.g. difficulty of content, scaffolding)

Considerations for computer delivery

The proposed CPS framework with computer agents is compatible with the current capabilities of the PISA 2015 computer platform. The presentation of materials on the computer displays are all conventional media, such as diagrams, figures, tables, simulations (e.g. a shared space that team members can all see and respond to), windows, canned e-mail messages, icons, multiple-choice items, and so on. The student interacts with the agent(s) via a chat window allowing the student to respond through communication menus. With respect to the student inputs, once again, there are conventional interface components, such as mouse clicks, sliders for manipulating quantitative scales, drag-and-drop, cut-and-paste, and typed text input.

All of these standard interactions are supported by the Question and Test Interoperability authoring tool within the computer-based assessment platform TAO and can be automatically scored. These provide a simple means for students to interact with the assessments without requiring specialised knowledge beyond core ICT skills.

One of the salient features of the CPS interface may be an interface for communication between the student and agents. The platform can support communication modes, such as simulated e-mail, web and chat. For example, the interface for a chat communication contains a communication window with lists of alternative messages that can be sent to agents. There are three to five pre-defined alternative speech acts in a communication window that the student can select (via a click), thereby registering an act of communication. These speech acts may be defined according to the described proficiency levels for each cell of the CPS framework matrix. For instance, one act might ask the agent for clarification because the message was ambiguous (failing to detect ambiguities) or another act might ask the agent if he or she performed what he or she was supposed to perform. The fact that there are a limited number of pre-defined message options makes such a communication facility analogous to conventional multiple-choice items in assessments.

Aside from communicating messages, the student can also perform other types of actions on other interfaces, such as verifying in the environment if an action has been performed by another agent or performing an action that another agent failed to perform. Consequently, a sequence of possible message communications, actions and verbal reflections can be collected throughout the process of collaborative problem solving. These are stored in the computer log file. Most messages sent and actions performed can be automatically scored.

Factors affecting item difficulty

A student's overall proficiency in collaborative problem solving can be coded, scored, scaled and measured after defining the specific behaviours to be evaluated for each item and the conditions under which a student demonstrates those behaviours. These behaviours and conditions identify factors from Table 7.2 that determine the difficulty of items for the different collaborative processes. Table 7.6 shows proficient behaviours and conditions under which the behaviours can be manipulated to create item difficulty.

Table 7.6 Relationship between proficient behaviour and determinants of item difficulty

Collaboration processes	Proficient behaviour (summary)	States
(1) Establishing and maintaining shared understanding	▪ Discovers others' abilities - share information about own ability ▪ Discusses the problem - asks questions, responds to others' questions ▪ Communicates during monitoring and resolution of group work	▪ Amount of explicit prior information about others ▪ Size of group ▪ Openness of problem (well-defined/ill-defined) ▪ Having to initiate vs. being prompted to talk
(2) Taking appropriate action to solve the problem	▪ Understands the type of interaction needed, makes sure to know who does what ▪ Describes and discusses tasks and task assignment ▪ Enacts plans together with others and performs the actions of the assigned role ▪ Monitors and evaluates others' work	▪ Interdependency ▪ Intrinsic complexity of problem ▪ Clarity of problem goal ▪ Openness of problem (well-defined/ill-defined) ▪ Distance to solution ▪ Problem space: Explicit or implicit information about group members' actions
(3) Establishing and maintaining team organisation	▪ Acknowledges and enquires about roles ▪ Follows rules of engagement – complies with plan, ensures others do ▪ Monitors team organisation – notices issues, suggests ways to fix them	▪ Symmetry of roles ▪ Problem space: Explicit or implicit information about group members' actions ▪ Co-operativeness of group members

Considerations for contextual questionnaire

Students' characteristics, their prior experiences of CPS and their attitude towards CPS are considered as affective factors towards their performance in the CPS assessment (Figure 7.1). However, general attitudes towards collaborative problem solving are not assessed directly within the cognitive component of the CPS assessment, but in the background questionnaire. In PISA 2012, some student dispositions related to individual problem solving were measured: openness to learning, perseverance and problem-solving strategies. For 2015, an updated set of constructs was developed to incorporate students' experiences and dispositions towards collaboration.

For the 2015 contextual questionnaire, three general constructs were defined as being of interest for psychometric and educational purposes:

Student characteristics: The composition of personality types in collaborative groups has been shown to be an important predictor of performance, particularly extraversion (McGivney, Smeaton and Lee, 2008). Knowing the personality traits of the students and controlling the traits of the agent-partners means that further research can be done to see what effect the "Big Five" personality types (openness, conscientiousness, extraversion, agreeableness and neuroticism) have on performance.

Experiences and **practices:** Collaborative problem solving is not a traditional domain, in that it is not explicitly taught as a school subject; rather, it is embedded as a practice in the classroom. The extent to which students in different PISA participating countries may be familiar with collaboration may differ; therefore it is important to have supporting data on their familiarity with CPS within the following contexts:

- educational: e.g. classroom and assessment experiences
- out-of-school: e.g. home life and hobbies
- technology-specific: e.g. gaming.

Disposition to CPS: The way in which students' perceive CPS and, in particular, their self-efficacy can also affect their performance. Therefore, the following areas are of interest:

- interest in and enjoyment of collaboration
- value of collaboration skills
- self-perception of CPS ability.

Due to logistical and space constraints in the background questionnaire, only some of these constructs are measured. In addition, some information can be gathered through the optional questionnaires, such as the IT, teacher and parent questionnaires.

Reporting proficiency in CPS

A single score summarises students' overall proficiency in collaborative problem solving. To illustrate what the score means, PISA has adopted an approach to reporting survey outcomes that involves the development of learning metrics, which are dimensions of educational progression. Several levels are distinguished and described along these scales in terms of what students typically know and can do.

Table 7.7 Proficiency scale descriptions for collaborative problem solving

Level	What students can typically do
4	At Level 4, students can successfully carry out complicated problem-solving tasks with high collaboration complexity. They are able to solve problems situated in complex problem spaces with multiple constraints, keeping relevant background information in mind. These students maintain an awareness of group dynamics and take actions to ensure that team members act in accordance with their agreed-upon roles. At the same time, they are able to monitor progress towards a solution to the given problem and identify obstacles to be overcome or gaps to be bridged. Level 4 students take initiative and perform actions or make requests to overcome obstacles and resolve disagreements and conflicts. They can balance the collaboration and problem-solving aspects of a presented task, identify efficient pathways to a problem solution, and take actions to solve the presented problem.
3	At Level 3, students can complete tasks with either complex problem-solving requirements or complex collaboration demands. These students can perform multi-step tasks that require the integration of multiple pieces of information, often in complex and dynamic problem spaces. They orchestrate roles within the team and identify information needed by particular team members to solve the problem. Level 3 students can recognise information needed to solve a problem, request it from the appropriate team member, and identify when the provided information is incorrect. When conflicts arise, they can help team members negotiate a solution.
2	At Level 2, students can contribute to a collaborative effort within a problem space of medium difficulty. They can help solve a problem by communicating with team members about the actions to be performed. They can volunteer information not specifically requested by another team member. Level 2 students understand that not all team members have the same information and are able to consider different perspectives. They can help the team establish a shared understanding of the steps required to solve a problem. These students can request additional information required to solve a given problem and solicit agreement or confirmation from team members about the approach to be taken. Students near the top of Level 2 can take the initiative to suggest a logical next step, or propose a new approach, to solve a problem.
1	At Level 1, students can complete tasks with low problem complexity and limited collaboration complexity. They can provide requested information and take actions to enact plans when prompted. Level 1 students can confirm actions or proposals made by others. They tend to focus on their individual role within the group. With support from team members, and working within a simple problem space, these students can contribute to a problem solution.

Four levels of proficiency are identified and described in Table 7.7 in an overall reporting scale for CPS to enable comparisons of student performance between and within participating countries and economies. The descriptions reflect the items that students performing at each level typically can and cannot perform, and the collaborative problem-solving skills associated with these items.

SUMMARY

Collaborative problem solving (CPS) is introduced in PISA for the first time in 2015. The 2015 definition described here builds on the PISA 2012 individual problem-solving assessment, but extends it into the collaborative domain by incorporating the theoretical bases of individual and group cognition. The four processes of the 2012 individual problem-solving framework have been retained and added to the three core competencies identified for collaborative problem solving to produce a matrix of CPS skills. Each of these skills is defined with levels of proficiency that can be measured by the assessment instrument.

The PISA 2015 definition of CPS competency has its origin in the consideration of the types of problems and collaborative interactions that 15-year-old students face in and outside of the classroom, as well as a consideration for their "preparedness for life" in the workplace and in further studies. The ability of each participant in a group to communicate, manage conflict, organise a team, build consensus and manage progress is crucial to its success; the measurement of these skills is at the heart of the three competencies that will form the reporting scales for the assessment.

This framework for 2015 describes and illustrates the collaborative and problem-solving skills that are assessed in PISA 2015, the knowledge and student characteristics that factor into the assessment, and the contexts, team composition and task types that form the basis of the computer-based assessment (Figure 7.1). The framework also explains the rationale for using computer agents to operationalise the measurement of students' collaborative skills. This should enable measurement of the proficiency levels to quantify student performance in CPS.

GLOSSARY OF TERMS

Term	Explanation
Actions	Any explicit acts made by the individual that change the state of the collaborative problem.
Agent	Either a human or a computer-simulated participant in a CPS group.
Cluster	Several units grouped into a 30-minute block for testing.
Consensus-building	A task type where the group needs to make a decision after considering the views, opinions and arguments of different members.
Conversational agent	Computer-based agents representing team members with a range of skills and abilities.
Cost of grounding	How easy it is for members of the group to communicate with each other and find common ground.
ECD (evidence-centred design)	A framework for developing assessments by reasoning from imperfect evidence using claims and evidence to support the inferences being made about student proficiency (Mislevy and Haertel, 2006; Mislevy, Steinberg and Almond, 2003).
Hidden profile task	See jigsaw.
Item	Each problem scenario is divided into different tasks termed "items". Items are a unit of measurement.
Jigsaw	Also known as hidden profile. A task type where each group member has different information or skills. The group needs to pool the information and recruit each other's skills in order to achieve the group goal. The group goal cannot be achieved by any one member alone.
Log file	File to which the computer writes a record of student activities.
Negotiation	A task where group members have different amounts of information and different personal goals. Through negotiation, select information can be passed so that there can be mutual win-win optimisation that satisfies overall group goals.
Openness	The degree to which a problem is "well-defined" (e.g. all the information is at hand for the problem solver) vs. "ill-defined" (e.g. the problem solver must discover or generate new information in order for the problem to be solved).
Probe	A question that stops the problem scenario to assess a student's cognitive state relative to the skills in the framework, e.g. a multiple-choice question to assess knowledge states, shared understanding.
Problem scenario	The problem that the group must solve. Each scenario involves one or more task types and settings. Each unit contains one scenario.

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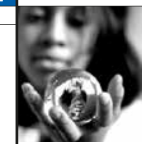
Problem space	The space in which the actions are carried out to solve the problem. Can be explicitly or implicitly visible to team members.
Problem state	Any stage within a problem space. Actions or communication can change the state of a problem to another state that is closer or further from the goal.
Product	Outcomes that provide a measure of the success that the actions are being enacted properly and that the group is moving the problem state forward appropriately.
Referentiality	An item's context may have high referentiality to the outside world and real-world contexts or, at the other end of the spectrum, low referentiality with little reference to external knowledge.
Rescue agent	If students reach an impasse or run out of time, a rescue agent will intervene to take students to the beginning of the next item.
Semantic richness	The degree to which the problem provides a rich, elaborated problem context that relates to the external world.
Settings	The context dimensions of the problem scenario, namely: ▪ private vs. public ▪ technology vs. non-technology ▪ school vs. non-school.
Symmetry of roles	The degree to which team members are assigned similar or different roles in a problem scenario.
Symmetry of status	The degree to which the status of team members is the same or different (e.g. peers vs. supervisor-and-subordinate relationships).
Task	A task is a particular phase within the problem scenario consisting of a number of turns between the participants in the team. From a measurement point of view, a task is an item that can be scored.
Task type	The type of collaborative problem-solving task that elicits different types of interactions and problem-solving behaviours. The three types are: consensus-building, jigsaw, negotiations.
Turns	A set of one or more human actions and/or communications in an item.
Unit	Each unit contains one problem scenario and several items.



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Annex 7.A

STUDIES ON CONVERSATIONAL AGENTS

There is a broad spectrum of computer-based agents that have been used in tasks that involve tutoring, collaborating learning, co-construction of knowledge and collaborative problem solving. (See Table 7.8 for examples of operationally implemented systems). These agents provide a range of techniques that can be potentially incorporated in CPS assessments. At one extreme there are fully embodied conversational agents in a virtual environment, with speech recognition capabilities embedded in a serious game (e.g. the *Tactical Language and Culture System*, Johnson and Valente, 2008). Although this might be motivating to 15-year-old students, this solution would be prohibitively costly and impractical to implement in multiple countries.

A less-expensive solution is animated conversational agents that express themselves with speech, facial expression, gesture, posture and/or other embodied actions. Such systems have been developed and tested in dozens of learning environments during the past two decades, such as *AutoTutor* (Graesser, Jeon and Dufty, 2008; VanLehn et al., 2007), *Betty's Brain* (Biswas et al., 2005), *Operation ARIES* (Millis et al., 2011) and *iSTART* (McNamara et al., 2007a). Although these systems have proven successful in facilitating learning in an impressive body of empirical research, there would be major challenges in technology, costs and cultural variations in language and discourse to implement them in PISA 2015. For example, there are considerable differences among countries in language, speech, communication style, dress, facial demeanour, facial expressions, gesture and so on.

A minimalist approach to assessment using agents provides much of the same control as the more interactive agent approaches, while avoiding some of the above complications. Minimalist agents may consist of printed messages in windows on the computer display, such as e-mail messages, chat facilities, print in bubbles besides icons and documents in various social communication media (Rouet, 2006). Some of these forms of agent-based social communication media have already been implemented in PIAAC (OECD, 2009). There would be no speech generation because of concern of variations among dialects. There might be static visual depictions of the agents who send the messages, which is helpful to mitigate confusion on "who says what" when there are multiple agents playing multiple roles. However, such an approach can minimise the depiction of gender, ethnicity and other visual characteristics of agents that present complications of cultural bias and measurement error.

An important consideration is that it is important for the human to pay attention to the agent when the agent communicates, in a fashion that is analogous to a human who takes the floor when speaking and gets noticed. This can be accomplished with a minimalist agent by a dynamic highlighting of messages and windows through colour, flash and co-ordination of messages with auditory signals (Mayer, 2010).

Computer agents can communicate through a variety of channels. The simplest interface would have the student clicking an alternative on a menu of optional speech acts and for there to be a limited number of options (2 to 7). Other possibilities are open-ended responses that range from typing (or speaking) a single word to articulating sentences and composing lengthier essays. The simplest, but still effective, click interface supports online conditional branching to different system and conversational states, depending on the options the human selects.

Open-ended responses of sentences or essays may be incorporated in the CPS items for later assessment by expert human markers; however, online assessment is still impractical because the advances in computational linguistics (Jurafsky and Martin, 2008) and essay grading (Landauer, Laham and Foltz, 2003; Shermis et al., 2010) are limited or non-existent for some languages. Nevertheless, it would be prudent to collect such open-ended responses for a percentage of assessment items in order to advance research and development of automated language-discourse analyses for future generations. An intermediate solution is semi-structured interfaces, when the system proposes "sentence openers" and then the student completes the sentence (e.g., Soller and Lesgold, 2007). The computer agents can adopt different roles (Baylor and Kim, 2005; Biswas et al., 2005; Millis et al., 2011). For example, the student might take the role of midlevel management and communicate with a supervisor agent and a subordinate agent. The computer agent might be a peer, with equal status to the agent, depending on the way the agent is presented to the subject at the beginning of the text.

The number of computer agents can also vary from only one partner in a dyad, to two agents in a triad, to three or more agents in larger group ensembles. The ensembles of agent configurations are essentially unlimited. Triads (a student and two agents) have advantages because the number of agents is small (minimising confusion in agent roles) but affords interesting complexities in social interaction, such as status differences, agents disagreeing with each other, and agents making comments or taking actions that would make sense to a knowledgeable human (Millis et al., 2011; Wiley and Jensen, 2007). It can also be used to measure social conformity, e.g. whether the student would follow the two agents when they agree on a solution for which the human subject has evidence that it is wrong.

An agent-based approach provides a means to assess individuals' competencies. The proposed minimalist approach to the presence of agents is compatible with the tasks developed for PIAAC (2010) in assessments of problem solving in technology-rich environments. While PIAAC focuses on interaction with technology rather than collaboration, the user interface approach would not be that different. The human would receive e-mail messages from different individuals in addition to working with spreadsheets and web-like searches. Contemporary social communication media (e.g., e-mail, chat, blogs, discussion portals) frequently have messages sent by individuals who cannot be seen and who might not even be known by the recipient of a message (National Research Council, 2011). Teenagers are extensive users of these 21st-century communication media so such interfaces have high ecological validity. Companies also are increasingly adopting mediated natural language communication. Artificial agents are ubiquitous in the modern world and are likely to become even more prevalent in the future.

The following table is a summary of studies with conversational agents in tasks that involve tutoring, collaborative learning, co-construction of knowledge and collaborative problem solving. Innovative assessment systems with agents are being developed at Pearson, Education Testing Service and other assessment organisations (e.g. Forsyth et al., 2012).

Table 7.8 Examples of operationally implemented agent-human based training and assessment systems

Tutor agent and human co-constructing answer to difficult question or solution to problem			
AutoTutor, GuruTutor, Why-Atlas	Physics, biology, computer literacy	Agent helps student articulate answers and solutions through natural language interaction with feedback, hints, prompts for information, corrections and assertions of missing information. Learning gains are the same as human tutors.	Graesser et al. (2004) Olney et al. (2012) VanLehn et al. (2007)
Two agents training humans in skills of reading, writing and speaking			
iSTART	Science texts	Teacher and peer agent train students how to generate self-explanations during reading. Computer interprets natural language and gives feedback. The computer improves comprehension and can accurately identify student paraphrases, relevant elaborations, predictions and other categories of speech acts.	McNamara et al. (2007b) McNamara et al. (2006)
Writing Pal	Argument essays	Teacher and peer agent train students how to write essays by interactively scaffolding different phases of writing. Computer gives feedback on writing quality and scaffolds student's mastery of particular writing components.	McNamara et al. (2012)
Tactical Language and Culture Training System	Language learning	Students learn new languages with multiple agents in socio-cultural contexts. Speech recognition is excellent and students learn. Won the DARPA technological achievement award in 2005 for Tactical Iraqi.	Johnson and Valente (2008)
Tutor, mentor and peer agents collaboratively work with the student on reasoning and problem-solving tasks			
Operation ARIES Operation ARA	Scientific methods and reasoning	Tutor and student peer agents hold trialog conversations with the student on scientific reasoning, finding flaws in research studies and asking questions to critique poor research. There is mixed-initiative dialogue in these interactions. Computer agent helps students learn scientific reasoning and can evaluate the quality of student natural language as well as human experts.	Cai et al. (2011) Millis et al. (2011)
Betty's Brain	Biology, environmental science	Student teaches a student agent how to reason and construct a conceptual graph to understand science well enough to take tests. The human and student collaboratively interact in the inquiry process, with a mentor agent stepping in at appropriate points. This teachable agent system helps students learn the skills of self-regulated learning in addition to deep mental models for problem solving and reasoning.	Biswas et al. (2010) Schwartz et al. (2009)
Crystal Island	Biology	Students interact with agents in a virtual world to explore why a disease evolved. The goal is to build enquiry skills.	Rowe et al. (forthcoming)
River City, ECOMove	Ecology	Agents interact with students in groups on problem solving about hazards in ecological systems.	Ketelhut et al. (2007) Metcalf et al. (2011)
MetaTutor	Biology	Students interact with agents to acquire the skills of self-regulated learning and metacognition in the context of biological systems.	Azevedo et al. (2010)
Coach Mike Ada and Grace	Museums of science	Multiple agents interact with patrons in a science museum.	Lane et al. (2011)
BiLAT	Negotiation	Agents help people learn how to negotiate in a different cultural context.	Kim et al. (forthcoming)

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Annex 7.B

COLLABORATIVE PROBLEM-SOLVING LITERATURE REVIEW

Collaborative problem solving has been investigated in the social sciences for several decades, resulting in a number of theoretical frameworks, models and paradigms of empirical studies. These contributions span the areas of communication, individual and group problem solving, computer-supported co-operative work, and team assessment. Annex 7.B reviews and outlines research from a number of areas that have implications for the design decisions of the CPS assessment. Many studies have assessed particular components of collaborative problem solving, but few have been validated across diverse populations. Moreover, most studies have focused on business, military contexts or college students (Loughry, Moore and Ohland, 2007; Morgeson, Reider and Campion, 2005; Zhuang et al., 2008). Nevertheless, many of the models, studies and frameworks can apply to the 15-year-old PISA population.

Existing frameworks and models for collaborative skills

A number of existing models and frameworks were reviewed in order to conceptualise the key processes involved in CPS. The conceptualisations of collaborative skills differ in the details across the models, but there are a number of correspondences and some convergence. For example, a number divide out different skills related to collaboration and those related to problem solving. Some of these models formed the basis of the development of definitions of the three core competencies adopted in the PISA 2015 CPS framework, namely:

- establishing and maintaining shared understanding
- taking appropriate action to solve the problem
- establishing and maintaining team organisation.

These three core competencies incorporate major processes taken from theoretical frameworks in the literature cited below. Moreover, they correspond to skills that are important for students entering academic and workplace environments and they adhere to the additional constraint that they can be measured in the PISA 2015 assessment.

The ATC21S framework for collaborative problem solving (Griffin, Care and McGaw, 2011) views CPS as a multi-dimensional skill that includes both social or collaborative skills, and cognitive skills. CPS was conceptualised as having five broad skills.

Social skills include:

- **participation and co-operation:** the ability to participate as a member of a group and contribute knowledge
- **perspective-taking:** the ability to place oneself in another's position, which can lead to adaptation, and modification of communication to take the other's perspective into consideration.
- **social regulation:** such as negotiation and resolution of conflicts or misunderstandings.

Cognitive skills include:

- **task regulation:** the identification of the problem space (its description, goals, needs and resources); clear understanding of the problem space supports the skills of social regulation (being aware that the problem space provides a structure within which learners can locate themselves and each other's needs for knowledge or resources)
- **knowledge building:** where unique contributions of information, skills or resources are combined to contribute to the solution of a problem.

The PIAAC Problem Solving in Technology-Rich Environments Framework (OECD, 2009), incorporates several skills related to CPS. It defines problem solving in technology-rich environments as "using digital technology communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks". It focuses on "ability to solve problems for personal, work and civic purposes by setting up appropriate goals and plans, accessing and making use of information through computers and computer networks" (OECD, 2009). The skills of communicating with others, and setting goals and plans while solving problems are critical in using digital technologies and are core components of collaboration skills.

The Partnership for 21st-Century Skills' framework (Fadel and Trilling, 2009) presents definitions of communication, collaboration skills and problem solving:

- **Communicate clearly**

  Articulate thoughts and ideas effectively using oral, written and non-verbal communication skills in a variety of forms and contexts.

  Listen effectively to decipher meaning, including knowledge, values, attitudes and intentions.

  Use communication for a range of purposes (e.g. to inform, instruct, motivate and persuade).

  Utilise multiple media and technologies, and know how to judge their effectiveness a priori as well as assess their impact.

  Communicate effectively in diverse environments (including multi-lingual).

- **Collaborate with others**

  Demonstrate ability to work effectively and respectfully with diverse teams.

  Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal.

  Assume shared responsibility for collaborative work, and value the individual contributions made by each team member.

- **Solve problems**

  Solve different kinds of non-familiar problems in both conventional and innovative ways.

  Identify and ask significant questions that clarify various points of view and lead to better solutions.

Stevens and Campion (1994) provide a five-component model of teamwork that includes the following knowledge, ability and skills:

- **conflict solving:** the ability to recognise and encourage useful conflicts and to employ appropriate conflict resolution strategies when conflicts are not useful
- **collaborative problem solving:** the ability to identify situations requiring group problem solving and decision making
- **communication:** listening skills and a willingness and ability to develop open and supportive communication
- **goal setting and performance management:** setting acceptable and appropriate goals and providing feedback
- **planning and task co-ordination:** the ability to co-ordinate activities with other team members.

Another framework suggested by the Center for Research on Evaluation, Standards and Student Testing (CRESST) consists of six measures (O'Neil et al., 2003, 1997):

- **adaptability:** the group's ability to monitor the source and nature of problems, and provide appropriate feedback
- **co-ordination:** a process by which group resources, activities and responses are organised to ensure success
- **decision making:** the ability to integrate information, use judgement, identify possible alternatives, select the optimal solution, and evaluate the consequences
- **interpersonal:** the ability to improve the quality of team member interactions
- **leadership:** the ability to direct and co-ordinate the activities of the team, assess the performance, assign tasks, plan and organise, and establish a positive atmosphere
- **communication:** efficient information exchange between team members in the agreed manner and by using proper terms, and the ability to clarify and acknowledge.

Zhuang et al. (2008) developed a framework that incorporates some of the considerations of the other frameworks to create five content areas:

- **task-related process skills:** collaborative problem solving, decision making, planning and task co-ordination, strategy formulation, co-ordination, goal setting, performance management
- **co-operation with other team members:** adaptability, interpersonal skills
- **influencing team members through support and encouragement**: confidence building, social support
- **resolution of conflicts or disagreements among team members via negotiation strategies:** conflict solving, communication
- **guidance and mentorship of other team members**: leadership, helping others.

Collazos et al. (2007) suggest five system-based indicators of the success in CPS:

- **use of strategies:** the ability of group members to generate, communicate and consistently use a strategy to jointly solve the problem
- **intra-group co-operation:** the application of collaborative strategies during the process of group work
- **reviewing success criteria:** the degree of involvement of group members in reviewing boundaries, guidelines and roles during the group activity
- **monitoring:** the extent to which the group maintains the chosen strategies to solve the problem, keeping focused on the goals and the success criteria
- **the performance of the group:** how good is the result of collaborative work, total elapsed time while working, and total amount of work done.

Interpersonal skills and the attitudinal, behavioural and cognitive components are also considered critical for performing effectively in collaborative situations. Interpersonal skills have been described as a form of social perception and social cognition involving processes such as attention, and decoding in interpersonal situations. These skills can be likened to a form of social intelligence, involving knowledge of social customs, expectations and problem solving (McDonald et al., 2003). Further, they rest on an "ability to understand" behaviours, cognitions and attitudes of individuals (including oneself) and to translate understanding into appropriate behaviour in social situations (Marlowe, 1986). In a dynamic context, interpersonal skills involve continuous correction of social performance based on reactions of others during social exchanges (Argyle, 1979). This requires a type of monitoring with feedback loops where one continually adapts behaviours based on verbal and non-verbal cues from others involved in the social exchange. In their review of interpersonal skills, Klein, DeRouin and Salas (2006) synthesised the literature to develop a taxonomy of these skills. They defined interpersonal skills as an umbrella term that refers to "goal-directed behaviours, including communication and relationship-building competencies, employed in interpersonal interaction episodes characterised by complex perceptual and cognitive processes, dynamic verbal and non-verbal interaction exchanges, diverse roles, motivations and expectancies" (p. 81).

Discourse in collaborative problem solving

The theoretical framework for problem solving as a social process was developed by Vygotsky (1986, 1978). According to this theory, personal potential could be realised through a process of interaction with and support from the human environment and from various tools. Interpersonal activity when appropriately implemented could lead to intrapersonal mental development. When trying to solve a problem together through the exchange of ideas, a group of learners constructs shared meanings that the individual would not have attained alone. The shared meaning can only be achieved through communication within the group.

Collaborative problem solving is a co-ordinated joint dynamic process that requires periodic communication between group members (i.e. human or computer agents). The discourse that is communicated among the agents provides both a means for the collaboration to occur as well as a means for measuring the collaborative processes. Communication is a primary means of constructing a shared understanding, as modelled in Common Ground Theory (Clark, 1996; Clark and Brennan, 1991). Clark's theory is widely used within CPS literature as a way of addressing the fact that all agents in a problem solving situation must have some sense of shared knowledge in order to solve a task. Some interpretations of this theory have suggested that the original portrayal of grounding must be extended and adapted to group problem solving because of the complex nature of these interactions (Dillenbourg and Traum, 2006).

In order to apply grounding to problem solving, one major discrepancy exists. In the original theory, conversational partners need only achieve a high enough level of shared understanding necessary to facilitate resulting actions (Clark and Wilkes-Gibbs, 1986). However, Schwartz (1995) suggests that effort is required to acquire new knowledge. Dillenbourg, Traum and Schneider (1996) propose that "optimal collaborative effort" is required of all of the participants in order to achieve adequate learning and performance in a collaborative environment. Some empirical evidence from human interactions in collaborative learning environments suggests that persistence in communication may be more important than a common external representation that facilitates grounding, thus supporting the hypothesis of optimal collaborative effort (Dillenbourg and Traum, 2006).

Researchers of Transactive Memory Theory (Barnier et al., 2008; Theiner, 2010; Theiner and O'Connor, 2010) propose that discourse can allow for an externalised representation of knowledge, leading to the emergence of new information from a group beyond that of any one individual. Fiore and Schooler (2004) adopt a view of macrocognition from this proposition and blended two ideas in order to accommodate group problem solving, namely macrocognition with an application of group communication theory (Chi, Glaser and Rees, 1982; Fiore and Schooler, 2004; Hirokawa, 1980; Orlitzky and Hirokawa, 2001). Specifically, the idea of macrocognition in teams focuses on how people of varying backgrounds and expertise are able to interact with other individuals in a fashion that allows for not only a shared representation but also the formation of new knowledge by applying previously acquired information to new situations.

Group communication theory (as functionally applied to decision-making in problem solving) suggests that the degree to which groups contribute time and effort to completing specific subgoals predicts final performance. The first subgoal is to analyse the problem (Campbell, 1968). The next goal is to define the seriousness of the problem or the reason for solving it, followed by identifying causes, and finally consequences to solutions of the problem. Specific concentration to the negative consequences resulting from solutions may increase a group's effectiveness (Orlitzky and Hirokawa, 2001). The need for communication and achievement of subgoals leads to the conclusion that predicting group performance in problem solving tasks relies heavily on the time spent and quality of the interactions of the group members (Fiore et al., 2010). It is important to place students in an environment that facilitates optimal circumstances for both communicating and reaching a solution.

Considerations for problem-solving environments and tasks

Many collaborative problem-solving studies focus on social dilemmas in which group members must resolve a conflict between personal vs. group benefits. For example, the classic Prisoner's Dilemma consists of a scenario in which multiple people are called in by the police and accused of a crime. By co-operating, an individual may receive the least amount of jail time only if all of the other parties do not co-operate. Rational theory predicts that each person will defect (Hargreaves and Varoufakis, 2004) with deleterious effects. Conversely, real-life experiments show that communication leads to higher co-operation in resolving conflicts within groups during this type of problem-solving task (Balliet, 2010; Sally, 1995).

In contrast to asymmetries in goals, hidden profile tasks create asymmetries in information among participants (Stasser and Titus, 1985). A hidden profile task, or "jigsaw" is one where some information is shared among group members but other important parts of the problem are left unshared. That is, all participants possess some information prior to discussion but other pieces of information are distributed separately to members. To effectively solve the problem, all information must be pooled (Stasser, 1988; Stasser and Titus, 2003).

Technology allows investigators to place humans in orchestrated situations and observe their behaviour and reactions. For example, many technological environments are based on naturalistic decision making (Klein, 2008; Klein et al., 1993; Lipshitz et al., 2001; Zsambok and Klein, 1997) in which each individual has his/her own goals, identity, and expertise which must be aligned in decisions and action in order to reach the end goal that affects both the individual and the group as a whole. According to Fan, McNeese and Yen (2010), naturalistic decision making focuses on decisions that people make in real life. Ill-structured situations can be created in computer-simulated environments in order to conduct group problem solving research. For example, naturalistic decision making has been examined in a computer-mediated environment in order to discover the beneficial aspects of including artificial agents as collaborators during complex problem solving (Fan, McNeese and Yen, 2010).

Problem solving has also been studied with a focus on goal orientation and achievement rather than decision making, an approach derived from operative intelligence theory (Dörner, 1986). This approach concentrates on the cognitive processes of the group members rather than the results of any given task. Researchers analyse behaviour in complex and dynamic situations that are instantiated in computer-simulated environments, as in the case of the microworlds of Tailorshop (Brehmer and Dörner, 1993) and Microdyn (Funke and Frensch, 2007; Greiff, Wüstenberg and Funke, 2012). Tailorshop creates a scenario in which participants must run a business while maintaining multiple and intertwining goals. Microdyn is an artificial environment that can be altered by allowing systematic variation as group members attempt to manage a complex situation with independent subgoals. Because the goals are independent, multiple scenarios can be presented in succession in order to solve the issue of members achieving only one task (Greiff and Funke, 2009).

Measures of teamwork, taskwork and team cognition

Effective teams engage in both taskwork, i.e. efforts focused on accomplishing the required tasks, and teamwork, i.e. efforts aimed at operating cohesively as a unit (McIntyre and Salas, 1995). There have been a number of techniques developed for assessment of these skills. The approaches have included peer evaluation, behavioural observation scales for experts/instructors, peer review questionnaires and surveys. While none are practical for individual measurement for PISA, these methods inform the taskwork, teamwork and interpersonal skills that are critical to measure in collaborative problem solving. Furthermore, many of these same skills being assessed can be measured in a computer-based collection of collaborative problem-solving data. The logs of the communication and actions performed by the students can be directly related to particular skills and processes used in the scales.

Observation scales

Behavioural observation scales are typically assessed through an instructor or rater observing the team interaction or through peer rating. Taggar and Brown (2001) developed behavioural observation scales that focused on interpersonal skills and self-management skills. These were derived from critical incidents to provide context relevant examples. Each member of the team rated each other team member on items related to the following 13 different dimensions:

1. Reaction to conflict
2. Addresses conflict
3. Averts conflict
4. Synthesis of team's ideas
5. Involving others
6. Effective communication
7. Goal-setting/achievement
8. Team citizenship
9. Commitment to team
10. Focus on task-at-hand
11. Preparation for meetings
12. Providing/reaction to feedback
13. Performance management

A subset of specific behaviours relevant to PISA may be derived from these constructs and be captured in an automated fashion.

Team Dimensional Training was developed in the context of complex decision making tasks for the US Navy. It has been validated in a number of settings with a variety of types of teams (e.g. Smith-Jentsch et al., 2008, 1998). In team dimensional training, behavioural observation is used to rate teamwork process along four dimensions:

- **Information exchange:** addresses "what" is passed "to whom" and is meant to capture those processes foundational to a team's ability to develop and maintain shared situation awareness
- **Communication:** addresses "how" information is delivered
- **Supporting behaviour:** captures how teams compensate for one another in service of achieving team objectives
- **Initiative and leadership:** encompasses guidance and direction provided by team members.

A Likert-type scale is used to make performance ratings for each team member. Ratings are typically provided on a Likert-type scale ranging from 1 to 5 (highly ineffective to highly effective). In Table 7.9, the specific components of team dimensional training are listed.

Table 7.9 Components of team dimensional training

Teamwork dimensions	Component behaviours
Information exchange	▪ Passing relevant information to appropriate teammate at the correct time ▪ Gathering information from all relevant sources ▪ Providing periodic situation updates to summarise big picture
Communication delivery	▪ Using proper terminology ▪ Avoiding excess chatter ▪ Speaking clearly and audibly ▪ Delivering complete standard reports containing data in the appropriate order
Supporting behaviour	▪ Offering, requesting and accepting backup when needed ▪ Noting/correcting errors and accepting correction
Initiative and leadership	▪ Explicitly stating priorities ▪ Providing guidance and suggestions to other team members ▪ Providing direction to other team members

Source: Smith-Jentsch et al. (2008), "Guided team self-correction: Impacts on team mental models, processes and effectiveness".

The Comprehensive Assessment of Team Member Effectiveness instrument is a form of peer evaluation developed from a distillation of numerous team behaviour measurement instruments. It uses "peer evaluations" which have been shown to be a reliable and valid indicator of team process in prior research (e.g. Loughry, Moore and Ohland, 2007; Taggar and Brown, 2001). With this form of assessment, following some interaction experiences, peers rate each other's teamwork behaviours using various scales. For example, the 33-item version of the assessment (Loughry, Moore and Ohland, 2007) has been validated in different team problem-solving and decision-making contexts. The teamwork behaviours in the assessment are categorised along the following five dimensions. With this instrument, peers anonymously rate each other based upon their experience in the team interaction. The Comprehensive Assessment of Team Member Effectiveness relies upon Likert-type scales for rating team members on questions relating to four dimensions:

- Contributing to the team's work
- Interacting with teammates
- Keeping the team on track
- Expecting quality
- Having relevant knowledge, skills and abilities

Measures of team cognition

Problem-solving theory states that mental models can be thought of as an organised understanding or mental representation of knowledge. A team mental model, as an extension of an individual mental model, is an organised understanding or mental representation of knowledge regarding a team's goals, tasks, actions, members and performance. This can be related to either taskwork or teamwork. According to team-cognition theory, effective teams hold multiple compatible mental models (Cannon-Bowers, Salas and Converse, 1993) which support both implicit and explicit co-ordination processes.

Four such models have been elaborated. First is an "equipment model" that captures the shared understanding of the technology and equipment necessary for the team task. Second is the task model that captures the understanding of procedures, task contingencies and strategies of the task. Third is the team-interaction model that captures the understanding of the norms of the team, their responsibilities and their interaction patterns. More specifically, this includes roles, responsibilities, information sources, communication channels and role interdependencies, and is essentially "teammate-generic". Last, the teammate model captures understanding of each other's knowledge, skills, and attitudes, that is, their strengths and weaknesses (Lim and Klein, 2006). This is an assessment of teammates' knowledge, skills, abilities and tendencies, and it is essentially "teammate-specific".

Table 7.10 Accuracy and sharedness of mental models

		Accuracy	
		Low-quality mental model	**High-quality mental model**
Sharedness	**Weak agreement**	Worst performance	Accurate but different (e.g. in situations with differing functional roles the team members may have accurate mental models of their own task but not their teammates)
	Strong agreement	Inaccurate but agreed-upon mental models; they may be able to co-ordinate but it would be down the wrong solution paths (e.g., they will get to an incorrect solution rapidly)	Best co-ordination

Source: Lim and Klein (2006), "Team mental models and team performance: A field study of the effects of team mental model similarity and accuracy".

What is critical for problem solving assessments using shared mental model theory is that we must distinguish between accuracy/quality of the mental model and the sharedness/overlap of the mental model. This is illustrated in Table 7.10.

Items used by Lim and Klein (2006) for pairwise comparisons to assess taskwork and teamwork models:

Taskwork mental model survey items:

- Team members are proficient with their own weapons.
- Team members are proficient with other members' weapons.
- Team members are very good at IA drills.
- Team members have a good understanding of the characteristics of the enemy's weapons.
- Team members conduct routine maintenance of their equipment and weapons in the field.
- Team members are allowed to bring their personal weapon home.
- Team members understand the team's task.
- Team members agree on a strategy to carry out the team task.
- Team members understand other members' tasks.
- Tasks in the team are assigned according to individual member's ability.
- Team members are cross-trained to carry out other members' tasks.
- Team members adhere strictly to the team's SOP.
- Team members understand the battlefield situation.
- The team is highly effective.

Teamwork mental model survey items:

- Team members work well together.
- Team members often disagree with each other on issues faced by the team.
- Team members trust each other.
- Team members communicate openly with each other.
- Team members agree on decisions made in the team.
- Team members accept decisions made by the leader.
- Team members interact with one another outside the camp compound.
- Team members back each other up in carrying out team tasks.
- Team members are similar to each other (e.g. personality, temperament and abilities).
- Team members are aware of other team members' abilities.
- Team members are aware of other team members' personal backgrounds (e.g. family background, hobbies and habits).
- Team members know other team members' family members.
- Team members treat each other as friends.
- The team is highly effective.

Early research on team member surveys (Moreland and Myaskovsky, 2000) analysed team interactions to identify examples of awareness of differentiated member knowledge (specialisation), beliefs about team member reliability on that knowledge (credibility) and the effectiveness in orchestrated knowledge processing (co-ordination). More recently, a large portion of the literature on team member surveys has used surveys of member agreement on expertise surrounding these three particular facets of these surveys (see below). This technique was validated in an important series of studies conducted by Lewis (2003). Lewis examined how assessments of specialisation, credibility and co-ordination could be compared against earlier measures of transactive memory (e.g. verbal protocol analysis, recall measures). The Lewis team member survey scale relies upon Likert-type questions for rating team members.

Items from Lewis's (2003) Transactive Memory System Scale:

- **Specialisation:**

  Each team member has specialised knowledge of some aspect of our project.

  I have knowledge about an aspect of the project that no other team member has.

  Different team members are responsible for expertise in different areas.

  The specialised knowledge of several different team members was needed to complete the project deliverables.

  I know which team members have expertise in specific areas.

- **Credibility:**

  I was comfortable accepting procedural suggestions from other team members.

  I trusted that other members' knowledge about the project was credible.

  I was confident relying on the information that other team members brought to the discussion.

  When other members gave information, I wanted to double-check it for myself. (reversed)

  I did not have much faith in other members' "expertise." (reversed)

- **Co-ordination:**

  Our team worked together in a well-co-ordinated fashion.

  Our team had very few misunderstandings about what to do.

  Our team needed to backtrack and start over a lot. (reversed)

  We accomplished the task smoothly and efficiently.

  There was much confusion about how we would accomplish the task. (reversed)

Small teams do not always require a leader, while large groups always need some form of leadership. Much of the small-team collaborations tasks being assessed within PISA would not require leadership by a single individual. The skills however, remain relevant to the CPS framework, incorporating many of the same competencies. Morgeson, Reider and Campion (2010) developed the measure below to examine leadership in teams. This took a functional approach and outlined what types of behaviours in teams are related to leadership. Although this distinguishes between "action" and "transition" phases in teams and the different functions engaged by teams and their leaders it has items examining both "taskwork" and "teamwork". As such, some variant of this may be warranted. That is, even members of a team who are not leaders can engage in leadership behaviours related to both taskwork and to teamwork.

Morgeson et al.'s Team Leadership Questionnaire (2010) includes the following functions:

- **Transition phase leadership functions:**

  Compose team.

  Define mission.

  Establish expectations and goals.

  Structure and plan.

  Train and develop team.

  Sense-making.

  Provide feedback.

- **Action phase leadership functions**

  Monitor team.

  Manage team boundaries.

  Challenge team.

  Perform team task.

  Solve problems.

  Provide resources.

  Encourage team self-management.

  Support social climate.

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Annex 7.C

PISA 2015 COLLABORATIVE PROBLEM-SOLVING SAMPLE UNITS

Purpose and scope of sample units

Two collaborative problem-solving (CPS) units were developed as preliminary samples to illustrate the concepts of the assessment framework and show how it might be operationalised. These samples were tried out with a small number of students representing the target testing population in the context of cognitive lab interviews. This confirmed that students could demonstrate the targeted skills when answering the items and that those skills could, therefore, potentially be measured. The samples are not intended to be complete units: they do not cover all item types available, and they do not demonstrate the computer platform used in PISA 2015. These samples will be replaced by released items that contain more detailed information about scoring and student performance.

Both units contain several items, showing how the different competencies in the CPS skills matrix (Table 7.1) are measured. The following assessment and educational principles guided the development of the sample units:

- evidence-centred design (ECD)
- engaging CPS scenarios relevant for 15-year-old students
- phrase chat to operationalise communication between the student and the computer agent (canned words and phrases, appropriate for each situation, are presented in a menu format; the student constructs the dialogue by selecting phrases)
- progression through each unit based on a mapping of the phrase chat and actions possible for each situation; this functionality allows for a standardised CPS assessment of each student
- consideration of cognitive load, colour contrast, and navigation complexity
- scaffolding (embedded "rescue agent" functionality is provided by the computer agent[s] to allow sufficient control over interaction to assure assessment of the full range of CPS proficiencies in the skills matrix)
- clear stimulus material and brief task statements to reduce the dependency on reading proficiency.

To illustrate appropriate coverage of the major CPS skills, one of the units is characterised by a symmetrical nature of collaboration (THE AQUARIUM), while in the second unit the student is assigned as leader of a team with two agents to achieve a common goal (CLASS LOGO). The assessment scenarios include simulations of disagreements between the agent and the student, collaboratively-orientated agent behaviours (e.g. initiating ideas, building consensus, and supporting and praising other team members), and low collaborative agent behaviours (e.g. interrupting other members of the team or commenting negatively about work of others). This allows for a range of situations and team compositions to be presented to the student and thus provides a sufficient dataset for CPS assessment.

Sample CPS unit: THE AQUARIUM

Unit classifications

Context: <u>in-school</u> | outside school
Contents: <u>**consensus building**</u>, <u>win-win negotiation</u>, <u>**hidden profile (jigsaw) task**</u>
Type of CPS task: <u>**decision making**</u> | co-ordination | production
Number of agents: <u>two agents</u>, including the student
Target unit timing: 5 minutes | 10 minutes | <u>**15 minutes**</u> | 20 minutes

Unit overview (team composition, problem context and overview of tasks)

In this unit the test-taker and Abby (a computer agent) collaborate to find the optimal conditions for fish living in an aquarium. The test-taker controls three variables (water, scenery and lighting) and Abby controls three other variables (food, fish population and temperature). Within each unit, there are several tasks, each of which may contain one or more assessment items. Scores are accumulated based on the test-taker's performance on individual items.

The first task involves an initial consensus-building discussion between the test-taker and Abby on how to solve the problem (exploring and understanding). Then the team proceeds to a series of collaborative hidden-profile tasks to find the optimal conditions for the fish (representing and formulating, and planning and executing). In the final task, the test-taker monitors and reflects on the collaborative work. The test-taker is told that the number of attempts to solve the problem (known as "trials") is limited to five. The first attempt is set up so that the test-taker will not be able to solve it right away, i.e. the underlying principle of the task forces the test-taker to be involved in at least two trials to gather sufficient data in order to measure CPS skills.

Agent overview

Abby represents collaboratively orientated agent behaviour (e.g. she initiates ideas, builds consensus, and responds to, supports and praises the test-taker). However, in some situations Abby shows misunderstanding of the results and suggests misleading strategies to solve the problem. As long as the test-taker clarifies or repairs misunderstandings or points out the advantages or disadvantages of different strategies, Abby is persuaded. However, if the test-taker does not clarify misinterpretations of results or provide evidence that counters a suggested strategy, Abby will press for a rationale for accepting the strategy.

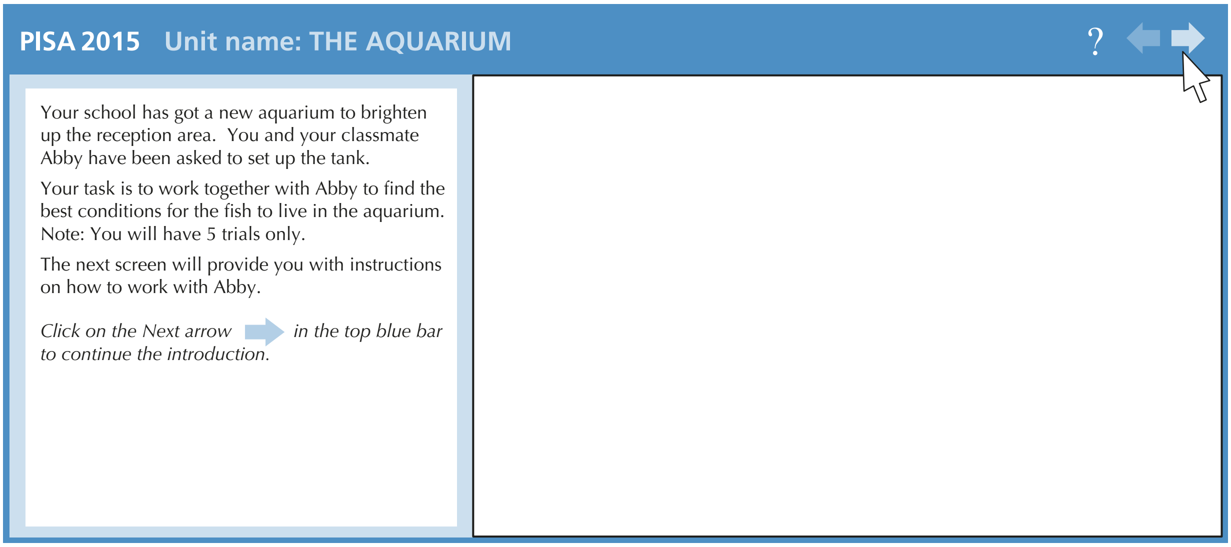
CPS skills

In this unit the test-taker demonstrates CPS skills by establishing a shared understanding of the problem, clarifying misunderstandings and building consensus with a team member on the actions to be performed. The specific cells addressed in the framework matrix from Table 7.1 are described below.

Introduction and orientation

The unit starts with a briefing on the scenario outline and training on the Chat, Control Panel and Task Space areas of the screen. This section is not timed or scored.

Figure 7.2 [1/2] ■ **Sample unit THE AQUARIUM: Introduction**



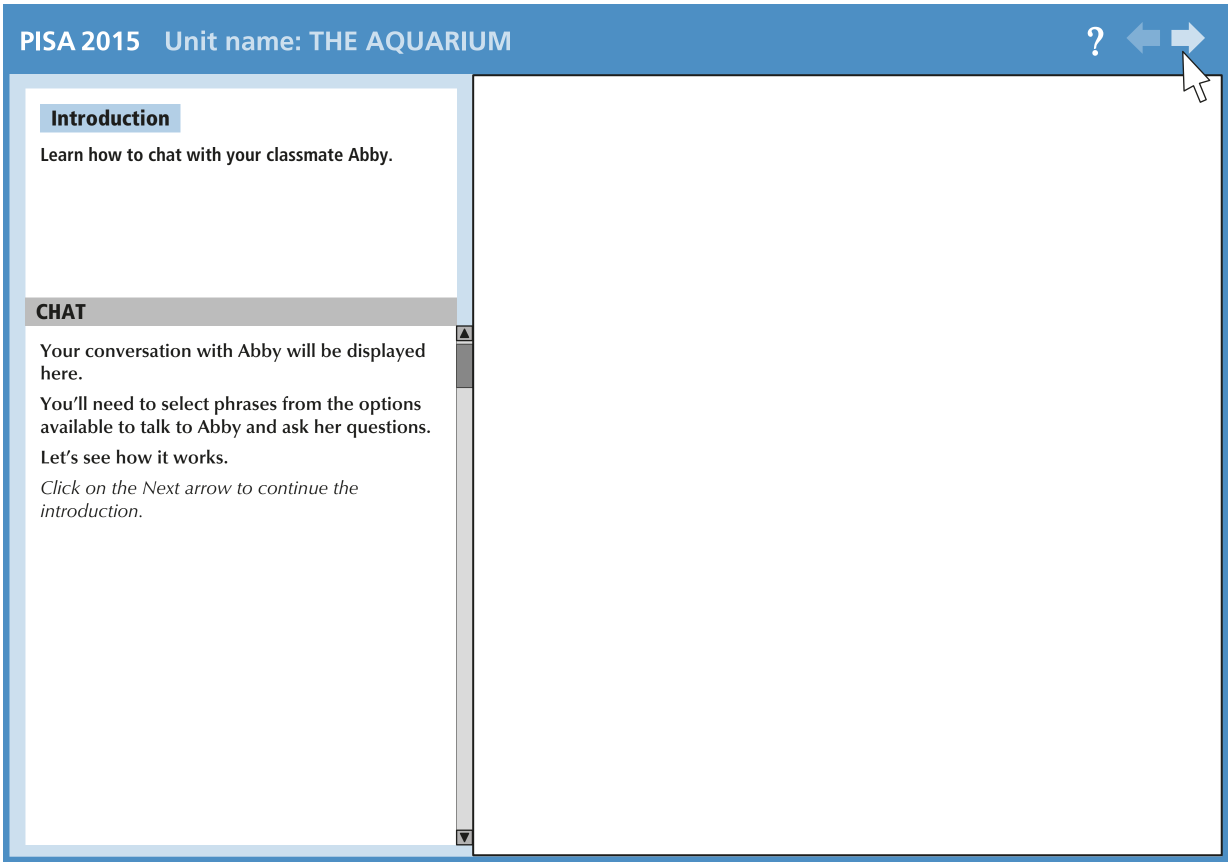
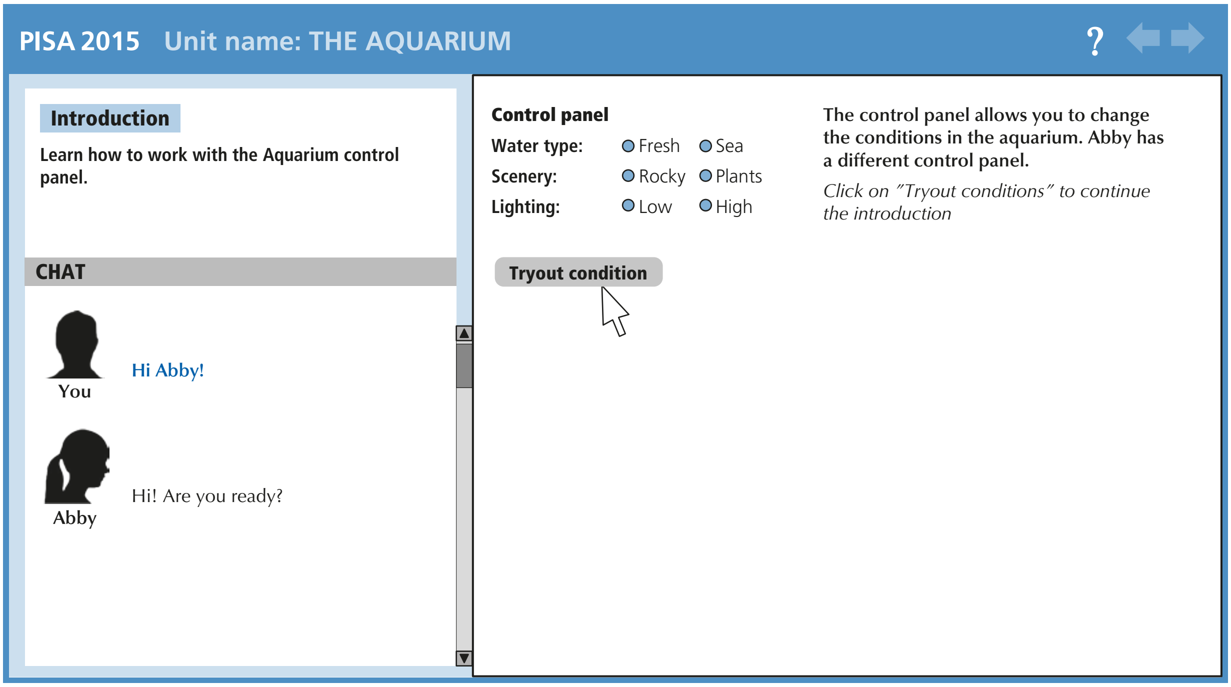
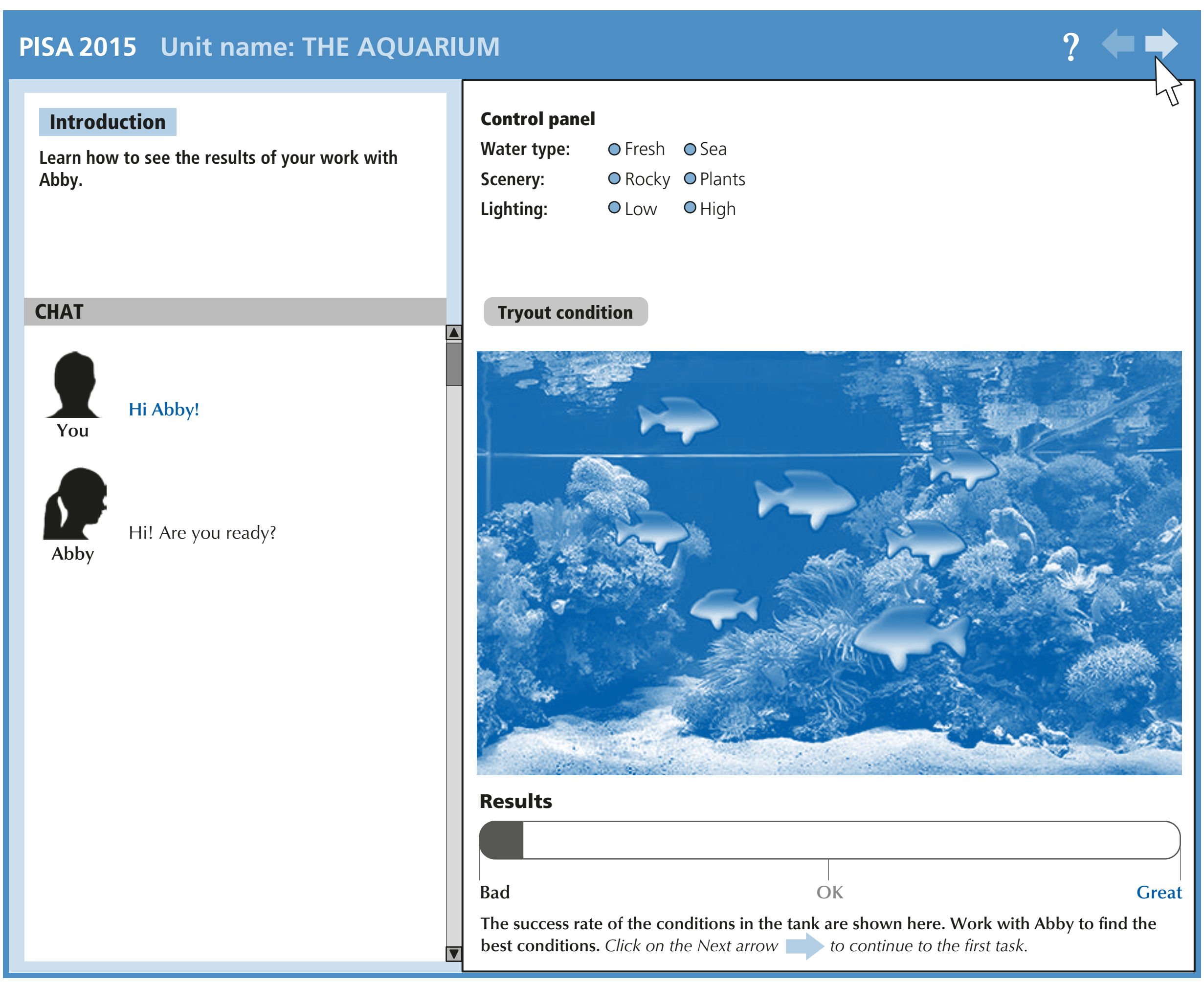


Figure 7.2 [2/2] ▪ **Sample unit THE AQUARIUM: Introduction**





Outline of unit tasks

Task 1: Establish shared understanding

Activity

- **Item 1:** The test-taker has to find out what Abby's controls are by asking her. If the test-taker asks, Abby shares her screen (and the test-taker receives one score point for the skill). If the test-taker doesn't ask and tries to move too quickly to actions, then Abby will perform a rescue and offer to share her screen (and the test-taker receives zero score points for the skill).
- **Item 2:** The test-taker has to click on the "share screen" button to reciprocate and allow Abby to see his or her controls. If the test-taker doesn't perform the action within a certain amount of time, then Abby will prompt again.
- **Item 3:** The test-taker offers a plan of how to reach the optimum solution and asks Abby for her point of view. If the test-taker doesn't offer an idea, then Abby prompts. If still no idea is offered, Abby will suggest an idea herself.
- **Item 4:** The test-taker has to ensure that Abby is in agreement (i.e. monitors shared understanding) before clicking on "Next" to try out the new conditions for fish. If the test-taker doesn't offer to click "Next", then Abby will rescue and request or encourage the test-taker to do something. When the test-taker clicks "Next", a pop-up asks if both team members are ready to start the next task. If the test-taker did not agree with Abby beforehand, then Abby can interject here and the test-taker can repair before clicking "Yes" to proceed.

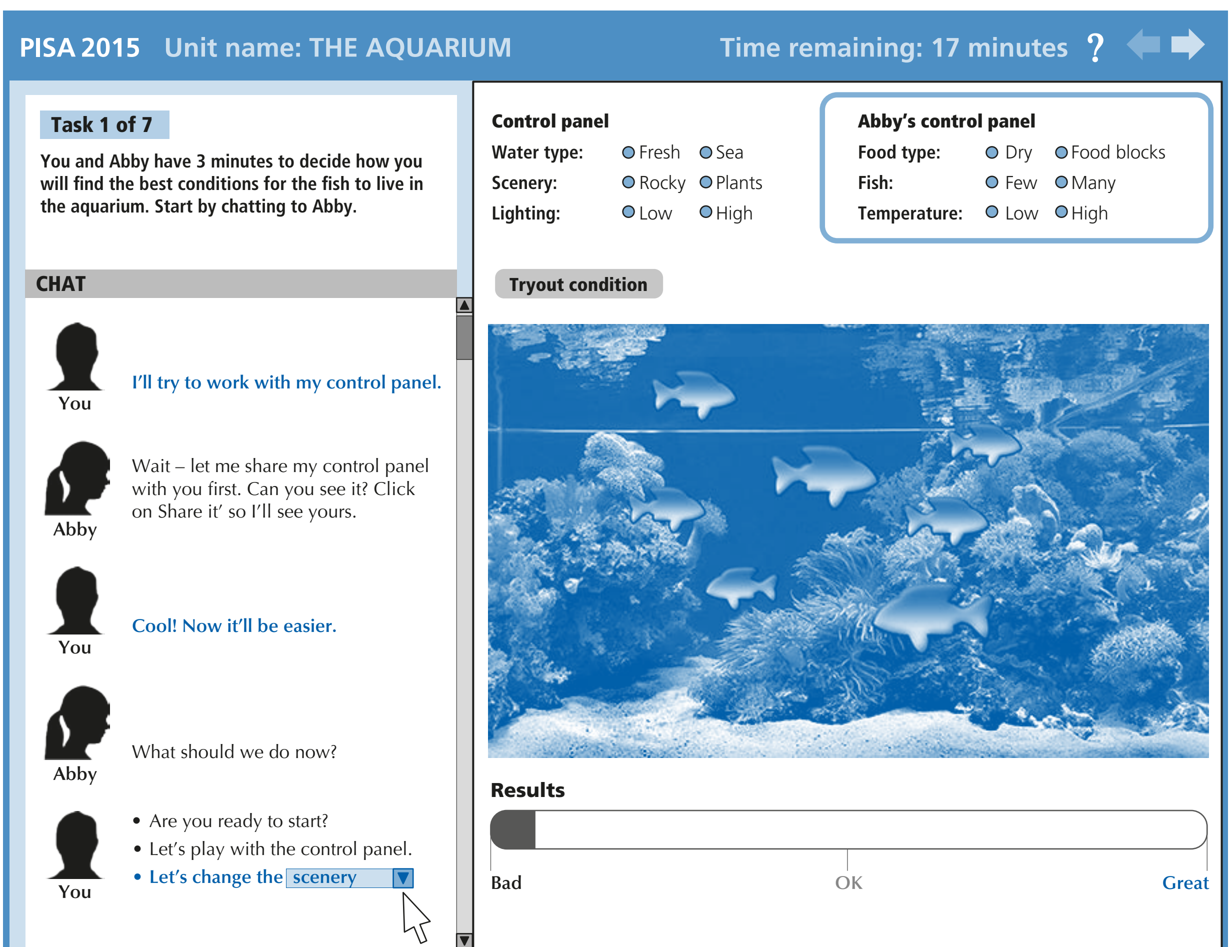
Convergence

The test-taker can see Abby's controls and vice versa. The test-taker and the agent have decided on a plan.

CPS skill(s) assessed across the items within the task:

(A1) Discovering perspectives and abilities of team members; **(A2)** discovering the type of collaborative interaction to solve the problem, along with goals; **(C1)** communicating with team members about the actions to be/being performed; **(B1)** building a shared representation and negotiating the meaning of the problem (common ground).

Figure 7.3 ▪ **Sample unit THE AQUARIUM: Task 1**



Task 2: Enacting plans and monitoring the results

Activity

- **Item 1:** The test-taker monitors whether Abby followed the plan as discussed, while Abby's controls show that she didn't follow the plan. The test-taker shares his or her understanding of the result (fish conditions).
- **Item 2:** The test-taker has to offer a plan of how to proceed (e.g. "let's change this variable"). If the test-taker doesn't offer an idea, then Abby can prompt. If still no idea is offered, then Abby will suggest an idea herself.
- **Item 3:** The test-taker asks Abby for her point of view before implementing the plan. If the test-taker doesn't ask, then Abby shares her view with the test-taker.

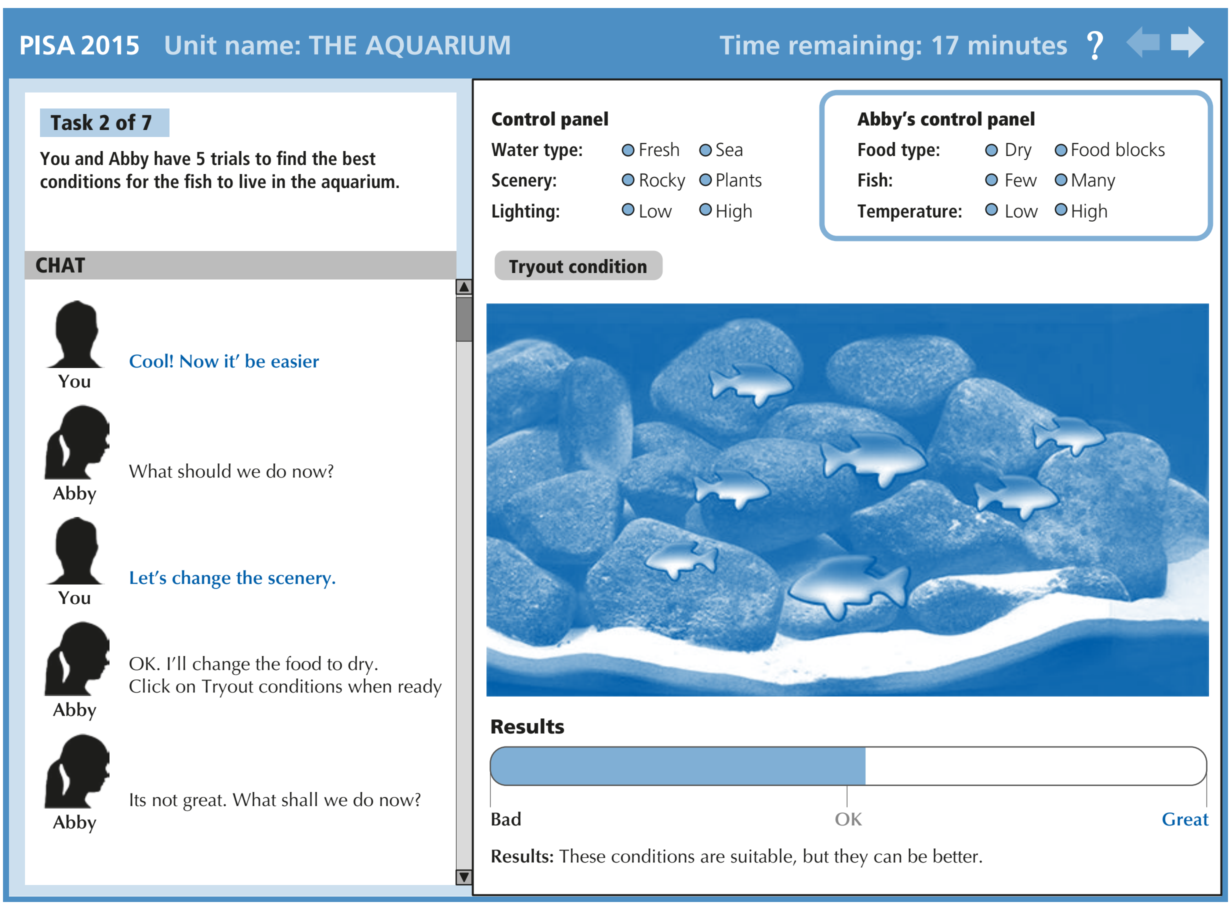
Convergence

There is a change in the aquarium variables. The results of the trial are presented.

CPS skill(s) assessed:

(A1) Discovering perspectives and abilities of team members; **(A2)** discovering the type of collaborative interaction to solve the problem, along with goals; **(C1)** communicating with team members about the actions to be/being performed; **(B1)** building a shared representation and negotiating the meaning of the problem (common ground).

Figure 7.4 ▪ **Sample unit THE AQUARIUM: Task 2**



Task 3: Monitoring and repairing the shared understanding

Activity

- **Item 1:** The test-taker implements the plan as discussed with Abby. The test-taker monitors whether Abby followed the plan as discussed. Abby's controls show that she is following the plan.
- **Item 2:** The test-taker shares his or her understanding of the result (fish conditions).
- **Item 3:** The test-taker repairs Abby's misunderstanding of the result.

- **Item 4:** The test-taker has to offer a plan of how to proceed (e.g. “let’s change this variable to start”). If the test-taker doesn’t offer an idea, then Abby can prompt. If still no idea is offered, then Abby will suggest an idea herself.
- **Item 5:** The test-taker asks Abby for her point of view before implementing the plan. If the test-taker doesn’t ask, then Abby shares her perspective with the test-taker.

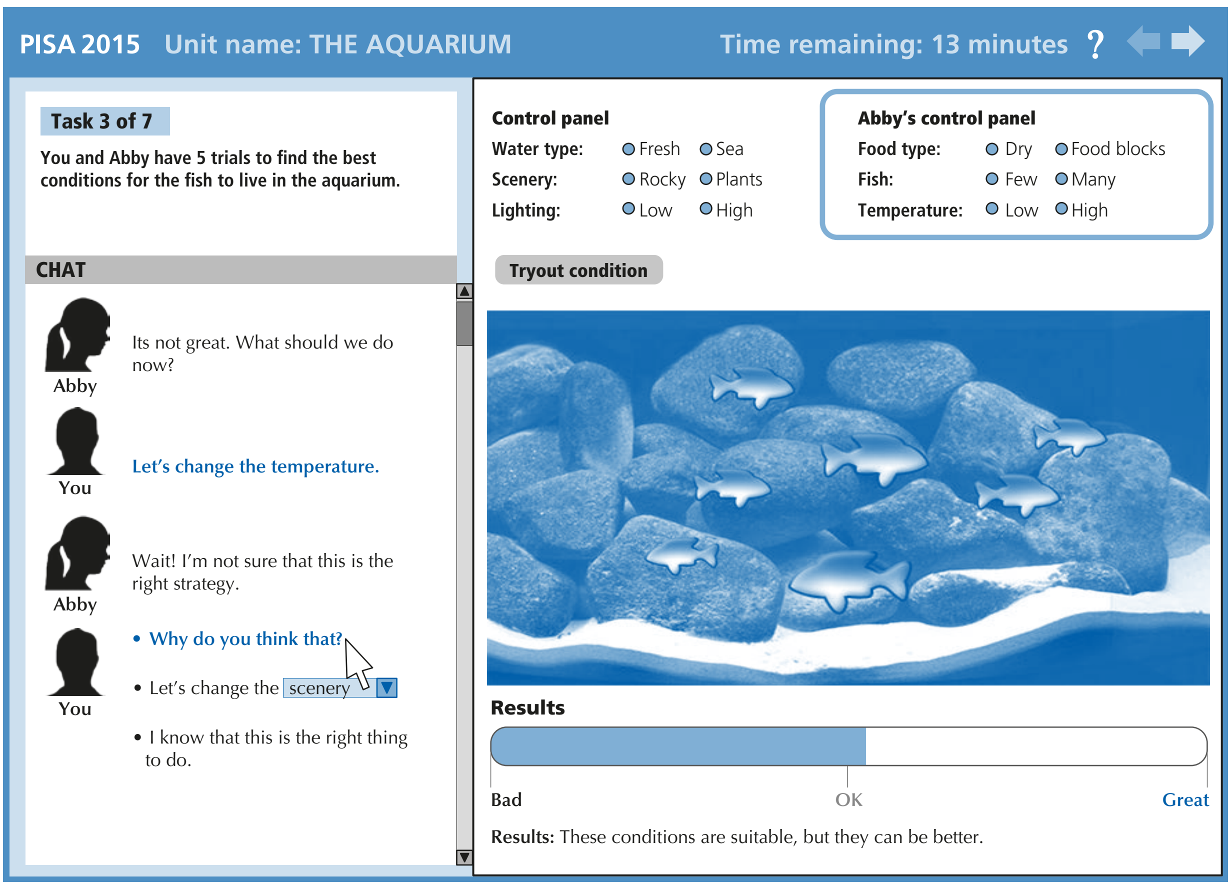
Convergence

There is a change in the aquarium variables. The results of the trial are presented.

CPS skill(s) assessed across the items within the task:

(**C2**) Enacting plans; (**D2**) monitoring results of actions and evaluating success in solving the problem; (**D1**) monitoring and repairing the shared understanding; (**C1**) communicating with team members about the actions to be/being performed; (**B1**) building a shared representation and negotiating the meaning of the problem (common ground).

Figure 7.5 ▪ **Sample unit THE AQUARIUM: Task 3**



Tasks 4-6

These are only presented if applicable, depending on the test-taker’s performance.

Activity

Optimising the strategy to solve the problem

- **Item 1:** The test-taker implements the plan as discussed with Abby. The test-taker monitors whether Abby followed the plan as discussed. Abby’s controls show that she is following the plan.
- **Item 2:** The test-taker shares his or her understanding of the result (fish conditions).
- **Item 3:** The test-taker has to offer a plan of how to proceed (e.g. “let’s change this variable”). If the test-taker doesn’t offer an idea, then Abby can prompt. If still no idea is offered, then Abby will suggest an idea herself.
- **Item 4:** The test-taker asks Abby for her point of view before implementing the plan. If the test-taker doesn’t ask, Abby shares her perspective with the test-taker.

Figure 7.6 ▪ **Sample unit THE AQUARIUM: Tasks 4-6**

PISA 2015 Unit name: THE AQUARIUM Time remaining: 13 minutes ?

Task 4 of 7

You and Abby have 5 trials to find the best conditions for the fish to live in the aquarium.

CHAT

Abby: Let's change the scenery again. The results were much better for rocky scenery.

You:
- You're right. I'll change it back.
- Why do you think that?
- No, the results with the plant scenery were better.

Control panel

Water type: Fresh Sea
Scenery: Rocky Plants
Lighting: Low High

Abby's control panel

Food type: Dry Food blocks
Fish: Few Many
Temperature: Low High

Tryout condition

Results

Bad OK Great

Results: These conditions are suitable, but they can be better.

PISA 2015 Unit name: THE AQUARIUM Time remaining: 3 minutes ?

Task 6 of 7

You and Abby have 5 trials to find the best conditions for the fish to live in the aquarium.

CHAT

Abby: This is our last trial now.

You: Yeah, do you want to decide what change should we make?

Abby: Oh, we didn't try the temperature.

You: You're right. Go for it!

Control panel

Water type: Fresh Sea
Scenery: Rocky Plants
Lighting: Low High

Abby's control panel

Food type: Dry Food blocks
Fish: Few Many
Temperature: Low High

Tryout condition

Results

Bad OK Great

Results: You've selected almost the best conditions!

Convergence

There is a change in the aquarium variables. The results of the trials are presented.

CPS skill(s) assessed across the items within the task:

(C2) Enacting plans; **(D2)** monitoring results of actions and evaluating success in solving the problem; **(C1)** communicating with team members about the actions to be/ being performed.

As test-takers may make multiple attempts to optimise the strategy to solve the problem, they would receive scores based on the number of attempts, with fewer attempts resulting in higher scores (0-2) for C2. Test-takers would also receive the maximum score achieved across attempts for skills D2 and C1.

Task 7: Providing feedback

Activity

- **Item 1:** The test-taker provides reflective feedback on his or her work with Abby. The test-taker is required to suggest a more collaborative method to promote co-operation with Abby on the task (e.g. talk more to Abby).

Convergence

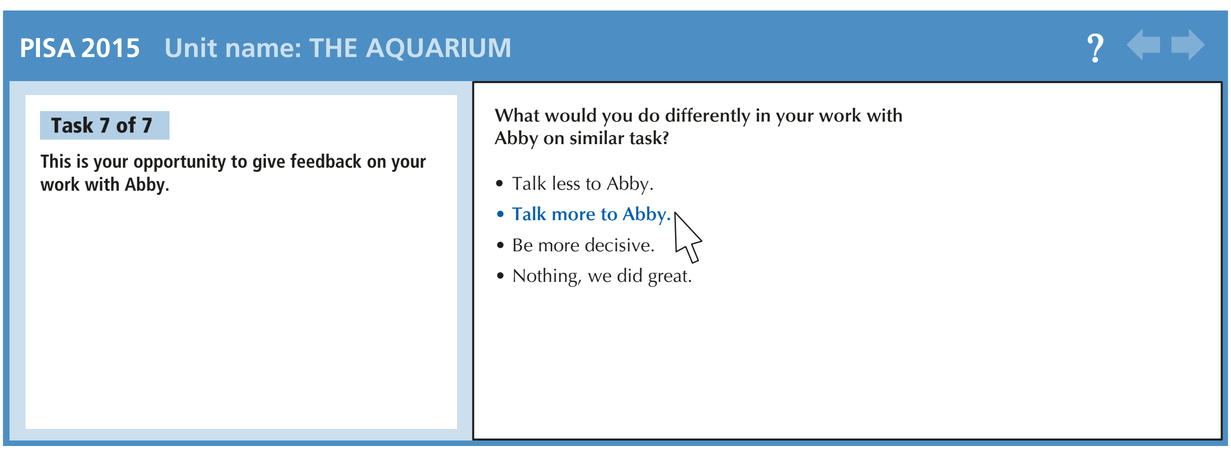
Abby and the test-taker give feedback on the collaborative work.

CPS skill(s) assessed across the items within the task:

(D3) Monitoring, providing feedback and adapting the team organisation and roles.

The question is presented in a multiple-choice format. There is a single optimal answer, which receives full credit. Some of the other options would receive partial credit, and some options would receive no credit.

Figure 7.7 ▪ **Sample unit THE AQUARIUM: Task 7**



Unit measurement profile

At the end of each task, there is a convergence point. This ensures that all students start from the same point and have the same opportunity to score.

Table 7.11 Profile of assessment items within sample unit THE AQUARIUM

Task no.	Item no.	Item short description	Target collaborative problem-solving skill	Data type	Score range (0-x)
1	1	Test-taker finds out what Abby's controls are by asking her.	**(A1)** Discovering perspectives and abilities of team members	Communication	0-2
1	2	Test-taker clicks on "share screen" button to reciprocate and allow Abby to see his or her controls.	**(A2)** Discovering the type of collaborative interaction to solve the problem, along with goals	Action	0-2
1	3	Test-taker offers a plan of how to reach the optimum solution.	**(C1)** Communicating with team members about the actions to be/ being performed	Communication	0-2
1	4	Test-taker asks Abby for her point of view before implementing the plan.	**(B1)** Building a shared representation and negotiating the meaning of the problem (common ground)	Communication	0-2
2	1	Test-taker implements the plan as discussed with Abby.	**(C2)** Enacting plans	Action	0-2
2	2	Test-taker monitors if Abby followed the plan as discussed.	**(D1)** Monitoring and repairing the shared understanding	Communication	0-2
2	3	Test-taker shares his or her understanding of the result (fish conditions).	**(D2)** Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
2	4	Test-taker offers a plan of how to reach the optimum solution.	**(C1)** Communicating with team members about the actions to be/ being performed	Communication	0-2
2	5	Test-taker asks Abby for her point of view before implementing the plan.	**(B1)** Building a shared representation and negotiating the meaning of the problem (common ground)	Communication	0-2
3	1	Test-taker implements the plan as discussed with Abby.	**(C2)** Enacting plans	Action	0-2
3	2	Test-taker shares his or her understanding of the result (fish conditions).	**(D2)** Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
3	3	Test-taker repairs Abby's misunderstanding of the result.	**(D1)** Monitoring and repairing the shared understanding	Communication	0-2
3	4	Test-taker offers a plan of how to reach the optimum solution.	**(C1)** Communicating with team members about the actions to be/ being performed	Communication	0-2
3	5	Test-taker asks Abby for her point of view before implementing the plan.	**(B1)** Building a shared representation and negotiating the meaning of the problem (common ground)	Communication	0-2
4	1	Test-taker implements the plan as discussed with Abby.	**(C2)** Enacting plans	Action	0-2
4	2	Test-taker shares his or her understanding of the result (fish conditions).	**(D2)** Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
4	3	Test-taker asks Abby for her point of view before implementing the plan.	**(C1)** Communicating with team members about the actions to be/ being performed	Communication	0-2
5	1	Test-taker implements the plan as discussed with Abby.	**(C2)** Enacting plans	Action	0-2
5	2	Test-taker shares his or her understanding of the result (fish conditions).	**(D2)** Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
5	3	Test-taker asks Abby for her point of view before implementing the plan.	**(C1)** Communicating with team members about the actions to be/ being performed	Communication	0-2
6	1	Test-taker implements the plan as discussed with Abby.	**(C2)** Enacting plans	Action	0-2
6	2	Test-taker shares his or her understanding of the result (fish conditions).	**(D2)** Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
6	3	Test-taker asks Abby for her point of view before implementing the plan.	**(C1)** Communicating with team members about the actions to be/ being performed	Communication	0-2
7	1	Test-taker provides reflective feedback on the work with Abby.	**(D3)** Monitoring, providing feedback and adapting the team organisation and roles	Probe, MC	0-2

Note: Score points are assigned based on exhibiting behaviour (performing actions or communicating). Items are scored polytomously (0, 1, 2) according to levels of competency.

Sample CPS unit: CLASS LOGO

Unit classifications

Context: in-school | outside school
Contents: consensus building, win-win negotiation, hidden profile (jigsaw) task
Type of CPS task: decision making | co-ordination | production
Number of agents: three agents, including the student
Target unit timing: 5 minutes | 10 minutes | 15 minutes | 20 minutes

Unit overview (team composition, problem context and overview of tasks)

In this unit, a team of three students – the test-taker, Mark and Sarah (two computer agents) collaborate to produce a logo for a sports event. The goal is to achieve a five-star rating from the class. Mark and Sarah draw the logo and the test-taker's role is to lead the group.

The first task of the unit is an initial discussion between the test-taker, Mark and Sarah on how to design the logo. The team then produces drafts that are rated. The test-taker encounters challenges in collaborating with Mark and Sarah during this stage. Finally, the test-taker gives feedback on the collaborative tasks. The test-taker is told that the number of attempts to design the draft logo (known as "trials") is limited to five. The underlying structure of the task forces the test-taker to be involved in at least two trials to achieve a five-star rating in order to provide sufficient data for CPS measurement.

Agent overview

Mark represents collaboratively orientated agent behaviour (e.g. he initiates ideas, builds consensus, responds to, supports and praises the test-taker). He also reveals information about what to do in the task (e.g. shares his past experience that is relevant to the task). However, in some situations, Mark shows a misunderstanding of the results. As long as the test-taker repairs any misunderstandings or points out the advantages or disadvantages of different strategies, Mark is persuaded. However, if the test-taker doesn't clarify or repair misinterpretations of results or provide evidence that counters a suggested strategy, Mark will press for a rationale for accepting the strategy. Sarah represents the behaviour of a low collaboratively orientated agent (e.g. she interrupts other members of the team, disagrees with the test-taker and Mark, comments negatively about Mark's work, and doesn't follow plans).

Collaborative problem-solving skills

In this unit, the test-taker demonstrates CPS proficiency by establishing a shared understanding of the problem, repairing misunderstanding, monitoring the agents' work, and building consensus with team members. The specific cells addressed in the framework skills matrix (Table 1) are described below.

Introduction and orientation

The unit starts with a briefing on the scenario outline and training on the Chat, Control Panel and Task Space areas of the screen. This section is not timed or scored.

Figure 7.8 [1/2] ▪ **Sample unit CLASS LOGO: Introduction**

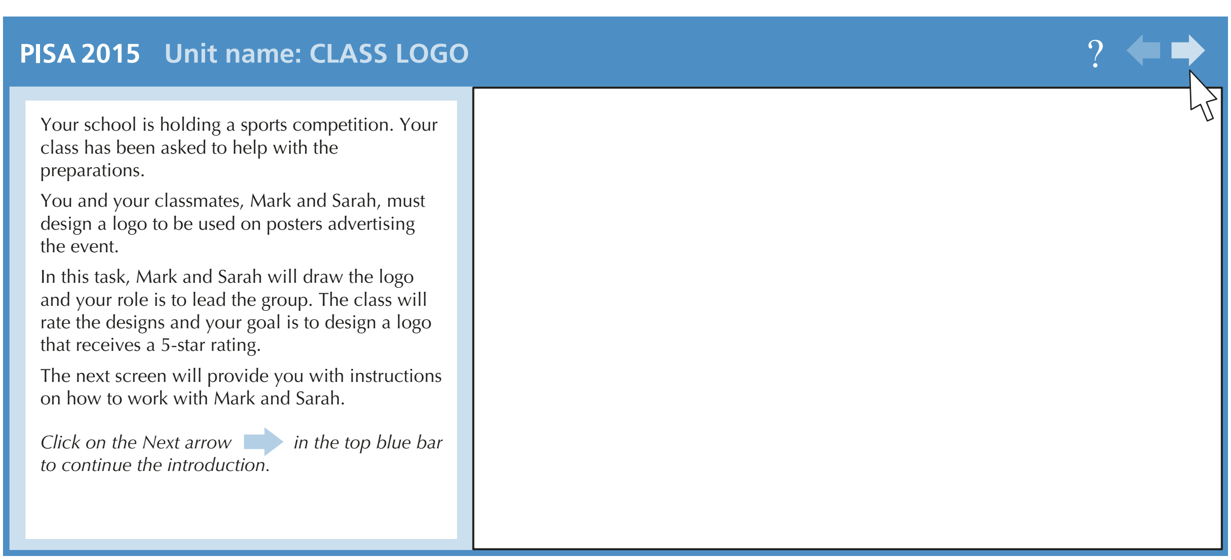
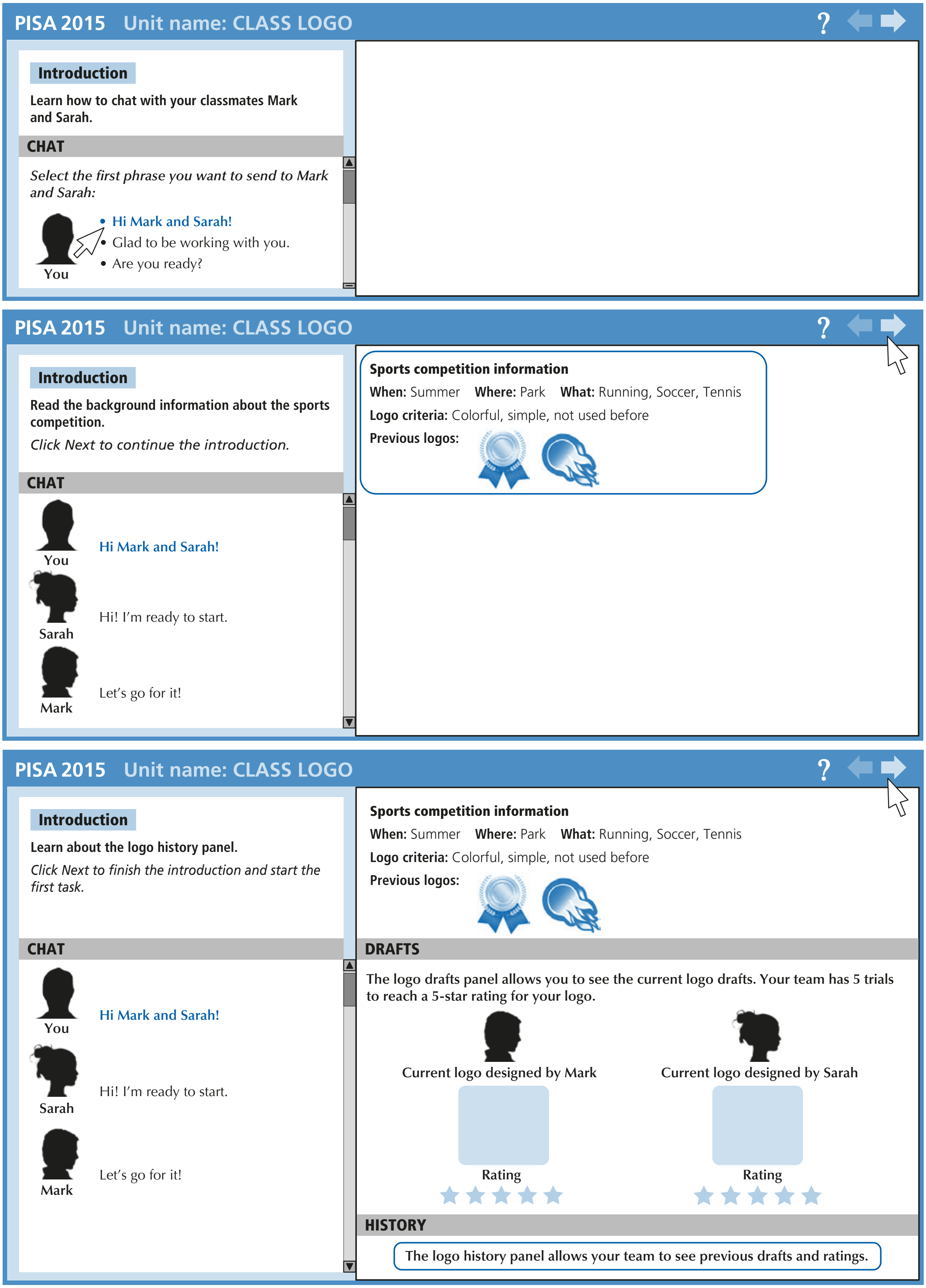


Figure 7.8 [2/2] ■ **Sample unit CLASS LOGO: Introduction**



Outline of unit tasks

Task 1: Establish shared understanding

Activity

- **Item 1:** The test-taker asks Mark and Sarah to describe their abilities in logo design. Mark and Sarah provide a short description. If the test-taker doesn't ask after a certain amount of time or a set number of exchanges, then Mark initiates by describing his ability. There can be multiple exchanges to release the information gradually.
- **Item 2:** The test-taker asks Mark and Sarah about the tools available for them to design the logo. If the test-taker does not do this, then Mark initiates and provides a description.
- **Item 3:** The test-taker offers a plan of how to design a logo (e.g. provides suggestions in the chat on symbols and colours) and asks Mark and Sarah for their point of view. Mark asks the test-taker to provide reasoning (e.g. why do you think so?). If the test-taker provides some reasoning for the plan, then Mark agrees. Otherwise, Mark disagrees and shares his alternative plan with the team. Sarah disagrees with both the test-taker and Mark's plans and suggests her own plan without providing any reasoning.
- If the test-taker doesn't offer an idea, then Mark and Sarah prompt. If still no idea is offered, then Mark and Sarah suggest two different ideas for use of symbols and colours.
- **Item 4:** The test-taker has to ensure that Mark and Sarah agree (e.g. monitor shared understanding) before clicking on "Next" to allow them to produce draft logos. If the test-taker doesn't offer to click "Next", then Mark will rescue and ask if they should do that. When the test-taker clicks "Next", a pop-up asks if all the team members are ready to design the first logo draft. If the test-taker did not agree with Mark and Sarah beforehand, then they can interject here and the test-taker can repair before clicking "Yes" to proceed.

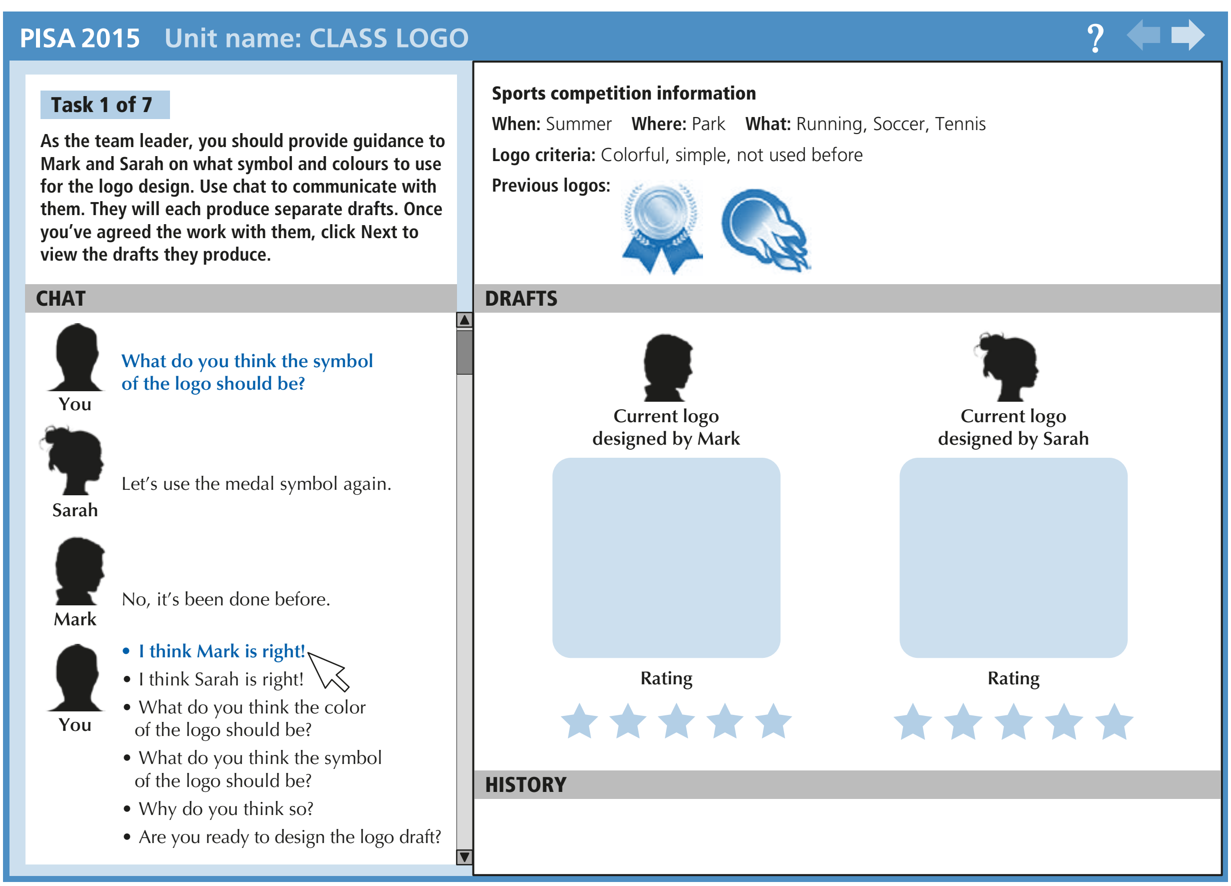
Convergence

A plan is agreed. The test-taker sees Mark and Sarah's draft logos.

CPS skill(s) assessed:

(A1) Discovering perspectives and abilities of team members; **(A2)** discovering the type of collaborative interaction to solve the problem, along with goals; **(C1)** communicating with team members about the actions to be/being performed; **(B1)** building a shared representation and negotiating the meaning of the problem (common ground).

Figure 7.9 ■ **Sample unit CLASS LOGO: Task 1**



Task 2: Monitoring the results and repairing misunderstanding

Activity

- **Item 1:** The test-taker monitors whether Mark and Sarah followed the plan as discussed, and raises additional comments and suggestions to improve the logo drafts.
- **Item 2:** The test-taker asks the agents for their points of view and their readiness to proceed before clicking on "Rate the logos". While Mark is ready to rate the logos, Sarah raises concerns regarding the readiness of the logo drafts, without providing any reasoning. The test-taker asks Sarah to explain her concerns. If the test-taker does not ask, Mark initiates the question. The team agrees to rate the logo drafts.
- **Item 3:** The test-taker shares his or her understanding of the result (the rating and comments for each logo draft). If not, Mark provides a reasonable interpretation.
- **Item 4:** The test-taker has to offer a plan of how to proceed (e.g. "let's change the symbol"). If the test-taker doesn't offer an idea, then Mark can prompt. If still no idea is offered, then Mark will suggest an idea himself.
- **Item 5:** Sarah raises a negative comment regarding Mark's logo draft (e.g. "I don't think that we should work with Mark's logo. It got a very low rating. Let's switch to mine."), but Mark's logo receives a higher rating than Sarah's logo. The test-taker has to repair Sarah's misunderstanding of the collaborative work and/or the results, as well as clarify the roles of the team members.

Convergence

The test-taker can see the ratings and comments for the logo drafts. A plan is decided.

CPS skill(s) assessed:

(D2) Monitoring results of actions and evaluating success in solving the problem; **(D1)** monitoring and repairing the shared understanding; **(B3)** describing roles and team organisation (communication protocol/rules of engagement).

Figure 7.10 [1/2] ▪ **Sample unit CLASS LOGO: Task 2**

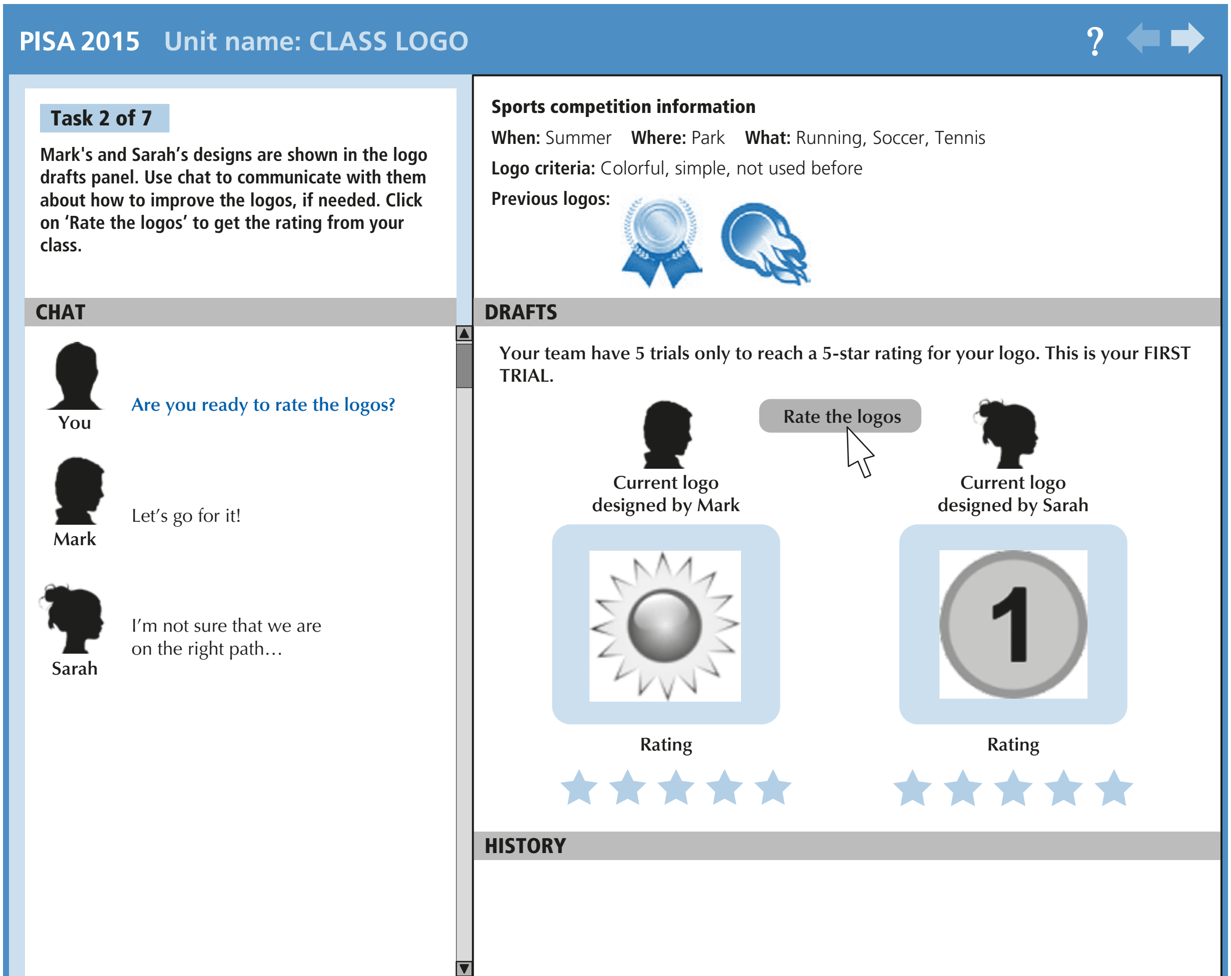
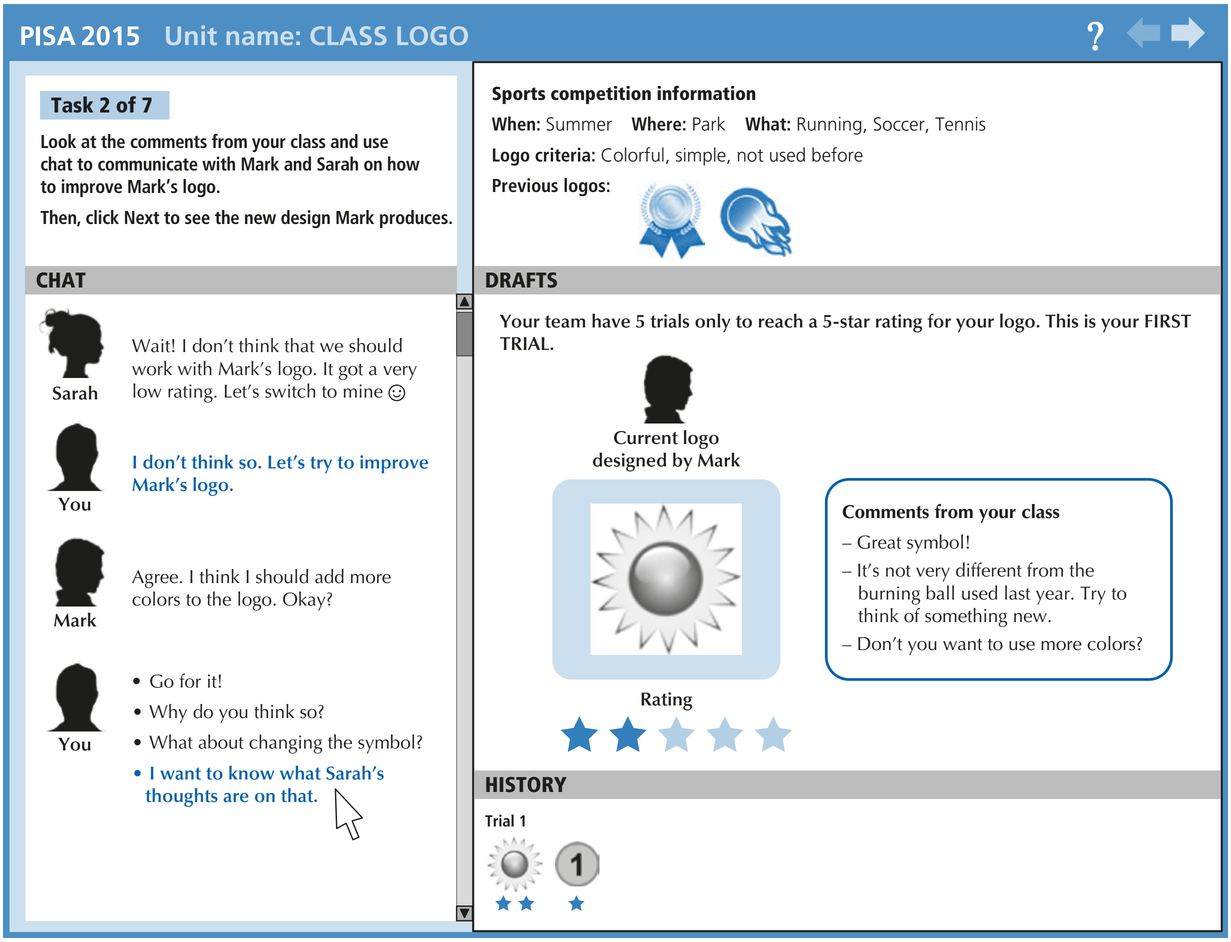


Figure 7.10 [2/2] ■ **Sample unit CLASS LOGO: Task 2**



Task 3: Monitoring and repairing the shared understanding

Activity

- **Item 1:** The test-taker monitors whether Mark and Sarah followed the plan as discussed, and raises additional comments and suggestions to improve the logo drafts.
- **Item 2:** The test-taker discovers that Sarah didn't provide an updated version for the logo as discussed. The test-taker asks Sarah to share the updated draft (e.g. "Sarah, can you share your new draft with us?"). If the test-taker does not ask, then Mark prompts Sarah with a question. Sarah then shares the draft with the team.
- **Item 3:** The test-taker asks the agents for their points of view and their readiness to proceed before clicking on "Rate the logos". If the test-taker does not ask, then Mark initiates the question. The team agrees to rate the updated logo drafts.
- **Item 4:** The test-taker shares his or her understanding of the result (the rating and comments for each logo draft). Mark provides an incorrect interpretation of the result (e.g. "Oh, now the rating is even worse."). The test-taker has to repair this misunderstanding and/or invites Sarah to comment. Sarah comments with a correct explanation.
- **Item 5:** The test-taker has to offer a plan of how to proceed (e.g. "let's change the symbol"). If the test-taker doesn't offer an idea, then Mark prompts. If still no idea is offered, then Mark will suggest an idea himself.
- The team agrees to proceed.

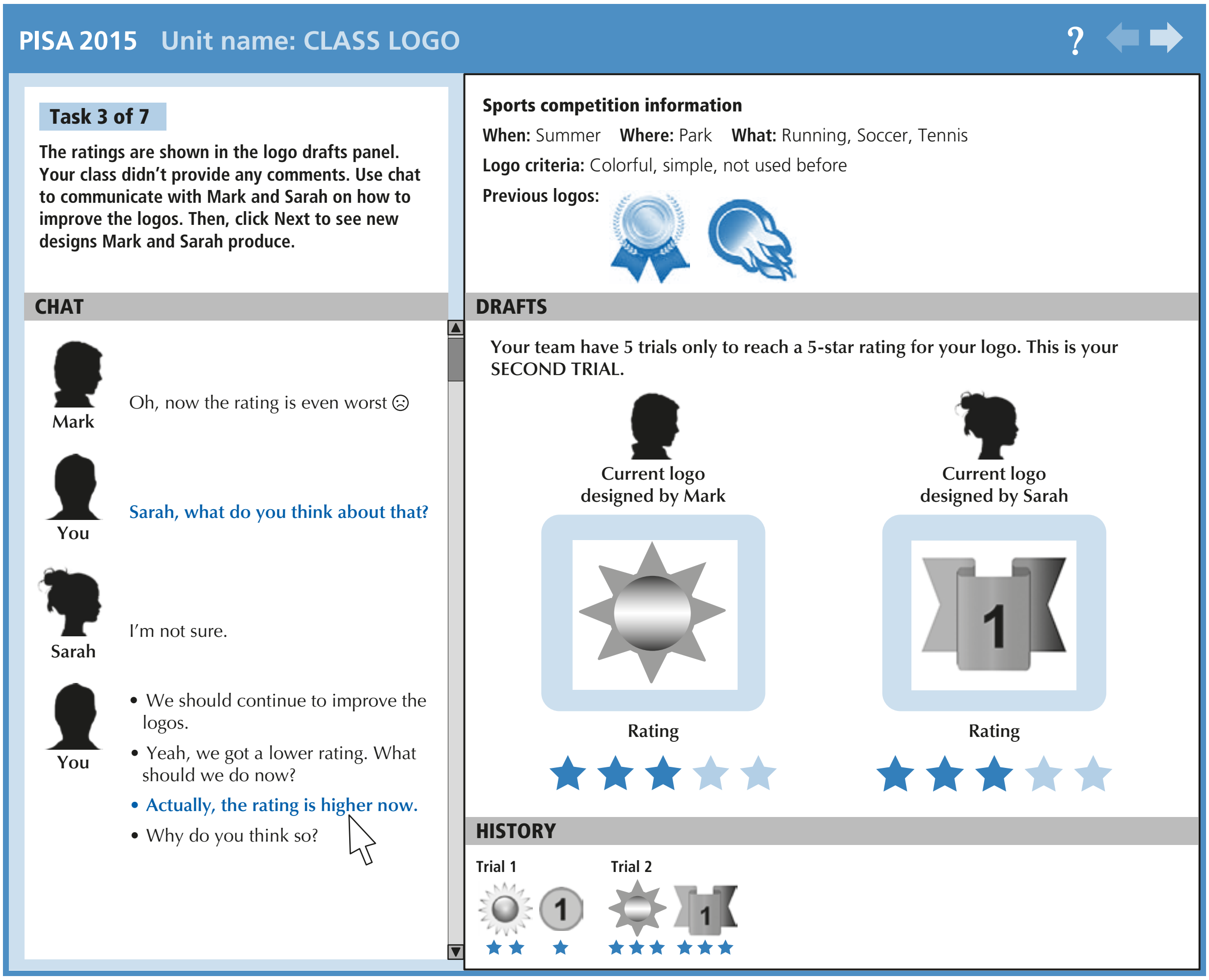
Convergence

The test-taker can see the ratings and comments for the updated logo drafts. Any misunderstanding is repaired. A plan is decided.

CPS skill(s) assessed:

(D2) Monitoring results of actions and evaluating success in solving the problem; **(D1)** monitoring and repairing the shared understanding; **(C1)** communicating with team members about the actions to be/being performed.

Figure 7.11 ■ **Sample unit CLASS LOGO: Task 3**



Task 4: Discovering perspectives and abilities of team members

<u>Activity</u>

- **Item 1:** The test-taker monitors whether Mark and Sarah followed the plan as discussed, and raises additional comments and suggestions to improve the logo drafts.
- **Item 2:** Mark shares with the team that he designed all the previous logos for the class. Sarah comments that it doesn't matter. The test-taker has to explore Mark's newly revealed abilities. Mark provides a clue on how to design a logo that would reach a five-star rating. If the test-taker chooses not to explore Mark's experience, the clue is not presented during this stage.
- **Item 3:** The test-taker asks the agents for their points of view and their readiness to proceed before clicking on "Rate the logos". If the test-taker does not, Mark initiates the question. The team agrees to rate the logo drafts.
- **Item 4:** The test-taker shares his or her understanding of the result (the rating and comments for each logo draft). The test-taker has to offer a plan of how to proceed (e.g. "let's change the symbol"). If the test-taker doesn't offer an idea, then Mark can prompt. If still no idea is offered, then Mark will suggest an idea himself.
- The team agrees to proceed.

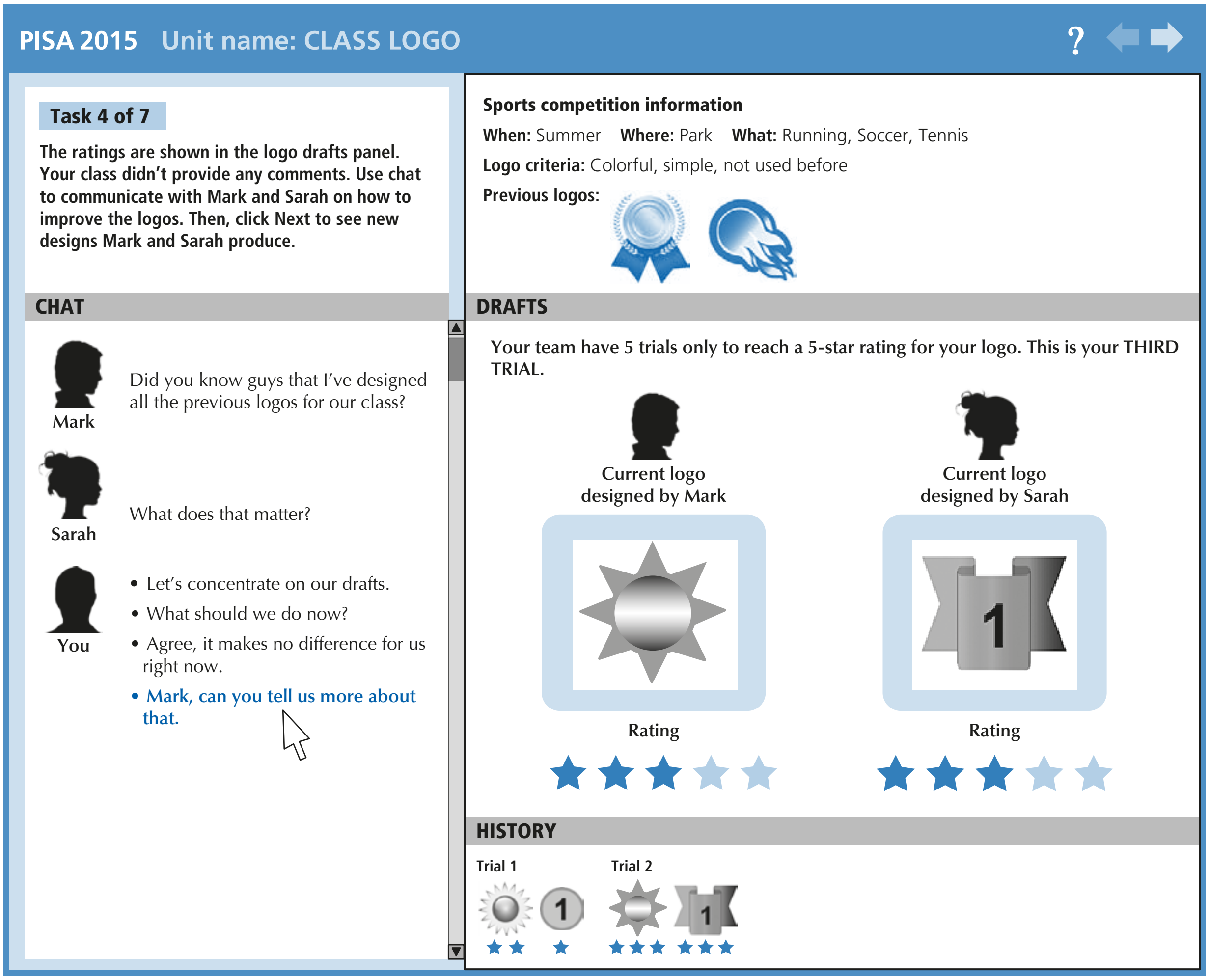
<u>Convergence</u>

The test-taker can see the rating and comments for the updated logo drafts. A clue for a solution is conditionally provided. A new plan is decided.

CPS skill(s) assessed:

(A1) Discovering perspectives and abilities of team members; **(D2)** monitoring results of actions and evaluating success in solving the problem; **(C1)** communicating with team members about the actions to be/being performed.

Figure 7.12 ▪ **Sample unit CLASS LOGO: Task 4**



Task 5-6

These are only presented if applicable, depending on the test-taker's performance.

<u>Activity</u>

Optimising the strategy to solve the problem

- **Item 1:** The test-taker monitors whether Mark and Sarah followed the plan as discussed, and raises additional comments and suggestions to improve the logo drafts.
- **Item 2:** The test-taker asks the agents for their points of view and their readiness to proceed before clicking on "Rate the logos". If the test-taker does not ask, Mark initiates the question. The team agrees to rate the logo drafts.
- **Item 3:** The test-taker shares his or her understanding of the result (the rating and comments for each logo draft). The test-taker has to offer a plan of how to proceed (e.g. "let's change the symbol"). If the test-taker doesn't offer an idea then Mark prompts. If still no idea is offered, then Mark will suggest an idea himself.
- The team agrees to proceed.

<u>Convergence</u>

The test-taker can see the rating and comments for the updated logo drafts. A new plan is decided.

CPS skill(s) assessed:

(D2) Monitoring results of actions and evaluating success in solving the problem; **(C1)** communicating with team members about the actions to be/being performed; **(C2)** enacting plans.

As test-takers may make multiple attempts to optimise the strategy to solve the problem, they would receive scores based on the number of attempts with fewer attempts resulting in higher scores (0-2) for C2. In addition, test-takers would receive the maximum score achieved across attempts for skills D2 and C1.

Task 7: Feedback

Activity

- **Item 1:** The test-taker provides reflective feedback on the work with Mark and Sarah regarding shared understanding of the task.
- **Item 2:** The test-taker suggests a collaborative method (e.g. talk more to Sarah) to promote better collaboration on the task.

Convergence

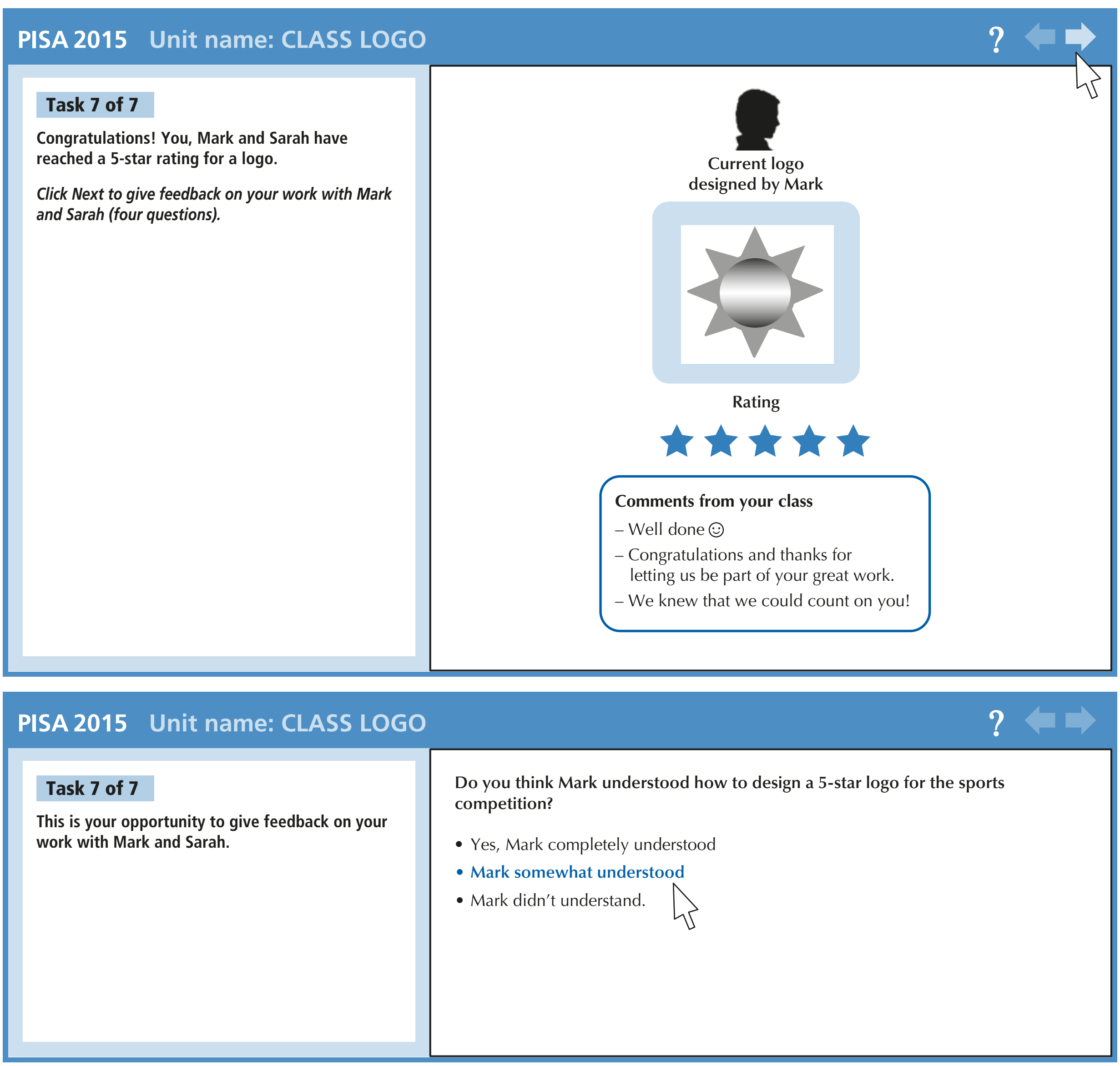
The test-taker, Mark and Sarah share feedback on the task.

CPS skill(s) assessed:

(D3) Monitoring, providing feedback and adapting the team organisation and roles.

These questions are presented in a multiple-choice format. There is a single optimal answer, which receives full credit. Some of the other options would receive partial credit and some options would receive no credit.

Figure 7.13 ■ **Sample unit CLASS LOGO: Task 7**



Unit measurement profile

At the end of each task, there is a convergence point. This ensures that all test-takers start from the same point and have the same opportunity to score.

Table 7.12 Profile of assessment items within sample unit CLASS LOGO

Task no.	Item no.	Item short description	Target collaborative problem-solving skill	Data type	Score range (0-x)
1	1	Test-taker explores Mark's and Sarah's abilities in logo design.	(A1) Discovering perspectives and abilities of team members	Communication	0-2
1	2	Test-taker asks Mark and Sarah about the tools available for them to design a logo.	(A2) Discovering the type of collaborative interaction to solve the problem, along with goals	Communication	0-2
1	3	Test-taker offers a plan of how to improve the logo drafts.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
1	4	Test-taker asks Mark and Sarah for their point of view before implementing the plan.	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	Communication	0-2
2	1	Test-taker monitors whether Mark and Sarah followed the plan as discussed.	(D1) Monitoring and repairing the shared understanding	Communication	0-2
2	2	Test-taker shares his or her understanding of the result.	(D2) Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
2	3	Test-taker repairs Sarah's misunderstanding of the collaborative work and the roles of the team members.	(B3) Describe roles and team organisation (communication protocol/rules of engagement)	Communication	
2	4	Test-taker offers a plan of how to improve the logo design.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
2	5	Test-taker asks Mark and Sarah for their point of view before implementing the plan.	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	Communication	0-2
3	1	Test-taker shares his/her understanding of the result.	(D2) Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
3	2	Test-taker repairs Sarah's misunderstanding of the actions to be performed.	(D1) Monitoring and repairing the shared understanding	Communication	0-2
3	3	Test-taker repairs Mark's misunderstanding of the result.	(D1) Monitoring and repairing the shared understanding	Communication	0-2
3	4	Test-taker offers a plan of how to improve the logo design.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
3	5	Test-taker asks Mark and Sarah for their point of view before implementing the plan.	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	Communication	0-2
4	1	Test-taker shares his or her understanding of the result.	(D2) Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
4	2	Test-taker explores Mark's new discovered abilities.	(A1) Discovering perspectives and abilities of team members	Communication	0-2
4	3	Test-taker offers a plan of how to improve the logo design.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
4	4	Test-taker asks Mark and Sarah for their point of view before implementing the plan.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
5	1	Test-taker shares his or her understanding of the result.	(D2) Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
5	2	Test-taker offers a plan of how to improve the logo design.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
5	3	Test-taker asks Mark and Sarah for their point of view before implementing the plan.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
6	1	Test-taker shares his or her understanding of the result.	(D2) Monitoring results of actions and evaluating success in solving the problem	Communication	0-2
6	2	Test-taker offers a plan of how to improve the logo design.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
6	3	Test-taker asks Mark and Sarah for their point of view before implementing the plan.	(C1) Communicating with team members about the actions to be/ being performed	Communication	0-2
7	1	Test-taker provides reflective feedback on the work with Mark and Sarah.	(D3) Monitoring, providing feedback and adapting the team organisation and roles	Probe response	0-2
7	2	Test-taker suggests a collaborative method to improve CPS performance.	(D3) Monitoring, providing feedback and adapting the team organisation and roles	Probe response	0-2

Note: Score points are assigned based on exhibiting behaviour (performing actions or communicating). Items are scored polytomously (0, 1, 2) according to levels of competency.

Annex A

PISA 2015 BACKGROUND QUESTIONNAIRES

Annex A presents the background questionnaires used in the PISA 2015. These are the **school questionnaire** distributed to school principals; the **student questionnaire** distributed to all participating students; two optional questionnaires for students: the **educational career questionnaire** and the **ICT familiarity questionnaire**; an optional **questionnaire for parents**; an optional **questionnaire for teachers**.

SCHOOL QUESTIONNAIRE

Computer-based version/main survey version

The school principal completed the school questionnaire. The questionnaire takes about 60 minutes to complete and covers:

- School background information
- School management
- Teaching staff
- Assessment and evaluation
- Targeted groups
- School climate

Technical terms are given in <brackets> and are adapted to the national context by the national data collection centre of the participating country or economy. In this annex, an explanation of the technical terms is given below the questionnaire item.

School background information

SC001 SC001Q01TA	**Which of the following definitions best describes the community in which your school is located?** *(Please select one response.)*	
	A village, hamlet or rural area (fewer than 3 000 people)	☐1
	A small town (3 000 to about 15 000 people)	☐2
	A town (15 000 to about 100 000 people)	☐3
	A city (100 000 to about 1 000 000 people)	☐4
	A large city (with over 1 000 000 people)	☐5

SC002	**As at <February 1, 2015>, what was the total school enrolment (number of students)?** *(Please enter a number for each response. Enter "0" [zero] if there are none.)*	
SC002Q01TA	Number of boys:	
SC002Q02TA	Number of girls:	

SC003 SC003Q01TA	**What is the average size of <test language> classes in <national modal grade for 15-year-olds> in your school?** *(Please select one response.)*	
	15 students or fewer	☐1
	16-20 students	☐2
	21-25 students	☐3
	26-30 students	☐4
	31-35 students	☐5
	36-40 students	☐6
	41-45 students	☐7
	46-50 students	☐8
	More than 50 students	☐9

SC004	**The goal of the following set of questions is to gather information about the student-computer ratio for students in the <national modal grade for 15-year-olds> at your school.** *(Please enter a number for each response. Enter "0" [zero] if there are none.)*	
		Number
SC004Q01TA	At your school, what is the total number of students in the <national modal grade for 15-year-olds>?	
SC004Q02TA	Approximately, how many computers are available for these students for educational purposes?	
SC004Q03TA	Approximately, how many of these computers are connected to the Internet/World Wide Web?	
SC004Q04NA	Approximately, how many of these computers are portable (e.g. laptop, tablet)?	
SC004Q05NA	Approximately how many interactive whiteboards are available in the school altogether?	
SC004Q06NA	Approximately how many data projectors are available in the school altogether?	
SC004Q07NA	Approximately how many computers with internet connection are available **for teachers** in your school?	

SC053	**<This academic year>, which of the following activities does your school offer to students in the <national modal grade for 15-year-olds>?** *(Please select one response in each row.)*		
		Yes	No
SC053Q01TA	Band, orchestra or choir	☐1	☐2
SC053Q02TA	School play or school musical	☐1	☐2
SC053Q03TA	School yearbook, newspaper or magazine	☐1	☐2
SC053Q04TA	Volunteering or service activities, e.g. <national examples>	☐1	☐2
SC053Q05NA	Science club	☐1	☐2
SC053Q06NA	Science competitions, e.g. <national examples>	☐1	☐2
SC053Q07TA	Chess club	☐1	☐2
SC053Q08TA	Club with a focus on computers/ information and communication technology	☐1	☐2
SC053Q09TA	Art club or art activities	☐1	☐2
SC053Q10TA	Sporting team or sporting activities	☐1	☐2
SC053Q11TA	<country specific item>	☐1	☐2

SC059	**Which of the following are true for the science department of your school?** *(Please select one response in each row.)*		
		Yes	No
SC059Q01NA	Compared to other departments, our school's <school science department> is well equipped.	☐1	☐2
SC059Q02NA	If we ever have some extra funding, a big share goes into improvement of our <school science> teaching.	☐1	☐2
SC059Q03NA	<School science> teachers are among our best educated staff members.	☐1	☐2
SC059Q04NA	Compared to similar schools, we have a well-equipped laboratory.	☐1	☐2
SC059Q05NA	The material for hands-on activities in <school science> is in good shape.	☐1	☐2
SC059Q06NA	We have enough laboratory material that all courses can regularly use it.	☐1	☐2
SC059Q07NA	We have extra laboratory staff that helps support <school science> teaching.	☐1	☐2
SC059Q08NA	Our school spends extra money on up-to-date <school science> equipment.	☐1	☐2

SC052	**For 15-year-old students, does your school provide the following study help?** *(Please select one response in each row.)*		
		Yes	No
SC052Q01NA	Room(s) where the students can do their homework	☐1	☐2
SC052Q02NA	Staff help with homework	☐1	☐2

School management

SC009 **Below are statements about your management of this school. Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>.**

(Please select one response in each row.)

		Did not occur	1-2 times during the year	3-4 times during the year	Once a month	Once a week	More than once a week
SC009Q01TA	I use student performance results to develop the school's educational goals.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q02TA	I make sure that the professional development activities of teachers are in accordance with the teaching goals of the school.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q03TA	I ensure that teachers work according to the school's educational goals.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q04TA	I promote teaching practices based on recent educational research.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q05TA	I praise teachers whose students are actively participating in learning.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q06TA	When a teacher has problems in his/her classroom, I take the initiative to discuss matters.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q07TA	I draw teachers' attention to the importance of pupils' development of critical and social capacities.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q08TA	I pay attention to disruptive behaviour in classrooms.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q09TA	I provide staff with opportunities to participate in school decision-making.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q10TA	I engage teachers to help build a school culture of continuous improvement.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q11TA	I ask teachers to participate in reviewing management practices.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q12TA	When a teacher brings up a classroom problem, we solve the problem together.	☐1	☐2	☐3	☐4	☐5	☐6
SC009Q13TA	I discuss the school's academic goals with teachers at faculty meetings.	☐1	☐2	☐3	☐4	☐5	☐6

SC010 Regarding your school, who has a considerable responsibility for the following tasks?

(Please select as many boxes as appropriate in each row.)

		Principal	Teachers	<School governing board>	<Regional or local education authority>	National education authority
SC010Q01T	Selecting teachers for hire	☐1	☐1	☐1	☐1	☐1
SC010Q02T	Firing teachers	☐1	☐1	☐1	☐1	☐1
SC010Q03T	Establishing teachers' starting salaries	☐1	☐1	☐1	☐1	☐1
SC010Q04T	Determining teachers' salary increases	☐1	☐1	☐1	☐1	☐1
SC010Q05T	Formulating the school budget	☐1	☐1	☐1	☐1	☐1
SC010Q06T	Deciding on budget allocations within the school	☐1	☐1	☐1	☐1	☐1
SC010Q07T	Establishing student disciplinary policies	☐1	☐1	☐1	☐1	☐1
SC010Q08T	Establishing student assessment policies	☐1	☐1	☐1	☐1	☐1
SC010Q09T	Approving students for admission to the school	☐1	☐1	☐1	☐1	☐1
SC010Q10T	Choosing which textbooks are used	☐1	☐1	☐1	☐1	☐1
SC010Q11T	Determining course content	☐1	☐1	☐1	☐1	☐1
SC010Q12T	Deciding which courses are offered	☐1	☐1	☐1	☐1	☐1

SC012 How often are the following factors considered when students are admitted to your school?

(Please select one response in each row.)

		Never	Sometimes	Always
SC012Q01TA	Student's record of academic performance (including placement tests)	☐1	☐2	☐3
SC012Q02TA	Recommendation of feeder schools	☐1	☐2	☐3
SC012Q03TA	Parents' endorsement of the instructional or religious philosophy of the school	☐1	☐2	☐3
SC012Q04TA	Whether the student requires or is interested in a special programme	☐1	☐2	☐3
SC012Q05TA	Preference given to family members of current or former students	☐1	☐2	☐3
SC012Q06TA	Residence in a particular area	☐1	☐2	☐3
SC012Q07TA	Other	☐1	☐2	☐3

SC013 SC013Q01TA Is your school a public or a private school?

(Please select one response.)

A public school *(This is a school managed directly or indirectly by a public education authority, government agency, or governing board appointed by government or elected by public franchise.)*	☐1
A private school *(This is a school managed directly or indirectly by a non-government organisation; e.g. a church, trade union, business, or other private institution.)*	☐2

This is a filter question:
If the school is a private school (SC013Q01TA is "A private school"), then respondents answer SC014Q01NA.
Else proceed to SC016.

SC014 SC014Q01NA	This is a filtered question: Only if SC013Q01TA is "A private school". Else proceed to SC016. **What kind of organisation runs your school?** *(Please select one response.)*	
	A church or other religious organisation	☐1
	Another not-for-profit organisation	☐2
	A for-profit organisation	☐3

SC016	**About what percentage of your total funding for a typical school year comes from the following sources?** *(Please enter a number for each response. Enter "0" [zero] if there are none.)*	
		%
SC016Q01TA	Government (includes departments, local, regional, state and national)	
SC016Q02TA	Student fees or school charges paid by parents	
SC016Q03TA	Benefactors, donations, bequests, sponsorships, parent fundraising	
SC016Q04TA	Other	
	Total	**100%**

Consistency check/soft reminder if sum is more or less than 100.

SC017	**Is your school's capacity to provide instruction hindered by any of the following issues?** *(Please select one response in each row.)*				
		Not at all	Very little	To some extent	A lot
SC017Q01NA	A lack of teaching staff.	☐1	☐2	☐3	☐4
SC017Q02NA	Inadequate or poorly qualified teaching staff.	☐1	☐2	☐3	☐4
SC017Q03NA	A lack of assisting staff.	☐1	☐2	☐3	☐4
SC017Q04NA	Inadequate or poorly qualified assisting staff.	☐1	☐2	☐3	☐4
SC017Q05NA	A lack of educational material (e.g. textbooks, IT equipment, library or laboratory material).	☐1	☐2	☐3	☐4
SC017Q06NA	Inadequate or poor quality educational material (e.g. textbooks, IT equipment, library or laboratory material).	☐1	☐2	☐3	☐4
SC017Q07NA	A lack of physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems).	☐1	☐2	☐3	☐4
SC017Q08NA	Inadequate or poor quality physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems).	☐1	☐2	☐3	☐4

Teaching staff

SC018	**How many of the following teachers are on the staff of your school?** ***Include both full-time and part-time teachers.*** *A full-time teacher is employed at least 90% of the time as a teacher for the full school year. All other teachers should be considered part-time. Regarding the qualification level, please refer only to the teacher's* ***highest qualification level.*** *(Please enter a number in each space provided. Enter "0" [zero] if there are none.)*		
		Full-time	**Part-time**
SC018Q01TA	Teachers in TOTAL		
SC018Q02TA	Teachers <fully certified> by <the appropriate authority>		
SC018Q05NA	Teachers with an <ISCED Level 5A Bachelor degree> qualification		
SC018Q06NA	Teachers with an <ISCED Level 5A Master's degree> qualification		
SC018Q07NA	Teachers with an <ISCED Level 6> qualification		

SC019	**How many of the following teachers are on the <school science> staff of your school?** ***Include both full-time and part-time teachers.*** *A full-time teacher is employed at least 90% of the time as a teacher for the full school year. All other teachers should be considered part-time.* *(Please enter a number in each space provided. Enter "0" [zero] if there are none.)*		
		Full-time	**Part-time**
SC019Q01NA	<School science> teachers in TOTAL		
SC019Q02NA	<School science> teachers <fully certified> by <the appropriate authority>		
SC019Q03NA	<School science> teachers with an <ISCED Level 5A or higher> qualification <with a major> in <school science>		

SC025	**During the last three months, what percentage of teaching staff in your school has attended a programme of professional development?** *A programme of professional development here is a formal programme designed to enhance teaching skills or pedagogical practices. It may or may not lead to a recognised qualification. The programme must last for at least one day in total and have a focus on teaching and education.* *(Please move the slider to the appropriate percentage. If none of your teachers participated in any professional development activities select "0" [zero].)*	
SC025Q01NA	All teaching staff at your school	
SC025Q02NA	Science teaching staff at your school	

Slider bar: parking position, "0-100"; step=1.

SC027	**Which of the following types of in-house professional development exist at your school?** *(Please select one response in each row.)*		
		Yes	**No**
SC027Q01NA	The teachers in our school cooperate by exchanging ideas or material when teaching specific units or series of lessons.	☐1	☐2
SC027Q02NA	Our school invites specialists to conduct in-service training for teachers.	☐1	☐2
SC027Q03NA	Our school organises in-service workshops which deal with specific issues that our school faces.	☐1	☐2
SC027Q04NA	Our school organises in-service workshops for specific groups of teachers (e.g. newly appointed teachers).	☐1	☐2

Assessment and evaluation

SC032	**During <the last academic year>, have any of the following methods been used to monitor the practice of teachers at your school?** *(Please select one response in each row.)*		
		Yes	No
SC032Q01TA	Tests or assessments of student achievement	☐1	☐2
SC032Q02TA	Teacher peer review (of lesson plans, assessment instruments, lessons)	☐1	☐2
SC032Q03TA	Principal or senior staff observations of lessons	☐1	☐2
SC032Q04TA	Observation of classes by inspectors or other persons external to the school	☐1	☐2

SC034	**Generally, in your school, how often are students in <national modal grade for 15-year-olds> assessed using the following methods?** *If you need further explanation of the term "<standardised tests>", please use the help button.* *(Please select one response in each row.)*					
		Never	1-2 times a year	3-5 times a year	Monthly	More than once a month
SC034Q01NA	Mandatory <standardised tests>, e.g. <country specific example>	☐1	☐2	☐3	☐4	☐5
SC034Q02NA	Non-mandatory <standardised tests> (e.g. publicly or commercial available standardised test material like <country specific example>)	☐1	☐2	☐3	☐4	☐5
SC034Q03TA	Teacher-developed tests	☐1	☐2	☐3	☐4	☐5
SC034Q04TA	Teachers' judgmental ratings	☐1	☐2	☐3	☐4	☐5
Help button	<Standardised tests> are consistent in design, content, administration and scoring. Results can be compared across students and schools.					

This is a filter question:
If either SC034Q01NA, or SC034Q02NA, or SC034Q03TA is larger than 1 ("never"), then respondents answer SC035.
Else respondents skip the question on the use of test results and proceed to SC036.

SC035	This is a filtered question: Only if SC034Q01NA, or SC034Q02NA, or SC034Q03TA is larger than 1 ("never"). Else proceed to SC036. **In your school, are <standardised tests> and/or teacher-developed tests of students in <national modal grade for 15-year-olds> used for any of the following purposes?** *If you need further explanation of the term "<standardised tests>", please use the help button.* *(Please select either "yes" or "no" to indicate the use of <standardised tests> and teacher-developed tests for each of the specified purposes.)*				
		<Standardised tests>		Teacher-developed tests	
		Yes	No	Yes	No
SC035Q01N	To guide students' learning	☐1	☐2	☐1	☐2
SC035Q02T	To inform parents about their child's progress	☐1	☐2	☐1	☐2
SC035Q03T	To make decisions about students' retention or promotion	☐1	☐2	☐1	☐2
SC035Q04T	To group students for instructional purposes	☐1	☐2	☐1	☐2
SC035Q05T	To compare the school to <district or national> performance	☐1	☐2	☐1	☐2
SC035Q06T	To monitor the school's progress from year to year	☐1	☐2	☐1	☐2
SC035Q07T	To make judgements about teachers' effectiveness	☐1	☐2	☐1	☐2
SC035Q08T	To identify aspects of instruction or the curriculum that could be improved	☐1	☐2	☐1	☐2
SC035Q09N	To adapt teaching to the students' needs	☐1	☐2	☐1	☐2
SC035Q10T	To compare the school with other schools	☐1	☐2	☐1	☐2
SC035Q11N	To award certificates to students	☐1	☐2	☐1	☐2
Help button	The term <standardised tests> includes standardised mandatory tests (mandated e.g. by national, state or district authorities) as well as standardised non-mandatory tests (e.g. publicly or commercially available standardised test material). These tests are consistent in design, content, administration and scoring. Results can be compared across students and schools.				

Table of drop down menus, each providing answering options "yes" and "no".

SC036	**In your school, are achievement data used in any of the following <accountability procedures>?** *Achievement data include **aggregated** school or grade-level test scores or grades, or graduation rates.* *(Please select one response in each row.)*		
		Yes	**No**
SC036Q01TA	Achievement data are posted publicly (e.g. in the media)	☐1	☐2
SC036Q02TA	Achievement data are tracked over time by an administrative authority	☐1	☐2
SC036Q03NA	Achievement data are provided directly to parents	☐1	☐2

SC037	**Do the following arrangements aimed at quality assurance and improvements exist in your school and where do they come from?** *If you need further explanation of the term "internal school evaluation" or "external school evaluation", please use the help button.* *(Please select one response in each row.)*			
		Yes, this is mandatory, e.g. based on district or ministry policies	**Yes, based on school initiative**	**No**
SC037Q01TA	Internal evaluation/Self-evaluation	☐1	☐2	☐3
SC037Q02TA	External evaluation	☐1	☐2	☐3
SC037Q03TA	Written specification of the school's curricular profile and educational goals	☐1	☐2	☐3
SC037Q04TA	Written specification of student performance standards	☐1	☐2	☐3
SC037Q05NA	Systematic recording of data such as teacher or student attendance and professional development	☐1	☐2	☐3
SC037Q06NA	Systematic recording of student test results and graduation rates	☐1	☐2	☐3
SC037Q07TA	Seeking written feedback from students (e.g. regarding lessons, teachers or resources)	☐1	☐2	☐3
SC037Q08TA	Teacher mentoring	☐1	☐2	☐3
SC037Q09TA	Regular consultation aimed at school improvement with one or more experts over a period of at least six months	☐1	☐2	☐3
SC037Q10NA	Implementation of a standardised policy for science subjects (i.e. school curriculum with shared instructional materials accompanied by staff development and training)	☐1	☐2	☐3
Help button	Internal school evaluation: Evaluation as part of a process controlled by a school in which the school defines which areas are judged; the evaluation may be conducted by members of the school or by persons/institutions commissioned by the school.			
Help button	External school evaluation: Evaluation as part of a process controlled and headed by an external body. The school does not define the areas which are judged.			

This is a filter question:
If SC037Q01TA is "Yes, this is mandatory, e.g. based on district or ministry policies" or "Yes, based on school initiative" then respondents answer additional questions on internal evaluation (SC040).
Else proceed to questions on external evaluation (SC041) if SC037Q02TA is "Yes, this is mandatory, e.g. based on district or ministry policies" or "Yes, based on school initiative".
Else skip all evaluation items and proceed to question SC042.

SC040	This is a filtered question: Only if SC037Q01TA is "Yes, this is mandatory, e.g. based on district or ministry policies" or "Yes, based on school initiative". Else proceed to questions on external evaluation (SC041) if SC037Q2TA is "Yes, this is mandatory, e.g. based on district or ministry policies" or "Yes, based on school initiative". Else proceed to SC042. **Based on your last internal school evaluation results, did your school implement any measures in the following areas?** *If you need further explanation of the term "internal school evaluation", please use the help button.* *(Please select one response in each row.)*			
		Yes	**No, because results were satisfactory**	**No, for other reasons**
SC040Q02NA	Educational staff (e.g. workload, personal requirements, qualifications)	☐ 1	☐ 2	☐ 3
SC040Q03NA	Implementation of the curriculum	☐ 1	☐ 2	☐ 3
SC040Q05NA	Quality of teaching and learning	☐ 1	☐ 2	☐ 3
SC040Q11NA	Parental engagement in school	☐ 1	☐ 2	☐ 3
SC040Q12NA	Teacher professional development	☐ 1	☐ 2	☐ 3
SC040Q15NA	Student achievement	☐ 1	☐ 2	☐ 3
SC040Q16NA	Students' cross-curricular competencies	☐ 1	☐ 2	☐ 3
SC040Q17NA	Equity in school	☐ 1	☐ 2	☐ 3
Help button	Internal school evaluation: Evaluation as part of a process controlled by a school in which the school defines which areas are judged; the evaluation may be conducted by members of the school or by persons/institutions commissioned by the school.			

SC041	This is a filtered question: Only if SC037Q01NTA is "Yes, this is mandatory, e.g. based on district or ministry policies" or "Yes, based on school initiative". Else proceed to SC042. **Thinking about the last external evaluation in your school: do the following statements apply?** *If you need further explanation of the term "external school evaluation", please use the help button.* *(Please select one response in each row.)*		
		Yes	**No**
SC041Q01NA	The results of external evaluations led to changes in school policies.	☐ 1	☐ 2
SC041Q03NA	We used the data to plan specific action for school development.	☐ 1	☐ 2
SC041Q04NA	We used the data to plan specific action for the improvement of teaching.	☐ 1	☐ 2
SC041Q05NA	We put measures derived from the results of external evaluations into practice promptly.	☐ 1	☐ 2
SC041Q06NA	The impetus triggered by the external evaluation "disappeared" very quickly at our school.	☐ 1	☐ 2
Help button	External school evaluation: Evaluation as part of a process controlled and headed by an external body. The school does not define the areas which are judged.		

Targeted groups

Some schools organise instruction differently for students with different abilities.

SC042	What is your school's policy about this for students in <national modal grade for 15-year-olds>? *(Please select one response in each row.)*			
		For all subjects	For some subjects	Not for any subjects
SC042Q01TA	Students are grouped by ability into different classes	☐1	☐2	☐3
SC042Q02TA	Students are grouped by ability within their classes	☐1	☐2	☐3

SC048	Please estimate the percentage of students in <national modal grade for 15-year-olds> at your school who have the following characteristics. *(Please consider that students may fall into multiple categories.)* *(Please move the slider to the appropriate percentage.)*		
		0%	100%
SC048Q01NA	Students whose <heritage language> is different from <test language>		
SC048Q02NA	Students with special needs		
SC048Q03NA	Students from socioeconomically disadvantaged homes		
Slider bar: parking position, 0-100%; step=1.			

School climate

SC061	In your school, to what extent is the learning of students hindered by the following phenomena? *(Please select one response in each row.)*				
		Not at all	Very little	To some extent	A lot
SC061Q01TA	Student truancy	☐1	☐2	☐3	☐4
SC061Q02TA	Students skipping classes	☐1	☐2	☐3	☐4
SC061Q03TA	Students lacking respect for teachers	☐1	☐2	☐3	☐4
SC061Q04TA	Student use of alcohol or illegal drugs	☐1	☐2	☐3	☐4
SC061Q05TA	Students intimidating or bullying other students	☐1	☐2	☐3	☐4
SC061Q06TA	Teachers not meeting individual students' needs	☐1	☐2	☐3	☐4
SC061Q07TA	Teacher absenteeism	☐1	☐2	☐3	☐4
SC061Q08TA	Staff resisting change	☐1	☐2	☐3	☐4
SC061Q09TA	Teachers being too strict with students	☐1	☐2	☐3	☐4
SC061Q10TA	Teachers not being well prepared for classes	☐1	☐2	☐3	☐4

SC063	Do the following statements about parental involvement apply to your school? *(Please select one response in each row.)*		
		Yes	No
SC063Q02NA	Our school provides a welcoming and accepting atmosphere for parents to get involved.	☐1	☐2
SC063Q03NA	Our school designs effective forms of school-to-home and home-to-school communications about school programmes and children's progress.	☐1	☐2
SC063Q04NA	Our school includes parents in school decisions.	☐1	☐2
SC063Q06NA	Our school provides information and ideas for families about how to help students at home with homework and other curriculum-related activities, decisions, and planning.	☐1	☐2
SC063Q07NA	Our school identifies and integrates resources and services from the community to strengthen school programmes, family practices, and student learning and development.	☐1	☐2
SC063Q09NA	There is a <national, state or district legislation> on including parents in school activities.	☐1	☐2

SC064	**During <the last academic year>, what proportion of students' parents participated in the following school-related activities?** *(Please move the slider to the appropriate position. If no parents participated in the activity, please select "0" [zero]. Select "100" (one hundred) if all parents participated in the activity.)*	
		%
SC064Q01TA	Discussed their child's progress with a teacher on their own initiative	
SC064Q02TA	Discussed their child's progress on the initiative of one of their child's teachers	
SC064Q03TA	Participated in local school government (e.g. parent council or school management committee)	
SC064Q04NA	Volunteered in physical or extra-curricular activities (e.g. building maintenance, carpentry, gardening or yard work, school play, sports, field trip)	

Slider bar: parking position, 0-100%; step=1.

STUDENT QUESTIONNAIRE

Computer-based version/main survey version

Students complete the student questionnaire after the literacy assessment. The questionnaire takes about 35 minutes to complete.

The core questions on home background are similar to those used in previous PISA assessments. The questionnaire covers:

- Student, student's family and student's home
- Student's view about his/her life
- Student's school
- Student's school schedule and learning time
- Science learning in school
- Student's views about science

Technical terms are given in <brackets> and are adapted to the national context by the national data collection centre of the participating country or economy. In this annex, an explanation of the technical terms is given below the questionnaire item.

Student, student's family and student's home

ST001
ST001Q01TA

What <grade> are you in?
(Please select from the drop-down menu to answer the question.)

Please choose ▼

Option A
Option B
Option C
Option …

Drop down menu, including all possible grades attended by 15-year-olds, according to your study programme table as agreed on in the Demographic Tasks.

ST002
ST002Q01TA

Which one of the following <programmes> are you in?
(Please select one response.)

<Programme 1>	☐ 1
<Programme 2>	☐ 2
<Programme 3>	☐ 3
<Programme 4>	☐ 4
<Programme 5>	☐ 5
<Programme 6>	☐ 6

ST003	**On what date were you born?** *(Please select the day, month and year from the drop-down menus to answer the question.)*				
ST003Q01TA	Day	*Please choose* ▼ *Option A* *Option B* *Option C* *Option …*	1 2 3 4 5 6 7 8 10 …		
ST003Q02TA	Month	*Please choose* ▼ *Option A* *Option B* *Option C* *Option …*		January February March April May June July August September October November December	
ST003Q03TA	Year	*Please choose* ▼ *Option A* *Option B* *Option C* *Option …*			1998 1999 2000 2001

Consistency check/soft reminder if day, month or year is missing: "Please enter your complete birth date".

ST004 ST004Q01TA	**Are you female or male?** *(Please select one response.)*	Female	Male
		☐1	☐2

ST005 ST005Q01TA	**What is the <highest level of schooling> completed by your mother?** *If you are not sure which box to choose, please ask the <test administrator> for help.* *(Please select one response.)*	
	<ISCED level 3A>	☐1
	<ISCED level 3B, 3C>	☐2
	<ISCED level 2>	☐3
	<ISCED level 1>	☐4
	She did not complete <ISCED level 1>	☐5

ST006	**Does your mother have any of the following qualifications?** *If you are not sure how to answer this question, please ask the <test administrator> for help.* *(Please select one response in each row.)*		
		Yes	**No**
ST006Q01TA	<ISCED level 6>	☐ 1	☐ 2
ST006Q02TA	<ISCED level 5A>	☐ 1	☐ 2
ST006Q03TA	<ISCED level 5B>	☐ 1	☐ 2
ST006Q04TA	<ISCED level 4>	☐ 1	☐ 2

ST007 ST007Q01TA	**What is the <highest level of schooling> completed by your father?** *If you are not sure which box to choose, please ask the <test administrator> for help.* *(Please select one response.)*	
	<ISCED level 3A>	☐ 1
	<ISCED level 3B, 3C>	☐ 2
	<ISCED level 2>	☐ 3
	<ISCED level 1>	☐ 4
	He did not complete <ISCED level 1>	☐ 5

ST008	**Does your father have any of the following qualifications?** *If you are not sure how to answer this question, please ask the <test administrator> for help.* *(Please select one response in each row.)*		
		Yes	**No**
ST008Q01TA	<ISCED level 6>	☐ 1	☐ 2
ST008Q02TA	<ISCED level 5A>	☐ 1	☐ 2
ST008Q03TA	<ISCED level 5B>	☐ 1	☐ 2
ST008Q04TA	<ISCED level 4>	☐ 1	☐ 2

ST011	**Which of the following are in your home?** *(Please select one response in each row.)*		
		Yes	**No**
ST011Q01TA	A desk to study at	☐ 1	☐ 2
ST011Q02TA	A room of your own	☐ 1	☐ 2
ST011Q03TA	A quiet place to study	☐ 1	☐ 2
ST011Q04TA	A computer you can use for school work	☐ 1	☐ 2
ST011Q05TA	Educational software	☐ 1	☐ 2
ST011Q06TA	A link to the Internet	☐ 1	☐ 2
ST011Q07TA	Classic literature (e.g. <Shakespeare>)	☐ 1	☐ 2
ST011Q08TA	Books of poetry	☐ 1	☐ 2
ST011Q09TA	Works of art (e.g. paintings)	☐ 1	☐ 2
ST011Q10TA	Books to help with your school work	☐ 1	☐ 2
ST011Q11TA	<Technical reference books>	☐ 1	☐ 2
ST011Q12TA	A dictionary	☐ 1	☐ 2
ST011Q16NA	Books on art, music or design	☐ 1	☐ 2
ST011Q17TA	<Country-specific wealth item 1>	☐ 1	☐ 2
ST011Q18TA	<Country-specific wealth item 2>	☐ 1	☐ 2
ST011Q19TA	<Country-specific wealth item 3>	☐ 1	☐ 2

ST012	How many of these are there at your home? *(Please select one response in each row.)*	None	One	Two	Three or more
ST012Q01TA	Televisions	☐1	☐2	☐3	☐4
ST012Q02TA	Cars	☐1	☐2	☐3	☐4
ST012Q03TA	Rooms with a bath or shower	☐1	☐2	☐3	☐4
ST012Q05NA	<Cell phones> with Internet access (e.g. smartphones)	☐1	☐2	☐3	☐4
ST012Q06NA	Computers (desktop computer, portable laptop or notebook)	☐1	☐2	☐3	☐4
ST012Q07NA	<Tablet computers> (e.g. <iPad®>, <BlackBerry® PlayBook™>)	☐1	☐2	☐3	☐4
ST012Q08NA	E-book readers (e.g. <Kindle™>, <Kobo>, <Bookeen>)	☐1	☐2	☐3	☐4
ST012Q09NA	Musical instruments (e.g. guitar, piano)	☐1	☐2	☐3	☐4

ST013 ST013Q01TA

How many books are there in your home?

There are usually about 40 books per metre of shelving. Do not include magazines, newspapers or your schoolbooks.

(Please select one response.)

0-10 books	☐1
11-25 books	☐2
26-100 books	☐3
101-200 books	☐4
201-500 books	☐5
More than 500 books	☐6

ST014

The following two questions concern your mother's job:

(If she is not working now, please tell us her last main job.)

ST014Q01TA	What is your mother's main job? (e.g. school teacher, kitchen-hand, sales manager) *Please type in the job title.* ______________________________
ST014Q02TA	What does your mother do in her main job? (e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team) *Please use a sentence to describe the kind of work she does or did in that job.* ______________________________

ST015

The following two questions concern your father's job:

(If he is not working now, please tell us his last main job.)

ST015Q01TA	What is your father's main job? (e.g. school teacher, kitchen-hand, sales manager) *Please type in the job title.* ______________________________
ST015Q02TA	What does your father do in his main job? (e.g. teaches high school students, helps the cook prepare meals in a restaurant, manages a sales team) *Please use a sentence to describe the kind of work he does or did in that job.* ______________________________

ST123

Thinking about the <this academic year>: to what extent do you agree or disagree with the following statements?

(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
ST123Q01NA	My parents are interested in my school activities.	☐1	☐2	☐3	☐4
ST123Q02NA	My parents support my educational efforts and achievements.	☐1	☐2	☐3	☐4
ST123Q03NA	My parents support me when I am facing difficulties at school.	☐1	☐2	☐3	☐4
ST123Q04NA	My parents encourage me to be confident.	☐1	☐2	☐3	☐4

ST019

In what country were you and your parents born?

(Please select one response in each column.)

	You ST019Q01TA	Mother ST019Q01TB	Father ST019Q01TC
<Country A>	☐1	☐1	☐1
<Country B>	☐2	☐2	☐2
<Country C>	☐3	☐3	☐3
<Country D>	☐4	☐4	☐4
<…etc.>	☐5	☐5	☐5
Other country	☐6	☐6	☐6

This is a filter question. If the student was born in <country of test> skip ST021. If he or she was NOT born in <country of test> go to ST021. ELSE go to ST022.

ST021
ST021Q01TA

→ Only if answer in ST019 "you" was NOT "<country of test>". ELSE skip and proceed to ST022.

How old were you when you arrived in <country of test>?

(Please select from the drop-down menu to answer the question.
If you were less than 12 months old, please select "age 0-1" [age zero to one])

Please choose ▼

Option A
Option B
Option C
Option …

age 0-1	1
age 1	2
age 2	3
age 3	4
age 4	5
age 5	6
age 6	7
age 7	8
age 8	9
age 9	10
age 10	11
age 11	12
age 12	13
age 13	14
age 14	15
age 15	16
age 16	17

ST022	What language do you speak at home most of the time? *(Please select one response.)*	
ST022Q01TA	<Language 1>	☐1
ST022Q02TA	<Language 2>	☐2
ST022Q03TA	<Language 3>	☐3
ST022Q04TA	< …etc. >	☐4
ST022Q05TA	Other language	☐5

ST125 ST125Q01NA	How old were you when you started <ISCED 0>? *(Please choose from the drop-down menu to answer the question.)*	
	Years:	*Please choose ▼* *Option A* *Option B* *Option C* *Option …*

Drop-down menu, offering answers “1 year or younger”, 2 years, 3 years, 4 years, 5 years, “6 years or older”, “I did not attend <ISCED 0>”, “I do not remember”.

ST126 ST126Q01TA	How old were you when you started <ISCED 1>? *(Please choose from the drop-down menu to answer the question.)*	
	Years:	*Please choose ▼* *Option A* *Option B* *Option C* *Option …*

Drop-down menu, offering answers “3 years or younger”, 4 years, 5 years, 6 years, 7 years, 8 years, “9 years or older”.

ST127	Have you ever repeated a <grade>? *(Please select one response in each row.)*	No, never	Yes, once	Yes, twice or more
ST127Q01TA	At <ISCED 1>	☐1	☐2	☐3
ST127Q02TA	At <ISCED 2>	☐1	☐2	☐3
ST127Q03TA	At <ISCED 3>	☐1	☐2	☐3

Student's view about his/her life

ST016 ST016Q01NA	*The following question asks how satisfied you feel about your life, on a scale from "0" to "10". Zero means you feel "not at all satisfied" and "10" means "completely satisfied".* **Overall, how satisfied are you with your life as a whole these days?** *(Please move the slider to the appropriate number.)*

Slider bar: parking position, range 0-10 (not at all satisfied, completely satisfied), step = 1.

ST111 ST111Q01TA	**Which of the following do you expect to complete?** *(Please select one response.)*	
	<ISCED level 2>	☐1
	<ISCED level 3B or C>	☐2
	<ISCED level 3A>	☐3
	<ISCED level 4>	☐4
	<ISCED level 5B>	☐5
	<ISCED level 5A or 6>	☐6

ST114 ST114Q01TA	**What kind of job do you expect to have when you are about 30 years old?**
	Please type in the job title. ________________________________

ST118 **To what extent do you disagree or agree with the following statements about yourself?**
(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
ST118Q01NA	I often worry that it will be difficult for me taking a test.	☐1	☐2	☐3	☐4
ST118Q02NA	I worry that I will get poor <grades> at school.	☐1	☐2	☐3	☐4
ST118Q03NA	Even if I am well prepared for a test I feel very anxious.	☐1	☐2	☐3	☐4
ST118Q04NA	I get very tense when I study for a test.	☐1	☐2	☐3	☐4
ST118Q05NA	I get nervous when I don't know how to solve a task at school.	☐1	☐2	☐3	☐4

ST119 **To what extent do you disagree or agree with the following statements about yourself?**
(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
ST119Q01NA	I want top grades in most or all of my courses.	☐1	☐2	☐3	☐4
ST119Q02NA	I want to be able to select from among the best opportunities available when I graduate.	☐1	☐2	☐3	☐4
ST119Q03NA	I want to be the best, whatever I do.	☐1	☐2	☐3	☐4
ST119Q04NA	I see myself as an ambitious person.	☐1	☐2	☐3	☐4
ST119Q05NA	I want to be one of the best students in my class.	☐1	☐2	☐3	☐4

ST121 **Please read the descriptions about the following three students. Based on the information provided here, how much would you disagree or agree with the statement that this student is <u>motivated</u>?**

(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
ST121Q01NA	<NAME 1> gives up easily when confronted with a problem and is often not prepared for his classes. **<Name 1> is motivated.**	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST121Q02NA	<NAME 2> mostly remains interested in the tasks she starts and sometimes does more than what is expected from her. **<Name 2> is motivated.**	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST121Q03NA	<NAME 3> wants to get top grades at school and continues working on tasks until everything is perfect. **<Name 3> is motivated.**	$\square_1$	$\square_2$	$\square_3$	$\square_4$

Student's school

ST082 **To what extent do you disagree or agree with the following statements about yourself?**

(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
ST082Q01NA	I prefer working as part of a team to working alone.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q02NA	I am a good listener.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q03NA	I enjoy seeing my classmates be successful.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q08NA	I take into account what others are interested in.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q09NA	I find that teams make better decisions than individuals.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q12NA	I enjoy considering different perspectives.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q13NA	I find that teamwork raises my own efficiency.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST082Q14NA	I enjoy cooperating with peers.	$\square_1$	$\square_2$	$\square_3$	$\square_4$

ST034 **Thinking about your school: to what extent do you agree with the following statements?**

(Please select one response in each row.)

		Strongly agree	Agree	Disagree	Strongly disagree
ST034Q01TA	I feel like an outsider (or left out of things) at school.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST034Q02TA	I make friends easily at school.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST034Q03TA	I feel like I belong at school.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST034Q04TA	I feel awkward and out of place in my school.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST034Q05TA	Other students seem to like me.	$\square_1$	$\square_2$	$\square_3$	$\square_4$
ST034Q06TA	I feel lonely at school.	$\square_1$	$\square_2$	$\square_3$	$\square_4$

ST039 **During the past 12 months, how often did you have the following experiences at school?**
(Please select one response in each row.)

		Never or almost never	A few times a year	A few times a month	Once a week or more
ST039Q01NA	Teachers called on me less often than they called on other students.	☐1	☐2	☐3	☐4
ST039Q02NA	Teachers graded me harder than they graded other students.	☐1	☐2	☐3	☐4
ST039Q03NA	Teachers gave me the impression that they think I am less smart than I really am.	☐1	☐2	☐3	☐4
ST039Q04NA	Teachers disciplined me more harshly than other students.	☐1	☐2	☐3	☐4
ST039Q05NA	Teachers ridiculed me in front of others.	☐1	☐2	☐3	☐4
ST039Q06NA	Teachers said something insulting to me in front of others.	☐1	☐2	☐3	☐4

ST038 **During the past 12 months, how often have you had the following experiences in school?**
(Please select one response in each row.)

		Never or almost never	A few times a year	A few times a month	Once a week or more
ST038Q01NA	I got called names by other students.	☐1	☐2	☐3	☐4
ST038Q02NA	I got picked on by other students.	☐1	☐2	☐3	☐4
ST038Q03NA	Other students left me out of things on purpose.	☐1	☐2	☐3	☐4
ST038Q04NA	Other students made fun of me.	☐1	☐2	☐3	☐4
ST038Q05NA	I was threatened by other students.	☐1	☐2	☐3	☐4
ST038Q06NA	Other students took away or destroyed things that belonged to me.	☐1	☐2	☐3	☐4
ST038Q07NA	I got hit or pushed around by other students.	☐1	☐2	☐3	☐4
ST038Q08NA	Other students spread nasty rumours about me.	☐1	☐2	☐3	☐4

Student's school schedule and learning time

ST059 **How many <class periods> per week are you typically <u>required to attend</u> for the following subjects?**
(Please enter a number in each row. Enter "0" [zero] if you have none.)

ST059Q01TA	Number of <class periods> per week in <test language>	
ST059Q02TA	Number of <class periods> per week in mathematics	
ST059Q03TA	Number of <class periods> per week in <science>	

Open text entry full numbers only. Consistency check, if entries are greater than 15.

ST060 ST060Q01NA **In a normal, full week at school, how many <class periods> are you required to attend in total?**
(Please move the slider to the number of <class periods> per week.)

	Number of ALL <class periods>	

Slider bar: parking position, range 0–"80 or more", step 1; consistency check/soft reminder for values smaller than 10 and greater than 60.

ST061 ST061Q01NA **How many minutes, on average, are there in a <class period>?**
(Please move the slider to the number of minutes per <class period>.)

	Average minutes in a <class period>	

Slider range 0–"120 or more"; consistency check/soft reminder for values smaller than 10 and greater than 80; step 5.

ST062 **In the last two full weeks of school, how often did the following things occur?**

(Please select one response in each row.)

		Never	One or two times	Three or four times	Five or more times
ST062Q01TA	I <skipped> a whole school day	☐1	☐2	☐3	☐4
ST062Q02TA	I <skipped> some classes	☐1	☐2	☐3	☐4
ST062Q03TA	I arrived late for school	☐1	☐2	☐3	☐4

ST071 **This school year, approximately how many hours per week do you spend learning in <u>addition to your required school schedule</u> in the following subjects?**

(Please include the total hours for homework, additional instruction and private study.)

(Please move the slider to the number of total hours. Select "0" [zero] if you do not do homework, study or practice for a subject.)

ST071Q01NA	<School science>	
ST071Q02NA	Mathematics	
ST071Q03NA	<Test language>	
ST071Q04NA	<Foreign language>	
ST071Q05NA	Other	

Slider bar: parking position, range 0–"30 hours per week or more", step = 1; consistency check/soft reminder for values > 20.

ST031
ST031Q01NA **This school year, on average, on how many days do you attend physical education classes each week?**

(Please select from the drop-down menu to answer the question.)

Please choose ▼
- *Option A*
- *Option B*
- *Option C*
- *Option …*

Drop down menu, 0"<number of instructional days per calendar week> days".

ST032 **Outside of school, during the past 7 days, on how many days did you engage in the following?**

(Please select one response from the drop-down menus to answer the questions.)

ST032Q01NA	<u>Moderate physical activities</u> for a <u>total of at least 60 minutes per day</u> (e.g. walking, climbing stairs, riding a bike to school, <country-specific>)	*Please choose* ▼ *Option A* *Option B* *Option C* *Option …*
ST032Q02NA	<u>Vigorous physical activities</u> for <u>at least 20 minutes per day</u> that made you sweat and breathe hard (e.g. running, cycling, aerobics, soccer, skating, <country-specific>)	*Please choose* ▼ *Option A* *Option B* *Option C* *Option …*

Drop down menus 0-7 days.

Science learning in school

ST063 **Which of the following <school science> courses did you attend this school year or last school year?**

(Please select all that apply in each row.)

		This year	Last year
ST063Q01N	Physics	☐ 1	☐ 1
ST063Q02N	Chemistry	☐ 1	☐ 1
ST063Q03N	Biology	☐ 1	☐ 1
ST063Q04N	<Earth and space>	☐ 1	☐ 1
ST063Q05N	Applied sciences and technology (e. g. <country-specific example>)	☐ 1	☐ 1
ST063Q06N	<General, integrated, or comprehensive science> course (e. g. <country-specific example>)	☐ 1	☐ 1

This is a filter question. ST064-ST107 only apply if sum of clicks in category "this year" is greater than 0 (at least one science course this year). Else skip ST064-ST107 and proceed to section on "Student's view on science".

ST064

→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063.

To what extent can you choose the following for your <school science> courses?

(Please select one response in each row.)

		No, not at all	Yes, to a certain degree	Yes, I can choose freely
ST064Q01NA	I can choose the <school science> course(s) I study.	☐ 1	☐ 2	☐ 3
ST064Q02NA	I can choose the level of difficulty.	☐ 1	☐ 2	☐ 3
ST064Q03NA	I can choose the number of <school science> courses or <class periods>.	☐ 1	☐ 2	☐ 3

ST097

→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063.

How often do these things happen in your <school science> lessons?

(Please select one response in each row.)

		Every lesson	Most lessons	Some lessons	Never or hardly ever
ST097Q01TA	Students don't listen to what the teacher says.	☐ 1	☐ 2	☐ 3	☐ 4
ST097Q02TA	There is noise and disorder.	☐ 1	☐ 2	☐ 3	☐ 4
ST097Q03TA	The teacher has to wait a long time for students to quiet down.	☐ 1	☐ 2	☐ 3	☐ 4
ST097Q04TA	Students cannot work well.	☐ 1	☐ 2	☐ 3	☐ 4
ST097Q05TA	Students don't start working for a long time after the lesson begins.	☐ 1	☐ 2	☐ 3	☐ 4

ST098

→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063.

When learning <school science> topics at school, how often do the following activities occur?

(Please select one response in each row.)

		In all lessons	In most lessons	In some lessons	Never or hardly ever
ST098Q01TA	Students are given opportunities to explain their ideas.	☐1	☐2	☐3	☐4
ST098Q02TA	Students spend time in the laboratory doing practical experiments.	☐1	☐2	☐3	☐4
ST098Q03NA	Students are required to argue about science questions.	☐1	☐2	☐3	☐4
ST098Q05TA	Students are asked to draw conclusions from an experiment they have conducted.	☐1	☐2	☐3	☐4
ST098Q06TA	The teacher explains how a <school science> idea can be applied to a number of different phenomena (e.g. the movement of objects, substances with similar properties).	☐1	☐2	☐3	☐4
ST098Q07TA	Students are allowed to design their own experiments.	☐1	☐2	☐3	☐4
ST098Q08NA	There is a class debate about investigations.	☐1	☐2	☐3	☐4
ST098Q09TA	The teacher clearly explains the relevance of <broad science> concepts to our lives.	☐1	☐2	☐3	☐4
ST098Q10NA	Students are asked to do an investigation to test ideas.	☐1	☐2	☐3	☐4

When answering the following questions, please keep one of your current <school science> courses in mind all the time. You are free to choose which course this should be.

ST065
ST065Q01NA

→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063.

What is the name of this <school science> course?

(Please type the name of the course.)

ST100

→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063.

How often do these things happen in your <school science> lessons?

(Please select one response in each row.)

		Every lesson	Most lessons	Some lessons	Never or hardly ever
ST100Q01TA	The teacher shows an interest in every student's learning.	☐1	☐2	☐3	☐4
ST100Q02TA	The teacher gives extra help when students need it.	☐1	☐2	☐3	☐4
ST100Q03TA	The teacher helps students with their learning.	☐1	☐2	☐3	☐4
ST100Q04TA	The teacher continues teaching until the students understand.	☐1	☐2	☐3	☐4
ST100Q05TA	The teacher gives students an opportunity to express opinions.	☐1	☐2	☐3	☐4

ST103	→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063. **How often do these things happen in your lessons for this <school science> course?** *(Remember to answer this question in reference to the <school science> course you indicated earlier.)* *(Please select one response in each row.)*				
		Never or almost never	Some lessons	Many lessons	Every lesson or almost every lesson
ST103Q01NA	The teacher explains scientific ideas.	☐1	☐2	☐3	☐4
ST103Q03NA	A whole class discussion takes place with the teacher.	☐1	☐2	☐3	☐4
ST103Q08NA	The teacher discusses our questions.	☐1	☐2	☐3	☐4
ST103Q11NA	The teacher demonstrates an idea.	☐1	☐2	☐3	☐4

ST104	→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063. **How often do these things happen in your lessons for this <school science> course?** *(Remember to answer this question in reference to the <school science> course you indicated earlier.)* *(Please select one response in each row.)*				
		Never or almost never	Some lessons	Many lessons	Every lesson or almost every lesson
ST104Q01NA	The teacher tells me how I am performing in this course.	☐1	☐2	☐3	☐4
ST104Q02NA	The teacher gives me feedback on my strengths in this <school science> subject.	☐1	☐2	☐3	☐4
ST104Q03NA	The teacher tells me in which areas I can still improve.	☐1	☐2	☐3	☐4
ST104Q04NA	The teacher tells me how I can improve my performance.	☐1	☐2	☐3	☐4
ST104Q05NA	The teacher advises me on how to reach my learning goals.	☐1	☐2	☐3	☐4

ST107	→ Only applies if the student answered to attend at least one <school science> course in this school year in ST063. **How often do these things happen in your lessons for this <school science> course?** *(Remember to answer this question in reference to the <school science> course you indicated earlier.)* *(Please select one response in each row.)*				
		Never or almost never	Some lessons	Many lessons	Every lesson or almost every lesson
ST107Q01NA	The teacher adapts the lesson to my class's needs and knowledge.	☐1	☐2	☐3	☐4
ST107Q02NA	The teacher provides individual help when a student has difficulties understanding a topic or task.	☐1	☐2	☐3	☐4
ST107Q03NA	The teacher changes the structure of the lesson on a topic that most students find difficult to understand.	☐1	☐2	☐3	☐4

Student's view on science

ST092 **How informed are you about the following environmental issues?**
(Please select one response in each row.)

		I have never heard of this	I have heard about this but I would not be able to explain what it is really about	I know something about this and could explain the general issue	I am familiar with this and I would be able to explain this well
ST092Q01TA	The increase of greenhouse gases in the atmosphere	☐1	☐2	☐3	☐4
ST092Q02TA	The use of genetically modified organisms (<GMO>)	☐1	☐2	☐3	☐4
ST092Q04TA	Nuclear waste	☐1	☐2	☐3	☐4
ST092Q05TA	The consequences of clearing forests for other land use	☐1	☐2	☐3	☐4
ST092Q06NA	Air pollution	☐1	☐2	☐3	☐4
ST092Q08NA	Extinction of plants and animals	☐1	☐2	☐3	☐4
ST092Q09NA	Water shortage	☐1	☐2	☐3	☐4

ST093 **Do you think problems associated with the environmental issues below will improve or get worse over the next 20 years?**
(Please select one response in each row.)

		Improve	Stay about the same	Get worse
ST093Q01TA	Air pollution	☐1	☐2	☐3
ST093Q03TA	Extinction of plants and animals	☐1	☐2	☐3
ST093Q04TA	Clearing of forests for other land use	☐1	☐2	☐3
ST093Q05TA	Water shortages	☐1	☐2	☐3
ST093Q06TA	Nuclear waste	☐1	☐2	☐3
ST093Q07NA	The increase of greenhouse gases in the atmosphere	☐1	☐2	☐3
ST093Q08NA	The use of genetically modified organisms (<GMO>)	☐1	☐2	☐3

ST094 **How much do you disagree or agree with the statements about yourself below?**
(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
ST094Q01NA	I generally have fun when I am learning <broad science> topics.	☐1	☐2	☐3	☐4
ST094Q02NA	I like reading about <broad science>.	☐1	☐2	☐3	☐4
ST094Q03NA	I am happy working on <broad science> topics.	☐1	☐2	☐3	☐4
ST094Q04NA	I enjoy acquiring new knowledge in <broad science>.	☐1	☐2	☐3	☐4
ST094Q05NA	I am interested in learning about <broad science>.	☐1	☐2	☐3	☐4

ST095 **To what extent are you interested in the following <broad science> topics?**

(Please select one response in each row.)

		Not interested	Hardly interested	Interested	Highly interested	I don't know what this is
ST095Q04NA	Biosphere (e.g. ecosystem services, sustainability)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ST095Q07NA	Motion and forces (e.g. velocity, friction, magnetic and gravitational forces)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ST095Q08NA	Energy and its transformation (e.g. conservation, chemical reactions)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ST095Q13NA	The Universe and its history	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
ST095Q15NA	How science can help us prevent disease	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

ST113 **How much do you agree with the statements below?**

(Please select one response in each row.)

		Strongly agree	Agree	Disagree	Strongly disagree
ST113Q01TA	Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on.	☐ 1	☐ 2	☐ 3	☐ 4
ST113Q02TA	What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on.	☐ 1	☐ 2	☐ 3	☐ 4
ST113Q03TA	Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects.	☐ 1	☐ 2	☐ 3	☐ 4
ST113Q04TA	Many things I learn in my <school science> subject(s) will help me to get a job.	☐ 1	☐ 2	☐ 3	☐ 4

ST129 **How easy do you think it would be for you to perform the following tasks on your own?**

(Please select one response in each row.)

		I could do this easily	I could do this with a bit of effort	I would struggle to do this on my own	I couldn't do this
ST129Q01TA	Recognise the science question that underlies a newspaper report on a health issue.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q02TA	Explain why earthquakes occur more frequently in some areas than in others.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q03TA	Describe the role of antibiotics in the treatment of disease.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q04TA	Identify the science question associated with the disposal of garbage.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q05TA	Predict how changes to an environment will affect the survival of certain species.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q06TA	Interpret the scientific information provided on the labelling of food items.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q07TA	Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.	☐ 1	☐ 2	☐ 3	☐ 4
ST129Q08TA	Identify the better of two explanations for the formation of acid rain.	☐ 1	☐ 2	☐ 3	☐ 4

ST131	**How much do you disagree or agree with the statements below?** *(Please select one response in each row.)*	Strongly disagree	Disagree	Agree	Strongly agree
ST131Q01NA	A good way to know if something is true is to do an experiment.	☐1	☐2	☐3	☐4
ST131Q03NA	Ideas in <broad science> sometimes change.	☐1	☐2	☐3	☐4
ST131Q04NA	Good answers are based on evidence from many different experiments.	☐1	☐2	☐3	☐4
ST131Q06NA	It is good to try experiments more than once to make sure of your findings.	☐1	☐2	☐3	☐4
ST131Q08NA	Sometimes <broad science> scientists change their minds about what is true in science.	☐1	☐2	☐3	☐4
ST131Q11NA	The ideas in <broad science> science books sometimes change.	☐1	☐2	☐3	☐4

ST146	**How often do you do these things?** *(Please select one response in each row.)*	Very often	Regularly	Sometimes	Never or hardly ever
ST146Q01TA	Watch TV programmes about <broad science>	☐1	☐2	☐3	☐4
ST146Q02TA	Borrow or buy books on <broad science> topics	☐1	☐2	☐3	☐4
ST146Q03TA	Visit web sites about <broad science> topics	☐1	☐2	☐3	☐4
ST146Q04TA	Read <broad science> magazines or science articles in newspapers	☐1	☐2	☐3	☐4
ST146Q05TA	Attend a <science club>	☐1	☐2	☐3	☐4
ST146Q06NA	Simulate natural phenomena in computer programs/ virtual labs	☐1	☐2	☐3	☐4
ST146Q07NA	Simulate technical processes in computer programs/ virtual labs	☐1	☐2	☐3	☐4
ST146Q08NA	Visit web sites of ecology organisations	☐1	☐2	☐3	☐4
ST146Q09NA	Follow news of science, environmental, or ecology organizations via blogs and microblogging	☐1	☐2	☐3	☐4

ST076	**On the most recent day *you attended school*, did you do any of the following before going to school?** *(Please select one response in each row.)*	Yes	No
ST076Q01NA	Eat breakfast	☐1	☐2
ST076Q02NA	Study for school or homework	☐1	☐2
ST076Q03NA	Watch TV/<DVD>/Video	☐1	☐2
ST076Q04NA	Read a book/newspaper/magazine	☐1	☐2
ST076Q05NA	Internet/Chat/Social networks (e.g. <Facebook>, <country-specific social network>)	☐1	☐2
ST076Q06NA	Play video games	☐1	☐2
ST076Q07NA	Meet friends or talk to friends on the phone	☐1	☐2
ST076Q08NA	Talk to your parents	☐1	☐2
ST076Q09NA	Work in the household or take care of other family members	☐1	☐2
ST076Q10NA	Work for pay	☐1	☐2
ST076Q11NA	Exercise or practice a sport	☐1	☐2

ST078	**On the most recent day *you attended school*, did you do any of the following after leaving school?** *(Please select one response in each row.)*	Yes	No
ST078Q01NA	Eat dinner	☐ 1	☐ 2
ST078Q02NA	Study for school or homework	☐ 1	☐ 2
ST078Q03NA	Watch TV/<DVD>/Video	☐ 1	☐ 2
ST078Q04NA	Read a book/newspaper/magazine	☐ 1	☐ 2
ST078Q05NA	Internet/Chat/Social networks (e.g. <Facebook>, <country-specific social network>)	☐ 1	☐ 2
ST078Q06NA	Play video games	☐ 1	☐ 2
ST078Q07NA	Meet friends or talk to friends on the phone	☐ 1	☐ 2
ST078Q08NA	Talk to your parents	☐ 1	☐ 2
ST078Q09NA	Work in the household or take care of other family members	☐ 1	☐ 2
ST078Q10NA	Work for pay	☐ 1	☐ 2
ST078Q11NA	Exercise or practice a sport	☐ 1	☐ 2

EDUCATIONAL CAREER QUESTIONNAIRE
(International option)

Main Survey Version

As in previous PISA cycles, additional questionnaires were developed and offered as options to the participating countries and economies. In PISA 2015, these optional questionnaires are the educational career questionnaire and the ICT familiarity questionnaire for students, the parent questionnaire and the teacher questionnaire.

The educational career questionnaire covers:

- Additional instruction in science
- Additional instruction in mathematics
- Additional instruction in <test language>
- Educational pathway

The following questions ask about any additional instruction in school subjects and other domains that you attend in this school year. This instruction might take place at school or somewhere else, but is not part of your mandatory school schedule. Please consider all regularly attended, institutionalised, organised additional learning activities in which you receive some kind of instruction, guidance or support (e.g. <national examples>).

EC001	**In this school year, approximately how many hours per week do you attend additional instruction in the following domains in addition to mandatory school lessons?** *(An hour here refers to 60 minutes, not to a class period.)* *(Please move the slider to the number of hours you attend, move it to “0” [zero] if you don’t attend any additional instruction.)*	
EC001Q01NA	<School science> or <broad science>	
EC001Q02NA	Mathematics	
EC001Q03NA	<Test language>	
EC001Q04NA	<Foreign languages>	
EC001Q05NA	Social sciences (e.g. history, sociology, politics)	
EC001Q06NA	Music (e.g. musical instrument, choir, composition)	
EC001Q07NA	Sports (e.g. in clubs, lessons, team)	
EC001Q08NA	Performing arts (e.g. dancing, acting)	
EC001Q09NA	Visual arts (e.g. photography, drawing, sculpting)	
EC001Q10NA	Other	

Slider bar: “parking position”, “0”-“20 or more”

This question is a filter question.

a) The following question EC003 only applies, if any of the answers in EC001 are greater than 0.

b) The following sections A, B, and C only apply if a student attends “additional instruction” in this subject domain: Section A applies only if a students attends some kind of <school science> or <broad science> “additional instruction”, section B only applies if a student attends “additional mathematics instruction” and section C only applies if a student attends “additional instruction” in <test language>.

All students not attending either form of additional instruction proceed to the respective questions on reasons for not attending “additional instruction”.

PART A ADDITIONAL INSTRUCTION IN SCIENCE

EC003

→ Questions EC003-EC012 only apply, if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to EC0013.

Which <school science> subjects are covered in your additional science instruction?

(Please select all that apply.)

EC003Q01NA	Physics	☐1
EC003Q02NA	Chemistry	☐1
EC003Q03NA	Biology	☐1
EC003Q04NA	<Earth and space>	☐1
EC003Q05NA	Applied science and technology (e.g. <country-specific example>)	☐1
EC003Q06NA	<General, integrated, or comprehensive science> (e.g. <country-specific example>)	☐1

EC004

→ Questions EC003-EC012 only apply, if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to EC013.

Which of the following does this additional science instruction cover?

(Please select one response in each row.)

		Yes	No
EC004Q01NA	Content covered in regular school courses	☐1	☐2
EC004Q02NA	New or additional content not covered in regular school courses	☐1	☐2

EC005

→ Questions EC003-EC012 only apply, if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to EC013.

Which type of additional science instruction do you participate in during this school year?

(Please select all that apply.)

EC005Q01NA	One-on-one tutoring with a person	☐1
EC005Q02NA	Internet tutoring with a person (including e.g. <Skype™>)	☐1
EC005Q03NA	Internet or computer tutoring with a programme or application	☐1
EC005Q04NA	Live instruction by a person	☐1
EC005Q05NA	Video-recorded instruction by a person	☐1
EC005Q06NA	Small group study or practice (2 to 7 students)	☐1
EC005Q07NA	Large group study or practice (8 or more students)	☐1
EC005Q08NA	Other additional science instruction	☐1

EC007

→ Questions EC003-EC012 only apply if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to EC013.

Where do you attend this additional science instruction?

(Please select all that apply.)

EC007Q01NA	In my regular school building	☐1
EC007Q02NA	At some other place, i.e. not in my regular school building	☐1

EC008

→ Questions EC003-EC012 only apply, if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to EC013.

Which of the following best describes your teacher or instructor in your additional science instruction?

(Please select all that apply.)

EC008Q01NA	The teacher is one of my regular teachers in this year’s school courses.	☐1
EC008Q02NA	The teacher regularly teaches students my age in school but is not my teacher in any of my regular courses.	☐1
EC008Q03NA	The teacher mainly works for a business or organisation specialised in additional instruction.	☐1
EC008Q04NA	The teacher is not specialised teaching personnel (e.g. a student).	☐1

EC009

→ Questions EC003-EC012 only apply, if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to EC013.

Compare your <school science> lessons at school and your additional science instruction. Where are the following teacher characteristics more likely to occur?

(If you have more than one <school science> teacher in school, please keep one and the same <school science > teacher in mind for all comparisons.)
(Please select one response in each row.)

		More likely in my regular school lessons	No difference	More likely in my additional instruction
EC009Q03NA	My teacher does a lot to help me.	☐1	☐2	☐3
EC009Q07NA	My teacher is pleased when I come up with new solutions to a problem.	☐1	☐2	☐3
EC009Q10NA	My teacher gives hints or offers strategies that help me to solve a task.	☐1	☐2	☐3
EC009Q12NA	My teacher helps me to find ways to solve a problem.	☐1	☐2	☐3
EC009Q13NA	Once we identify why I have a certain problem, my teacher provides me with a working strategy.	☐1	☐2	☐3
EC009Q14NA	My teacher adapts the content and method to my needs.	☐1	☐2	☐3

EC010

→ Questions EC003-EC012 only apply, if a student attends any “additional science instruction”.
Otherwise skip EC003-EC012 and proceed to ECN013.

Compare <school science> lessons in your regular school and your additional science instruction. Where are the following situations more likely to occur?

(If you have more than one <school science> teacher in school, please keep one and the same <school science > teacher in mind for all comparisons.)
(Please select one response in each row.)

		More likely in my regular school lessons	No difference	More likely in my additional instruction
EC010Q04NA	It takes a long time until I have gathered all the material to get started.	☐1	☐2	☐3
EC010Q06NA	I talk about things that don’t have anything to do with our tasks and the topic.	☐1	☐2	☐3
EC010Q07NA	At the end of a lesson, my teacher summarises the learning content I have covered.	☐1	☐2	☐3
EC010Q08NA	My teacher points out the most important aspects of a topic.	☐1	☐2	☐3
EC010Q09NA	I am often bored.	☐1	☐2	☐3
EC010Q10NA	It takes very long until I am ready to get started.	☐1	☐2	☐3
EC010Q11NA	My teacher tells me what I should learn in a certain activity.	☐1	☐2	☐3
EC010Q12NA	My teacher points out the broader context of a learning unit.	☐1	☐2	☐3

EC011

→ Questions EC003-EC012 only apply, if a student attends any "additional science instruction". Otherwise skip EC003-EC012 and proceed to EC013.

Compare <school science> lessons in your school and your additional science instruction. Where are the following teacher-student interactions more likely to occur?

(If you have more than one <school science> teacher in school, please keep one and the same <school science> teacher in mind for all comparisons.)
(Please select one response in each row.)

		More likely in my regular school lessons	No difference	More likely in my additional instruction
EC011Q01NA	I get along well with my teacher.	☐1	☐2	☐3
EC011Q02NA	My teacher is interested in my well-being.	☐1	☐2	☐3
EC011Q03NA	My teacher really listens to what I have to say.	☐1	☐2	☐3
EC011Q04NA	If I need extra help, I will receive it from my teacher.	☐1	☐2	☐3
EC011Q05NA	My teacher treats me fairly.	☐1	☐2	☐3

EC012

→ Questions EC003-EC012 only apply, if a student attends any "additional science instruction". Otherwise skip EC003-EC012 and proceed to EC013.

Why do you attend additional science instruction in this school year?

(Please select all that apply.)

EC012Q01NA	I want to learn more.	☐1
EC012Q02NA	I want to prepare for exams.	☐1
EC012Q03NA	I was attracted by the tutoring advertisement.	☐1
EC012Q04NA	My parents wanted me to attend.	☐1
EC012Q05NA	Many of my friends are doing it.	☐1
EC012Q06NA	My teachers recommend it.	☐1
EC012Q07NA	I want to improve my grades.	☐1
EC012Q08NA	I need to improve my grades.	☐1
EC012Q09NA	It is gratifying to study.	☐1
EC012Q10NA	It looks good on a résumé.	☐1
EC012Q11NA	It is necessary for a job.	☐1
EC012Q12NA	Other reason.	☐1

EC013

→ Only if a student does not attend any "additional science instruction". Otherwise skip and proceed to EC014.

Why don't you attend additional science instruction in this school year?

(Please select all that apply.)

EC013Q01NA	I don't need any additional science instruction.	☐1
EC013Q02NA	None of the available offerings seem to suit my needs.	☐1
EC013Q03NA	Not many of my friends are doing it.	☐1
EC013Q04NA	I don't have time.	☐1
EC013Q05NA	I don't have the money.	☐1
EC013Q06NA	My school teachers are knowledgeable enough.	☐1
EC013Q07NA	My parents don't want me to do it.	☐1
EC013Q08NA	It doesn't seem worth the money.	☐1
EC013Q09NA	My teachers say it is not useful.	☐1
EC013Q10NA	I have never considered taking additional science instruction.	☐1
EC013Q11NA	Additional science instruction is not available where I live.	☐1
EC013Q12NA	My family helps me instead.	☐1
EC013Q13NA	My peers and friends help me instead.	☐1

PART B ADDITIONAL INSTRUCTION IN MATHEMATICS

EC014

→ Questions EC014-EC022 only apply, if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023.

Which of the following does this additional mathematics instruction cover?

(Please select one response in each row.)

		Yes	No
EC014Q01NA	Content covered in regular school courses	☐$_1$	☐$_2$
EC014Q02NA	New or additional content not covered in regular school courses	☐$_1$	☐$_2$

EC015

→ Questions EC014-EC022 only apply, if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023.

Which type of additional mathematics instruction do you participate in during this school year?

(Please select all that apply.)

EC015Q01NA	One-on-one tutoring with a person	☐$_1$
EC015Q02NA	Internet tutoring with a person (including e.g. <Skype™>)	☐$_1$
EC015Q03NA	Internet or computer tutoring with a programme or application	☐$_1$
EC015Q04NA	Live instruction by a person	☐$_1$
EC015Q05NA	Video-recorded instruction by a person	☐$_1$
EC015Q06NA	Small group study or practice (2 to 7 students)	☐$_1$
EC015Q07NA	Large group study or practice (8 or more students)	☐$_1$
EC015Q08NA	Other additional mathematics instruction	☐$_1$

EC017

→ Questions EC014-EC022 only apply, if a students attend any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023.

Where do you attend this additional mathematics instruction?

(Please select all that apply.)

EC017Q01NA	In my regular school building	☐$_1$
EC017Q02NA	At some other place, i.e. not in my regular school building	☐$_1$

EC018

→ Questions EC014-EC022 only apply if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023.

Which of the following best describes your teacher or instructor in your additional mathematics instruction?

(Please select all that apply.)

EC018Q01NA	The teacher is one of my regular teachers in this year's school courses.	☐$_1$
EC018Q02NA	The teacher regularly teaches students my age in school but is not my teacher in any of my regular school courses.	☐$_1$
EC018Q03NA	The teacher mainly works for a business or organisation specialised in additional instruction.	☐$_1$
EC018Q04NA	The teacher is not specialised teaching personnel (e.g. a student).	☐$_1$

EC019

→ Questions EC014-EC022 only apply if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023.

Compare your mathematics lessons at school and your additional mathematics instruction. Where are the following teacher characteristics more likely to occur?

(If you have more than one mathematics teacher in school, please keep one and the same mathematics teacher in mind for all comparisons.)

(Please select one response in each row.)

		More likely in my regular school lessons	No difference	More likely in my additional instruction
EC019Q03NA	My teacher does a lot to help me.	☐1	☐2	☐3
EC019Q07NA	My teacher is pleased when I come up with new solutions to a problem.	☐1	☐2	☐3
EC019Q10NA	My teacher gives hints or offers strategies that help me to solve a task.	☐1	☐2	☐3
EC019Q12NA	My teacher helps me to find ways to solve a problem.	☐1	☐2	☐3
EC019Q13NA	Once we identify why I have a certain problem, my teacher provides me with a working strategy.	☐1	☐2	☐3
EC019Q14NA	My teacher adapts the content and method to my needs.	☐1	☐2	☐3

EC020

→ Questions EC014-EC022 only apply, if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023.

Compare mathematics lessons in your regular school and your additional mathematics instruction. Where are the following situations more likely to occur?

(If you have more than one mathematics teacher in school, please keep one and the same mathematics teacher in mind for all comparisons.)

(Please select one response in each row.)

		More likely in my regular school lessons	No difference	More likely in my additional instruction
EC020Q04NA	It takes a long time until I have gathered all the material to get started.	☐1	☐2	☐3
EC020Q06NA	I talk about things that don't have anything to do with our tasks and the topic.	☐1	☐2	☐3
EC020Q07NA	At the end of a lesson, my teacher summarises the learning content I have covered.	☐1	☐2	☐3
EC020Q08NA	My teacher points out the most important aspects of a topic.	☐1	☐2	☐3
EC020Q09NA	I am often bored.	☐1	☐2	☐3
EC020Q10NA	It takes very long until I am ready to get started.	☐1	☐2	☐3
EC020Q11NA	My teacher tells me what I should learn in a certain activity.	☐1	☐2	☐3
EC020Q12NA	My teacher points out the broader context of a learning unit.	☐1	☐2	☐3

EC021	→ Questions EC014-EC022 only apply, if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023. **Compare mathematics lessons in your school and your additional mathematics instruction. Where are the following student-teacher interactions more likely to occur?** *(If you have more than one mathematics teacher in school, please keep one and the same mathematics teacher in mind for all comparisons.)* *(Please select one response in each row.)*			
		More likely in my regular school lessons	No difference	More likely in my additional instruction
EC021Q01NA	I get along well with my teacher.	☐1	☐2	☐3
EC021Q02NA	My teacher is interested in my well-being.	☐1	☐2	☐3
EC021Q03NA	My teacher really listens to what I have to say.	☐1	☐2	☐3
EC021Q04NA	If I need extra help, I will receive it from my teacher.	☐1	☐2	☐3
EC021Q05NA	My teacher treats me fairly.	☐1	☐2	☐3

EC022	→ Questions EC014-EC022 only apply, if a student attends any "additional mathematics instruction". Otherwise skip EC014-EC022 and proceed to EC023. **Why do you attend additional mathematics instruction in this school year?** *(Please select all that apply.)*	
EC022Q01NA	I want to learn more.	☐1
EC022Q02NA	I want to prepare for exams.	☐1
EC022Q03NA	I was attracted by the tutoring advertisement.	☐1
EC022Q04NA	My parents wanted me to attend.	☐1
EC022Q05NA	Many of my friends are doing it.	☐1
EC022Q06NA	My teachers recommend it.	☐1
EC022Q07NA	I want to improve my grades.	☐1
EC022Q08NA	I need to improve my grades.	☐1
EC022Q09NA	It is gratifying to study.	☐1
EC022Q10NA	It looks good on a résumé.	☐1
EC022Q11NA	It is necessary for a job.	☐1
EC022Q12NA	Other reason.	☐1

EC023	→ Only if a student does not attend any "additional mathematics instruction". Otherwise skip and proceed to EC024. **Why don't you attend additional mathematics instruction in this school year?** *(Please select all that apply.)*	
EC023Q01NA	I don't need any additional mathematics instruction.	☐1
EC023Q02NA	None of the available offerings seem to suit my needs.	☐1
EC023Q03NA	Not many of my friends are doing it.	☐1
EC023Q04NA	I don't have time.	☐1
EC023Q05NA	I don't have the money.	☐1
EC023Q06NA	My school teachers are knowledgeable enough.	☐1
EC023Q07NA	My parents don't want me to do it.	☐1
EC023Q08NA	It doesn't seem worth the money.	☐1
EC023Q09NA	My teachers say it is not useful.	☐1
EC023Q10NA	I have never considered taking additional mathematics instruction.	☐1
EC023Q11NA	Additional mathematics instruction is not available where I live.	☐1
EC023Q12NA	My family helps me instead.	☐1
EC023Q13NA	My peers and friends help me instead.	☐1

PART C ADDITIONAL INSTRUCTION IN <TEST LANGUAGE>

EC024	→ Questions EC024-EC027 only apply, if a student attends any “additional <test language> instruction”. Otherwise skip EC024-EC027 and proceed to EC028. **Which type of additional <test language> instruction do you participate in during this school year?** *(Please select all that apply.)*	
EC024Q01NA	One-on-one tutoring with a person	☐ 1
EC024Q02NA	Internet tutoring with a person (including e.g. <Skype™>)	☐ 1
EC024Q03NA	Internet or computer tutoring using a programme or application	☐ 1
EC024Q04NA	Live instruction by a person	☐ 1
EC024Q05NA	Video-recorded instruction by a person	☐ 1
EC024Q06NA	Small group study or practice (2 to 7 students)	☐ 1
EC024Q07NA	Large group study or practice (8 or more students)	☐ 1
EC024Q08NA	Other additional <test language> instruction	☐ 1

EC026	→ Questions EC024-EC027 only apply, if a student attends any “additional <test language> instruction”. Otherwise skip EC024-EC027 and proceed to EC028. **Where do you attend this additional <test language> instruction?** *(Please select all that apply.)*	
EC026Q01NA	In my regular school building	☐ 1
EC026Q02NA	At some other place, i.e. not in my regular school building	☐ 1

EC027	→ Questions EC024-EC027 only apply if a student attends any “additional <test language> instruction”. Otherwise skip EC024-EC027 and proceed to EC028. **Which of the following best describes your teacher or instructor in your additional <test language> instruction?** *(Please select all that apply.)*	
EC027Q01NA	The teacher is one of my regular teachers in this year’s school courses.	☐ 1
EC027Q02NA	The teacher regularly teaches students my age in school but is not my teacher in any of my regular school courses.	☐ 1
EC027Q03NA	The teacher mainly works for a business or organisation specialised in additional instruction.	☐ 1
EC027Q04NA	The teacher is not specialised teaching personnel (e.g. a student).	☐ 1

PART D EDUCATIONAL PATHWAY

EC028	**Did you attend additional instruction earlier in your education?** *(Please select one response in each row.)*		
		Yes	No
EC028Q01NA	In <ISCED 0>	☐ 1	☐ 2
EC028Q02NA	In <ISCED 1>	☐ 1	☐ 2
EC028Q03NA	In <ISCED 2>	☐ 1	☐ 2

This is a filter question. EC029 only applies, if any of the answers in EC028 is greater than 0.

EC029
EC029Q01NA

→ Only if any answer in EC028 = 1 (student attended "additional instruction" earlier in education)

How many years altogether have you attended additional instruction?

(Please select from the drop-down menu to answer the question.)

Years: *Please choose* ▼

Option A
Option B
Option C
Option …

Drop down menu: answering options 0-16.

EC030 **In your family, who helps you regularly with your homework or private study?**

(Please select one response in each row.)

		Yes	No
EC030Q01NA	Mother or other female guardian	☐ 1	☐ 2
EC030Q02NA	Father or other male guardian	☐ 1	☐ 2
EC030Q03NA	Sister(s)/brother(s)	☐ 1	☐ 2
EC030Q04NA	Grandparents	☐ 1	☐ 2
EC030Q05NA	Other relatives	☐ 1	☐ 2
EC030Q06NA	Nobody	☐ 1	☐ 2
EC030Q07NA	Other person	☐ 1	☐ 2

EC031 **Did you change schools when you were attending <ISCED 1>?**

(Please select one response.)

EC031Q01TA	No, I attended all of <ISCED 1> at the same school.	☐ 1
EC031Q02TA	Yes, I changed schools once.	☐ 2
EC031Q03TA	Yes, I changed schools twice or more.	☐ 3

EC032 **Did you change schools when you were attending <ISCED 2>?**

(Please select one response.)

EC032Q01TA	No, I attended all of <ISCED 2> at the same school.	☐ 1
EC032Q02TA	Yes, I changed schools once.	☐ 2
EC032Q03TA	Yes, I changed schools twice or more.	☐ 3

EC033 **Have you ever changed your <study programme>?**

(<example>)

(Please select one response.)

EC033Q01NA	No	☐ 1
EC033Q02NA	Yes, I changed the <study programme> once.	☐ 2
EC033Q03NA	Yes, I changed the <study programme> twice or more.	☐ 3

ICT FAMILIARITY QUESTIONNAIRE
(International option)

Main Survey Version

The information and communication technology (ICT) familiarity questionnaire consists of questions regarding the availability of ICT and the student's use of, and attitudes towards, computers. Students can complete the questionnaire in about five minutes, after they have completed the student questionnaire.

The questionnaire covers:

- Availability of ICT
- General computer use
- Use of ICT outside of school
- Use of ICT at school
- Attitudes towards computers

In the following questions, you will be asked about different aspects related to digital media and digital devices, including desktop computers, portable laptops, notebooks, smartphones, tablet computers, cell phones without internet access, game consoles and internet-connected television.

IC001 **Are any of these devices available for you to use at home?**
(Please select one response in each row.)

		Yes, and I use it	Yes, but I don't use it	No
IC001Q01TA	Desktop computer	☐1	☐2	☐3
IC001Q02TA	Portable laptop, or notebook	☐1	☐2	☐3
IC001Q03TA	<Tablet computer> (e.g. <iPad®>, <BlackBerry® PlayBook™>)	☐1	☐2	☐3
IC001Q04TA	Internet connection	☐1	☐2	☐3
IC001Q05TA	<Video games console>, e.g. <Sony® PlayStation®>	☐1	☐2	☐3
IC001Q06TA	<Cell phone> (without Internet access)	☐1	☐2	☐3
IC001Q07TA	<Cell phone> (with Internet access)	☐1	☐2	☐3
IC001Q08TA	Portable music player (Mp3/Mp4 player, iPod® or similar)	☐1	☐2	☐3
IC001Q09TA	Printer	☐1	☐2	☐3
IC001Q10TA	USB (memory) stick	☐1	☐2	☐3
IC001Q11TA	<ebook reader>, e.g. <Amazon® Kindle™>	☐1	☐2	☐3

IC009 **Are any of these devices available for you to use at school?**
(Please select one response in each row.)

		Yes, and I use it	Yes, but I don't use it	No
IC009Q01TA	Desktop computer	☐1	☐2	☐3
IC009Q02TA	Portable laptop or notebook	☐1	☐2	☐3
IC009Q03TA	<Tablet computer> (e.g. <iPad®>, <BlackBerry® PlayBook™>)	☐1	☐2	☐3
IC009Q05NA	Internet-connected school computers	☐1	☐2	☐3
IC009Q06NA	Internet connection via wireless network	☐1	☐2	☐3
IC009Q07NA	Storage space for school-related data, e.g. a folder for own documents	☐1	☐2	☐3
IC009Q08TA	USB (memory) stick	☐1	☐2	☐3
IC009Q09TA	<ebook reader>, e.g. <Amazon® Kindle™>	☐1	☐2	☐3
IC009Q10NA	Data projector, e.g. for slide presentations	☐1	☐2	☐3
IC009Q11NA	Interactive whiteboard, e.g. <SmartBoard®>	☐1	☐2	☐3

IC002
IC002Q01NA

How old were you when you first used <u>a digital device</u>?

(Please think of different kinds of digital devices such as for example desktop computers, portable laptops, notebooks, smartphones, tablet computers, cell phones without internet access, game consoles, or internet-connected television.)
(Please select one response.)

6 years old or younger	7-9 years old	10-12 years old	13 years old or older	I had never used a digital device until today
☐1	☐2	☐3	☐4	☐5

→ If the student selects "I have never used a digital device until today", the questionnaire will terminate because the following questions will not be relevant to the student.

IC003
IC003Q01TA

How old were you when you first used <u>a computer</u>?

(Please select one response.)

6 years old or younger	7-9 years old	10-12 years old	13 years old or older	I had never used a computer until today
☐1	☐2	☐3	☐4	☐5

IC004
IC004Q01T

How old were you when you first accessed the Internet?

(Please select one response.)

6 years old or younger	7-9 years old	10-12 years old	13 years old or older	I have never accessed the Internet
☐1	☐2	☐3	☐4	☐5

This is a filter question. If a student responds "5", I have never accessed the Internet, IC005-IC007 are not applicable and students will proceed to IC008.

IC005
IC005Q01TA

→ Only if students answered "1"-"4" in IC004.

During a *typical* <u>weekday</u>, for how long do you use the Internet <u>at school</u>?

(Please select one response.)

No time	1-30 minutes per day	31-60 minutes per day	Between 1 hour and 2 hours per day	Between 2 hours and 4 hours per day	Between 4 hours and 6 hours per day	More than 6 hours per day
☐1	☐2	☐3	☐4	☐5	☐6	☐7

IC006
IC006Q01TA

→ Only if students answered "1"-"4" in IC004.

During a *typical* <u>weekday</u>, for how long do you use the Internet <u>outside of school</u>?

(Please select one response.)

No time	1-30 minutes per day	31-60 minutes per day	Between 1 hour and 2 hours per day	Between 2 hours and 4 hours per day	Between 4 hours and 6 hours per day	More than 6 hours per day
☐1	☐2	☐3	☐4	☐5	☐6	☐7

IC007
IC007Q01TA

→ Only if students answered "1"-"4" in IC004.

On a *typical* <u>weekend day</u>, for how long do you use the Internet <u>outside of school</u>?

(Please select one response.)

No time	1-30 minutes per day	31-60 minutes per day	Between 1 hour and 2 hours per day	Between 2 hours and 4 hours per day	Between 4 hours and 6 hours per day	More than 6 hours per day
☐1	☐2	☐3	☐4	☐5	☐6	☐7

IC008 **How often do you use digital devices for the following activities <u>outside of school</u>?**
(Please select one response in each row.)

		Never or hardly ever	Once or twice a month	Once or twice a week	Almost every day	Every day
IC008Q01TA	Playing one-player games	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q02TA	Playing collaborative online games	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q03TA	Using email	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q04TA	<Chatting online> (e.g. <MSN®>)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q05TA	Participating in social networks (e.g. <Facebook>, <MySpace>)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q07NA	Playing online games via social networks (e.g. <Farmville®>, <The Sims Social>)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q08TA	Browsing the Internet for fun (such as watching videos, e.g. <YouTube™>)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q09TA	Reading news on the Internet (e.g. current affairs)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q10TA	Obtaining practical information from the Internet (e.g. locations, dates of events)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q11TA	Downloading music, films, games or software from the internet	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q12TA	Uploading your own created contents for sharing (e.g. music, poetry, videos, computer programs)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC008Q13NA	Downloading new apps on a mobile device	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

IC010 **How often do you use digital devices for the following activities <u>outside of school</u>?**
(Please select one response in each row.)

		Never or hardly ever	Once or twice a month	Once or twice a week	Almost every day	Every day
IC010Q01TA	Browsing the Internet for schoolwork (e.g. for preparing an essay or presentation)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q02NA	Browsing the Internet to follow up lessons, e.g. for finding explanations	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q03TA	Using email for communication with other students about schoolwork	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q04TA	Using email for communication with teachers and submission of homework or other schoolwork	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q05NA	Using social networks for communication with other students about schoolwork (e.g. <Facebook>, <MySpace>)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q06NA	Using social networks for communication with teachers (e.g. <Facebook>, <MySpace>)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q07TA	Downloading, uploading or browsing material from my school's website (e.g. timetable or course materials)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q08TA	Checking the school's website for announcements (e.g. absence of teachers)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q09NA	Doing homework on a computer	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q10NA	Doing homework on a mobile device	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q11NA	Downloading learning apps on a mobile device	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
IC010Q12NA	Downloading science learning apps on a mobile device	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

IC011 **How often do you use digital devices for the following activities <u>at school</u>?**

(Please select one response in each row.)

		Never or hardly ever	Once or twice a month	Once or twice a week	Almost every day	Every day
IC011Q01TA	<Chatting online> at school.	☐1	☐2	☐3	☐4	☐5
IC011Q02TA	Using email at school.	☐1	☐2	☐3	☐4	☐5
IC011Q03TA	Browsing the Internet for schoolwork.	☐1	☐2	☐3	☐4	☐5
IC011Q04TA	Downloading, uploading or browsing material from the school's website (e.g. <intranet>).	☐1	☐2	☐3	☐4	☐5
IC011Q05TA	Posting my work on the school's website.	☐1	☐2	☐3	☐4	☐5
IC011Q06TA	Playing simulations at school.	☐1	☐2	☐3	☐4	☐5
IC011Q07TA	Practicing and drilling, such as for foreign language learning or mathematics.	☐1	☐2	☐3	☐4	☐5
IC011Q08TA	Doing homework on a school computer.	☐1	☐2	☐3	☐4	☐5
IC011Q09TA	Using school computers for group work and communication with other students.	☐1	☐2	☐3	☐4	☐5

IC013 **Thinking about your experience with digital media and digital devices: to what extent do you disagree or agree with the following statements?**

(Please think of different kinds of digital devices such as for example desktop computers, portable laptops, notebooks, smartphones, tablet computers, cell phones without internet access, game consoles, or internet-connected television.)

(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
IC013Q01NA	I forget about time when I'm using digital devices.	☐1	☐2	☐3	☐4
IC013Q04NA	The Internet is a great resource for obtaining information I am interested in (e.g. news, sports, dictionary).	☐1	☐2	☐3	☐4
IC013Q05NA	It is very useful to have social networks on the Internet.	☐1	☐2	☐3	☐4
IC013Q11NA	I am really excited discovering new digital devices or applications.	☐1	☐2	☐3	☐4
IC013Q12NA	I really feel bad if no internet connection is possible.	☐1	☐2	☐3	☐4
IC013Q13NA	I like using digital devices.	☐1	☐2	☐3	☐4

IC014 **Thinking about your experience with digital media and digital devices: to what extent do you disagree or agree with the following statements?**

(Please think of different kinds of digital devices such as for example desktop computers, portable laptops, notebooks, smartphones, tablet computers, cell phones without internet access, game consoles, or internet-connected television.)
(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
IC014Q03NA	I feel comfortable using digital devices that I am less familiar with.	☐1	☐2	☐3	☐4
IC014Q04NA	If my friends and relatives want to buy new digital devices or applications, I can give them advice.	☐1	☐2	☐3	☐4
IC014Q06NA	I feel comfortable using my digital devices at home.	☐1	☐2	☐3	☐4
IC014Q08NA	When I come across problems with digital devices, I think I can solve them.	☐1	☐2	☐3	☐4
IC014Q09NA	If my friends and relatives have a problem with digital devices, I can help them.	☐1	☐2	☐3	☐4

IC015 **Thinking about your experience with digital media and digital devices: to what extent do you disagree or agree with the following statements?**

(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
IC015Q02NA	If I need new software, I install it by myself.	☐1	☐2	☐3	☐4
IC015Q03NA	I read information about digital devices to be independent.	☐1	☐2	☐3	☐4
IC015Q05NA	I use digital devices as I want to use them.	☐1	☐2	☐3	☐4
IC015Q07NA	If I have a problem with digital devices I start to solve it on my own.	☐1	☐2	☐3	☐4
IC015Q09NA	If I need a new application, I choose it by myself.	☐1	☐2	☐3	☐4

IC016 **Thinking about your experience with digital media and digital devices: to what extent do you disagree or agree with the following statements?**

(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
IC016Q01NA	To learn something new about digital devices, I like to talk about them with my friends.	☐1	☐2	☐3	☐4
IC016Q02NA	I like to exchange solutions to problems with digital devices with others on the internet.	☐1	☐2	☐3	☐4
IC016Q04NA	I like to meet friends and play computer and video games with them.	☐1	☐2	☐3	☐4
IC016Q05NA	I like to share information about digital devices with my friends.	☐1	☐2	☐3	☐4
IC016Q07NA	I learn a lot about digital media by discussing with my friends and relatives.	☐1	☐2	☐3	☐4

PARENT QUESTIONNAIRE

(International option)

Main Survey Version

One parent questionnaire is distributed per student. The parent questionnaire takes about 20 minutes for parents to complete and covers:

- The student's family
- The student's school
- The student's educational pathway in early childhood
- Parents' views on science and the environment
- Background information

PART A THE STUDENT'S FAMILY

PA001	**Who will complete this questionnaire?** *(Please tick all that apply.)*	
PA001Q01TA	Mother or other female guardian	☐1
PA001Q02TA	Father or other male guardian	☐1
PA001Q03TA	Other	☐1

PA002	*Please answer this question with reference to <the student who brought this questionnaire home>.* **Thinking back to when your child was about 10 years old, how often would your child have done these things?** *(Please tick only one box in each row.)*				
		Very often	Regularly	Sometimes	Never
PA002Q01TA	Watched TV programmes about science	☐1	☐2	☐3	☐4
PA002Q02TA	Read books on scientific discoveries	☐1	☐2	☐3	☐4
PA002Q03TA	Watched, read or listened to science fiction	☐1	☐2	☐3	☐4
PA002Q04TA	Visited web sites about science topics	☐1	☐2	☐3	☐4
PA002Q05TA	Attended a science club	☐1	☐2	☐3	☐4
PA002Q06NA	Construction play, e.g.<lego bricks>	☐1	☐2	☐3	☐4
PA002Q07NA	Took apart technical devices	☐1	☐2	☐3	☐4
PA002Q08NA	Fixed broken objects or items, e.g. broken electronic toys	☐1	☐2	☐3	☐4
PA002Q09NA	Experimented with a science kit, electronics kit, or chemistry set, used a microscope or telescope	☐1	☐2	☐3	☐4
PA002Q10NA	Played computer games with a science content	☐1	☐2	☐3	☐4

PA003 **How often do you or someone else in your home do the following things with your child?**

(Please tick only one box in each row.)

		Never or hardly ever	Once or twice a year	Once or twice a month	Once or twice a week	Every day or almost every day
PA003Q01TA	Discuss how well my child is doing at school.	☐1	☐2	☐3	☐4	☐5
PA003Q02TA	Eat <the main meal> with my child around a table.	☐1	☐2	☐3	☐4	☐5
PA003Q03TA	Spend time just talking to my child.	☐1	☐2	☐3	☐4	☐5
PA003Q04NA	Help my child with his/her science homework.	☐1	☐2	☐3	☐4	☐5
PA003Q05NA	Ask how my child is performing in science class.	☐1	☐2	☐3	☐4	☐5
PA003Q06NA	Obtain science-related materials (e.g. applications, software, study guides, etc.) for my child.	☐1	☐2	☐3	☐4	☐5
PA003Q07NA	Discuss with my child how science is used in everyday life.	☐1	☐2	☐3	☐4	☐5
PA003Q08NA	Discuss <science related career> options with my child.	☐1	☐2	☐3	☐4	☐5

PA004 **Thinking about <the last academic year>, to what extent do you agree with the following statements?**

(Please tick only one box in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
PA004Q01NA	I am interested in my child's school activities.	☐1	☐2	☐3	☐4
PA004Q02NA	I am supportive of my child's efforts at school and his/her achievements.	☐1	☐2	☐3	☐4
PA004Q03NA	I support my child when he/she is facing difficulties at school.	☐1	☐2	☐3	☐4
PA004Q04NA	I encourage my child to be confident.	☐1	☐2	☐3	☐4

PART B THE STUDENT'S SCHOOL

We are interested in the options you had as parents when choosing the school your child is currently attending.

PA005 PA005Q01TA **Which of the following statements best describes the schooling available to students in your location?**

(Please tick only one box.)

There are two or more other schools in this area that compete with the school my child is currently attending.	☐1
There is one other school in this area that competes with the school my child is currently attending.	☐2
There are no other schools in this area that compete with the school my child is currently attending.	☐3

PA006 **How important are the following reasons for choosing a school for your child?**
(Please tick only one box in each row.)

		Not important	Somewhat important	Important	Very important
PA006Q01TA	The school is at a short distance to home.	□1	□2	□3	□4
PA006Q02TA	The school has a good reputation.	□1	□2	□3	□4
PA006Q03TA	The school offers particular courses or school subjects.	□1	□2	□3	□4
PA006Q04TA	The school adheres to a particular <religious philosophy>.	□1	□2	□3	□4
PA006Q05TA	The school has a particular approach to <pedagogy/didactics, e.g. example>.	□1	□2	□3	□4
PA006Q06TA	Other family members attended the school.	□1	□2	□3	□4
PA006Q07TA	<Expenses are low> (e.g. tuition, books, room and board).	□1	□2	□3	□4
PA006Q08TA	The school has < financial aid> available, such as a school loan, scholarship or grant.	□1	□2	□3	□4
PA006Q09TA	The school has an active and pleasant school climate.	□1	□2	□3	□4
PA006Q10TA	The academic achievements of students in the school are high.	□1	□2	□3	□4
PA006Q11TA	There is a safe school environment.	□1	□2	□3	□4

We are interested in what you think about your child's school.

PA007 **How much do you agree or disagree with the following statements?**
(Please tick only one box in each row.)

		Strongly agree	Agree	Disagree	Strongly disagree
PA007Q01TA	Most of my child's school teachers seem competent and dedicated.	□1	□2	□3	□4
PA007Q02TA	Standards of achievement are high in my child's school.	□1	□2	□3	□4
PA007Q03TA	I am happy with the content taught and the instructional methods used in my child's school.	□1	□2	□3	□4
PA007Q04TA	I am satisfied with the disciplinary atmosphere in my child's school.	□1	□2	□3	□4
PA007Q05TA	My child's progress is carefully monitored by the school.	□1	□2	□3	□4
PA007Q06TA	My child's school provides regular and useful information on my child's progress.	□1	□2	□3	□4
PA007Q07TA	My child's school does a good job in educating students.	□1	□2	□3	□4
PA007Q09NA	My child's school provides an inviting atmosphere for parents to get involved.	□1	□2	□3	□4
PA007Q11NA	My child's school provides effective communication between the school and families.	□1	□2	□3	□4
PA007Q12NA	My child's school involves parents in the school's decision-making process.	□1	□2	□3	□4
PA007Q13NA	My child's school offers parent education (e.g. <courses on family literacy>) or family support programmes (e.g. <to assist with health, nutrition>).	□1	□2	□3	□4
PA007Q14NA	My child's school informs families about how to help students with homework and other school-related activities.	□1	□2	□3	□4
PA007Q15NA	My child's school cooperates with <community services> to strengthen school programmes and student development.	□1	□2	□3	□4

PA008 **During <the last academic year>, have you participated in any of the following school-related activities?**
(Please tick only one box in each row.)

		Yes	No	Not supported by school
PA008Q01TA	Discussed my child's behaviour with a teacher on my own initiative.	☐1	☐2	☐3
PA008Q02TA	Discussed my child's behaviour on the initiative of one of his/her teachers.	☐1	☐2	☐3
PA008Q03TA	Discussed my child's progress with a teacher on my own initiative.	☐1	☐2	☐3
PA008Q04TA	Discussed my child's progress on the initiative of one of their teachers.	☐1	☐2	☐3
PA008Q05TA	Participated in local school government, e.g. parent council or school management committee.	☐1	☐2	☐3
PA008Q06NA	Volunteered in physical or extra-curricular activities (e.g. building maintenance, carpentry, gardening or yard work, school play, sports, field trip).	☐1	☐2	☐3
PA008Q07NA	Volunteered to support school activities (volunteered in the school library, media centre, or canteen, assisted a teacher, appeared as a guest speaker).	☐1	☐2	☐3
PA008Q08NA	Attended a scheduled meeting or conferences for parents.	☐1	☐2	☐3
PA008Q09NA	Talked about how to support learning at home and homework with my child's teachers.	☐1	☐2	☐3
PA008Q10NA	Exchanged ideas on parenting, family support, or the child's development with my child's teachers.	☐1	☐2	☐3

PA009 **During <the last academic year>, has your participation in activities at your child's school been hindered by any of the following issues?**
(Please tick only one box in each row.)

		Yes	No
PA009Q01NA	The meeting times were inconvenient.	☐1	☐2
PA009Q02NA	I was not able to get off from work.	☐1	☐2
PA009Q03NA	I had no one to take care of my child/ children.	☐1	☐2
PA009Q04NA	The way to school is unsafe.	☐1	☐2
PA009Q05NA	I had problems with transportation.	☐1	☐2
PA009Q06NA	I felt unwelcome at my child's school.	☐1	☐2
PA009Q08NA	My <language skills> were not sufficient.	☐1	☐2
PA009Q09NA	I think participation is not relevant for my child's development.	☐1	☐2
PA009Q10NA	I do not know how I could participate in school activities.	☐1	☐2
PA009Q11NA	My child does not want me to participate.	☐1	☐2

PA011 **We are interested in parents' interaction with the child's school friends and school staff.**
(Please tick only one box in each row.)

		0	1-2	3-5	6 or more
PA011Q01NA	How many parents of your child's friends at this school do you know?	☐1	☐2	☐3	☐4
PA011Q02NA	How many friends of your child at school do you know by name?	☐1	☐2	☐3	☐4
PA011Q03NA	How many of the school staff would you feel comfortable talking to if you had a question about your child?	☐1	☐2	☐3	☐4

PART C THE STUDENT'S EDUCATIONAL PATHWAY IN EARLY CHILDHOOD

PA014	At what age did your child start attending <ISCED 1>?	
PA014Q01NA	Years:	____________

PA018	Did your child regularly attend an arrangement with one of the following main purposes prior to <grade 1 in ISCED 1>? *(Please tick only one box in each row.)*			
		Yes	No	
PA018Q01NA	Supervision and care (e.g. <national examples>)	☐1	☐2	If yes, please answer questions 19–22.
PA018Q02NA	Early childhood educational development (e.g. <national examples>)	☐1	☐2	If yes, please answer questions 23 and 26.
PA018Q03NA	Pre-primary education (e.g. <national examples>)	☐1	☐2	If yes, please answer questions 27–30.

In case your child did not visit any <early childhood education and care arrangement> prior to <grade 1 in ISCED 1> please proceed to Q32.

PA019	At what ages did your child attend a <supervision and care arrangement> prior to <grade 1 in ISCED 1>? *(Please tick all that apply.)*	
PA019Q01NA	Up to age 1	☐1
PA019Q02NA	Age 1	☐1
PA019Q03NA	Age 2	☐1
PA019Q04NA	Age 3	☐1
PA019Q05NA	Age 4	☐1
PA019Q06NA	Age 5	☐1
PA019Q07NA	Age 6	☐1
PA019Q08NA	Age 7	☐1

PA020	Who took care of or educated your child in a <supervision and care arrangement>? *(Please tick all that apply.)*	
PA020Q01NA	An underage sibling of the child	☐1
PA020Q02NA	An adult relative of the child (e.g. grandparents)	☐1
PA020Q03NA	An adult untrained in child care, not a relative (e.g. baby-sitter, friend, neighbour)	☐1
PA020Q04NA	A trained adult (e.g. <teacher>, nurse)	☐1

PA021	Where was your child cared for or educated in a <supervision and care arrangement>? *(Please tick all that apply.)*	
PA021Q01NA	The child's own home	☐1
PA021Q02NA	Another person's private home	☐1
PA021Q03NA	An institutional setting (e.g. <national example>)	☐1
PA021Q04NA	Another place	☐1

PA022 PA022Q01NA	What was the most important reason why your child attended a <supervision and care arrangement>? *(Please tick only one box.)*	
	Attendance was mandatory.	☐1
	We/I could not care for the child (e.g. work, illness).	☐2
	We/I wanted additional learning stimulation for the child (e.g. social, academic).	☐3
	Most other children attended a < supervision and care arrangement>.	☐4

PA023	At what ages did your child attend an <early childhood educational development arrangement> prior to <grade 1 in ISCED 1>? *(Please tick all that apply.)*	
PA023Q01NA	Up to age 1	☐ 1
PA023Q02NA	Age 1	☐ 1
PA023Q03NA	Age 2	☐ 1
PA023Q04NA	Age 3	☐ 1
PA023Q05NA	Age 4	☐ 1
PA023Q06NA	Age 5	☐ 1
PA023Q07NA	Age 6	☐ 1
PA023Q08NA	Age 7	☐ 1

PA026 PA026Q01NA	What was the most important reason why your child attended an <early childhood educational development arrangement>? *(Please tick only one box.)*	
	Attendance was mandatory.	☐ 1
	We/I could not care for the child (e.g. work, illness).	☐ 2
	We/I wanted additional learning stimulation for the child (e.g. social, academic).	☐ 3
	Most other children attended a <early childhood educational development arrangement>.	☐ 4

PA027	At what ages did your child attend a <pre-primary education arrangement> prior to <grade 1 in ISCED 1>? *(Please tick all that apply.)*	
PA027Q01NA	Up to age 1	☐ 1
PA027Q02NA	Age 1	☐ 1
PA027Q03NA	Age 2	☐ 1
PA027Q04NA	Age 3	☐ 1
PA027Q05NA	Age 4	☐ 1
PA027Q06NA	Age 5	☐ 1
PA027Q07NA	Age 6	☐ 1
PA027Q08NA	Age 7	☐ 1

Please consider now the last <pre-primary education arrangement> which your child attended prior to <grade 1 in ISCED 1>.

PA028 PA028Q01NA	What type of provider offered this <pre-primary education arrangement>? *(Please tick only one box.)*	
	Public management and mainly public funding (e.g. <national example>)	☐ 1
	Private management and mainly public funding (e.g. <national example>)	☐ 2
	Private management and mainly private funding (e.g. <national example>)	☐ 3

PA029 PA029Q01NA	How many hours per week did your child attend a <pre-primary education arrangement> at the age of three years? *(Please tick only one box.)*	
	0 hours per week	☐ 1
	up to 10 hours per week	☐ 2
	11-20 hours per week	☐ 3
	21-30 hours per week	☐ 4
	31-40 hours per week	☐ 5
	41-50 hours per week	☐ 6
	51 hours per week or more	☐ 7

PA030 PA030Q01NA	**What was the most important reason why your child attended a <pre-primary education arrangement>?** *(Please tick only one box.)*	
	Attendance was mandatory.	☐ 1
	We/I could not care for the child (e.g. work, illness).	☐ 2
	We/I wanted additional learning stimulation for the child (e.g. social, academic).	☐ 3
	Most other children attended a <pre-primary education arrangement >.	☐ 4

PART D PARENTS' VIEWS ON SCIENCE AND THE ENVIRONMENT

The following questions refer to <science-related careers>. A <science-related career> is one that requires studying science at tertiary level (e.g. university). So, careers like engineer (involving physics), weather forecaster (involving Earth science), optician (involving biology and physics) and medical doctors (involving the medical sciences) are all examples of <science-related careers>.

PA032	**Please answer the questions below.** *(Please tick only one box in each row.)*		
		Yes	No
PA032Q01TA	Does anybody in your family (including you) work in a <science-related career>?	☐ 1	☐ 2
PA032Q02TA	Does your child show an interest in working in a <science-related career>?	☐ 1	☐ 2
PA032Q03TA	Do you expect your child will go into a < science-related career>?	☐ 1	☐ 2
PA032Q04TA	Has your child shown interest in studying science after completing <secondary school>?	☐ 1	☐ 2
PA032Q05TA	Do you expect your child will study science after completing <secondary school>?	☐ 1	☐ 2

PA033	*Science is an important part of the PISA study. We are interested in parents' opinions on science and on environmental issues.* *The following question asks about your views towards science.* **How much do you agree with the following statements?** *(Please tick only one box in each row.)*				
		Strongly agree	Agree	Disagree	Strongly disagree
PA033Q02TA	<Broad science> is important to help us to understand the natural world.	☐ 1	☐ 2	☐ 3	☐ 4
PA033Q06TA	<Broad science> is valuable to society.	☐ 1	☐ 2	☐ 3	☐ 4
PA033Q07TA	<Broad science> is very relevant to me.	☐ 1	☐ 2	☐ 3	☐ 4
PA033Q08TA	I find that <broad science> helps me to understand the things around me.	☐ 1	☐ 2	☐ 3	☐ 4
PA033Q09TA	Advances in <broad science> usually bring social benefits.	☐ 1	☐ 2	☐ 3	☐ 4

PA035 **Do you see the environmental issues below as a serious concern for yourself and/or others?**
(Please tick only one box in each row.)

		This is a serious concern for me personally as well as others	This is a serious concern for other people in my country but not for me personally	This is a serious concern only for people in other countries	This is not a serious concern for anyone
PA035Q01TA	Air pollution	☐1	☐2	☐3	☐4
PA035Q03TA	Extinction of plants and animals	☐1	☐2	☐3	☐4
PA035Q04TA	Clearing of forests for other land use	☐1	☐2	☐3	☐4
PA035Q05TA	Water shortages	☐1	☐2	☐3	☐4
PA035Q06TA	Nuclear waste	☐1	☐2	☐3	☐4
PA035Q07NA	Extreme weather conditions	☐1	☐2	☐3	☐4
PA035Q08NA	Human contact with animal diseases	☐1	☐2	☐3	☐4

PA036 **Do you think problems associated with the environmental issues below will improve or get worse over the next 20 years?**
(Please tick only one box in each row.)

		Improve	Stay about the same	Get worse
PA036Q01TA	Air pollution	☐1	☐2	☐3
PA036Q03TA	Extinction of plants and animals	☐1	☐2	☐3
PA036Q04TA	Clearing of forests for other land use	☐1	☐2	☐3
PA036Q05TA	Water shortages	☐1	☐2	☐3
PA036Q06TA	Nuclear waste	☐1	☐2	☐3
PA036Q07NA	Extreme weather conditions	☐1	☐2	☐3
PA036Q08NA	Human contact with animal diseases	☐1	☐2	☐3

PART E PARENT'S BACKGROUND

PA039 **In what country were the following people in the child's family born?**
(Please tick only one answer per column.)

	Mother	Father	Maternal grand-mother	Maternal grand-father	Paternal grand-mother	Paternal grand-father
	PA039Q01TA	PA039Q02TA	PA039Q03TA	PA039Q04TA	PA039Q05TA	PA039Q06TA
<Country of test>	☐1	☐1	☐1	☐1	☐1	☐1
<Country A>	☐2	☐2	☐2	☐2	☐2	☐2
<Country B>	☐3	☐3	☐3	☐3	☐3	☐3
<Country C>	☐4	☐4	☐4	☐4	☐4	☐4
<Country D>	☐5	☐5	☐5	☐5	☐5	☐5
<Country E>	☐6	☐6	☐6	☐6	☐6	☐6
<Country F>	☐7	☐7	☐7	☐7	☐7	☐7

PA041
PA041Q01TA

Please answer the following question thinking just of expenses related to <the student who brought this questionnaire home>.

In the last twelve months, about how much would you have paid to educational providers for services?

In determining this, please include any tuition fees you pay to your child's school, any other fees paid to individual teachers in the school or to other teachers for any tutoring your child receives, as well as any fees for cram school.

*Do **not** include the costs of goods like sports equipment, school uniforms, computers or textbooks if they are not included in a general fee (that is, if you have to buy these things separately).*

(Please tick only one box.)

Nothing	☐1
<More than $0 but less than $W>	☐2
<$W or more but less than $X>	☐3
<$X or more but less than $Y>	☐4
<$Y or more but less than $Z>	☐5
<$Z> or more	☐6

PA042
PA042Q01TA

What is your annual household income?

Please add together the total income, before tax, from all members of your household.

*Please remember we ask you to answer questions only if you feel comfortable doing so, and that all responses are kept **strictly confidential**.*

(Please tick only one box.)

Less than <$A>	☐1
<$A> or more but less than <$B>	☐2
<$B> or more but less than <$C>	☐3
<$C> or more but less than <$D>	☐4
<$D> or more but less than <$E>	☐5
<$E> or more	☐6

TEACHER QUESTIONNAIRE

(International Option)

Main Survey Versions

For PISA 2015, countries had the option to add a questionnaire for teachers. There is a version of this questionnaire for science teachers and a different version for teachers who teach other subjects. In both cases, the questionnaire takes about 30 minutes to complete.

For science teachers, the questionnaire covers:

- Background information
- Teacher's initial education and professional development
- Teacher's school
- Science teaching practices

For other teachers, the questionnaire covers:

- Background information
- Teacher's initial education and professional development
- Teacher's school
- Teaching practices

PART A SCIENCE TEACHER QUESTIONNAIRE

Background information

TC001 TC001Q01NA	**Are you female or male?** *(Please select one response.)*	
	Female	☐1
	Male	☐2

TC002 TC002Q01NA	**How old are you?** *(Please move the slider to the appropriate number of years.)*	
	Years:	
Slider bar: Parking position; range: "20 years or younger"-"70 years or older"; step=1.		

TC004 TC004Q01NA	**What is your employment status as a teacher at this school?** *(Please select one response.)*	
	Permanent employment (an ongoing contract with no fixed end-point before the age of retirement)	☐1
	Fixed-term contract for a period of more than 1 school year	☐2
	Fixed-term contract for a period of 1 school year or less	☐3

TC005 **What is your current employment status as a teacher?**

(Please consider your employment status at this school and for all your teaching employments together.)
(Please select one response in each row.)

		Full-time (more than 90% of full-time hours)	Part-time (71-90% of full-time hours)	Part-time (50-70% of full-time hours)	Part-time (less than 50% of full-time hours)
TC005Q01NA	My employment status at this school	☐1	☐2	☐3	☐4
TC005Q02NA	All my teaching employments together	☐1	☐2	☐3	☐4

TC006 TC006Q01NA **In how many schools have you worked over the course of your teaching career?**

(Include all schools, even if you worked at several schools at once.)
(Please move the slider to the appropriate number of schools.)

Schools:

Slider bar: Parking position; range: "1 school"-"20 schools or more"; step=1

TC007 **How many years of work experience do you have?**

(Please round up to whole years no matter whether you worked part-time or full-time and move the slider to the appropriate number of years. If any option does not apply to you select "0" [zero].)

TC007Q01NA	Year(s) working as a teacher at this school
TC007Q02NA	Year(s) working as a teacher in total

Slider bar: Parking position; range: "0 years"-"50 years or more"; step=1.
Consistency check/soft reminder if the response to item TC007Q01NA is bigger than to item TC007Q02NA.

Teacher's initial education and professional development

TC012 TC012Q01NA **What is the highest level of formal education you have completed?**

(Please select one response.)

<Below ISCED Level 5>	☐1
<ISCED Level 5B>	☐2
<ISCED Level 5A Bachelor degree>	☐3
<ISCED Level 5A Master's degree>	☐4
<ISCED Level 6>	☐5

TC013 TC013Q01NA **After completing <ISCED level 3 or below>, was your goal to pursue a career in the teaching profession?**

(Please select one response.)

Yes	☐1
No	☐2

TC014 TC014Q01NA **Did you complete a teacher education or training programme?**

(Please select one response.)

Yes	☐1
No	☐2

TC015 TC015Q01NA	**How did you receive your teaching qualifications?** *(Please select one response.)*	
	I attended a standard teacher education or training programme at a <educational institute which is eligible to educate or train teachers>.	☐1
	I attended an in-service teacher education or training programme.	☐2
	I attended a work-based teacher education or training programme.	☐3
	I attended training in another pedagogical profession.	☐4
	Other	☐5

TC018	**Were any of the following included in your teacher education or training programme or other professional qualification and do you teach them to the <national modal grade for 15-year-olds> in the current school year?** *(Because this is an international survey, we had to categorise many of the actual subjects taught in schools into broad categories. If the exact name of one of your subjects is not listed, please mark the category you think best fits the subject.)* *(If you need further explanation for terms used in this question, please use the help button.)* *Please select all that apply.)*		
		Included in my teacher education or training programme or other professional qualification	I teach it to the <national modal grade for 15-year-olds> in the current school year
TC018Q01N	Reading, writing and literature	☐1	☐1
TC018Q02N	Mathematics	☐1	☐1
TC018Q03N	Science	☐1	☐1
TC018Q04N	Technology	☐1	☐1
TC018Q05N	Social studies	☐1	☐1
TC018Q06N	Modern foreign languages	☐1	☐1
TC018Q07N	Ancient languages (e.g. Latin)	☐1	☐1
TC018Q08N	Arts	☐1	☐1
TC018Q09N	Physical education	☐1	☐1
TC018Q10N	Religion and/or ethics	☐1	☐1
TC018Q11N	Practical and vocational skills	☐1	☐1

Help button

Reading, writing and literature: reading and writing (and literature) in the mother tongue, in the language of instruction, or in the tongue of the country (region) as a second language (for non-natives); language studies, public speaking, literature

Mathematics: mathematics, mathematics with statistics, geometry, algebra, etc.

Science: natural sciences, physics, physical science, chemistry, biology, human biology, earth and space sciences, environmental science, agriculture/horticulture/forestry

Technology: orientation in technology, including information technology, computer studies, construction/surveying, engineering, electronics, graphics and design, keyboard skills, word processing, workshop technology/design technology

Social studies: social studies, community studies, contemporary studies, economics, environmental studies, geography, history, humanities, legal studies, studies of the own country, social sciences, ethical thinking, philosophy

Modern foreign languages: languages different from the language of instruction

Ancient languages (e.g. Latin)

Arts: arts, music, visual arts, practical art, drama, performance music, photography, drawing, creative handicraft, creative needlework

Physical education: physical education, gymnastics, dance, health

Religion and/or ethics: religion, history of religions, religion culture, ethics

Practical and vocational skills: vocational skills (preparation for a specific occupation), technics, domestic science, accountancy, business studies, career education, clothing and textiles, driving, home economics, polytechnic courses, secretarial studies, tourism and hospitality, handicraft.

Consistency check/soft reminder if any button remains unmarked.

TC029	**What proportion of your teacher education or training programme or other professional qualification was dedicated to each of the following areas?** *(For each area please enter an approximate percentage, e.g. "20" in the first row to indicate 20% of initial education time used for <broad science> and technology content matter.)* *(Note that the percentages must add up to 100.)*	
TC029Q01NA	**<Broad science> and technology content matter:** knowledge and skills in any <broad science> discipline	_____ %
TC029Q02NA	**Teaching and learning <school science>:** teaching methodology related to <school science>, instructional skills (e.g. use of experiments), student misconceptions	_____ %
TC029Q03NA	**General topics in education:** e.g. teacher-student interaction, classroom management, school evaluation, special education	_____ %
TC029Q04NA	**Other topics**	_____ %

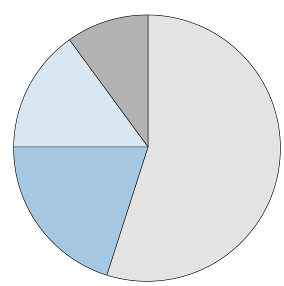
Consistency check/soft reminder if sum is more or less than 100%.

What proportion of your teacher education or training programme or other professional qualification was dedicated to each of the following areas?

(For each area please enter an approximate percentage, e.g. "20" in the first row to indicate 20% of initial education time used for <broad science> and technology content matter.)

(Note that the percentages must add up to 100.)

	Extent
<Broad science> and technology content matter: knowledge and skills in any <broad science> discipline	55%
Teaching and learning <school science>: teaching methodology related to <school science>, instructional skills (e.g. use of experiments), student misconceptions	20%
General topics in education: e.g. teacher-student interaction, classroom management, school evaluation, special education	15%
Other topics	10%



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The pie chart gives immediate interactive feedback and the respondent can change answers as often as desired.

TC020	**During the last 12 months, did you participate in any of the following activities?** *(Please select one response in each row.)*	Yes	No
TC020Q01NA	Qualification programme (e.g. a <degree programme>)	☐1	☐2
TC020Q02NA	Participation in a network of teachers formed specifically for the professional development of teachers	☐1	☐2
TC020Q03NA	Individual or collaborative research on a topic of interest to you professionally	☐1	☐2
TC020Q04NA	Mentoring and/or peer observation and coaching, as part of a formal school arrangement	☐1	☐2
TC020Q05NA	Reading professional literature (e.g. journals, evidence-based papers, thesis papers)	☐1	☐2
TC020Q06NA	Engaging in informal dialogue with your colleagues on how to improve your teaching	☐1	☐2

TC030	**During the last 12 months, what proportion of your professional development activities was dedicated to each of the following areas?** *(For each area please enter an approximate percentage, e.g. "20" in the first row to indicate 20% of professional development activity time used for <broad science> and technology content matter.)* *(Note that the percentages must add up to 100.)*	
TC030Q01NA	**<Broad science> and technology content matter:** knowledge and skills in any <broad science> discipline	______ %
TC030Q02NA	**Teaching and learning <school science>:** teaching methodology related to <school science>, instructional skills (e.g. use of experiments), student misconceptions	______ %
TC030Q03NA	**General topics in education:** e.g. teacher-student interaction, classroom management, school evaluation, special education	______ %
TC030Q04NA	**Other topics**	______ %

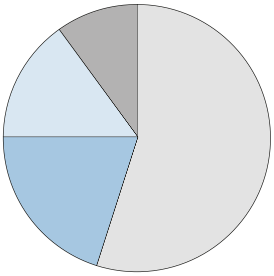
Consistency check/soft reminder if sum is more or less than 100 %.

During the last 12 months, what proportion of your professional development activities was dedicated to each of the following areas?

(For each area please enter an approximate percentage, e.g. "20" in the first row to indicate 20% of initial education time used for <broad science> and technology content matter.)

(Note that the percentages must add up to 100.)

	Extent
<Broad science> and technology content matter: knowledge and skills in any <broad science> discipline	55%
Teaching and learning <school science>: teaching methodology related to <school science>, instructional skills (e.g. use of experiments), student misconceptions	20%
General topics in education: e.g. teacher-student interaction, classroom management, school evaluation, special education	15%
Other topics	10%



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The pie chart gives immediate interactive feedback and the respondent can change answers as often as desired.

TC021 TC021Q01NA	**Are you required to take part in professional development activities?** *(Please select one response.)*	
	Yes	☐1
	No	☐2

Teacher's school

TC028 **Is your school's capacity to provide instruction hindered by any of the following issues?**
(Please select one response in each row.)

		Not at all	Very little	To some extent	A lot
TC028Q01NA	A lack of teaching staff	☐1	☐2	☐3	☐4
TC028Q02NA	Inadequate or poorly qualified teaching staff	☐1	☐2	☐3	☐4
TC028Q03NA	A lack of assisting staff	☐1	☐2	☐3	☐4
TC028Q04NA	Inadequate or poorly qualified assisting staff	☐1	☐2	☐3	☐4
TC028Q05NA	A lack of educational material (e.g. textbooks, IT equipment, library or laboratory material)	☐1	☐2	☐3	☐4
TC028Q06NA	Inadequate or poor quality educational material (e.g. textbooks, IT equipment, library or laboratory material)	☐1	☐2	☐3	☐4
TC028Q07NA	A lack of physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems)	☐1	☐2	☐3	☐4
TC028Q08NA	Inadequate or poor quality physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems)	☐1	☐2	☐3	☐4

TC039
TC039Q01NA

Is there any formal curriculum for <school science> in <national modal grade for 15-year-olds>?
(Please consider national, state, regional, or school policies.)
(Please select one response.)

Yes	☐1
No	☐2

TC041

→ Only, if TC039 = 'yes'. Else proceed to TC031.

How much emphasis is given to the following approaches and processes in the intended <school science> curriculum for <the national modal grade of 15-year-olds>?
(Please select one response in each row.)

		No emphasis	Very little emphasis	Some emphasis	A lot of emphasis
TC041Q01NA	Knowing basic science facts and principles	☐1	☐2	☐3	☐4
TC041Q02NA	Observing natural phenomena and describing what is seen	☐1	☐2	☐3	☐4
TC041Q03NA	Providing explanations of what is being studied	☐1	☐2	☐3	☐4
TC041Q04NA	Designing and planning experiments or investigations	☐1	☐2	☐3	☐4
TC041Q05NA	Conducting experiments or investigations	☐1	☐2	☐3	☐4
TC041Q06NA	Integrating science with other subjects	☐1	☐2	☐3	☐4
TC041Q07NA	Relating what students are learning to their daily lives	☐1	☐2	☐3	☐4
TC041Q08NA	Incorporating the experiences of different ethnic/cultural groups	☐1	☐2	☐3	☐4

TC043 TC043Q01NA	→ Only if TC039 = 'yes'. Else proceed to TC031. **Are parents informed about the availability and content of the <school science> curriculum (e.g. in a parent-teacher conference or a newsletter)?** *(Please select one response.)*	
	Yes	☐1
	No	☐2

TC031	**To what extent do you disagree or agree with the following statements about regular cooperation among your fellow <school science> teachers and yourself?** *(Please select one response in each row.)*				
		Strongly disagree	Disagree	Agree	Strongly agree
TC031Q04NA	We discuss the achievement requirements for <school science> when setting tests.	☐1	☐2	☐3	☐4
TC031Q07NA	It is natural for us to cooperate on what homework to give to our students.	☐1	☐2	☐3	☐4
TC031Q11NA	We discuss the criteria we use to grade written tests.	☐1	☐2	☐3	☐4
TC031Q13NA	We exchange tasks for lessons and homework that cover a range of different levels of difficulty.	☐1	☐2	☐3	☐4
TC031Q14NA	I prepare a selection of teaching units with my fellow <school science> teachers.	☐1	☐2	☐3	☐4
TC031Q15NA	We discuss ways to teach learning strategies and techniques to our students.	☐1	☐2	☐3	☐4
TC031Q18NA	My fellow <school science> teachers benefit from my specific skills and interests.	☐1	☐2	☐3	☐4
TC031Q20NA	We discuss ways to better identify students' individual strengths and weaknesses.	☐1	☐2	☐3	☐4

TC026	**We would like to know how you generally feel about your job. How strongly do you agree or disagree with the following statements?** *(Please select one response in each row.)*				
		Strongly disagree	Disagree	Agree	Strongly agree
TC026Q01NA	The advantages of being a teacher clearly outweigh the disadvantages.	☐1	☐2	☐3	☐4
TC026Q02NA	If I could decide again, I would still choose to work as a teacher.	☐1	☐2	☐3	☐4
TC026Q04NA	I regret that I decided to become a teacher.	☐1	☐2	☐3	☐4
TC026Q05NA	I enjoy working at this school.	☐1	☐2	☐3	☐4
TC026Q06NA	I wonder whether it would have been better to choose another profession.	☐1	☐2	☐3	☐4
TC026Q07NA	I would recommend my school as a good place to work.	☐1	☐2	☐3	☐4
TC026Q09NA	I am satisfied with my performance in this school.	☐1	☐2	☐3	☐4
TC026Q10NA	All in all, I am satisfied with my job.	☐1	☐2	☐3	☐4

Science teaching practices

TC037 **How often do these things happen in your <school science> lessons?**
(Please select one response in each row.)

		Never or almost never	Some lessons	Many lessons	Every lesson or almost every lesson
TC037Q01NA	Students are asked to draw conclusions from an experiment they have conducted.	☐1	☐2	☐3	☐4
TC037Q02NA	Students are given opportunities to explain their ideas.	☐1	☐2	☐3	☐4
TC037Q03NA	I explain scientific ideas.	☐1	☐2	☐3	☐4
TC037Q04NA	A small group discussion between students takes place.	☐1	☐2	☐3	☐4
TC037Q05NA	A whole class discussion takes place in which I participate.	☐1	☐2	☐3	☐4
TC037Q06NA	Current scientific issues are discussed.	☐1	☐2	☐3	☐4
TC037Q07NA	Students make calculations using scientific formulas.	☐1	☐2	☐3	☐4
TC037Q08NA	I use an interactive whiteboard.	☐1	☐2	☐3	☐4
TC037Q09NA	Students do their own scientific study and related research.	☐1	☐2	☐3	☐4
TC037Q10NA	I discuss questions that students ask.	☐1	☐2	☐3	☐4
TC037Q11NA	Students carry out practical work.	☐1	☐2	☐3	☐4
TC037Q12NA	Students write up laboratory reports.	☐1	☐2	☐3	☐4
TC037Q13NA	I demonstrate an idea.	☐1	☐2	☐3	☐4
TC037Q14NA	I discuss questions of practical relevance.	☐1	☐2	☐3	☐4
TC037Q15NA	Students read materials from a textbook.	☐1	☐2	☐3	☐4
TC037Q16NA	Students take notes from the board.	☐1	☐2	☐3	☐4
TC037Q17NA	Students discuss materials from a textbook.	☐1	☐2	☐3	☐4
TC037Q18NA	Students watch videos.	☐1	☐2	☐3	☐4
TC037Q19NA	Students use the internet.	☐1	☐2	☐3	☐4
TC037Q20NA	The class corrects homework or a test.	☐1	☐2	☐3	☐4
TC037Q21NA	Students fill out worksheets.	☐1	☐2	☐3	☐4
TC037Q22NA	Students present something to the rest of the class.	☐1	☐2	☐3	☐4

TC033 **To what extent can (or could) you do the following?**
(Please select one response in each row.)

		Not at all	Very little	To some extent	To a large extent
TC033Q04NA	Design experiments and hands-on activities for <inquiry-based learning>	☐1	☐2	☐3	☐4
TC033Q05NA	Assign tailored tasks to the weakest as well as to the best students	☐1	☐2	☐3	☐4
TC033Q06NA	Use a variety of assessment strategies	☐1	☐2	☐3	☐4
TC033Q08NA	Facilitate a discussion among students on how to interpret experimental findings	☐1	☐2	☐3	☐4

TC034	**To what extent can (or could) you do the following?** *(If you need further explanation of the term my "scientific discipline", please use the help button.)* *(Please select one response in each row.)*				
		Not at all	Very little	To some extent	To a large extent
TC034Q01NA	Explain a complex scientific concept to a fellow teacher	☐1	☐2	☐3	☐4
TC034Q02NA	State and defend an informed position on ethical problems relating to <broad science>	☐1	☐2	☐3	☐4
TC034Q04NA	Read state-of-the art papers in my scientific discipline	☐1	☐2	☐3	☐4
TC034Q06NA	Explain the links between biology, physics and chemistry	☐1	☐2	☐3	☐4
Help button	Your <scientific discipline> refers to one specific <broad science> discipline your main <school science> subject belongs to. If you teach the same number of hours for several <school science> subjects, you should choose only one and relate your answer to it.				

PART B GENERAL TEACHER QUESTIONNAIRE

Background information

TC001 TC001Q01NA	**Are you female or male?** *(Please select one response.)*	
	Female	☐1
	Male	☐2

TC002 TC002Q01NA	**How old are you?** *(Please move the slider to the appropriate number of years.)*	
	Years:	
Slider bar: Parking position; range: "20 years or younger"-"70 years or older"; step=1.		

TC004 TC004Q01NA	**What is your employment status as a teacher <u>at this school</u>?** *(Please select one response.)*	
	Permanent employment (an ongoing contract with no fixed end-point before the age of retirement)	☐1
	Fixed-term contract for a period of more than 1 school year	☐2
	Fixed-term contract for a period of 1 school year or less	☐3

TC005	**What is your current employment status as a teacher?** *(Please consider your employment status at this school and for all your teaching employments together.)* *(Please select one response in each row.)*				
		Full-time (more than 90% of full-time hours)	Part-time (71-90% of full-time hours)	Part-time (50-70% of full-time hours)	Part-time (less than 50% of full-time hours)
TC005Q01NA	My employment status at this school	☐1	☐2	☐3	☐4
TC005Q02NA	All my teaching employments together	☐1	☐2	☐3	☐4

TC006 TC006Q01NA	**In how many schools have you worked over the course of your teaching career?** *(Include all schools, even if you worked at several schools at once.)* *(Please move the slider to the appropriate number of schools.)*	
	Schools:	

Slider bar: Parking position; range: “1 school”-“20 schools or more”; step=1

TC007	**How many years of work experience do you have?** *(Please round up to whole years no matter whether you worked part-time or full-time and move the slider to the appropriate number of years. If any option does not apply to you select “0” [zero].)*	
TC007Q01NA	Year(s) working as a teacher at this school	
TC007Q02NA	Year(s) working as a teacher in total	

Slider bar: Parking position; range: “0 years”-“50 years or more”; step=1.
Consistency check/soft reminder if the response to item TC007Q01NA is bigger than to item TC007Q02NA.

Teacher’s initial education and professional development

TC012 TC012Q01NA	**What is the highest level of formal education you have completed?** *(Please select one response.)*	
	<Below ISCED Level 5>	☐ 1
	<ISCED Level 5B>	☐ 2
	<ISCED Level 5A Bachelor degree>	☐ 3
	<ISCED Level 5A Master’s degree>	☐ 4
	<ISCED Level 6>	☐ 5

TC013 TC013Q01NA	**After completing <ISCED level 3 or below>, was your goal to pursue a career in the teaching profession?** *(Please select one response.)*	
	Yes	☐ 1
	No	☐ 2

TC014 TC014Q01NA	**Did you complete a teacher education or training programme?** *(Please select one response.)*	
	Yes	☐ 1
	No	☐ 2

TC015 TC015Q01NA	**How did you receive your teaching qualifications?** *(Please select one response.)*	
	I attended a standard teacher education or training programme at an <educational institute which is eligible to educate or train teachers>.	☐ 1
	I attended an in-service teacher education or training programme.	☐ 2
	I attended a work-based teacher education or training programme.	☐ 3
	I attended training in another pedagogical profession.	☐ 4
	Other	☐ 5

TC018

Were any of the following included in your teacher education or training programme or other professional qualification and do you teach them to the <national modal grade for 15-year-olds> in the current school year?

(Because this is an international survey, we had to categorise many of the actual subjects taught in schools into broad categories. If the exact name of one of your subjects is not listed, please mark the category you think best fits the subject.)

(If you need further explanation for terms used in this question, please use the help button.)
(Please select all that apply.)

		Included in my teacher education or training programme or other professional qualification	I teach it to the <national modal grade for 15-year-olds> in the current school year
TC018Q01N	Reading, writing and literature	☐ 1	☐ 1
TC018Q02N	Mathematics	☐ 1	☐ 1
TC018Q03N	Science	☐ 1	☐ 1
TC018Q04N	Technology	☐ 1	☐ 1
TC018Q05N	Social studies	☐ 1	☐ 1
TC018Q06N	Modern foreign languages	☐ 1	☐ 1
TC018Q07N	Ancient languages (e.g. Latin)	☐ 1	☐ 1
TC018Q08N	Arts	☐ 1	☐ 1
TC018Q09N	Physical education	☐ 1	☐ 1
TC018Q10N	Religion and/or ethics	☐ 1	☐ 1
TC018Q11N	Practical and vocational skills	☐ 1	☐ 1

Help button

Reading, writing and literature: reading and writing (and literature) in the mother tongue, in the language of instruction, or in the tongue of the country (region) as a second language (for non-natives); language studies, public speaking, literature

Mathematics: mathematics, mathematics with statistics, geometry, algebra, etc.

Science: natural sciences, physics, physical science, chemistry, biology, human biology, earth and space sciences, environmental science, agriculture/horticulture/forestry

Technology: orientation in technology, including information technology, computer studies, construction/surveying, engineering, electronics, graphics and design, keyboard skills, word processing, workshop technology/design technology

Social studies: social studies, community studies, contemporary studies, economics, environmental studies, geography, history, humanities, legal studies, studies of the own country, social sciences, ethical thinking, philosophy

Modern foreign languages: languages different from the language of instruction

Ancient languages (e.g. Latin)

Arts: arts, music, visual arts, practical art, drama, performance music, photography, drawing, creative handicraft, creative needlework

Physical education: physical education, gymnastics, dance, health

Religion and/or ethics: religion, history of religions, religion culture, ethics

Practical and vocational skills: vocational skills (preparation for a specific occupation), technics, domestic science, accountancy, business studies, career education, clothing and textiles, driving, home economics, polytechnic courses, secretarial studies, tourism and hospitality, handicraft

Consistency check/soft reminder if any button remains unmarked.

TC020	**During the last <u>12 months</u>, did you participate in any of the following activities?** *(Please select one response in each row.)*		
		Yes	**No**
TC020Q01NA	Qualification programme (e.g. a <degree programme>)	☐1	☐2
TC020Q02NA	Participation in a network of teachers formed specifically for the professional development of teachers	☐1	☐2
TC020Q03NA	Individual or collaborative research on a topic of interest to you professionally	☐1	☐2
TC020Q04NA	Mentoring and/or peer observation and coaching, as part of a formal school arrangement	☐1	☐2
TC020Q05NA	Reading professional literature (e.g. journals, evidence-based papers, thesis papers)	☐1	☐2
TC020Q06NA	Engaging in informal dialogue with your colleagues on how to improve your teaching	☐1	☐2

TC021 TC021Q01NA	**Are you required to take part in professional development activities?** *(Please select one response.)*	
	Yes	☐1
	No	☐2

TC045	**Were any of the topics listed below included in your teacher education or training programme or other professional qualification and your professional development activities?** *(Please select all that apply.)*		
		Included in my teacher education or training programme or other professional qualification	**Included in my professional development activities during the last 12 months**
TC045Q01N	Knowledge and understanding of my subject field(s)	☐1	☐1
TC045Q02N	Pedagogical competencies in teaching my subject field(s)	☐1	☐1
TC045Q03N	Knowledge of the curriculum	☐1	☐1
TC045Q04N	Student assessment practices	☐1	☐1
TC045Q05N	ICT (information and communication technology) skills for teaching	☐1	☐1
TC045Q06N	Student behaviour and classroom management	☐1	☐1
TC045Q07N	School management and administration	☐1	☐1
TC045Q08N	Approaches to individualised learning	☐1	☐1
TC045Q09N	Teaching students with special needs	☐1	☐1
TC045Q10N	Teaching in a multicultural or multilingual setting	☐1	☐1
TC045Q11N	Teaching cross-curricular skills (e.g. problem solving, learning-to-learn)	☐1	☐1
TC045Q12N	Student career guidance and counselling	☐1	☐1
TC045Q13N	Internal evaluation or self-evaluation of schools	☐1	☐1
TC045Q14N	Use of evaluation results	☐1	☐1
TC045Q15N	Teacher-parent cooperation	☐1	☐1

Consistency check/soft reminder if not a single button is marked.

Teacher's school

TC028 **Is your school's capacity to provide instruction hindered by any of the following issues?**
(Please select one response in each row.)

		Not at all	Very little	To some extent	A lot
TC028Q01NA	A lack of teaching staff	☐1	☐2	☐3	☐4
TC028Q02NA	Inadequate or poorly qualified teaching staff	☐1	☐2	☐3	☐4
TC028Q03NA	A lack of assisting staff	☐1	☐2	☐3	☐4
TC028Q04NA	Inadequate or poorly qualified assisting staff	☐1	☐2	☐3	☐4
TC028Q05NA	A lack of educational material (e.g. textbooks, IT equipment, library or laboratory material)	☐1	☐2	☐3	☐4
TC028Q06NA	Inadequate or poor quality educational material (e.g. textbooks, IT equipment, library or laboratory material)	☐1	☐2	☐3	☐4
TC028Q07NA	A lack of physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems)	☐1	☐2	☐3	☐4
TC028Q08NA	Inadequate or poor quality physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems)	☐1	☐2	☐3	☐4

TC060 **To what extent do you disagree or agree with the following statements regarding your school?**
(Please select one response in each row.)

		Strongly disagree	Disagree	Agree	Strongly agree
TC060Q02NA	The principal tries to achieve consensus with all staff when defining priorities and goals in school.	☐1	☐2	☐3	☐4
TC060Q04NA	The principal is aware of my needs.	☐1	☐2	☐3	☐4
TC060Q06NA	The principal inspires new ideas for my professional learning.	☐1	☐2	☐3	☐4
TC060Q07NA	The principal treats teaching staff as professionals.	☐1	☐2	☐3	☐4
TC060Q09NA	The principal ensures our involvement in decision making.	☐1	☐2	☐3	☐4

TC046 **On average, how often do you do the following in this school?**
(Please select one response in each row.)

		Never	Once a year or less	2-4 times a year	5-10 times a year	1-3 times a month	Once a week or more
TC046Q01NA	Teach jointly as a team in the same class	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q02NA	Observe other teachers' classes and provide feedback	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q03NA	Engage in joint activities across different classes and age groups (e.g. projects)	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q04NA	Exchange teaching materials with colleagues	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q05NA	Engage in discussions about the learning development of specific students	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q06NA	Work with other teachers in my school to ensure common standards in evaluations for assessing student progress	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q07NA	Attend team conferences	☐1	☐2	☐3	☐4	☐5	☐6
TC046Q08NA	Take part in collaborative professional learning	☐1	☐2	☐3	☐4	☐5	☐6

TC026	We would like to know how you generally feel about your job. How strongly do you agree or disagree with the following statements? *(Please select one response in each row.)*				
		Strongly disagree	Disagree	Agree	Strongly agree
TC026Q01NA	The advantages of being a teacher clearly outweigh the disadvantages.	☐1	☐2	☐3	☐4
TC026Q02NA	If I could decide again, I would still choose to work as a teacher.	☐1	☐2	☐3	☐4
TC026Q04NA	I regret that I decided to become a teacher.	☐1	☐2	☐3	☐4
TC026Q05NA	I enjoy working at this school.	☐1	☐2	☐3	☐4
TC026Q06NA	I wonder whether it would have been better to choose another profession.	☐1	☐2	☐3	☐4
TC026Q07NA	I would recommend my school as a good place to work.	☐1	☐2	☐3	☐4
TC026Q09NA	I am satisfied with my performance in this school.	☐1	☐2	☐3	☐4
TC026Q10NA	All in all, I am satisfied with my job.	☐1	☐2	☐3	☐4

Teaching practices

TC048	How often do you assign the following activities to your students? *(Please select one response in each row.)*						
		Never or almost never	Once a year or less	2-4 times a year	5-9 times a year	1-3 times a month	Once a week or more
TC048Q01NA	Doing some short task (10 minutes to 2 hours) in teams such as exercises or problems	☐1	☐2	☐3	☐4	☐5	☐6
TC048Q02NA	Conducting a longer project (over several weeks) in teams such as writing a document, inventing something, etc.	☐1	☐2	☐3	☐4	☐5	☐6
TC048Q03NA	Preparing and giving a talk/presentation together	☐1	☐2	☐3	☐4	☐5	☐6

TC051	How often do you use the following appreciations during students´ team collaboration activities? *(Please select one response in each row.)*				
		Never or almost never	Sometimes	Often	Always or almost always
TC051Q01NA	No appreciations	☐1	☐2	☐3	☐4
TC051Q02NA	Individual appreciations for individual performance	☐1	☐2	☐3	☐4
TC051Q03NA	Collective appreciations for a group product	☐1	☐2	☐3	☐4
TC051Q04NA	Collective appreciations for individual contributions	☐1	☐2	☐3	☐4
TC051Q05NA	Individual appreciations for a group product	☐1	☐2	☐3	☐4

TC052	**How often do you use the following types of collaboration during students´ team collaboration activities?** *(Please select one response in each row.)*				
		Never or almost never	Sometimes	Often	Always or almost always
TC052Q01NA	Members of groups work according to specialisation of each member	☐1	☐2	☐3	☐4
TC052Q02NA	Members of groups work on a collective outcome	☐1	☐2	☐3	☐4
TC052Q03NA	Group members receive different information (resource interdependence)	☐1	☐2	☐3	☐4
TC052Q04NA	Group members are assigned different roles (role interdependence)	☐1	☐2	☐3	☐4

TC053	**How often do you use the following grouping practices during students´ team collaboration activities?** *(Please select one response in each row.)*				
		Never or almost never	Sometimes	Often	Always or almost always
TC053Q01NA	Groups with a mix of abilities	☐1	☐2	☐3	☐4
TC053Q02NA	Groups of students with similar abilities	☐1	☐2	☐3	☐4
TC053Q03NA	Groups as the students choose them	☐1	☐2	☐3	☐4

TC054	**How often do you use the following methods of assessing student learning?** *(If you need further explanation of the term “<standardised tests>”, please use the help button.)* *(Please select one response in each row.)*				
		Never or almost never	Some lessons	Many lessons	Every lesson or almost every lesson
TC054Q01NA	I develop and administer my own assessment.	☐1	☐2	☐3	☐4
TC054Q02NA	I administer a <standardised test>.	☐1	☐2	☐3	☐4
TC054Q03NA	I have individual students answer questions in front of the class.	☐1	☐2	☐3	☐4
TC054Q04NA	I provide written feedback on student work in addition to a <mark, i.e. numeric score or letter grade>.	☐1	☐2	☐3	☐4
TC054Q05NA	I let students judge their own progress.	☐1	☐2	☐3	☐4
TC054Q06NA	I observe students when working on particular tasks and provide immediate feedback.	☐1	☐2	☐3	☐4
TC054Q07NA	I collect data from classroom assignments or home work.	☐1	☐2	☐3	☐4
Help button	Here, the term <standardised tests> includes standardised mandatory tests (mandated e.g. by national, state or district authorities) as well as standardised non-mandatory tests (e.g. publicly or commercial available standardised test material). These tests are consistent in design, content, administration and scoring. Results can be compared across students and schools.				

TC055	**To what extent do you use the following approaches to assign final <semester> grades to students in <national modal grade for 15-year-olds>.** *(If you need further explanation of the term "<standardised tests>", please use the help button.) (Please select one response in each row.)*				
		Not at all	Very little	To some extent	To a large extent
TC055Q01NA	I consider students' individual improvement of performance since the beginning of the <semester>.	☐1	☐2	☐3	☐4
TC055Q02NA	I consider students' problem solving ability.	☐1	☐2	☐3	☐4
TC055Q03NA	I consider students' critical thinking ability.	☐1	☐2	☐3	☐4
TC055Q04NA	I consider students' performance in collaborative problem solving activities.	☐1	☐2	☐3	☐4
TC055Q05NA	I recognise students' effort; even if performance does not improve.	☐1	☐2	☐3	☐4
TC055Q06NA	I compare student performance in the current course to that of students from the previous course.	☐1	☐2	☐3	☐4
TC055Q07NA	I compare a student's performance to that of other students in the course.	☐1	☐2	☐3	☐4
TC055Q08NA	I compare students' performance to written <national or regional performance standards>.	☐1	☐2	☐3	☐4
TC055Q11NA	I consider the degree to which the student participates in the class.	☐1	☐2	☐3	☐4
TC055Q13NA	I base grades on <standardised tests> mandated by national, state or district authorities, e.g. <country specific example>.	☐1	☐2	☐3	☐4
TC055Q14NA	I base grades on non-mandatory, publicly or commercially available <standardised tests>, e.g. <country specific example>.	☐1	☐2	☐3	☐4
Help button	<Standardised tests> are consistent in design, content, administration and scoring. Results can be compared across students and schools. This excludes teacher-developed tests!				

Annex B

PISA 2015 EXPERT GROUPS

Annex B lists the members of the expert groups who were involved in developing the PISA 2015 framework for the major domain (science) and the questionnaires. The lists of the experts involved in developing the PISA 2009 framework for reading and the 2012 framework for mathematics and financial literacy can be found in the OECD publications *PISA 2009 Assessment Framework – Key competencies in Reading, Mathematics and Science (2009)* and *PISA 2012 Frameworks – Mathematics, Problem Solving and Financial Literacy (2013),* respectively.

Science expert group (SEG)

Jonathan Osborne (SEG Chair)
Stanford University
United States and United Kingdom

Marcus Hammann
Munster University
Germany

Sarah Howie
University of Pretoria
South Africa

Jody Clarke-Midura
University of Harvard
United States

Robin Millar
University of York
United Kingdom

Andrée Tiberghien
University of Lyon
France

Russell Tytler
Deakin University
Australia

Darren Wong
National Institute of Education
Singapore

Extended Scientific Literacy Expert Group

Rodger Bybee
Biological Sciences Curriculum Study (BSCS)
United States

Jens Dolin
University of Copenhagen
Denmark

Harrie Eijkelhof
Utrecht University
Netherlands

Geneva Haertel
SRI
United States

Michaela Mayer
University of Roma Tre.
Italy

Eric Snow
SRI
United States

Manabu Sumida
Ehime University
Japan

Benny Yung
University of Hong Kong
Hong Kong, China

Questionnaire expert group (QEG)

David Kaplan (QEG chair as of 2014)
University of Wisconsin
United States

Eckhard Klieme (QEG chair until 2013)
DIPF, Frankfurt
Germany

Gregory Elacqua
Diego Portales University
Chile

Marit Kjærnsli
University of Oslo
Norway

Leonidas Kyriakides
University of Cyprus
Cyprus

Henry M. Levin
Columbia University
United States

Naomi Miyake
University of Tokyo
Japan

Jonathan Osborne
Stanford University
United States

Kathleen Scalise
University of Oregon
United States

Fons van de Vijver
Tilburg University
Netherlands

Ludger Wößmann
University of Munich
Germany

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PISA 2015 Assessment and Analytical Framework

SCIENCE, READING, MATHEMATIC, FINANCIAL LITERACY AND COLLABORATIVE PROBLEM SOLVING

Revised edition

“What is important for citizens to know and be able to do?” The OECD Programme for International Student Assessment (PISA) seeks to answer that question through the most comprehensive and rigorous international assessment of student knowledge and skills. The PISA 2015 Assessment and Analytical Framework presents the conceptual foundations of the sixth cycle of the triennial assessment. This revised edition includes the framework for collaborative problem solving, which was evaluated for the first time, in an optional assessment, in PISA 2015. As in previous cycles, the 2015 assessment covers science, reading and mathematics, with the major focus in this cycle on scientific literacy. Financial literacy is an optional assessment, as it was in 2012. A questionnaire about students’ background is distributed to all participating students. Students may also choose to complete additional questionnaires: one about their future studies/career, a second about their familiarity with information and communication technologies. School principals complete a questionnaire about the learning environment in their schools, and parents of students who sit the PISA test can choose to complete a questionnaire about the home environment. Seventy-one countries and economies, including all 35 OECD countries, participated in the PISA 2015 assessment.

Contents

THE OECD PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT (PISA)

PISA does not just ascertain whether students can reproduce knowledge; it also examines how well students can extrapolate from what they have learned and can apply that knowledge in unfamiliar settings, both in and outside of school. This approach reflects the fact that modern economies reward individuals not for what they know, but for what they can do with what they know.

PISA’s unique features include its:

- policy orientation, which connects data on student learning outcomes with data on students’ backgrounds and attitudes towards learning, and on key factors that shape their learning in and outside school, in order to highlight differences in performance patterns and identify the characteristics of schools and education systems that perform well
- innovative concept of “literacy”, which refers to students’ capacity to apply knowledge and skills in key subjects, and to analyse, reason and communicate effectively as they identify, interpret and solve problems in a variety of situations
- relevance to lifelong learning, as PISA asks students to report on their motivation to learn, their beliefs about themselves and their learning strategies
- regularity, which enables countries to monitor their progress in meeting key learning objectives
- breadth of coverage, which, in PISA 2015, encompasses the 35 OECD countries and 36 partner countries and economies.

Consult this publication on line at: ***http://dx.doi.org/10.1787/9789264281820-en***

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