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Measurement Strategy for SDG Global Indicator 4.4.2 using International Largescale Assessments

MEASUREMENT STRATEGY FOR SDG GLOBAL INDICATOR 4.4.2 USING INTERNATIONAL LARGESCALE ASSESSMENTS[1]

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Abstract

This document aims to describe and implement a measurement strategy for SDG Global Indicator 4.4.2 using International Large-Scale Assessments (ILSAs) in Education. To do that, this document is divided into three main sections. In the first one, we identify a global content framework for the indicator based on existing mapping exercises. The second section evaluates the extent to which the concepts contained in the content framework can be measured with the instruments and procedures of existing ILSAs. In the third section, the document presents a proposal to define proficiency levels for the indicator together with a set of tables showing the average percentage of students who reach the SDG indicator 4.4.2 in each of the countries for which there is available data. Finally, we conclude with an overview of the four sections described above and their limitations.

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Introduction

The Sustainable Development Goals (SDGs) are the blueprint to achieve a better and more sustainable future for all. They address the most important global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The agenda contains 17 goals including a global education goal (SDG4). SDG4 establishes that by 2030 we have to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". SDG4 contains 10 specific targets. One of these targets, 4.4 (skills for work), sets the goal to "substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship" (UNESCO, 2020, p. 247) by 2030. Target 4.4 has one global and five thematic indicators.

Global indicator

4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship

Thematic indicators

- 4.4.1 Proportion of youth/adults with information and communications technology (ICT) skills, by type of skill.
- 4.4.2 Percentage of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills
- 4.4.3 Youth/adult educational attainment rates by age group, economic activity status, levels of education and programme orientation

In this document, we focus on the second thematic indicator (4.4.2) which refers to learning outcomes that are achieved as a result of the development of digital literacy skills in the contexts described in the global indicator. The main objective of this document is to describe and implement a measurement strategy for this thematic indicator using data from International Large-Scale Assessments (ILSAs) in education.

Apart from this introduction, this document is divided into four sections. The first section is dedicated to identifying a global content framework for indicator 4.4.2 based on a mapping exercise of existing International Large-Scale Assessments. In the second section, we evaluate the extent to which the different concepts included in the global content framework can be measured with the instruments and procedures of existing International Large-Scale Assessments (ILSAs). The third section describes the methods we used to produce scores and thresholds to

measure and monitor the progress towards SDG 4.4.2. Finally, the last section is dedicated to the discussion and conclusions.

A. Global content framework for SDG thematic indicator 4.4.2

A.1 Concepts

As mentioned above, indicator 4.4.2 refers to the proportion of youth/adults who have achieved at least a minimum level of proficiency in **digital literacy skills (DLS).** In this section, we establish an operational definition of DLS that will constitute the base of a global content framework for the construction of specific indicators.

There is a clear consensus on the importance of digital literacy. This is evidenced by the many national and global initiatives to promote the development of citizens' digital literacy. However, there is no definite agreement on the definition of this concept. While some frameworks understand it as a new form of literacy, some others consider it to be a combination of pre-existent forms of literacy (e.g. traditional literacy and computer literacy) (Ala-Mutka, 2011).

Reaching consensus on a definition of digital literacy is not an easy task. Digital literacy has a distinct history within UNESCO and beyond; and it is considered as an umbrella concept that encompasses a broad range of knowledge, skills, attitudes, values, identities and behaviours. To establish a unique operational definition, we build on the Digital Literacy Global Framework (Law et al., 2018) and the Recommendations on Assessment Tools for Monitoring Digital Literacy (Laanpere, 2019). We used these two reports to establish both an operational definition of DLS and a global content framework for indicator 4.4.2. In reviewing a wide array of related frameworks, Law and colleagues (2018, p. 6) found that the following notions were recurrent: access, manage, understand, integrate, communicate, evaluate and create. Hence, they propose (and we adopt) the following definition for digital literacy:

Digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship. It includes competences that are variously referred to as computer literacy, ICT literacy, information literacy and media literacy.

A.2 Operationalization

As mentioned before, we have adopted the Digital Literacy Global Framework developed by Law and colleagues (2018) for this project. This global content framework (see Table 1) is based on the extensive work already conducted by UNESCO to define and operationalise Digital Literacy (DL); and adopts the definitions

and operationalizations proposed in the European Commission's Digital Competence Framework for Citizens (Carretero et al., 2017).

Table 1. Global Content Framework for SDG indicators 4.4.2

Competence areas and competences	Description
0. Devices and software operations**	To identify and use hardware tools and technologies. To identify data, information and digital content needed to operate software tools and technologies.
0.1 Physical operations of digital devices**	To identify and use the functions and features of the hardware tools and technologies.
0.2 Software operations in digital devices**	To know and understand the data, information and/or digital content that are needed to operate software tools and technologies.
1. Information and data literacy	To articulate information needs, to locate and retrieve digital data, information and content. To judge the relevance of the source and its content. To store, manage and organise digital data, information and content.
1.1 Browsing, searching and filtering data, information and digital content	To articulate information needs, to search for data, information and content in digital environments, to access them and to navigate between them. To create and update personal search strategies.
1.2 Evaluating data, information and digital content	To analyse, compare and critically evaluate the credibility and reliability of sources of data, information and digital content. To analyse, interpret and critically evaluate the data, information and digital content.
1.3 Managing data, information and digital content	To organise, store and retrieve data, information and content in digital environments. To organise and process them in a structured environment.
2. Communication and collaboration	To interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity. To participate in society through public and private digital services and participatory citizenship. To manage one's digital identity and reputation.
2.1 Interacting through	To interact through a variety of digital technologies and to understand appropriate digital communication

Competence areas and competences	Description
digital technologies	means for a given context.
2.2 Sharing through digital technologies	To share data, information and digital content with others through appropriate digital technologies. To act as an intermediary, to know about referencing and attribution practices.
2.3 Engaging in citizenship through digital technologies	To participate in society through the use of public and private digital services. To seek opportunities for self-empowerment and for participatory citizenship through appropriate digital technologies.
2.4 Collaborating through digital technologies	To use digital tools and technologies for collaborative processes and for co-construction and co-creation of resources and knowledge.
2.5 Netiquette	To be aware of behavioural norms and know-how while using digital technologies and interacting in digital environments. To adapt communication strategies to the specific audience and to be aware of cultural and generational diversity in digital environments.
2.6 Managing digital identity	To create and manage one or multiple digital identities, to be able to protect one's own reputation, to deal with the data that one produces through several digital tools, environments and services.
3. Digital content creation	To create and edit digital content. To improve and integrate information and content into an existing body of knowledge while understanding how copyright and licenses are to be applied. To know how to give understandable instructions for a computer system.
3.1 Developing digital content	To create and edit digital content in different formats, to express oneself through digital means.
3.2 Integrating and re-elaborating digital content	To modify, refine, improve and integrate information and content into an existing body of knowledge to create new, original and relevant content and knowledge.
3.3 Copyright and licences	To understand how copyright and licences apply to data, information and digital content.
3.4 Programming	To plan and develop a sequence of understandable instructions for a computing system to solve a given problem or perform a specific task.

Competence areas and competences	Description
4. Safety	To protect devices, content, personal data and privacy in digital environments. To protect physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.
4.1 Protecting devices	To protect devices and digital content, and to understand risks and threats in digital environments. To know about safety and security measures and to have due regard to reliability and privacy.
4.2 Protecting personal data and privacy	To protect personal data and privacy in digital environments. To understand how to use and share personally identifiable information while being able to protect oneself and others from damages. To understand that digital services use a “Privacy policy” to inform how personal data is used.
4.3 Protecting health and well-being	To be able to avoid health risks and threats to physical and psychological well-being while using digital technologies. To be able to protect oneself and others from possible dangers in digital environments (e.g. cyberbullying). To be aware of digital technologies for social well-being and social inclusion.
4.4 Protecting the environment	To be aware of the environmental impact of digital technologies and their use.
5. Problem-solving	To identify needs and problems and to resolve conceptual problems and problem situations in digital environments. To use digital tools to innovate processes and products. To keep up to date with the digital evolution.
5.1 Solving technical problems	To identify technical problems when operating devices and using digital environments, and to solve them (from trouble-shooting to solving more complex problems).
5.2 Identifying needs and technological responses	To assess needs and to identify, evaluate, select and use digital tools and possible technological responses to solve them. To adjust and customise digital environments to personal needs (e.g. accessibility).
5.3 Creatively using digital technologies	To use digital tools and technologies to create knowledge and to innovate processes and products. To engage individually and collectively in cognitive processing to understand and resolve conceptual problems and problem situations in digital environments.

Competence areas and competences	Description
5.4 Identifying digital competence gaps	To understand where one's own digital competence needs to be improved or updated. To be able to support others with their digital competence development. To seek opportunities for self-development and to keep up-to-date with the digital evolution.
5.5 Computational thinking**	To process a computable problem into sequential and logical steps as a solution for human and computer systems.
6. Career-related competences**	To operate specialised digital technologies and to understand, analyse and evaluate specialised data, information and digital content for a particular field.
6.1 Operating specialised digital technologies for a particular field**	To identify and use specialised digital tools and technologies for a particular field.
6.2 Interpreting and manipulating data, information and digital content for a particular field**	To understand, analyse and evaluate specialised data, information and digital content for a particular field within a digital environment.

Source: Law, et al. (2018)

Note: In the competence areas and competences column, text in bold indicates competence areas and the plain text indicates competences.

** Added competence areas and competences which are not in the DigComp 2.0 framework.

B. Mapping existing tools from ILSAs into SDG thematic indicator 4.4.2

Once the operational definition of DLS was established and operationalised into a Digital Literacy Global Framework, the next step was to map existing tools from different ILSAs into the concepts included in the framework. The objective was to evaluate if and to what extent existing instruments and data could be used to measure and monitor SDG 4.4.2.

This mapping exercise used the following strategy. To carry out the mapping of this indicator we used the following analytic strategy:

First, informed by the operationalizations identified above, we consulted the latest version of the frameworks and the instruments applied in several ILSAs. These were the Programme for International Student Assessment (PISA) (OECD, 2003), the IEA International Computer and Information Literacy Study (ICILS) (Fraillon et al., 2019) and the OECD Programme for the International Assessment of Adult Competencies (PIAAC) (OECD, 2012). We assessed these sources of information with the following criteria in mind: the assessment framework should (at least partially) refer to the concepts relevant to SDG 4.4.2, the instruments should provide sufficient information on many of the aspects/concepts involved, and they should potentially allow long-term monitoring.

Below is an overview of the International Large-Scale Assessments (ILSAs) considered for this exercise and a summary of our evaluation.

B.1 PISA - OECD - The ICT Familiarity Questionnaire

PISA 2003 introduced the ICT familiarity computer-based student questionnaire as an option and gave it to all participating 15-year-olds students if a country/economy chose to use it. Among the questions included were those regarding students' digital and electronic device usage, as well as their confidence and attitudes towards ICT.

PISA offers limited coverage for the indicator 4.4.2. Furthermore, when contrasting the Global Content Framework for SDG indicators 4.4.2 and the items in the ICT familiarity questionnaire, only three out of the six competence areas are compatible.

Due to the above fundamental reasons, PISA was disregarded as the tool for measuring the 4.4.2 indicator.

B.2 ICILS

In response to the growing use of ICT in modern society, the IEA developed the International Computer and Information Literacy Study (ICILS). There have been two cycles, the first one in 2013 focused on the use of computers as information

searching, management, and communication tools, which are vital to participating in the digital age. While the second one in 2018 looked into students' computational thinking, along with their computer and information literacy (Fraillon et al., 2019).

Although the ILCIS measured a broad range of competences, including some concepts directly related to indicator 4.4.2, it only assessed eighth graders. Consequently, this resource was dismissed.

B.3 PIAAC

The OECD's International Assessments of Adult Competencies (PIAAC) were administered between 2012-2017 in 39 countries/economies. This first cycle was divided into three rounds of data collection. (See Table 2).

Table 2. First cycle of PIAAC and countries participating in each rou

PIAAC 1st Cycle	Round 1 (2011-2012)	Australia, Austria, Belgium (Flanders), Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Spain, Sweden, United Kingdom (England and Northern Ireland), United States.
	Round 2 (2014-15)	Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia, Turkey.
	Round 3 (2017)	Ecuador, Hungary, Kazakhstan, Mexico, Peru, United States.

PIAAC included both a background questionnaire and three cognitive assessments, focusing on literacy, numeracy, and Problem-solving in technology-rich environments (PSTRE).

The background questionnaire collects data about information and communication technologies (ICTs), skills at work and at home; specifically how often individuals use computers, their attitudes towards using technology, and their self-assessment of how well they use technology.

PIAAC introduced PSTRE as a new domain, and it was the first time that it was evaluated on a large scale and as a single component.

PSTRE is defined as using digital technology, communication tools and networks to gather and evaluate information, communicate with others and complete tasks. The first cycle of PIAAC emphasised “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).

PSTRE encompasses the intersection of skills sometimes referred to as "computer literacy" (i.e., using computer applications and tools) and cognitive skills needed to resolve problems. Knowledge of basic ICT input devices (e.g., keyboards, mice, and screens), file management tools, applications (e.g., word processing, email) and graphic interfaces are essential for completing the assessment tasks. Rather, its objective is to assess the capacity of adults to access, process, evaluate and analyze information effectively using ICT tools and applications.

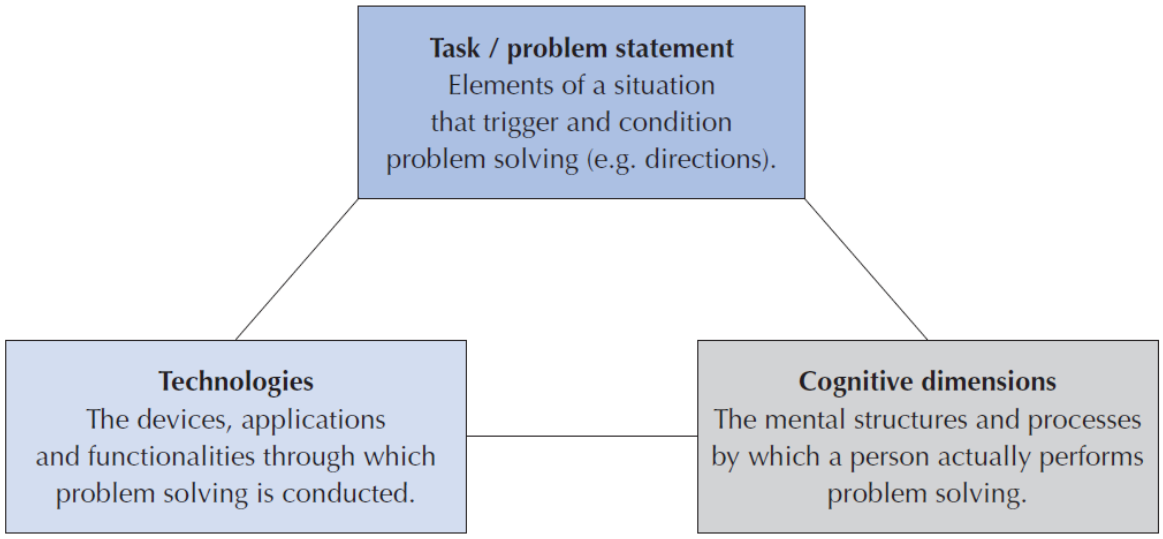
Our mapping exercise identified the OECD’s Programme for the International Assessment of Adult Competencies (PIAAC) as the most valuable source of information for SGD indicator 4.4.2. This study was chosen due to its conceptual framework (OECD, 2012), which showed the highest coverage of the topics relevant to this indicator. Additional reasons for the selection of PIAAC were that its target population covers the two groups mentioned in the indicator (youth and adults); as well as its potential to inform long-term monitoring.

C. SDG thematic indicator 4.4.2

The items used to operationalise SDG Indicator 4.4.2 were the ones corresponding to the PIAAC's dimension of Problem-Solving in Technology-Rich Environments. This dimension refers to the ability to use technology to solve problems and accomplish complex tasks. It is not a direct measure of computer literacy, as it also measures the capacity to operate within a digital environment to solve the types of problems that adults face in their everyday life as users of digital technologies (see OECD, 2012 for more details).

In PIAAC, the Problem-Solving in Technology-Rich Environments (PSTRE) dimension is measured with 14 tasks based on problem-solving scenarios, which are conceived along three dimensions (see Figure 1**Error! Reference source not found.**).

Figure 1. Core dimensions of PIAAC's problem-solving in technology-rich environments tasks.



Source: OECD (2012, p. 48).

PSTRE items were developed for testing participants' ability to handle tasks that may involve multiple cognitive processes (see Table 3), multiple technologies (see Table 4), or different contexts (see Table 5). Participants may, for example, need to move between email and spreadsheet environments when creating a table that represents the information for a specific purpose either personal or work-related. The PSTRE tasks are all scenario-based and vary in their difficulty.

Table 3. Selected test items to measure indicator 4.4.2 - Distribution of tasks as a function of the cognitive processes measured by PIAAC.

Cognitive processes	Number of items [1]
Goal setting and monitoring progress	4
Planning	7
Acquiring and evaluating information	8
Making use of information	6

[1]The number of items do not sum to 14 because some tasks are coded to more than one cognitive process.

Source: *Literacy, Numeracy and Problem-Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills*. Paris: OECD, 2012. Page 52.

Table 4. Selected test items to measure indicator 4.4.2 - Distribution of tasks as a function of technology environments.

Technology Environments	Number of items [1]
Web	7
Spreadsheet	4
E-mail	9

[1] The number of items do not sum to 14 because some tasks are coded to more than one technology environment.

Source: *Literacy, Numeracy and Problem-Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills*. Paris: OECD, 2012. Page 52.

Table 5. Selected test items to measure indicator 4.4.2 - Distribution of tasks by context.

Context	Number of items
Personal	8
Work / Occupation	4
Civic	2

Source: *Literacy, Numeracy and Problem-Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills*. Paris: OECD, 2012. Page 52.

In summary, PIAAC-PSTRE instruments contain items/tasks which overlap with all the areas of competences described in the framework for SDG indicator 4.4.2 (see Table 6, OECD, 2012 and Law et al., 2018).

Table 6. Mapping of PIAAC 2012-2017 scales into the indicator categories

PIAAC 2012-2018	**Construct**	**Areas of Competences Framework for SDG indicator 4.4.2**						
		Devices & software operations	Inf. & data literacy	Comms. & collab.	Digital content creation	Safety	Problem-solving	Career-related comp.
Cognitive process	Setting goals & monitoring progress	x	x	x	x	x		
	Planning	x	x	x			x	
	Acquiring & eval inf.	x	x	x		x		x
	Using inf.		x	x				
Technology environment	Web		x	x				
	Spread sheet		x	x				
	E-mail		x	x				
Context	Personal	x					x	
	Work	x					x	
	Civic	x					x	
By intrinsic complexity (num of steps)	Single step		x				x	
	Multiple steps		x				x	
By intrinsic complexity (num of constraints)	Single constraint		x				x	
	Multiple constraints		x				x	

Examples of the specific items/tasks used for the PSTRE dimension of PIAAc can be found in Annex 1.

C.1 Availability

PIAAC data has been collected in 40 countries/economies over three cycles between 2011 and 2017. However, PSTRE data was available only for 31 countries: Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, Germany, Ireland, Japan, Republic of Korea, Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Sweden, United Kingdom, Chile, Greece, Israel, Lithuania, New Zealand, Singapore, Slovenia, Turkey, Ecuador, Hungary, Kazakhstan, Mexico, Peru.

C.2 Calculation method

Since the test design for PIAAC is based on a variant of matrix sampling (using different sets of items, multistage adaptive testing, and different assessment modes) where each respondent was administered a subset of items from the total item pool. The responses to the subset of test items are scaled using item response theory (IRT) methodology and combined with other background information (provided by the respondent) and model parameters to produce a set of 10 plausible values (PVs). These PVs can be used to produce group-level estimations of proficiency values (OECD, 2013).

According to the PIAAC Technical Report (OECD, 2013), the following steps can be followed to calculate an estimate T of the proficiency values Θ using PVs and to calculate an estimate of the variance of T:

1. Using the first vector of plausible values for each respondent, evaluate T as if the plausible values were the true values of Θ. Denote the result T_1.
2. In the same manner as in step 1 above, evaluate the sampling variance of T, or Var(T_1), with respect to respondents' first vectors of plausible values. Denote the result Var_1.
3. Carry out steps 1 and 2 for the second through all 10 vectors of plausible values, thus obtaining T_v and Var_v for v=2,. . ., 10.
4. The best estimate of T obtainable from the plausible values is the average of the 10 values obtained from the different sets of plausible values:

$$\mathrm{T}_{\cdot} = \frac{\sum_v \mathrm{T}_v}{10} \qquad (1)$$

5. An estimate of the variance of T is the sum of two components: an estimate of Var(T_v) obtained as in step 4 and the variance among the T_vs:

$$Var\mathrm{T}_{\cdot} = \frac{\sum_n Var_v}{10} + \left(1 + \frac{1}{10}\right)\frac{\sum_v (\mathrm{T}_v - \mathrm{T}_{\cdot})^2}{10 - 1} \quad (2)$$

The first component in $Var\mathrm{T}_{\cdot}$ reflects uncertainty due to sampling from the population; the second component reflects uncertainty because the respondents' proficiencies Θ are only indirectly observed.

Then, using the cut-off points established for the scale (see below), the proportion of students respondents reaching the corresponding standard is estimated within each country or region as a simple proportion (*P*).

$$P = \frac{X}{n} \quad (3)$$

Where X is the number of respondents that reach the standard in each country and n is the total number of respondents in the same country.

C.3 Definition of cut-off points (standards)

The performance of the participants in PIAAC-PSTRE is used to produce a proficiency scale (i.e., score) that ranges from 0 to 500. This scale is then divided into four proficiency levels (i.e., below 1, 1, 2 and 3) based on the knowledge and skills required to complete the tasks within those levels. Respondents at a particular level not only demonstrate knowledge and skills associated with that level but also the proficiencies required at lower levels. So, for example, respondents scoring at Level 2 are also proficient at Level 1.

To create the proficiency levels, an expert group in problem-solving in technology-rich environments met with psychometricians and test developers and reviewed data, looked at the tasks along the 500-point scale, and determined the requisite skills and knowledge to complete those tasks progressively increased along the scale. These proficiency levels of PSTRE are defined as shown in Table 7.

Table 7. Description of the PSTRE proficiency levels.

Below Level 1 (0 to240 score points) Tasks are based on well-defined problems involving the use of only one function within a generic interface to meet one explicit criterion without any categorical, inferential reasoning or transforming of information. Few steps are required and no subgoal has to be generated.
Level 1 (241 to 290 score points) At this level, tasks typically require the use of widely available and familiar technology applications, such as email software or a Web browser. There is little or no navigation required to access the information or commands required to solve the problem. The problem may be solved regardless of one's awareness and use of specific tools and functions (e.g., a sort function). The task involves few steps and a minimal number of operators. At a cognitive level, the person can readily infer the goal from the task statement; problem resolution requires one to apply explicit criteria; there are few monitoring demands (e.g., the person does not have to check whether he or she has used the adequate procedure or made progress toward the solution). Identifying contents and operators can be done through simple match; only simple forms of reasoning, for example, assigning items to categories are required. There is no need to contrast or integrate information.
Level 2 (291 to 340 score points) At this level, tasks typically require the use of both generic and more specific technology applications. For instance, the person may have to make use of a novel online form. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g., a sort function) can facilitate the resolution of the problem. The task may involve multiple steps and operators. In terms of cognitive processing, the problem goal may have to be defined by the person, though the criteria to be met are explicit. There are higher monitoring demands. Some unexpected outcomes or impasses may appear. The task may require evaluating the relevance of a set of items to discard distractors. Some integration and inferential reasoning may be needed.
Level 3 (341 to 500 score points) At this level, tasks typically require the use of both generic and more specific technology applications. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g., a sort function) is required to make progress toward the solution. The task may involve multiple steps and operators. In terms of cognitive processing, the problem goal may have to be defined by the person, and the criteria to be met may or may not be explicit. There are typically high monitoring demands. Unexpected outcomes and impasses are likely to occur. The task may require evaluating the relevance and the reliability of information in order to discard distractors. Integration and inferential reasoning may be needed to a large extent.

Source: PIAAC Technical Report (OECD, 2013)

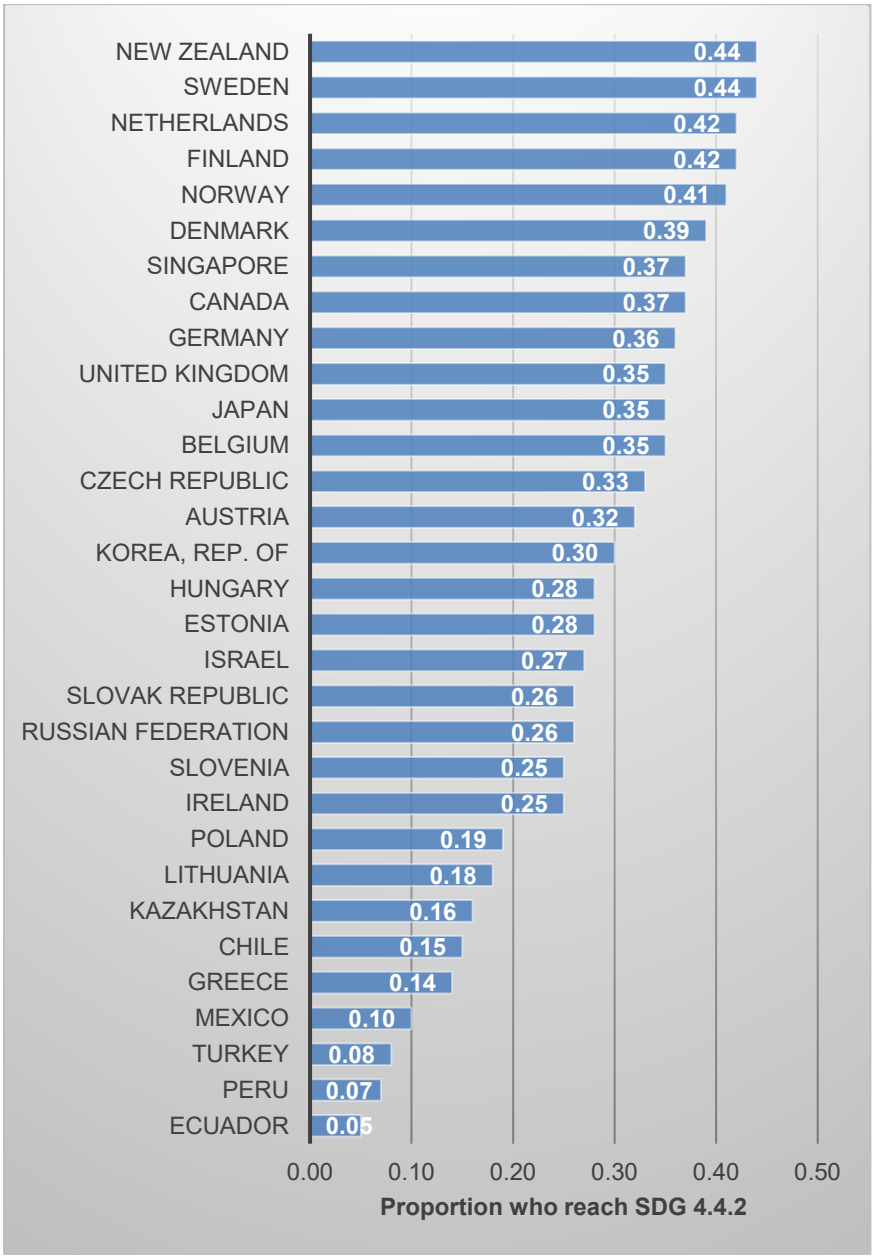
By comparing the definition of SDG Indicator 4.4.2 and the description of the problem-solving in technology-rich environments proficiency levels, we identified Level 2 as the threshold or cut-off point to estimate the proportion of respondents reaching the indicator within each country. At Level 2, tasks typically require the use of both generic and more specific technology applications.

At the threshold, respondents typically require the use of both generic and specific technology applications. Adults at this level are typically able to use software they have never seen before to solve problems, even when unexpected impasses/outcomes occur. For example, they are likely able to:

- Figure out how to send an email message to a number of contacts using an unfamiliar bulk email function;
- Use a sorting tool to make it easier to locate sales numbers for a specific product in a company spreadsheet;
- Conduct a web search to find out how to solve a problem with other software, such as how to view a column that won't display properly in a spreadsheet; and
- Find an email message or file that has been "lost" somewhere on a computer hard drive.

The proportion of youth/adults who reach the SDG 4.4.2 in each of the countries for which data is available is shown in Figure 2. Tables with the proportions of youth/adults reaching SDG 4.4.2 in each country disaggregated by sex, socioeconomic status, age and educational level can be found in Annex 2.

Figure 2. Proportion of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills.



Conclusions

Our analysis suggests that the items, scales and potential indicators (scores) based on the PSTRE dimension of PIAAC can be used to measure and monitor progress towards SDG 4.4.2. PIAAC-PSTRE is certainly well suited for providing (at least a proxy) measurement of SDG 4.4.2. It provides high coverage for the digital literacy competences included in our Global Content Framework and incorporates the relevant concepts naturally in its frameworks. It also systematically collects the same data across countries and would allow long-term monitoring (provided that there are further cycles of PIAAC). Finally, it has high-quality data quality assurance mechanisms in place (ensuring data accuracy, validity and comparability). Nevertheless, some aspects must be kept in mind when interpreting the scores and proportions presented here.

In very simple terms, cut-off scores refer to a point in a scale used to classify individuals according to the level of the attribute being measured between those above and below a threshold. As such, this threshold should represent a meaningful interpretation of the level of the attribute under study, in this case, "digital literacy skills". In other words, individuals scoring above the threshold should be able to demonstrate "a minimum level of proficiency in digital literacy skills". We have decided to follow the methodology proposed by the OECD to determine the thresholds for SDG Indicator 4.4.2. That is, we have selected proficiency Level 2 of the scale "problem-solving in technology-rich environments" as the threshold or cut-off point. Additionally, we have described what this threshold means according to the PIAAC framework (e.g., the types of tasks that can be completed by adults who reach the threshold). The selection and interpretation of this particular threshold are, however, open to discussion among the relevant stakeholders (see OECD, 2013 for details on the methodology and description of the proficiency levels).

PIAAC data are uniquely suited to contribute to measuring SDG Indicator 4.4.2 because its methods ensure that comparable information is collected across all participating countries. This is a significant advantage compared to the alternative of compiling and harmonizing national datasets or developing a purpose-built study. However, it is important to keep in mind that PIAAC was not designed to measure SDG Indicator 4.4.2. For this reason, the information used here has limitations related to at least two areas: availability (e.g. the country coverage), and relevance (e.g. the scales produced here can only be considered as proxy measures of the concepts established in SDG Indicator 4.4.2).

Finally, it is important to consider that the "problem-solving in technology-rich environments" assessment was not done if the respondent had insufficient computer skills, or if the respondent opted to do a paper-and-pencil-based

assessment, or if the respondent did not do the computer assessment for literacy-related reasons. As a result, there are missing values that are not addressed through imputation or weighting—as their characteristics are different from those that did complete the assessment. The estimates reported here assume that the individuals that, for any of the three reasons described above, did not complete the assessment did not reach the target established by SDG Indicator 4.4.2. We believe that this is a reasonable assumption since those individuals who have insufficient computer or literacy skills to answer the test are extremely unlikely to reach proficiency level 2 if they had taken the test. However, there is some degree of uncertainty because they did not take the “problem-solving in technology-rich environments” assessment.

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Appendix 1.

The examples of the PSTRE items presented below are taken from the PIAAC Framework (OECD, 2012, pp. 53–55). Please note that these items are administered in electronic format, and these examples correspond to the print layout.

Sample item 1

In this item, respondents must access and evaluate information in the context of a simulated job search. The instructions, located on the left side of the screen, require respondents to identify and then bookmark one or more sites that do not require users to register or pay a fee.

Figure 3. Screenshot 1 of sample item 1.

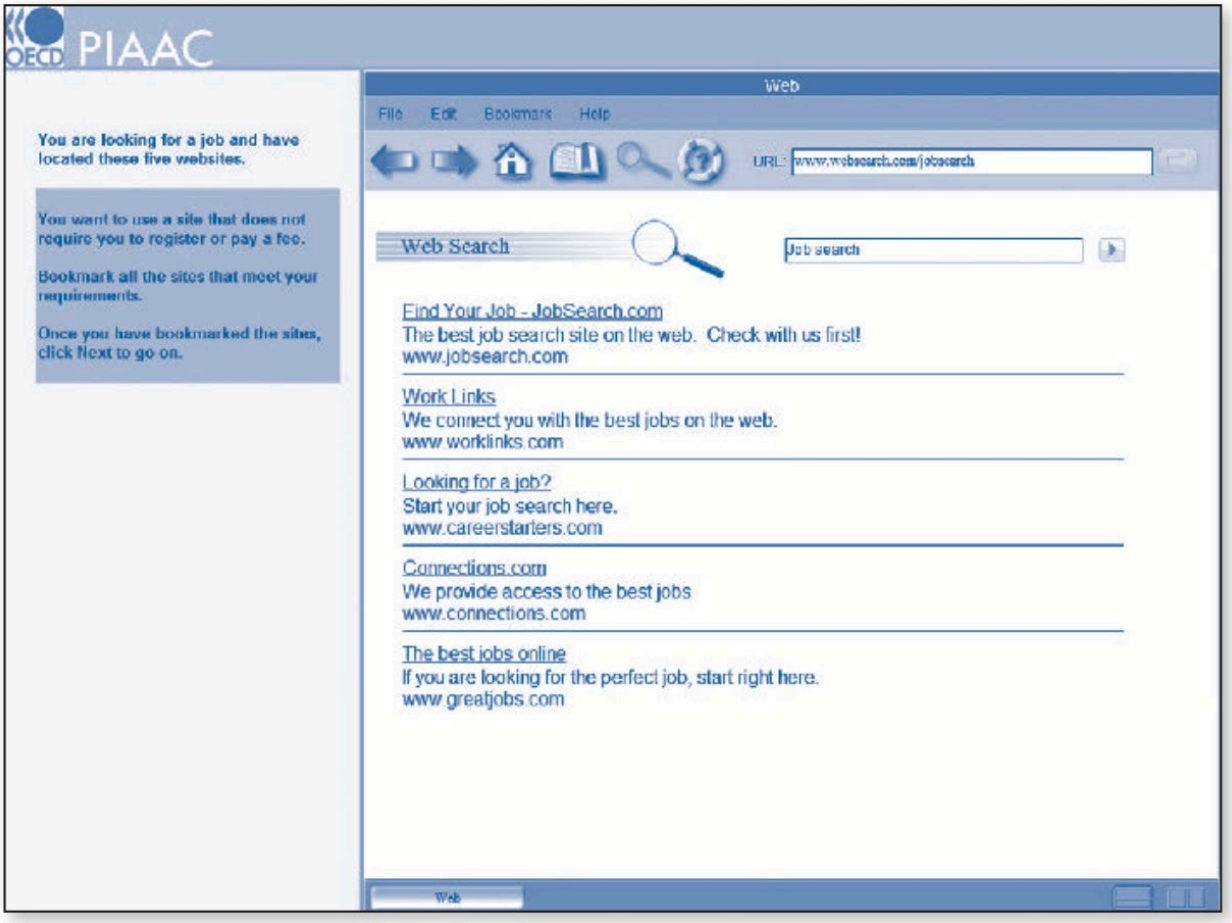
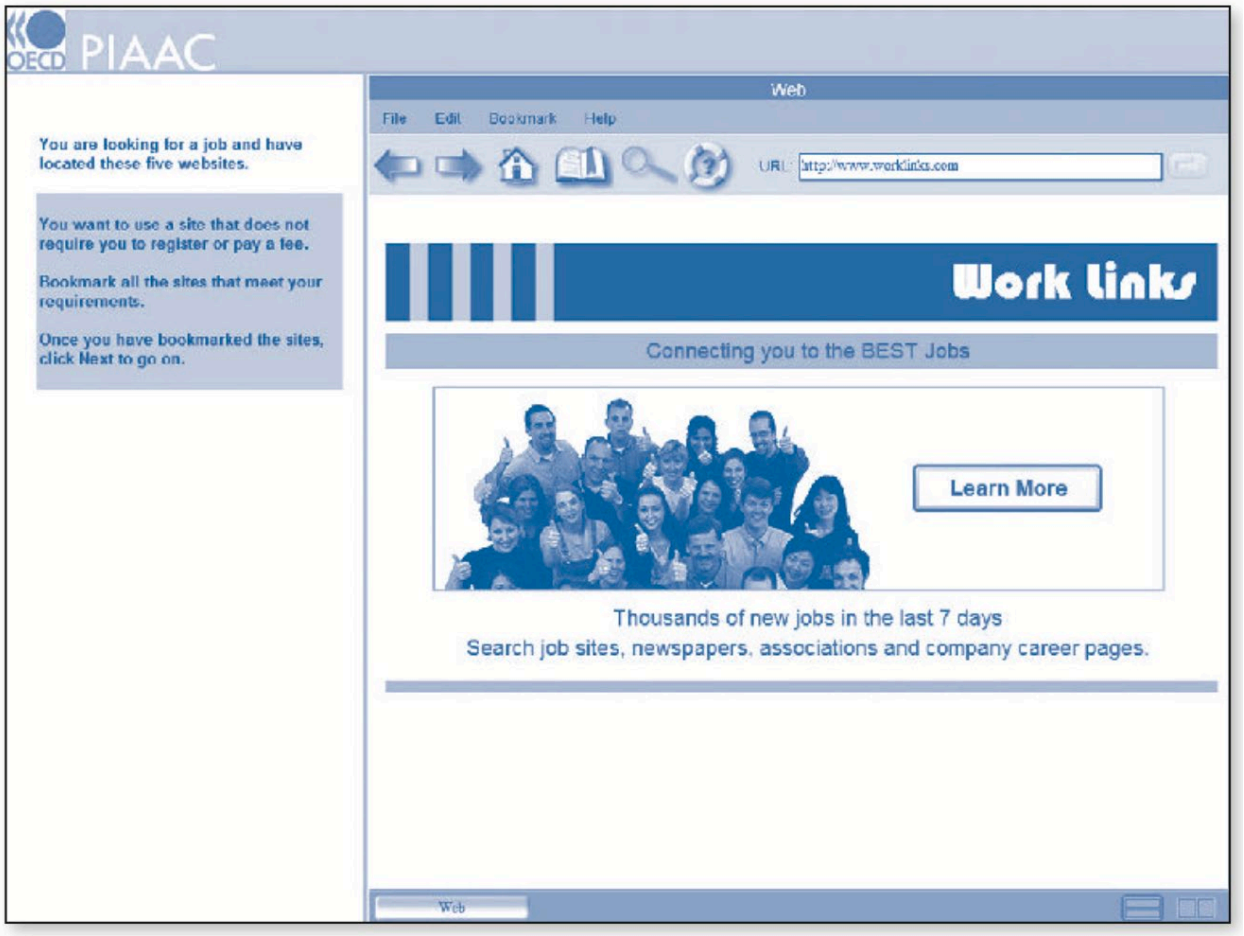


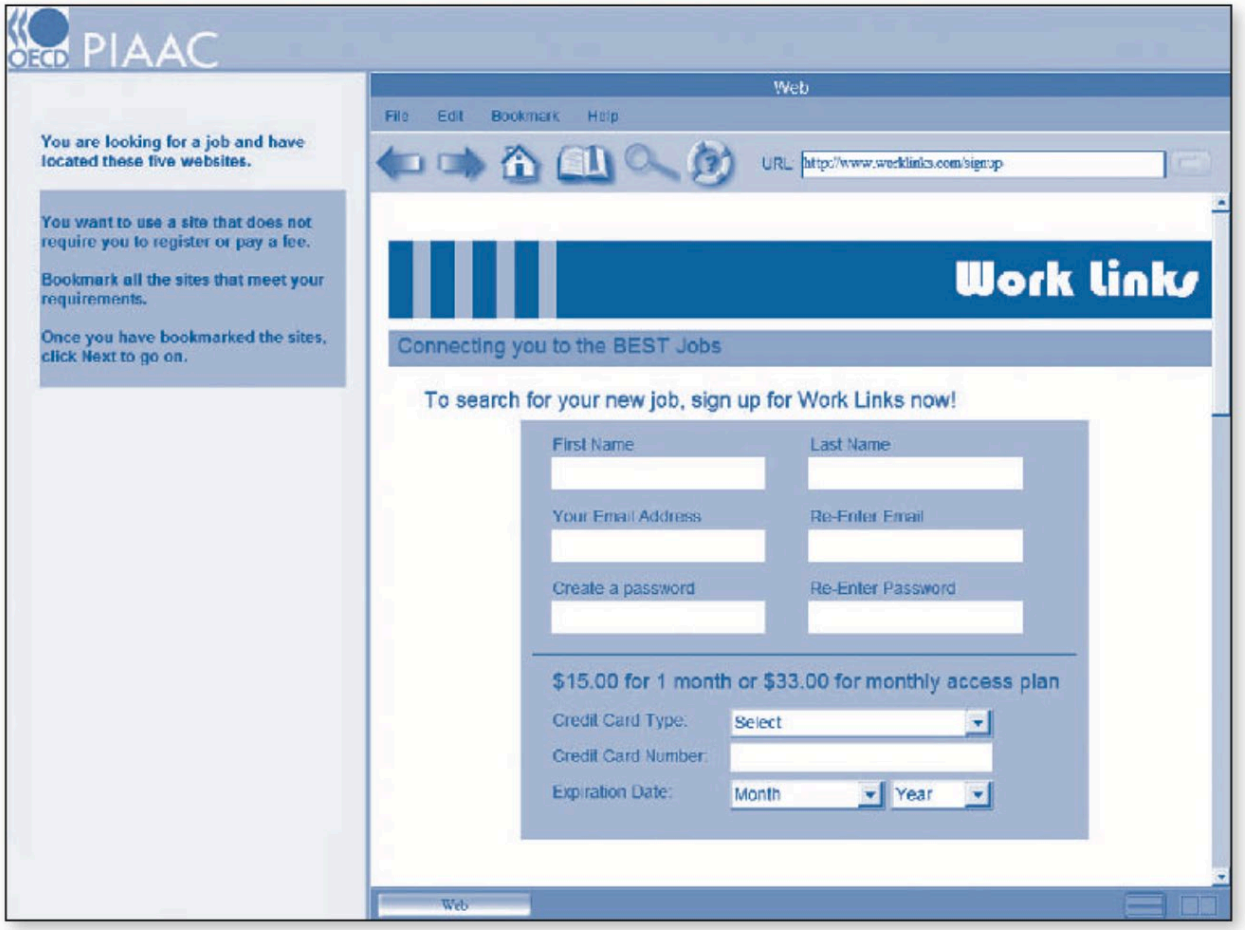
Figure 4. Screenshot 2 of sample item 1.



As can be seen, this item requires that respondents work within a simulated web environment that includes tools and functionality 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.

Figure 5. Screenshot 3 of sample item 1.



In order to perform this task correctly, respondents may have to search through several pages on a website. One of the features of PIAAC is that the process and paths by which a respondent responds to the tasks are captured. For example, one of the websites, presented below, does not meet the criteria of not requiring registration or the payment of a fee, but the relevant information is not on the opening page. If a respondent bookmarks this site without clicking on the "Learn more" link to view the relevant information (see the website on the following page), this response may be interpreted in a different way than if the relevant page had been viewed. The breadth of information, combined with frameworks that specify behaviours of interest, allow PIAAC to learn more about what adults know and can do relative to the construct of problem-solving.

The relevant information is located on the form that indicates that users must sign up (register) and pay a fee.

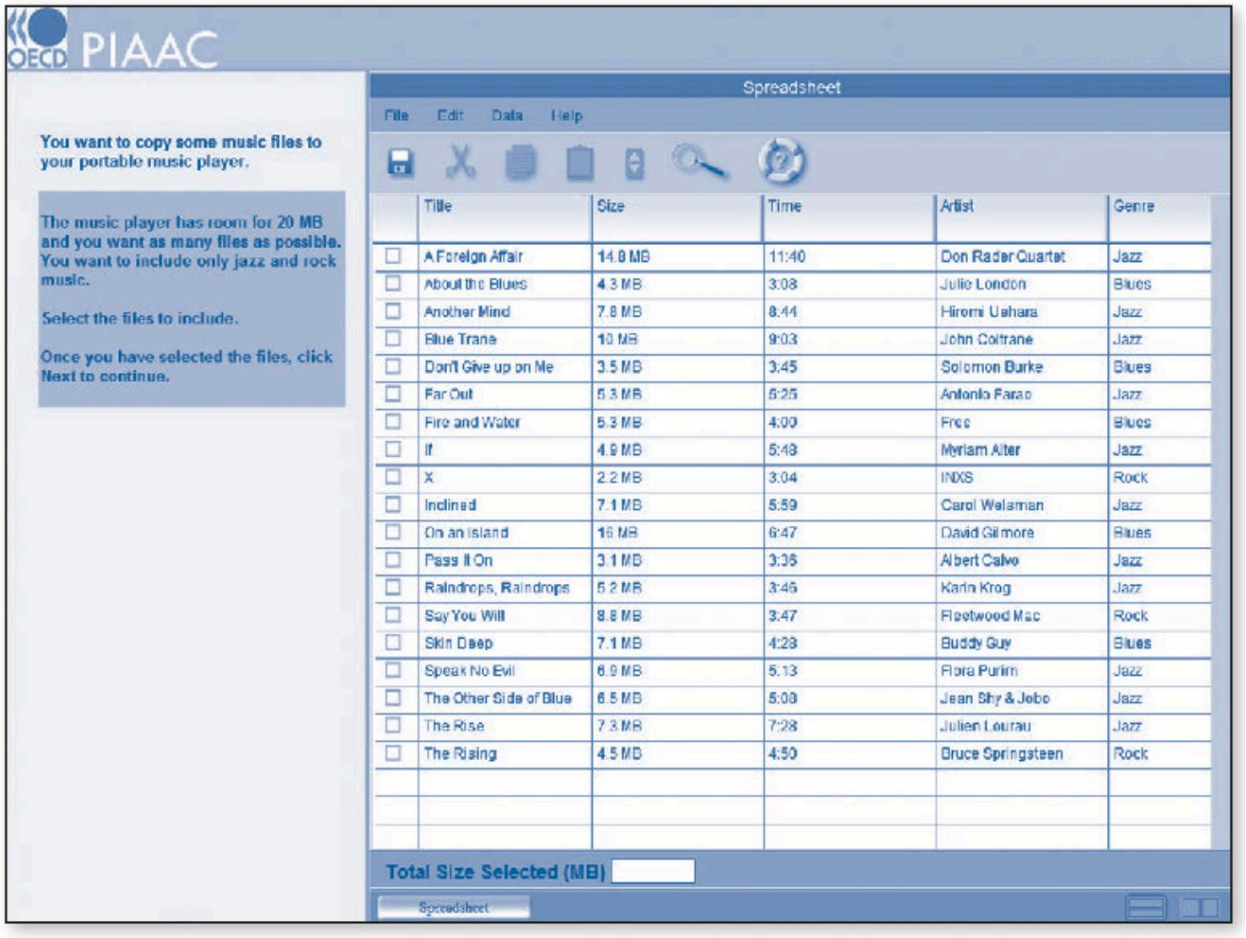
Sample item 2

In this item, respondents select a set of files to download onto a portable music player. The files must meet specified criteria in terms of genre (jazz and rock) and not exceed the capacity of the device (maximum of 20 MB).

The software includes an automatic summing functionality ("total Size Selected") that facilitates the task by updating the total file size as files are selected or de-selected. Respondents must monitor progress as they select files, checking against the specified criteria to know when they have satisfied the constraints presented in the problem.

It is also possible to sort the spreadsheet by file size and/or genre, a strategy that can improve task efficiency. The connection between the use of resources in a technology-rich environment and resulting efficiencies for solving problems is emphasised in the framework and therefore included across items in the assessment.

Figure 6. Screenshot 1 of sample item 2.



Appendix 2.

Table 8. Data disaggregation.

DEFINITION	METRICS	ITEM AND DESCRIPTION	CATEGORIES	INSTRUMENT
Sex	Nominal	Person resolved gender from Background questionnaire (derived)	Female, Male, Not stated or inferred (missing)	Background questionnaire (link)
Educational level	Ordinal	Which of the qualifications on this card is the highest you have obtained? *Response categories were collapsed into 'Tertiary education' (ISCED 5A, 5B and 6); and 'Non-tertiary education' (the rest). * In order to account for the fact that many of the youngest participants in PIAAC are still in education, the analysis here is restricted to adults aged 25-65 years.	- No formal qualification or below ISCED 1 - ISCED 1 - ISCED 2 - ISCED 3C shorter than 2 years - ISCED 3C 2 years or more - ISCED 3A-B - ISCED 3 (without distinction A-B-C, 2y+) - ISCED 4C - ISCED 4A-B - ISCED 4 (without distinction A-B-C) - ISCED 5B - ISCED 5A, bachelor degree - ISCED 5A, master degree - ISCED 6	Background questionnaire (link)
Socioeconomic status (SES) (parental education)	Ordinal	Highest of mother or father's level of education (derived) *Response categories were collapsed into 'High SES' or at least one parent with tertiary education (ISCED 5A, 5B and 6); 'Low SES' or none of the	- No formal qualification or below ISCED 1 - ISCED 1 - ISCED 2 - ISCED 3C shorter than 2 years - ISCED 3C 2 years or more	Background questionnaire (link)

DEFINITION	METRICS	ITEM AND DESCRIPTION	CATEGORIES	INSTRUMENT
		parents with tertiary education (the rest).	- ISCED 3A-B - ISCED 3 (without distinction A-B-C, 2y+) - ISCED 4C - ISCED 4A-B - ISCED 4 (without distinction A-B-C) - ISCED 5B - ISCED 5A, bachelor degree - ISCED 5A, master degree - ISCED 6	
Age	Ordinal	Person resolved age from Background Questionnaire (derived) *Response categories were collapsed into 'Older adults' (55 plus) and 'Younger adults' (the rest).	- 24 or less - 25-34 - 35-44 - 45-54 - 55 plus - <16 - >65 - Not stated or inferred	Background questionnaire (link)

Table 9. Proportion of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills

Country	**Prcentage**
Austria	.32 (.01)
Belgium	.35 (.01)
Canada	.37 (.01)
Czech Republic	.33 (.01)
Denmark	.39 (.01)
Estonia	.28 (.01)
Finland	.42 (.01)
Germany	.36(.01)
Ireland	.25 (.01)
Japan	.35 (.01)
Korea, Rep. of	.30 (.01)
Netherlands	.42 (.01)
Norway	.41 (.01)
Poland	.19 (.01)
Russian Federation	.26 (.02)
Slovak Republic	.26 (.01)
Sweden	.44 (.01)
United Kingdom	.35 (.01)
Chile	.15 (.02)
Greece	.14 (.01)
Israel	.27 (.01)
Lithuania	.18 (.01)
New Zealand	.44 (.01)
Singapore	.37 (.01)
Slovenia	.25 (.01)
Turkey	.08 (.01)
Ecuador	.05 (.00)
Hungary	.28 (.01)
Kazakhstan	.16 (.01)
Mexico	.10 (.01)
Peru	.07 (.00)

Table 10. Proportion of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills by sex

	Male		Female	
Country	**Below**	**Above**	**Below**	**Above**
Austria	.63 (.01)	.37 (.01)	.72 (.01)	.28 (.01)
Belgium	.63 (.01)	.37 (.01)	.68 (.01)	.32 (.01)
Canada	.63 (.01)	.37 (.01)	.64 (.01)	.36 (.01)
Czech Republic	.64 (.02)	.36 (.02)	.69 (.01)	.31 (.01)
Denmark	.60 (.01)	.40 (.01)	.63 (.01)	.37 (.01)
Estonia	.72 (.01)	.28 (.01)	.73 (.01)	.27 (.01)
Finland	.57 (.01)	.43 (.01)	.60 (.01)	.40 (.01)
Germany	.60 (.01)	.40 (.01)	.68 (.01)	.32 (.01)
Ireland	.73 (.01)	.27 (.01)	.76 (.01)	.24 (.01)
Japan	.60 (.01)	.40 (.01)	.71 (.01)	.29 (.01)
Korea, Rep. of	.67 (.01)	.33 (.01)	.72 (.01)	.28 (.01)
Netherlands	.55 (.01)	.45 (.01)	.62 (.01)	.38 (.01)
Norway	.56 (.01)	.44 (.01)	.62 (.01)	.38 (.01)
Poland	.79 (.01)	.21 (.01)	.82 (.01)	.18 (.01)
Russian Federation	.74 (.02)	.26 (.02)	.74 (.03)	.26 (.03)
Slovak Republic	.74 (.01)	.26 (.01)	.75 (.01)	.25 (.01)
Sweden	.54 (.01)	.46 (.01)	.58 (.01)	.42 (.01)
United Kingdom	.61 (.01)	.39 (.01)	.69 (.01)	.31 (.01)
Chile	.83 (.02)	.17 (.02)	.88 (.03)	.12 (.02)
Greece	.85 (.01)	.15 (.01)	.87 (.01)	.13 (.01)
Israel	.72 (.01)	.28 (.01)	.75 (.01)	.25 (.01)
Lithuania	.83 (.02)	.17 (.01)	.82 (.01)	.18 (.01)
New Zealand	.56 (.01)	.44 (.01)	.55 (.01)	.45 (.01)
Singapore	.60 (.01)	.40 (.01)	.66 (.01)	.34 (.01)
Slovenia	.74 (.01)	.26 (.01)	.75 (.01)	.25 (.01)
Turkey	.91 (.02)	.09 (.01)	.94 (.01)	.06 (.01)
Ecuador	.94 (.02)	.06 (.01)	.96 (.01)	.04 (.01)
Hungary	.70 (.01)	.30 (.01)	.73 (.01)	.27 (.01)
Kazakhstan	.84 (.02)	.16 (.01)	.84 (.02)	.16 (.01)
Mexico	.87 (.01)	.13 (.01)	.92 (.01)	.08 (.01)
Peru	.93 (.02)	.07 (.01)	.94 (.02)	.06 (.01)

Table 11. Proportion of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills by SES (low SES = none of the parents with tertiary education, high SES = at least one parent with tertiary education)

	Low		High	
Country	**Below**	**Above**	**Below**	**Above**
Austria	.71 (.01)	.29 (.01)	.48 (.02)	.52 (.02)
Belgium	.71 (.01)	.29 (.01)	.39 (.01)	.61 (.02)
Canada	.71 (.01)	.29 (.01)	.49 (.01)	.51 (.01)
Czech Republic	.71 (.01)	.29 (.01)	.40 (.02)	.60 (.03)
Denmark	.69 (.01)	.31 (.01)	.44 (.01)	.56 (.01)
Estonia	.81 (.01)	.19 (.01)	.54 (.01)	.46 (.01)
Finland	.65 (.01)	.35 (.01)	.32 (.01)	.68 (.02)
Germany	.70 (.01)	.30 (.01)	.47 (.01)	.53 (.01)
Ireland	.80 (.01)	.20 (.01)	.52 (.01)	.48 (.02)
Japan	.73 (.01)	.27 (.01)	.48 (.01)	.52 (.01)
Korea, Rep. of	.75 (.01)	.25 (.01)	.46 (.01)	.54 (.02)
Netherlands	.64 (.01)	.36 (.01)	.36 (.01)	.64 (.01)
Norway	.67 (.01)	.33 (.01)	.40 (.01)	.60 (.01)
Poland	.85 (.01)	.15 (.01)	.55 (.02)	.45 (.02)
Russian Federation	.79 (.02)	.21 (.02)	.64 (.04)	.36 (.03)
Slovak Republic	.78 (.01)	.22 (.01)	.49 (.01)	.51 (.03)
Sweden	.65 (.01)	.35 (.01)	.37 (.01)	.63 (.01)
United Kingdom	.68 (.01)	.32 (.01)	.42 (.01)	.58 (.02)
Chile	.90 (.02)	.10 (.01)	.65 (.03)	.35 (.03)
Greece	.88 (.01)	.12 (.01)	.68 (.03)	.32 (.03)
Israel	.82 (.02)	.18 (.01)	.56 (.01)	.44 (.01)
Lithuania	.93 (.01)	.07 (.01)	.66 (.01)	.34 (.02)
New Zealand	.62 (.01)	.38 (.01)	.40 (.01)	.60 (.01)
Singapore	.69 (.01)	.31 (.01)	.34 (.01)	.66 (.02)
Slovenia	.81 (.02)	.19 (.01)	.46 (.02)	.54 (.02)
Turkey	.93 (.01)	.07 (.01)	.72 (.04)	.28 (.04)
Ecuador	.96 (.01)	.04 (.00)	.81 (.04)	.19 (.03)
Hungary	.79 (.01)	.21 (.01)	.45 (.01)	.55 (.02)
Kazakhstan	.88 (.02)	.12 (.01)	.73 (.02)	.27 (.02)
Mexico	.92 (.01)	.08 (.01)	.67 (.03)	.33 (.03)
Peru	.96 (.02)	.04 (.00)	.79 (.02)	.21 (.02)

Table 12. Proportion of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills by age (younger adults < 55, older adults ≥ 55)

	younger		older	
Country	**Below**	**Above**	**Below**	**Above**
Austria	.62 (.01)	.38 (.01)	.92 (.02)	.08 (.01)
Belgium	.59 (.01)	.41 (.01)	.88 (.02)	.12 (.02)
Canada	.58 (.01)	.42 (.01)	.83 (.01)	.17 (.01)
Czech Republic	.61 (.01)	.39 (.01)	.88 (.02)	.12 (.02)
Denmark	.54 (.01)	.46 (.01)	.87 (.01)	.13 (.01)
Estonia	.67 (.01)	.33 (.01)	.95 (.01)	.05 (.01)
Finland	.48 (.01)	.52 (.01)	.91 (.01)	.09 (.01)
Germany	.58 (.01)	.42 (.01)	.87 (.02)	.13 (.02)
Ireland	.71 (.01)	.29 (.01)	.95 (.01)	.05 (.01)
Japan	.57 (.01)	.43 (.01)	.90 (.02)	.10 (.01)
Korea, Rep. of	.64 (.01)	.36 (.01)	.96 (.01)	.04 (.01)
Netherlands	.52 (.01)	.48 (.01)	.83 (.02)	.17 (.01)
Norway	.53 (.01)	.47 (.01)	.86 (.02)	.14 (.01)
Poland	.76 (.01)	.24 (.01)	.97 (.05)	.03 (.03)
Russian Federation	.70 (.02)	.30 (.03)	.91 (.02)	.09 (.02)
Slovak Republic	.70 (.01)	.30 (.01)	.91 (.01)	.09 (.01)
Sweden	.49 (.01)	.51 (.01)	.83 (.02)	.17 (.01)
United Kingdom	.61 (.01)	.39 (.01)	.83 (.02)	.17 (.02)
Chile	.83 (.03)	.17 (.02)	.98 (.02)	.02 (.01)
Greece	.84 (.01)	.16 (.01)	.95 (.01)	.05 (.01)
Israel	.70 (.01)	.30 (.01)	.91 (.02)	.09 (.01)
Lithuania	.79 (.01)	.21 (.01)	.96 (.01)	.04 (.01)
New Zealand	.51 (.01)	.49 (.01)	.76 (.02)	.24 (.02)
Singapore	.56 (.01)	.44 (.01)	.94 (.01)	.06 (.01)
Slovenia	.69 (.01)	.31 (.01)	.95 (.01)	.05 (.02)
Turkey	.91 (.01)	.09 (.01)	.98 (.02)	.02 (.01)
Ecuador	.94 (.02)	.06 (.01)	.99 (.01)	.01 (.01)
Hungary	.66 (.01)	.34 (.01)	.91 (.02)	.09 (.01)
Kazakhstan	.82 (.01)	.18 (.01)	.92 (.02)	.08 (.01)
Mexico	.89 (.01)	.11 (.01)	.98 (.01)	.02 (.01)
Peru	.93 (.01)	.07 (.01)	.99 (.01)	.01 (.00)

Table 13. Proportion of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills by educational level

	non-tertiary		tertiary	
Country	**Below**	**Above**	**Below**	**Above**
Austria	.75 (.01)	.25 (.01)	.50 (.01)	.50 (.01)
Belgium	.82 (.01)	.18 (.01)	.46 (.01)	.54 (.04)
Canada	.79 (.01)	.21 (.01)	.54 (.01)	.46 (.01)
Czech Republic	.78 (.01)	.22 (.01)	.42 (.02)	.58 (.03)
Denmark	.76 (.01)	.24 (.01)	.45 (.01)	.55 (.01)
Estonia	.86 (.01)	.14 (.01)	.65 (.01)	.35 (.01)
Finland	.77 (.01)	.23 (.01)	.44 (.01)	.56 (.01)
Germany	.77 (.01)	.23 (.01)	.47 (.01)	.53 (.02)
Ireland	.89 (.01)	.11 (.01)	.56 (.01)	.44 (.02)
Japan	.80 (.01)	.20 (.01)	.51 (.01)	.49 (.01)
Korea, Rep. of	.89 (.01)	.11 (.01)	.56 (.01)	.44 (.02)
Netherlands	.74 (.01)	.26 (.01)	.37 (.01)	.63 (.02)
Norway	.75 (.01)	.25 (.01)	.41 (.01)	.59 (.02)
Poland	.93 (.01)	.07 (.01)	.63 (.02)	.37 (.02)
Russian Federation	.84 (.03)	.16 (.03)	.73 (.03)	.27 (.02)
Slovak Republic	.84 (.01)	.16 (.01)	.52 (.02)	.48 (.02)
Sweden	.70 (.01)	.30 (.01)	.39 (.01)	.61 (.01)
United Kingdom	.78 (.01)	.22 (.01)	.48 (.02)	.52 (.02)
Chile	.96 (.02)	.04 (.01)	.70 (.03)	.30 (.03)
Greece	.93 (.01)	.07 (.01)	.72 (.02)	.28 (.02)
Israel	.86 (.01)	.14 (.01)	.63 (.01)	.37 (.02)
Lithuania	.93 (.01)	.07 (.01)	.64 (.02)	.36 (.02)
New Zealand	.69 (.02)	.31 (.01)	.45 (.01)	.55 (.01)
Singapore	.91 (.01)	.09 (.01)	.46 (.01)	.54 (.03)
Slovenia	.87 (.01)	.13 (.01)	.52 (.01)	.48 (.02)
Turkey	.96 (.01)	.04 (.00)	.74 (.02)	.26 (.03)
Ecuador	.99 (.01)	.01 (.00)	.88 (.02)	.12 (.02)
Hungary	.85 (.01)	.15 (.01)	.48 (.01)	.52 (.02)
Kazakhstan	.90 (.02)	.10 (.01)	.76 (.02)	.24 (.02)
Mexico	.96 (.02)	.04 (.01)	.74 (.03)	.26 (.02)
Peru	.98 (.01)	.02 (.00)	.86 (.02)	.14 (.01)