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What the Survey of Adult Skills (PIAAC) Measures

This chapter describes the approach used by the Survey of Adult Skills (PIAAC) and some of the key features of the survey. It then discusses the content, cognitive processes and contexts applicable to the three domains assessed: literacy, numeracy and problem solving in technology-rich environments. Sample items are also provided.



The Survey of Adult Skills (PIAAC) assesses the proficiency of adults in three information-processing skills essential for full participation in the knowledge-based economies and societies of the 21st century: literacy, numeracy and problem solving in technology-rich environments. This chapter describes the constructs measured in the survey and the information sought regarding skills use and the characteristics of respondents. First, a general description of the survey's approach to assessing adult skills is provided.

SOME MAJOR FEATURES OF THE ASSESSMENT

An assessment of key information-processing competencies

The skills assessed in the Survey of Adult Skills are conceived as “key information-processing competencies”.¹ They represent skills essential for accessing, understanding, analysing and using text-based information and, in the case of some mathematical information, information in the form of representations (e.g. pictures, graphs). These texts and representations may exist in the form of printed material or screen-based displays.

They are considered to be “key information-processing skills” in that they are:

- necessary for fully integrating and participating in the labour market, education and training, and social and civic life;
- highly transferable, in that they are relevant to many social contexts and work situations; and
- “learnable” and, therefore, subject to the influence of policy.

At the most fundamental level, literacy and numeracy constitute a foundation for developing higher-order cognitive skills, such as analytic reasoning, and are essential for gaining access to and understanding specific domains of knowledge. In addition, these skills are relevant across the range of life contexts, from education through work to home life and interaction with public authorities. In information-rich societies, in which information in text format (whether print-based or digital) is ubiquitous, a capacity to read and respond to text-based information is essential, whether that means understanding the user information on a packet of medicine, reacting appropriately to a memo from a colleague or superior at work, or enrolling a child at school. Similarly, numeracy skills are essential in most areas of life, from buying and selling goods, to understanding pension entitlements, to planning one's working day.

In addition, the capacity to manage information and solve problems in technology-rich environments – that is, to access, evaluate, analyse and communicate information – is becoming as important as understanding and interpreting text-based information and being able to handle mathematical content. Information and communication technology (ICT) applications have become a feature in most workplaces, in education, and in everyday life.

A use-oriented conception of competency

Literacy, numeracy and problem solving are competencies that are essential for functioning in the modern world, for realising the myriad tasks adults must undertake in the various life contexts. Adults read, deal with situations involving mathematical content and representations, and try to solve problems in order to do things and achieve certain objectives in a range of contexts. Consequently, the focus of the Survey of Adult Skills is less on the mastery of certain content (e.g. vocabulary or arithmetical operations) and a set of cognitive strategies than on the ability to draw on this content and these strategies to successfully perform information-processing tasks in a variety of real-world situations.

Proficiency as a continuum

The competencies assessed in the Survey of Adult Skills are understood as involving a continuum of proficiency. Individuals are considered to be proficient to a greater or a lesser degree in the competency in question as opposed to being either “proficient” or “not proficient”. In other words, there is no threshold that separates those who have the competency in question from those who do not. The measurement scales describe gradations in the complexity of the information-processing tasks in the domains of literacy, numeracy and problem solving in technology-rich environments. In each domain, this complexity is seen as a function of a small number of factors, such as the type of cognitive operations required by the task, the presence of distracting information, and the nature of information and knowledge required to successfully complete a task.

At the lower end of the proficiency scale, individuals have skills that allow them to undertake tasks of limited complexity, such as locating single pieces of information in short texts in the absence of other distracting information, or performing simple mathematical operations involving a single step, such as counting or ordering. At the highest level of proficiency, adults can undertake tasks that involve integrating information across multiple dense texts, reasoning by inference,



working with mathematical arguments and models, and solving complex problems using information technologies that require navigation and the use of multiple tools.

Literacy and numeracy are often described as “basic” skills, in that they provide a “foundation” on which the development of other competencies rests. This description is unfortunate in that it can give the impression that such skills are less complex than certain other “higher-order” skills or that the policy interest in such skills lies in ensuring that the population possesses an acceptable minimum or basic level of proficiency in these skills. It is important to emphasise that the objective of the Survey of Adult Skills is to see how the adult population is distributed over the entire spectrum of proficiency in each of the domains assessed, not to assess whether adults have achieved a basic level of skills.

The importance of contextual information

In addition to estimating the level and distribution of proficiency in the population, the Survey of Adult Skills seeks to provide information that will enable policy makers and others to better understand the relationship between the measured skills and economic and social outcomes, and the factors related to acquiring, maintaining, developing and losing skills. The assessment of literacy, numeracy and problem solving in technology-rich environments is, thus, complemented by information on the use of the measured cognitive skills and certain generic skills (see Chapter 2 for more information). This information includes details about respondents’ literacy and numeracy practices and their use of information and communication technologies (ICT) at work and in other contexts. It also encompasses the extent to which individuals are required to use a range of generic skills in their work, including interpersonal skills, such as collaboration and influencing, learning skills, organising, including both self-organisation and delegating tasks, and physical skills. Respondents also report on how and whether their skills and qualifications match the requirements of their jobs.

Box 1.1 Competencies or skills?

A distinction is sometimes made between “competency” and “skill” in the literature on education and training. Competency is often presented as a capacity that can be applied to a relatively wide range of “real” contexts, while “skill” is considered a constituent unit of competency, that is, a specific capacity, often technical in nature, relevant to a specific context. For example, competency has been defined as “a combination of knowledge, skills and attitudes appropriate to the context” (European Commission, 2007). In the context of the Survey of Adult Skills (PIAAC), however, no attempt is made to differentiate competency and skill, and the terms are used interchangeably in this report. Both terms refer to the ability or capacity of an agent to act appropriately in a given situation. Both involve the application of knowledge (explicit and/or tacit), the use of tools, cognitive and practical strategies and routines, and both imply beliefs, dispositions and values (e.g. attitudes). In addition, neither competency nor skill is conceived as being related to any particular context of performance, nor is a skill regarded as one of the atomic units that combine to form competency. Skills (competencies) can always be broken down into smaller and more specific skills (or competencies) or aggregated into more general skills (or competencies). This question is also discussed in Chapter 7.

AN OVERVIEW OF LITERACY, NUMERACY AND PROBLEM SOLVING IN TECHNOLOGY-RICH ENVIRONMENTS

Groups of experts in their fields developed the frameworks for each of the skills domains assessed in the Survey of Adult Skills. They guided the development and selection of assessment items and the interpretation of results. Their work is presented in *Literacy, Numeracy and Problem Solving in Technology-Rich Environments: Framework for the Survey of Adult Skills* (OECD, 2012).² The frameworks define and describe what is measured. In each case, three main dimensions are identified:

- content – the artefacts, tools, knowledge, representations and cognitive challenges that constitute the corpus adults must respond to or use;
- cognitive strategies – the processes that adults must bring into play to respond to or use given content in an appropriate manner; and
- context – the different situations in which adults have to read, display numerate behaviour, and solve problems.

Table 1.1 provides an overview of each of the three domains, including a definition and the content, cognitive strategies and contexts related to each. These are described in more detail in the remainder of this chapter.

Table 1.1
Summary of assessment domains in the Survey of Adult Skills (PIAAC)

	Literacy	Numeracy	Problem solving in technology-rich environments
Definition	<p>Literacy is defined as the ability to understand, evaluate, use and engage with <i>written texts</i> to participate in society, to achieve one's goals, and to develop one's knowledge and potential.</p> <p>Literacy encompasses a range of skills from the decoding of written words and sentences to the comprehension, interpretation, and evaluation of complex texts. It does not, however, involve the production of text (writing¹).</p> <p>Information on the skills of adults with low levels of proficiency is provided by an assessment of reading components that covers text vocabulary, sentence comprehension and passage fluency.</p>	<p>Numeracy is defined as the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life.</p> <p>To this end, numeracy involves managing a situation or solving a problem in a real context, by responding to mathematical content/information/ideas represented in multiple ways.</p>	<p>Problem solving in technology-rich environments is defined as the ability to use digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks. The assessment focuses on the abilities to solve problems for personal, work and civic purposes by setting up appropriate goals and plans, and accessing and making use of information through computers and computer networks.</p>
Content	<p>Different types of text. Texts are characterised by their medium (print-based or digital) and by their format:</p> <ul style="list-style-type: none"> ▪ Continuous or prose texts ▪ Non-continuous or document texts ▪ Mixed texts ▪ Multiple texts 	<p>Mathematical content, information and ideas:</p> <ul style="list-style-type: none"> ▪ Quantity and number ▪ Dimension and shape ▪ Pattern, relationships and change ▪ Data and chance <p>Representations of mathematical information:</p> <ul style="list-style-type: none"> ▪ Objects and pictures ▪ Numbers and symbols ▪ Visual displays (e.g. diagrams, maps, graphs, tables) ▪ Texts ▪ Technology-based displays 	<p>Technology:</p> <ul style="list-style-type: none"> ▪ Hardware devices ▪ Software applications ▪ Commands and functions ▪ Representations (e.g. text, graphics, video) <p>Tasks:</p> <ul style="list-style-type: none"> ▪ Intrinsic complexity ▪ Explicitness of the problem statement
Cognitive strategies	<ul style="list-style-type: none"> ▪ Access and identify ▪ Integrate and interpret (relating parts of text to one another) ▪ Evaluate and reflect 	<ul style="list-style-type: none"> ▪ Identify, locate or access ▪ Act upon and use (order, count, estimate, compute, measure, model) ▪ Interpret, evaluate and analyse ▪ Communicate 	<ul style="list-style-type: none"> ▪ Set goals and monitor progress ▪ Plan ▪ Acquire and evaluate information ▪ Use information
Contexts	<ul style="list-style-type: none"> ▪ Work-related ▪ Personal ▪ Society and community ▪ Education and training 	<ul style="list-style-type: none"> ▪ Work-related ▪ Personal ▪ Society and community ▪ Education and training 	<ul style="list-style-type: none"> ▪ Work-related ▪ Personal ▪ Society and community

1. The dimension of writing is, however, not part of what the Survey of Adult Skills measures, which is mainly due to the difficulty of assessing writing in a reliable and valid way in an international comparative assessment.



LITERACY

Definition

In the Survey of Adult Skills, literacy is defined as “understanding, evaluating, using and engaging with written texts to participate in society, to achieve one’s goals, and to develop one’s knowledge and potential”.

Key to this definition is the fact that literacy is defined in terms of the *reading of written texts* and does not involve either the comprehension or production of spoken language or the production of text (writing). While literacy is commonly seen as encompassing the ability to write as well as read (UNESCO, 2005), the dimension of writing is not part of the construct measured in the Survey of Adult Skills. This is largely because of the difficulty of assessing writing in a reliable and valid way in an international comparative assessment. In addition, literacy is conceived as a skill that involves constructing meaning, and evaluating and using texts to achieve a range of possible goals in a variety of contexts. In other words, in the Survey of Adult Skills, literacy extends well beyond the skills of decoding or comprehending texts to using them appropriately in context.

Content

The corpus of texts to which adults are required to respond are classified along two principle axes: medium and format. Medium refers to the nature of the support in which a text is instantiated or displayed. Format refers to the organisational and structural features of texts, whether digital or print-based.

In terms of *medium*, texts are classified as either digital or print-based. Digital texts are texts that are stored as digital information (a series of 1s and 0s) and accessed in the form of screen-based displays on devices such as computers and smart phones. Print-based texts are texts printed on paper or other material supports; these include newspapers, books, pamphlets and road signs. Digital texts have a range of features, in addition to being displayed on screens, that distinguishes them from print-based texts. These include hypertext links to other documents, specific navigation features (e.g. scroll bars, use of menus) and interactivity. The Survey of Adult Skills is the first international assessment of adult skills to incorporate the reading of digital texts as part of the construct of (reading) literacy.³

In terms of *format*, texts are categorised in the following way:

- continuous texts, which are made up of sentences organised in paragraphs that incorporate a range of rhetorical stances, such as description, narration, instruction and argumentation;
- non-continuous texts, which are organised in a matrix format or around graphic features. Several different organising structures are identified, including simple and complex lists, graphic documents (e.g. graphs, diagrams), locative documents (e.g. maps) and entry documents (e.g. forms);
- mixed texts, which involve combinations of continuous and non-continuous elements (e.g. a newspaper article or a webpage that includes text and graphics); and
- multiple texts, which consist of juxtaposing or linking independently generated elements, such as an e-mail that contains a record of the separate messages that constitute an exchange over a period of time, or a blog post that contains an initial text and a string of related texts consisting of comments in response to the initial text and comments in response to other comments.

Cognitive strategies

Readers generally use three broad cognitive strategies when responding to written texts:

- access and identify;
- integrate and interpret; and
- evaluate and reflect.

Accessing and identifying involves locating information in a text. At one extreme, this can be a relatively simple operation when the information sought is clearly identified. At the other, it can be a complicated operation requiring inferential reasoning and an understanding of rhetorical strategies.

Integrating and interpreting involves understanding the relationships between different parts of a text to construct meaning and draw inferences from the text as a whole.

Evaluating and reflecting requires the reader to relate the information in the text to other information, knowledge and experiences, for example, to assess the relevance or credibility of a text.

Contexts

Adults read materials in a variety of contexts that affect the types of texts they encounter, the nature of the content, the motivation to read, and the manner in which texts are interpreted. The texts selected for the literacy assessment are related to four broad contexts:

- work-related;
- personal;
- society and community; and
- education and training.

Texts related to *work and occupation* include materials that discuss job search, wages, salaries and other benefits, and the experience of work.

Materials in the area of *personal* include texts concerning the home and family (e.g. interpersonal relationships, personal finances, housing and insurance); health and safety (e.g. drugs and alcohol, disease prevention and treatment, safety and accident prevention, first aid, emergencies, and lifestyle); consumer economics (banking, savings, advertising, prices); and leisure and recreation (travel, recreational activities).

Texts related to *society and community* includes materials that deal with public services, government, community groups and activities, and current events. Materials related to *education and training* cover text which refer to learning opportunities for adults or others.

Distribution of test items by task characteristics

Tables 1.2, 1.3 and 1.4 below show the distribution of the literacy assessment items in the Survey of Adult Skills by task characteristics. The final selection of items was determined taking into account the following factors: the performance of items in the field test, the need to cover the main dimensions of literacy as defined by the assessment frameworks, the need to include sufficient items that had been used in previous surveys to ensure comparability of the results, and the constraints imposed by the assessment design.⁴

Table 1.2
Distribution of literacy items by medium

	Final item set	
	Number	%
Print-based texts	36	62
Digital texts	22	38
Total	58	100

Note: Each category includes continuous, non-continuous and combined texts.

Table 1.3
Distribution of literacy items by context

	Final item set	
	Number	%
Work-related	10	17
Personal	29	50
Society and community	13	23
Education training	6	10
Total	58	100

Table 1.4
Distribution of literacy items by cognitive strategy

	Final item set	
	Number	%
Access and identify	32	55
Integrate and interpret	17	29
Evaluate and reflect	9	16
Total	58	100



Literacy sample items


Two examples of the literacy items used in the Survey of Adult Skills (PIAAC) are presented below. Both use print-based stimuli. The sample problem-solving items presented further below give an idea of the type of “digital” stimulus material used.

The items are presented in the form delivered by the computer-based version of the assessment. To answer the questions, respondents highlighted words and phrases or clicked on the appropriate location on the screen using a mouse.

Sample Item 1: Preschool Rules

“Preschool Rules” represents an easy item and focuses on the following aspects of the literacy construct:

Medium	Print
Context	Personal
Cognitive strategy	Access and identify



Look at the list of preschool rules. Highlight information in the list to answer the question below.

What is the latest time that children should arrive at preschool?

Preschool Rules

Welcome to our Preschool! We are looking forward to a great year of fun, learning and getting to know each other. Please take a moment to review our preschool rules.

- Please have your child here by 9:00 am.
- Bring a small blanket or pillow and/or a small soft toy for naptime.
- Dress your child comfortably and bring a change of clothing.
- Please no jewelry or candy. If your child has a birthday please talk to your child's teacher about a special snack for the children.
- Please bring your child fully dressed, no pajamas.
- Please sign in with your full signature. This is a licensing regulation. Thank you.
- Breakfast will be served until 7:30 am.
- Medications have to be in original, labeled containers and must be signed into the medication sheet located in each classroom.
- If you have any questions, please talk to your classroom teacher or to Ms. Marlene or Ms. Tree.

Sample Items 2 and 3: Physical Exercise Equipment

In many cases, several questions are associated with the same stimulus material. In the case of the stimulus relating to physical exercise equipment, there are two associated questions or test items.

The first item represents a relatively easy item and focuses on the following aspects of the literacy construct:

Medium	Print
Context	Personal
Cognitive strategy	Access and identify

Respondents answer the question by clicking on the cell in the chart that contains information about exercise equipment. Each of the cells and all of the images can be highlighted by clicking on them and multiple cells can be selected.



OECD PIAAC

Physical Exercise Equipment

Look at the exercise equipment chart. Click on the chart to answer the question below.

Which muscles will benefit most if you use the gym bench?

How to choose?

- 1 Decide what effect you want the exercise to have on your body.
- 2 Assess the space you have available at home.
- 3 Choose the equipment that suits your objectives. If necessary ask a specialist for advice.

For example:

OBJECTIVE Burn off calories	STRATEGY Cardiovascular exercises	EQUIPMENT Rowing machine, Bicycle, Skimachine, Treadmill, Stairs, ...
Strengthen your muscles	Endurance exercises	Bench for Press-ups, Weights and Dumbbells, Elastic Tubes, ...

Effects on...	Cardio-Training					Muscle Building							
	Exercise bicycle	Rowing machine	Stepper	Tread-mill	Air trainer	Dumb-bells, weights	Elastic	Gym bench	Muscle-building bench	Multi-trainer	AB trimmer	AB shaper	AB roller
Arm strength	Ineff-ective	Good	Average	Ineff-ective	Good	Very good	Very good	Good	Good	Good	Very good	Good	Good
Leg strength	Good	Very good	Average	Very good	Good	Ineff-ective	Good	Average	Good	Good	Ineff-ective	Good	Good
Abdominal muscles	Average	Very good	Good	Good	Average	Ineff-ective	Good	Very good	Good	Average	Very good	Very good	Very good
Overall muscle building	Ineff-ective	Very good	Ineff-ective	Average	Ineff-ective	Average	Good	Good	Good	Average	Good	Good	Good
Heart/arteries	Very good	Good	Very good	Very good	Good	Ineff-ective	Average	Average	Average	Good	Average	Average	Average
Flexibility	Ineff-ective	Good	Ineff-ective	Ineff-ective	Average	Average	Average	Good	Ineff-ective	Ineff-ective	Average	Good	Good
Joints	Good	Very good	Good	Good	Good	Good	Average	Average	Good	Good	Average	Average	Average
Slimming	Good	Average	Very good	Good	Good	Ineff-ective	Average	Good	Average	Average	Good	Good	Good
Dangers	None	Back	None	Legs									

It is best to learn to use these types of apparatus properly before you make a major effort

The second item represents a relatively easy item and focuses on the following aspects of the literacy construct:

Medium	Print
Context	Personal
Cognitive strategy	Access and identify

OECD PIAAC

Physical Exercise Equipment

Look at the exercise equipment chart. Click on the chart to answer the question below.

Which piece of equipment listed received the largest number of "Ineffective" ratings?

How to choose?

- 1 Decide what effect you want the exercise to have on your body.
- 2 Assess the space you have available at home.
- 3 Choose the equipment that suits your objectives. If necessary ask a specialist for advice.

For example:

OBJECTIVE Burn off calories	STRATEGY Cardiovascular exercises	EQUIPMENT Rowing machine, Bicycle, Skimachine, Treadmill, Stairs, ...
Strengthen your muscles	Endurance exercises	Bench for Press-ups, Weights and Dumbbells, Elastic Tubes, ...

Effects on...	Cardio-Training					Muscle Building							
	Exercise bicycle	Rowing machine	Stepper	Tread-mill	Air trainer	Dumb-bells, weights	Elastic	Gym bench	Muscle-building bench	Multi-trainer	AB trimmer	AB shaper	AB roller
Arm strength	Ineff-ective	Good	Average	Ineff-ective	Good	Very good	Very good	Good	Good	Good	Very good	Good	Good
Leg strength	Good	Very good	Average	Very good	Good	Ineff-ective	Good	Average	Good	Good	Ineff-ective	Good	Good
Abdominal muscles	Average	Very good	Good	Good	Average	Ineff-ective	Good	Very good	Good	Average	Very good	Very good	Very good
Overall muscle building	Ineff-ective	Very good	Ineff-ective	Average	Ineff-ective	Average	Good	Good	Good	Average	Good	Good	Good
Heart/arteries	Very good	Good	Very good	Very good	Good	Ineff-ective	Average	Average	Average	Good	Average	Average	Average
Flexibility	Ineff-ective	Good	Ineff-ective	Ineff-ective	Average	Average	Average	Good	Ineff-ective	Ineff-ective	Average	Good	Good
Joints	Good	Very good	Good	Good	Good	Good	Average	Average	Good	Good	Average	Average	Average
Slimming	Good	Average	Very good	Good	Good	Ineff-ective	Average	Good	Average	Average	Good	Good	Good
Dangers	None	Back	None	Legs									

It is best to learn to use these types of apparatus properly before you make a major effort



Reading components

To provide more detailed information about adults with poor literacy skills, the survey's literacy assessment is complemented by a test of "reading components" skills. Reading components are the basic set of decoding skills that are essential for extracting meaning from written texts: knowledge of vocabulary (word recognition), the ability to process meaning at the level of the sentence, and fluency in reading passages of text. Skilled readers are able to undertake these types of operations automatically. To assess this skill, the time taken by respondents to complete the tasks was recorded.

Examples of reading component items

Print vocabulary

Items testing print vocabulary consist of a picture of an object and four printed words, one of which refers to the pictured object. Respondents are asked to circle the word that matches the picture.



ear

egg

lip

jar

Sentence processing

The sentence-processing items require the respondent to assess whether a sentence makes sense in terms of the properties of the real world or the internal logic of the sentence. The respondent reads the sentence and circles YES if the sentence makes sense or NO if the sentence does not make sense.

Three girls ate the song.	YES	NO
The man drove the green car.	YES	NO
The lightest balloon floated in the bright sky.	YES	NO
A comfortable pillow is soft and rocky.	YES	NO
A person who is twenty years old is older than a person who is thirty years old.	YES	NO

Passage comprehension

In items assessing passage comprehension, respondents are asked to read a passage in which they are required, at certain points, to select the word from the two alternatives provided that makes the most sense.

To the editor: Yesterday, it was announced that the cost of riding the bus will increase. The price will go up by twenty percent starting next wife / month. As someone who rides the bus every day, I am upset by this foot / increase. I understand that the cost of gasoline / student has risen. I also understand that riders have to pay a fair price / snake for bus service. I am willing to pay a little more because I rely on the bus to get to object / work. But an increase / uncle of twenty percent is too much.

This increase is especially difficult to accept when you see the city's plans to build a new sports stadium. The government will spend millions on this project even though we already have a science / stadium. If we delay the stadium, some of that money can be used to offset the increase in bus fares / views. Then, in a few years, we can decide if we really do need a new sports cloth / arena. Please let the city council know you care about this issue by attending the next public meeting / frames.



NUMERACY

Definition

The Survey of Adult Skills defines numeracy as “the ability to access, use, interpret and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life” (OECD, 2012). Numeracy is further defined in terms of the concept of “numerate behaviour” that involves managing a situation or solving a problem in a real context by responding to mathematical information and content represented in various ways.

It is recognised that literacy skills such as reading and writing enable numerate behaviour, and that when mathematical representations involve text, performance on numeracy tasks is, in part, dependent on the ability to read and understand text. However, numeracy in the Survey of Adult Skills involves more than applying arithmetical skills to information embedded in text. In particular, numeracy relates to a wide range of skills and knowledge, not just arithmetic knowledge and computation, a range of responses that may involve more than numbers, and responses to a range of representations, not just numbers in texts.

Content

The survey covers four areas of mathematical content, information and ideas:

- quantity and number;
- dimension and shape;
- pattern, relationships and change; and
- data and chance.

Quantity encompasses attributes such as the number of features or items, prices, size (e.g. length, area and volume), temperature, humidity, atmospheric pressure, populations and growth rates, revenues and profit, etc. *Number* is fundamental to quantification. Numbers (whether whole numbers or fractions, decimals or percentages) serve as counters or estimators, indicate parts or comparisons. Positive and negative numbers can also serve as directional indicators. In calculations, operations (i.e. the four main operations of $+$, $-$, \times , \div and others, such as squaring) are performed on quantities and numbers.

Dimension covers the description of “things” in space, such as projections, lengths, perimeters, areas, planes, surfaces, location, etc. *Shape* involves a category describing real images and entities that can be visualised in two or three dimensions (e.g. houses and buildings, designs in art and craft, safety signs, packaging, snowflakes, knots, crystals, shadows and plants).

Pattern covers regularities encountered in the world, such as those in musical forms, nature, traffic, etc. *Relationships* and *change* relate to the mathematics of how things in the world are associated with one another or develop over time.

Data and chance encompass two separate but related topics. *Data* covers the “big ideas” related to variability, sampling, error, prediction and statistical topics, such as data collection, data displays and graphs. *Chance* covers the “big ideas” related to probability and relevant statistical methods.

Representations of mathematical information

In the Survey of Adult Skills, mathematical information may be represented in the form of:

- objects and pictures;
- numbers and symbols;
- visual displays; texts; and
- technology-based displays.

Objects (physical entities) can be counted and measured. *Pictures* (e.g. photographs, paintings, videos) also represent mathematical information such as number, size, volume or location. *Numbers and symbols* include numerals, letters, and operation or relationship signs and formulae. *Visual displays* cover graphic presentations of mathematical information, such as diagrams or charts, graphs and tables (used to display aggregate statistical or quantitative information through objects, counting data, etc.) or maps (e.g. of a city or a project plan). Two different kinds of *text* may be encountered in



numeracy tasks. The first involves representing mathematical information in textual form, i.e. as words or phrases that carry mathematical meaning. The second involves expressing mathematical information in mathematical notations or symbols (e.g. numbers, plus or minus signs, symbols for units of measure, etc.) that are surrounded by text that provides additional information and context.

Cognitive strategies

Four processes define the dimension of cognitive strategies:

- identify, locate, or access;
- act upon or use;
- interpret, evaluate/analyse; and
- communicate.

In virtually all situations, people have to *identify, locate or access* some mathematical information relevant to their purpose or goal. In isolation, this response type often requires a low level of mathematical understanding or the application of simple arithmetic skills. However, this response type is usually combined with the other types of responses listed below.

Acting upon or using involves the use of known mathematical procedures and rules, such as counting and making calculations. It may also call for ordering or sorting, estimating or using various measuring devices, or for using (or developing) a formula that serves as a model of a situation or a process.

Interpretation involves evaluating the meaning and implications of mathematical or statistical information (e.g. a graph showing variation in an exchange rate) and developing an opinion about the information. *Evaluation/analysis* is in part an extension of interpretation. It involves analysing a problem, evaluating the quality of the solution against some criteria or contextual demands and, if necessary, reviewing the interpretation, analysis and evaluation stages.

While defined as a cognitive process forming part of this dimension of the numeracy framework, the ability to *communicate* numerical and mathematical content is not assessed in the Survey of Adult Skills.

Contexts

The items selected for the numeracy assessment are related to four contexts:

- work-related;
- personal;
- society and community; and
- education and training.

Representative tasks related to *work situations* include: completing purchase orders; totalling receipts; calculating change; managing schedules, budgets and project resources; using spreadsheets; organising and packing goods of different shapes; completing and interpreting control charts; making and recording measurements; reading blueprints; tracking expenditures; predicting costs; and applying formulas.

Representative tasks related to the context of *personal life* include: handling money and budgets; shopping and managing personal time; planning travel; playing games of chance; understanding sports scoring and statistics; reading maps; and using measurements in home situations, such as cooking, doing home repairs or pursuing hobbies.

Adults need to have an awareness of what is occurring in the *society, the economy and the environment* (e.g. trends in crime, health, wages, pollution), and may have to take part in social events or community action. This requires a capacity to read and interpret quantitative information presented in the media, including statistical messages and graphs. Adults also have to manage a variety of situations, such as raising funds for a football club or interpreting the results of a study on a medical condition.

Competency in numeracy may enable a person to participate in *education and training*, whether for academic purposes or as part of vocational training. In either case, it is important to know some of the more formal aspects of mathematics that involve symbols, rules and formulae and to understand some of the conventions used to apply mathematical rules and principles.

Distribution of test items by task characteristics

Tables 1.5, 1.6 and 1.7 below show the distribution of the numeracy assessment items included in the Survey of Adult Skills by task characteristics. As in the case of literacy, the final selection of items reflected the performance of items in the field test, the need to cover the main dimensions of literacy as defined by the assessment frameworks, the need to include sufficient items that had been used in previous surveys to ensure comparability of the results, and the constraints imposed by the assessment design.

Table 1.5
Distribution of numeracy items by response type

	Final item set	
	Number	%
Identify, locate or access	3	5
Act upon, use	34	61
Interpret, evaluate/analyse	19	34
Total	56	100

Table 1.6
Distribution of numeracy items by context

	Final item set	
	Number	%
Work-related	13	23
Personal	25	45
Society and community	14	25
Education and training	4	7
Total	56	100

Table 1.7
Distribution of numeracy items by mathematical content

	Final item set	
	Number	%
Data and chance	12	21
Dimension and shape	16	29
Pattern, relationships and change	15	27
Quantity and number	13	23
Total	56	100

Numeracy sample items

Sample Item 1: Births in the United States

The items are presented in the form delivered by the computer-based version of the assessment. To answer the questions, respondents clicked in the appropriate box or typed figures in the spaces provided.

This item (of medium difficulty) focuses on the following aspects of the numeracy construct:

Content	<i>Data and chance</i>
Process	<i>Interpret, evaluate</i>
Context	<i>Society and community</i>

Respondents were asked to respond by clicking on one or more of the time periods provided in the left pane on the screen.



OECD PIAAC

Look at the graph about the number of births. Click to answer the question below.

During which period(s) was there a decline in the number of births? Click all that apply.

- 1957 - 1967
- 1967 - 1977
- 1977 - 1987
- 1987 - 1997
- 1997 - 2007

The following graph shows the number of births in the United States from 1957 to 2007. Data are presented every 10 years.

Year	Number of Births
1957	4,300,000
1967	3,520,959
1977	3,326,632
1987	3,809,394
1997	3,880,894
2007	4,315,000

Sample Item 2: Thermometer

This item (of low difficulty) focuses on the following aspects of the numeracy construct:

Content	Dimension and shape
Process	Act upon, use (measure)
Context	Personal or work-related

Respondents were asked to type in a numerical response based on the graphic provided.

OECD PIAAC

Look at the thermometer. Using the number keys, type your answer to the question below.


If the temperature shown decreases by 30 degrees Celsius, what would the temperature be in degrees Celsius (°C)?

 °C

Sample Item 3: Wind Power Stations

This sample item (of medium difficulty) focuses on the following aspects of the numeracy construct:

Content	Quantity and number
Process	Act upon, use (compute)
Context	Society and community




Wind Power Stations

Read the article about wind power stations. Using the number keys, type your answer to the question below.

How many wind power stations would be needed to replace the power generated by the nuclear reactor?

In 2005, the Swedish government closed the last nuclear reactor at the Barsebäck power plant. The reactor had been generating an average energy output of 3,572 GWh of electrical energy per year.



Work continues in Sweden on installing large offshore wind farms using wind power stations. Each wind power station produces about 6,000 MWh of electrical energy per year.

For your information:
Electrical energy is measured in Watt hours (Wh)

1 kWh	= 1 kilo Wh	=	1,000 Wh
1 MWh	= 1 Mega Wh	=	1,000,000 Wh
1 GWh	= 1 Giga Wh	=	1,000,000,000 Wh

PROBLEM SOLVING IN TECHNOLOGY-RICH ENVIRONMENTS

Definition

In the Survey of Adult Skills, problem solving in technology-rich environments is defined as “using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks”. The first cycle of the Survey of Adult Skills focuses on “the abilities to solve problems for personal, work and civic purposes by setting up appropriate goals and plans, and accessing and making use of information through computers and computer networks” (OECD, 2012).

The problem solving in technology-rich environments domain covers the specific types of problems people deal with when using ICT. These problems share the following characteristics:

- The problem is primarily a consequence of the availability of new technologies.
- The solution to the problem requires the use of computer-based artefacts (applications, representational formats, computational procedures).
- The problems are related to technology-rich environments themselves (e.g. how to operate a computer, how to fix a settings problem, how to use an Internet browser).

Problem solving in technology-rich environments is a domain of competency that represents the intersection of what are sometimes described as “computer literacy” skills (i.e. the capacity to use ICT tools and applications) and the cognitive skills required to solve problems. Some basic knowledge regarding the use of ICT input devices (e.g. use of a keyboard and mouse and screen displays), file management tools, applications (word processing, e-mail), and graphic interfaces is essential for performing assessment tasks. However, the objective is not to test the use of ICT tools and applications in isolation, but rather to assess the capacity of adults to use these tools to access, process, evaluate and analyse information effectively.



Content

The content of the assessment encompasses two areas: technology and tasks.

Technology refers to the devices, applications and functionalities through which problem solving is conducted. It encompasses digital devices such as computers, mobile phones, GPS devices, software applications and the commands, functions and representations of information on which these applications depend. In the first cycle of the survey, only laptop computers with a limited number of simulated software applications – including e-mail, word processing, spreadsheets and websites – were used. For operational reasons, sound, animations and videos were not used.

Tasks are the circumstances that trigger a person's awareness and understanding of the problem and determine the actions needed to be taken in order to solve the problem. Ordinarily, a wide range of conditions can initiate problem solving. Tasks are defined in terms of intrinsic complexity and the explicitness of the problem statement. The *intrinsic complexity* of a problem is determined by:

- the minimum number of steps required to solve the problem;
- the number of options or alternatives at various stages in the solution path;
- the diversity of operators required to be used, and the complexity of computation/transformation;
- the likelihood of impasses or unexpected outcomes;
- the number of requirements that have to be satisfied to arrive at a solution; and
- the amount of transformation required to communicate a solution.

The *explicitness of the problem statement* relates to the extent to which the problem is ill-defined (the task is implicit and its components are largely unspecified) or well-defined (the task is explicit and its components are described in detail).

Cognitive strategies

The process aspect of the assessment relates to the mental structures and processes involved when a person solves a problem. These include setting goals and monitoring progress; planning; locating, selecting and evaluating information; and organising and transforming information.

Setting goals and monitoring progress involves identifying objectives in the context of the constraints (explicit and implicit) of a situation; establishing and applying criteria for respecting constraints and arriving at a solution; monitoring progress; and detecting and interpreting unexpected events, impasses and breakdowns as one proceeds along the path to a solution.

Planning and self-organisation covers the processes of setting up adequate plans, procedures and strategies (operators) and selecting appropriate devices, tools or categories of information.

Acquiring and evaluating information involves orienting and focusing attention; selecting information; assessing the reliability, relevance, adequacy and comprehensibility of information; and reasoning about sources and contents.

Using information involves organising information; integrating information drawn from different and possibly inconsistent texts and from different formats; making informed decisions; transforming information through rewriting, from text to table, from table to graph, etc.; and communicating with relevant parties.

Contexts

The contexts are those of personal life, work-related and society and community.

Distribution of test items by task characteristics

Tables 1.8 through 1.13 show the distribution of the problem-solving assessment items included in the Survey of Adult Skills by task characteristics.

In total 16 items were administered in the assessment of problem solving in technology environments. Items consisted of scenarios that involved a number of sub-tasks such as searching through simulated websites for relevant information or transferring information from one application to another. The time taken to complete the problem-solving tasks was considerably longer than that in either literacy or numeracy.



Table 1.8
Distribution of problem-solving tasks by cognitive dimensions

Dimension	Number*
Setting goals and monitoring progress	4
Planning	7
Acquiring and evaluating information	8
Using information	6

* Does not add up to 16 as some tasks are coded to more than one dimension.

Table 1.9
Distribution of problem-solving tasks by technology dimensions

Dimension	Number*
Web	7
Spreadsheet	4
E-mail	9

* Does not add up to 16 as some tasks are coded to more than one dimension.

Table 1.10
Distribution of problem-solving tasks by context

Dimension	Number
Personal	8
Work-related	4
Society and community	2

Table 1.11
Distribution of problem-solving tasks by intrinsic complexity (number of steps)

Dimension	Number
Single step	8
Multiple steps	6

Table 1.12
Distribution of problem-solving tasks by intrinsic complexity (number of constraints)

Dimension	Number
Single constraint	7
Multiple constraints	7

Table 1.13
Distribution of problem-solving tasks by explicitness of problem statement

Dimension	Number
Ill-defined problem statement	7
Well-defined problem statement	7

Problem-solving sample item

An example of a problem-solving item is provided below. This item involves a scenario in which the respondent assumes the role of a job-seeker. Respondents access and evaluate information relating to job search in a simulated web environment. This environment includes tools and functionalities similar to those found in real-life applications. Users are able to:

- click on links on both the results page and associated web pages;
- navigate, using the back and forward arrows or the Home icon; and
- bookmark web pages and view or change those bookmarks.

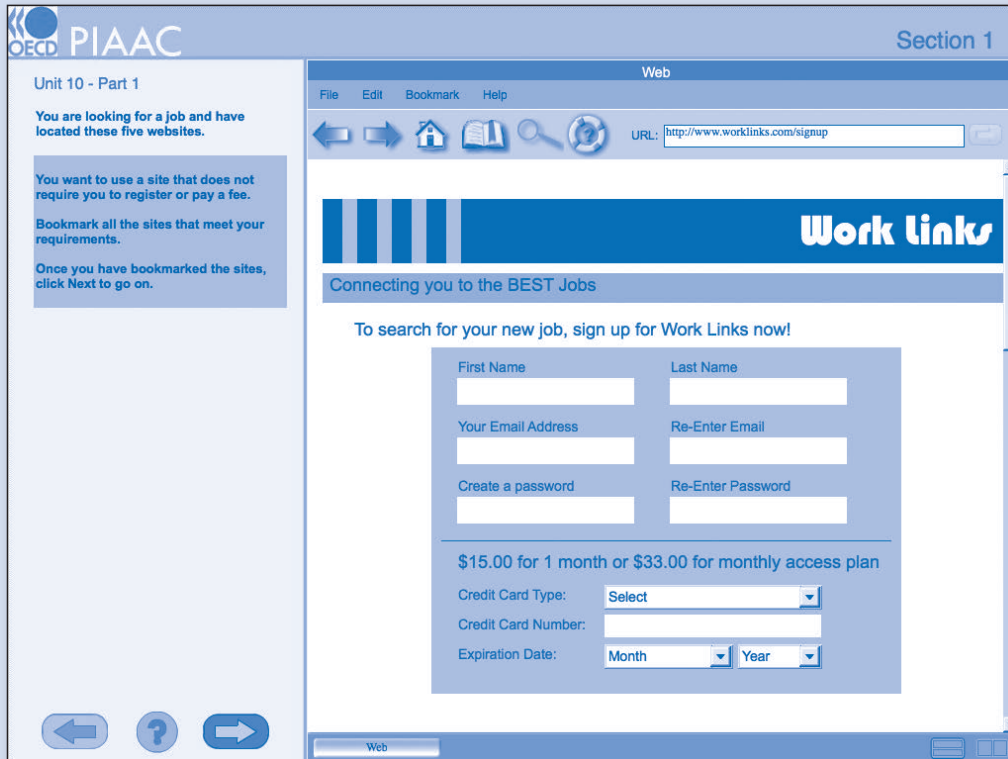
The screenshot shows a simulated web browser window titled "Web" with a menu bar (File, Edit, Bookmark, Help) and a toolbar with navigation icons. The address bar shows the URL "www.websearch.com/jobsearch". The main content area displays search results for "Job search". On the left side of the browser window, there is a sidebar with the OECD PIAAC logo and the text "Unit 10 - Part 1". Below this, it says "You are looking for a job and have located these five websites." and "You want to use a site that does not require you to register or pay a fee. Bookmark all the sites that meet your requirements. Once you have bookmarked the sites, click Next to go on." The search results list five job search websites:

- [Find Your Job - JobSearch.com](#)
The best job search site on the web. Check with us first!
www.jobsearch.com
- [Work Links](#)
We connect you with the best jobs on the web.
www.worklinks.com
- [Looking for a job?](#)
Start your job search here.
www.careerstarters.com
- [Connections.com](#)
We provide access to the best jobs
www.connections.com
- [The best jobs online](#)
If you are looking for the perfect job, start right here.
www.greatjobs.com

The first stimulus accessed by respondents is the results page of the search-engine application, which lists five employment agency websites. To complete the task successfully, respondents have to search through the pages of the listed websites to identify whether registration or the payment of a fee is required in order to gain further information about available jobs. Respondents can click on the links on the search page to be directed to the websites identified. For example, by clicking on the "Work Links" link, the respondent is directed to the home page of "Work Links".

The screenshot shows the "Work Links" website. The browser window title is "Web" and the address bar shows the URL "http://www.worklinks.com". The website has a blue header with the text "Work links" and "Connecting you to the BEST Jobs". Below the header, there is a large image of a diverse group of people smiling, with a "Learn More" button overlaid on the image. Below the image, the text reads "Thousands of new jobs in the last 7 days" and "Search job sites, newspapers, associations and company career pages." On the left side of the browser window, the same sidebar from the previous screenshot is visible, with the text "Unit 10 - Part 1" and instructions for the task.

In order to discover whether access to the information on available jobs requires registration with the organisation or payment of a fee, the respondent must click the “Learn More” button which opens the following page. The respondent must then return to the search results page to continue evaluating the sites in terms of the specified criteria, using the back arrows without bookmarking the page (correct answer) or having bookmarked the page (incorrect answer).



Notes

1. The concept of “key competencies” is discussed in greater detail in Chapter 7.
2. For the complete framework documents, see PIAAC Literacy Expert Group (2009), PIAAC Numeracy Expert Group (2009), PIAAC Expert Group in Problem Solving in Technology-Rich Environments (2009), and Sabatini and Bruce (2009).
3. The PISA 2009 assessment included a test of digital reading. This was implemented in 19 countries (OECD, 2011).
4. In particular, the survey was designed to be “adaptive” in that respondents were directed to different blocks of items based on their estimated proficiency. This is explained in more detail in Chapter 3.

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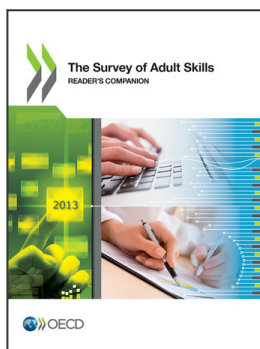
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