CHAPTER 3:

Students' computer and information literacy

Chapter highlights

Computer and information literacy (CIL) achievement can be described across four levels of increasing sophistication.

- Students working at Level 1 demonstrate a functional working knowledge of computers as tools. (Table 3.2)
- Students working at Level 2 use computers, under direct instruction, to complete basic and explicit information gathering and management tasks. (Table 3.2)
- Students working at Level 3 demonstrate the capacity to work independently when using computers as information gathering and management tools. (Table 3.2)
- Students working at Level 4 execute control and evaluative judgment when searching for information and creating information products. (Table 3.2)

Students' CIL varied more within countries than across countries.

- The range between the lowest five percent and the highest 95 percent of students' CIL scores within countries varied between 216 scale points (in Denmark) and 347 scale points (in Kazakhstan). (Table 3.4)
- The difference between the highest and lowest average CIL scores across countries was 157 scale points. (Table 3.4)

CIL achievement was associated with student gender.

- Female students demonstrated higher CIL achievement than male students. (Table 3.7)
- The average CIL scores of female students was statistically significantly higher than that of male students in 10 of 13 countries and benchmarking participants that met the ICILS technical requirements. (Table 3.7)

Socioeconomic status (SES), denoted by parental occupation, parental education, and number of books in the home, was significantly positively associated with student CIL achievement.

- In all countries, students in the high SES groups scored significantly higher than those in the lower SES groups on the CIL achievement scale. (Table 3.8)

Immigrant background and language background were associated with student CIL.

- In nine of 13 countries and benchmarking participants that met the ICILS technical requirements, students from non-immigrant families had statistically significantly higher CIL scores than students from immigrant families. (Table 3.9)
- In 10 of 13 countries and benchmarking participants that met the ICILS technical requirements, students who reported mainly speaking the language of the ICILS test at home had statistically significantly higher CIL scale scores than those who reported speaking another language at home. (Table 3.9)

J. Fraillon et al., *Preparing for Life in a Digital World*,
https://doi.org/10.1007/978-3-030-38781-5_3

Access to computers at home and years' experience using computers were associated with students' CIL.

- In all countries and benchmarking participants that met the ICILS technical requirements, students who reported having two or more computers at home had statistically significantly higher CIL scores than students who reported having fewer than two computers at home. (Table 3.10)
- In 12 of 13 countries and benchmarking participants that met the ICILS technical requirements, students who reported having five years or more experience using computers had statistically significantly higher CIL scale scores than those who reported having less than five years' experience. (Table 3.10)

Introduction

The International Computer and Information Literacy Study (ICILS) 2018 assessment framework defines computer and information literacy (CIL) as an "individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society" (Fraillon et al. 2013, p. 17). In ICILS, there is an operational emphasis on students' abilities to use computer technologies to collect and manage information, and to produce and exchange information. According to the framework, CIL comprises four strands, each of which is specified in terms of a number of aspects. The strands describe CIL in terms of the following: *understanding computer use*, *gathering information*, *producing information*, and *digital communication* (Fraillon et al. 2019).

In this chapter, we detail the measurement of CIL in ICILS and discuss student achievement across ICILS countries. We begin the chapter by describing the CIL assessment instrument and the proficiency scale derived from the ICILS test instrument and data. We also describe and discuss the student test results relating to CIL. The majority of content in this chapter relates to Research Question CIL 1, which focuses on the extent of variation existing among and within countries with respect to student CIL. In the final sections of the chapter we address aspects of Research Question CIL 3 focusing on the relationships between students' levels of access to, familiarity with, and self-reported proficiency in using computers and their CIL, and Research Question CIL 4 which focuses on aspects of students' personal and social backgrounds (such as gender and socioeconomic background) and their CIL.

Assessing CIL

The ICILS assessment design was established for the first cycle of ICILS in 2013. The design built on existing work in the assessment of digital literacy (Binkley et al. 2012; Dede 2009) and ICT literacy (ACARA 2012). It also included the following essential features of assessment in this domain:

- Students completing tasks solely on computer;
- The tasks having a real-world, cross-curricular focus;
- The tasks combining technical, receptive, productive, and evaluative skills; and
- The tasks referencing safe and ethical use of computer-based information.

In order to ensure standardization of students' test experiences and comparability of the resultant data, the ICILS instrument operates in a "walled garden," which means students can explore and create in an authentic environment without the comparability of student data being potentially contaminated by differential exposure to digital resources and information from outside the test environment.

The ICILS 2018 test instrument was built to be consistent with the instrument developed for ICILS 2013 and comprised five modules of questions and tasks which took 30 minutes each to complete. Three of the modules were secure modules from ICILS 2013 (trend modules) and were included to enable data collected in ICILS 2018 to be reported on the CIL proficiency scale established as part of ICILS 2013 and to compare CIL achievement over time in countries that participated in both cycles. Two new CIL test modules were developed for ICILS 2018. The new modules were developed to be consistent with the overarching design and conceptual principles established for use in ICILS 2013. They were also developed to represent the content of the ICILS 2018 assessment framework and used contexts that both complemented the existing content of the ICILS trend modules and reflected changes in student use of computer-based applications since 2013. Each student completed two modules randomly allocated from the set of five in a complete balanced rotation. Full details of the ICILS assessment design, including the computer-based test interface, can be found in the ICILS assessment framework (Fraillon et al. 2019).

Each CIL test module is comprised of a set of questions and tasks based on a real-world theme and following a linear narrative structure. Each module has a series of smaller discrete tasks,[11] each of which typically takes less than a minute to complete. The narrative of each module positions the smaller discrete tasks as a mix of skill execution and information management tasks that students need to do in preparation for completion of a large task. The large task in each module typically takes 15 to 20 minutes to complete. Students are free to control the time they take to complete each task, however, in each module they are given an indication of how much time is recommended for them to leave available to complete the large task.

When beginning each module, students were presented with an overview of the theme and purpose of the tasks in the module, as well as a basic description of what the large task would comprise. Students were required to complete the tasks in the allocated sequence and could not return to review completed tasks. There were five ICILS assessment modules and large tasks (Table 3.1).

Table 3.1: Summary of ICILS CIL test modules and large tasks

Module	Description and large task
Band competition	Students plan a website, edit an image, and use a simple website builder to create a webpage with information about a school band competition.
Breathing	Students manage files and evaluate and collect information to create a presentation to explain the process of breathing to eight- or nine-year-old students.
School trip	Students help plan a school trip using online database tools and select and adapt information to produce an information sheet about the trip for their peers. The information sheet includes a map created using an online mapping tool.
Board games	Students use a school-based social network for direct messaging and group posting to encourage peers to join a board games interest group.
Recycling	Students access and evaluate information from a video sharing website to identify a suitable information source relating to waste reduction, reuse, and recycling. Students take research notes from the video and use their notes as the basis for designing an infographic to raise awareness about waste reduction, reuse, and recycling.

Data collected from the five test modules were used to measure and describe CIL in this report. In total, the data comprised 102 score points derived from 81 discrete questions and tasks. Just over half of the score points were derived from criteria associated with the five large tasks. Students' responses to these tasks were scored in each country by trained expert scorers. Data were only included where they met or exceeded IEA technical requirements. The ICILS 2018 technical report (Fraillon et al. 2020) provides further information on adjudication of the test data.

As noted previously, the ICILS assessment framework has four strands, each specified in terms of several aspects. The strands refer to the overarching conceptual category for framing the skills and knowledge addressed by the CIL instruments, while the aspects further articulate CIL in terms of the main (but not exclusive) constituent processes that underpin the skills and knowledge. We used this structure primarily as an organizational tool when describing the breadth of content of the CIL construct. The structure was not intended to form the basis of analysis and reporting of achievement by sub-dimensions (such as by strand or aspect).

11 These tasks can be described as discrete because, although connected by the common narrative, students completed each one sequentially without explicit reference to the other tasks.

The following list sets out the four strands and corresponding aspects of the CIL framework. Also included are the respective percentages (of the 102 total score points) attributed to each strand and to each aspect within the strands.

- Strand 1: Understanding computer use, comprising two aspects, 15 percent:
  - Aspect 1.1: Foundations of computer use, 2 percent.
  - Aspect 1.2: Computer use conventions, 13 percent.
- Strand 2: Gathering information, comprising two aspects, 24 percent:
  - Aspect 2.1: Accessing and evaluating information, 16 percent.
  - Aspect 2.2: Managing information, 8 percent.
- Strand 3: Producing information, comprising two aspects, 50 percent:
  - Aspect 3.1: Transforming information, 20 percent.
  - Aspect 3.2: Creating information, 30 percent.
- Strand 4: Digital communication, comprising two aspects, 12 percent:
  - Aspect 4.1: Sharing information, 8 percent.
  - Aspect 4.2: Using information safely and securely, 4 percent.

As stated in the ICILS 2018 assessment framework, "[t]he test design of ICILS was not planned to assess equal proportions of all aspects of the CIL construct, but rather to ensure some coverage of all aspects as part of an authentic set of assessment activities in context" (Fraillon et al. 2019, p. 54). Approximately three times as many score points relate to Strands 2 and 3 as to Strands 1 and 4. These proportions correspond to the amount of time the students were expected to spend on the tasks assessing each strand. The aspects of Strand 3 were assessed primarily via the large tasks at the end of each module, with students expected to spend roughly two thirds of their working time on these tasks.

Each student completed two of the five available CIL test modules. These modules were allocated to students in a balanced randomized design. There were 20 possible permutations of the two CIL modules selected from the five available modules. Each student was randomly allocated one module permutation. The rotated module design enabled the assessment and subsequent reporting on achievement of a larger amount of content (covering the breadth of the CIL framework and a range of difficulties) than any single student could reasonably complete in 60 minutes. This design also controlled for the influence of item position on difficulty across the sampled students and provided a variety of contexts for the assessment of CIL.

The ICILS CIL reporting scale was established for ICILS 2013, with a mean of 500 (the average CIL scale score across countries in 2013) and a standard deviation of 100 for the equally weighted national samples. We used combined data from ICILS 2013 and ICILS 2018 and then applied the Rasch item response theory (IRT) model (Rasch 1960) to equate the 2018 data to the ICILS reporting scale. We used plausible value methodology with full conditioning to derive summary student achievement statistics. This approach enables estimation of the uncertainty inherent in a measurement process (e.g., von Davier et al. 2009). The ICILS 2018 technical report provides details on the procedures the study used to scale test items (Fraillon et al. 2020).

The CIL described achievement scale

When we established the ICILS described scale of CIL achievement in 2013 we considered the content and scaled difficulties of the test items. We described the CIL knowledge, skills, and understanding demonstrated by a student correctly responding to each item and ordered these descriptors, from least to most difficult, according to the scaled difficulties of their corresponding items. We then analyzed the item content and relative difficulty to identify themes of content

and process that we could use to characterize the different ranges (levels) on the scale. This process was iterative in that we varied the positions of the level boundaries and reviewed the content of each level until each level showed distinctive characteristics and the progression from low to high achievement across the levels was clear.

We established the level boundaries at 407, 492, 576, and 661 scale points. Student scores below 407 scale points indicate CIL proficiency below the lowest level targeted by the assessment instrument. The described CIL scale was established on the basis of a transformation of the original item calibration so that the relative positions of students' scaled scores and the item difficulties would represent a response probability of 0.62. Thus, a student with ability equal to that of the difficulty of a given item on the scale would have a 62 percent chance of answering that item correctly.

The width of the levels was 85 scale points. We can assume that students achieving a score corresponding to the lower boundary of a level correctly answered about 50 percent of items in that level. We can also expect that students with scores within a bounded level (above the lower boundary) correctly answered more than 50 percent of the items in that level. Thus, once we know where a student's proficiency score is located within a given level, we can expect that they will have correctly answered at least half of the questions for that level, regardless of the location of their score within the level.

We reviewed the content of the described scale using the content and scaled difficulty of the test items used in ICILS 2018. From this review, we concluded that the summary content of the level descriptors should remain unchanged.

The scale description comprises syntheses of the common elements of CIL knowledge, skills, and understanding at each proficiency level (Table 3.2). It also describes the typical ways in which students working at a level demonstrate their proficiency. Each level of the scale references the characteristics of students' use of computers to access and use information and to communicate with others. The scale thus reflects a broad range of development, extending from students' use of software commands under direction, through to their increasing independence in selecting and using information to communicate with others, and on to their ability to independently and purposefully select information and use a range of software resources in a controlled manner in order to communicate with others. Included in this development is students' knowledge and understanding of issues relating to online safety and ethical use of electronic information. This understanding encompasses knowledge of information types and security procedures through to demonstrable awareness of the social, ethical, and legal consequences of a broad range of known and unknown users accessing electronic information.

In summary, the developmental sequence that the CIL scale describes has the following underpinnings: knowledge and understanding of the conventions of electronic information sources and software applications; ability to critically reason about and determine the veracity and usefulness of information from a variety of sources; and the planning and evaluation skills needed to create and refine information products for specified communicative purposes.

The scale is hierarchical in the sense that CIL proficiency becomes more sophisticated as student achievement progresses up the scale. We can therefore assume that a student located at a particular place on the scale because of his or her achievement score will be able to undertake and successfully accomplish tasks up to that level of achievement.

The scale contains four proficiency levels (Table 3.2). A small number of test items had scaled difficulties below Level 1 of the scale. These items represented execution of the most basic skills such as clicking on hyperlinks and interacting with application user interfaces (e.g., adjusting sliders and selectively clicking functional buttons) and therefore did not provide sufficient information to warrant description on the scale.

Table 3.2: CIL described achievement scale

Description of the proficiency level	Examples of tasks achieved by students at this proficiency level
Level 1 (from 407 to 491 scale points)	
Students working at Level 1 demonstrate a functional working knowledge of computers as tools and a basic understanding of the consequences of computers being accessed by multiple users. They apply conventional software commands to perform basic research and communication tasks and add simple content to information products. They demonstrate familiarity with the basic layout conventions of electronic documents.	Students working at Level 1, for example: • Open a link in a new browser tab • Use an appropriate communication tool for a particular communicative context • Identify who receives an email by carbon copy (CC) • Identify problems that can result from mass messaging • Record key points from a video into a text-based note taking application • Use software to crop an image • Place a title in a prominent position on a webpage • Create a suitable title for a slide show • Demonstrate basic control of color when adding content to a simple document • Insert an image into a document • Suggest one or more risks of failing to log out from a user account when using a publicly accessible computer
Level 2 (from 492 to 576 scale points)	
Students working at Level 2 use computers to complete basic and explicit information gathering and management tasks. They locate explicit information from within given electronic sources. These students make basic edits and add content to existing information products in response to specific instructions. They create simple information products that show consistency of design and adherence to layout conventions. Students working at Level 2 demonstrate awareness of mechanisms for protecting personal information and some consequences of public access to personal information.	Students working at Level 2, for example: • Add contacts to a collaborative workspace • Explain the advantages of using a communication tool for a particular communicative context • Explain a potential problem if a personal email address is publicly available • Associate the breadth of a character set with the strength of a password • Navigate to a URL presented as plain text • Insert information to a specified cell in a spreadsheet • Locate explicitly stated simple information within a website with multiple webpages • Know that search engines can prioritize sponsored content over non-sponsored content • Differentiate between paid and non-paid search results returned by a search engine • Explain a benefit of citing sources of information obtained from the internet • Use formatting and location to denote the role of a title in an information sheet • Use the full canvas when laying out a poster • Control the size of elements relative to one another when laying out a poster • Demonstrate basic control of text layout and color use when creating a slide show • Use a simple webpage editor to add specified text to a webpage

Table 3.2: CIL described achievement scale (contd.)

Description of the proficiency level	Examples of tasks achieved by students at this proficiency level
Level 3 (from 577 to 661 scale points)	
Students working at Level 3 demonstrate the capacity to work independently when using computers as information gathering and management tools. These students select the most appropriate information source to meet a specified purpose, retrieve information from given electronic sources to answer concrete questions, and follow instructions to use conventionally recognized software commands to edit, add content to, and reformat information products. They recognize that the credibility of web-based information can be influenced by the identity, expertise, and motives of the creators of the information.	Students working at Level 3, for example: • Identify that a generic greeting in an email suggests that the sender does not know the recipient • Explain the disadvantages of using a communication tool for a particular communicative context • Evaluate the reliability of information presented on a crowdsourced website • Identify when content published on the internet may be biased as a result of a publisher's content guidelines or advertising revenue directing content • Explain the purpose of explicitly labelling sponsored content published on the internet websites • Select relevant information according to given criteria to include in a website • Explain the benefit of a common information organization and retrieval system • Know what information is useful to include when recording a source of information from the internet • Use generic online mapping software to represent text information as a map route • Select an appropriate website navigation structure for given content • Select and adapt some relevant information from given sources when creating a poster • Demonstrate control of image layout when creating a poster • Demonstrate control of color and contrast to support readability of a poster • Demonstrate control of text layout when creating a presentation
Level 4 (Above 661 scale points)	
Students working at Level 4 select the most relevant information to use for communicative purposes. They evaluate usefulness of information based on criteria associated with need and evaluate the reliability of information based on its content and probable origin. These students create information products that demonstrate a consideration of audience and communicative purpose. They also use appropriate software features to restructure and present information in a manner that is consistent with presentation conventions. They then adapt that information to suit the needs of an audience. Students working at Level 4 demonstrate awareness of problems that can arise regarding the use of proprietary information on the internet.	Students working at Level 4, for example: • Evaluate the reliability of information intended to promote a product on a commercial website • Select and use relevant images to represent a three-stage process in a presentation • Select and use relevant images to support information presented in a digital poster • Select from sources and adapt text for a presentation so that it suits a specified audience and purpose • Demonstrate control of color to support the communicative purpose of a presentation • Use text layout and formatting features to denote the role of elements in an information poster • Create a balanced layout of text and images for an information sheet • Recognize the difference between legal, technical, and social requirements when using images on a website • Explain that passwords can be encrypted and decrypted

Table 3.2: CIL described achievement scale (contd.)

Description of the proficiency level	Examples of tasks achieved by students at this proficiency level
Level 4 (Above 661 scale points)	
	• Source relevant facts from electronic sources for use in a social media post to generate support • Explain how communication tools can be used to demonstrate inclusive behavior • Cite the relevant source of information from the internet when constructing an information product

Describing CIL learning progress

In this section we briefly describe the key characteristics of each level on the CIL scale with a focus on the differences between achievements at each level. These differences are discussed with a view to providing ideas for educators about target areas for teaching to support students' learning progress through the levels.

Students working at Level 1 demonstrate familiarity with the basic range of software commands that enable them to access files and complete routine text and layout editing under instruction. They recognize not only some basic conventions used by electronic communications software, including knowing which communication tool to use in a given context, but also the potential for misuse of computers by unauthorized users. A key factor differentiating Level 1 achievement from Below Level 1 achievement is the range of software commands students can use. Students working at Below Level 1 are unlikely to be able to create digital information products unless they have support and guidance. Key factors differentiating Level 1 achievement from achievement at the higher levels are the breadth of students' familiarity with conventional software commands, the degree to which they can search for and locate information, and their capacity to plan how they will use information when creating information products.

Students working at Level 2 demonstrate basic use of computers as information resources. They are able to locate explicit information in simple digital resources, select and add content to information products, and exercise some control over laying out and formatting text and images in information products. They can explain the advantage of using a given communication tool in a given context and demonstrate awareness of the need to protect access to some electronic information and of possible consequences of unwanted access to information. A key factor differentiating Level 2 achievement from achievement at the higher levels is the extent to which students can work autonomously and with a critical perspective when accessing information and using it to create information products.

Students working at Level 3 possess sufficient knowledge, skills, and understanding to independently search for and locate information. They also have ability to edit and create information products. They can select relevant information from within electronic resources, and the information products they create exhibit their capacity to control layout and design. Furthermore, students working at Level 3 demonstrate awareness that the information they access may be biased, inaccurate, or unreliable. They also can evaluate the weaknesses of the use of a given communication tool in a given context. The key factors differentiating achievement at Level 3 from Level 4 are the degree of precision with which students search for and locate information and the level of control they demonstrate when using layout and formatting features to support the communicative purpose of information products.

Students working at Level 4 execute control and evaluative judgment when searching for information and creating information products. They also demonstrate awareness of audience and purpose when searching for information, selecting information to include in information products, and formatting and laying out the information products they create. Students working at Level 4 additionally demonstrate awareness of the potential for information to be a commercial and malleable commodity and apply the conventions of a given communication tool in a given context to support inclusivity.

Example CIL items

To provide a clearer understanding of the nature of the scale items, we include in this section of the chapter a set of example items. These indicate the types and range of items that students were required to complete during the ICILS test of CIL. The items also provide examples of responses corresponding to the different proficiency levels of the CIL scale.

The example items are all from the band competition module. This module required students to work on a sequence of tasks associated with planning a website for a school band competition. Students were then asked to create a website page to represent one of the bands in the competition. In this section we present five discrete items followed by a description of the band competition's large task and a discussion of its scoring criteria. The five discrete items and the large task criteria illustrate achievement at different levels of the CIL scale.

Example discrete tasks

Example Item 1 (Figure 3.1), an open text response item, was the first task in the band competition module. The stimulus presented the login page for a webmail account. The item required students to respond by answering a question relating to browser security. The students' written responses to this item were scored by scorers in each country through an online delivery platform. All scorers had been trained to international standards.[12] Only data that met the requisite ICILS scoring standards were included in the analysis of this item.[13]

Example Item 1 illustrates achievement at Level 1 on the CIL scale. The item assessed students' understanding of the consequences of allowing a browser or web application to save a password while using a computer that could be accessed by other people. Students who referred to unauthorized access to the webmail account or access to private information stored in the account received credit on this item. On average across all countries, 64 percent of students achieved full credit on Example Item 1. The percentages across countries and benchmarking participants ranged from 50 percent to 84 percent.

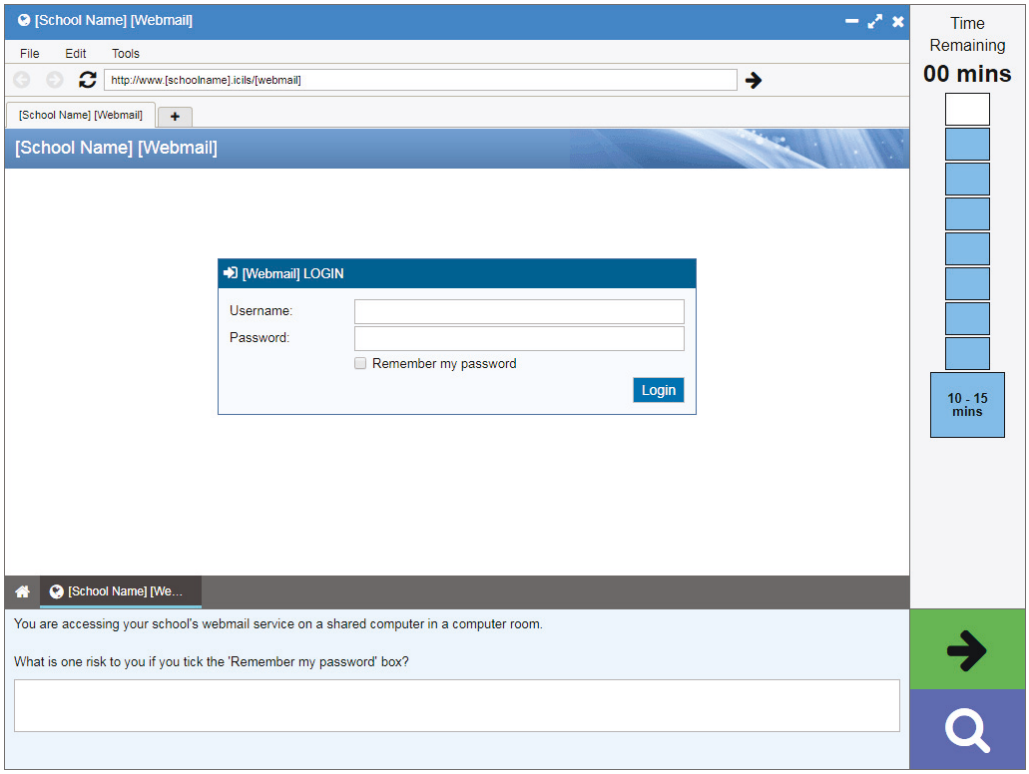
Example Item 2 (Figure 3.2) required students to explain how the characteristics of a password can improve the secureness of the password.

Students were presented with two passwords and asked to choose the most secure and explain their choice. Student responses were scored as correct if they selected the password Fky_38% and included an explanation that related the broader character set used in the second password to password security. A correct response to this item illustrates achievement at Level 2 of the CIL scale. On average across all countries, 62 percent of students achieved full credit on this item. The percentages across countries and benchmarking participants varied from 27 to 80 percent.

12 All scorers across countries were provided the same set of example responses as the basis for training.

13 Three hundred student responses to each constructed response item and large task criterion were independently scored by two scorers in each country in order to assess the reliability of scoring of each item or task within each country. The only data included in the analysis were those with a scoring reliability of at least 70 percent.

Figure 3.1: Example Item 1 with framework references and overall percent correct



CIL scale level	CIL scale difficulty	ICILS 2018 average percentage correct responses
1	489	64 (0.5)
Item descriptor		
Identify a danger of ticking "Remember your password" on a shared computer		
ICILS assessment framework reference		
4.2	Digital communication	
	Using information responsibly and safely	

Figure 3.1: Example Item 1 with framework references and overall percent correct (contd.)

Country	Percentage of correct responses
Chile	64 (1.7)
Denmark†1	72 (1.3)
Finland	70 (1.7)
France	51 (1.5)
Germany	56 (1.3)
Kazakhstan1	50 (2.2)
Korea, Republic of	77 (1.4)
Luxembourg	56 (0.9)
Portugal††1	84 (1.2)
Uruguay	59 (2.1)
Testing at the beginning of the school year	
Italy	35 (1.7)
Not meeting sample participation requirements	
United States	58 (1.1)
Benchmarking participants meeting sample participation requirements	
Moscow (Russian Federation)	71 (1.8)
North Rhine-Westphalia (Germany)	57 (2.0)

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

1 National defined population covers 90% to 95% of national target population.

Figure 3.2: Example Item 2 with framework references and overall percent correct

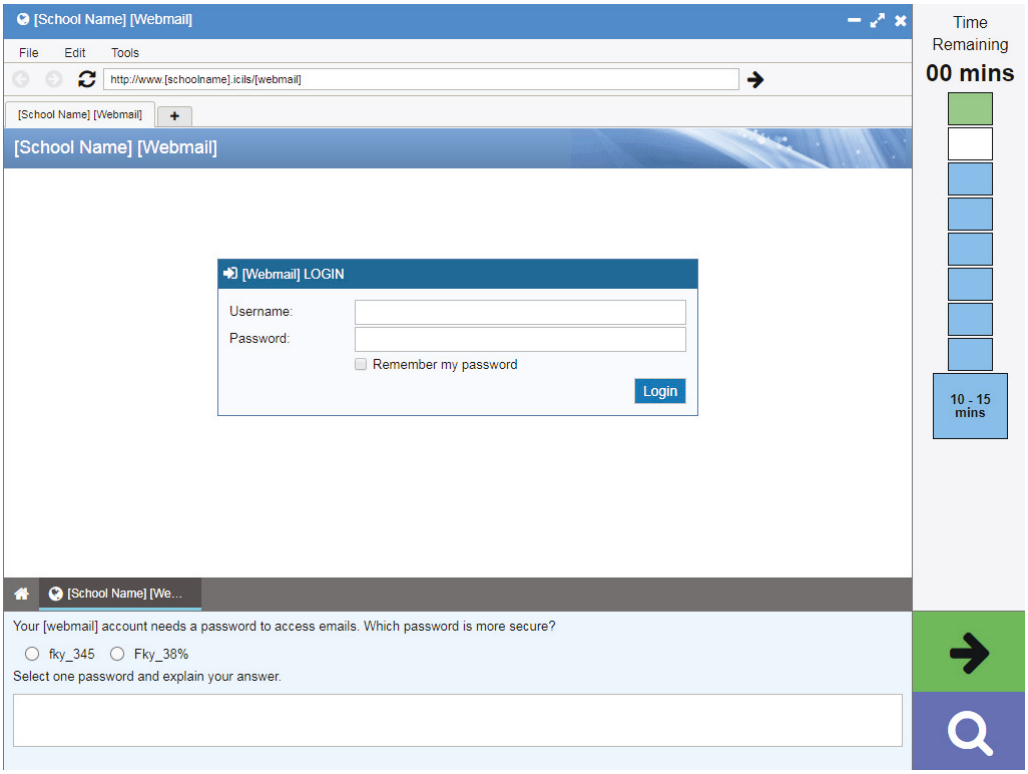


Figure 3.2: Example Item 2 with framework references and overall percent correct (contd.)

CIL scale level	CIL scale difficulty	ICILS 2018 average percentage correct responses
2	493	62 (0.5)
Item descriptor		
Explain the characteristics that make one of two passwords more secure		
ICILS assessment framework reference		
1.1	Understanding computer use	
	Foundations of computer use	

Country	Percentage of correct responses
Chile	56 (1.7)
Denmark†1	77 (1.5)
Finland	78 (1.4)
France	61 (1.8)
Germany	79 (1.5)
Kazakhstan1	27 (1.8)
Korea, Republic of	43 (1.7)
Luxembourg	74 (0.8)
Portugal††1	68 (1.6)
Uruguay	56 (1.9)
Testing at the beginning of the school year	
Italy	49 (1.5)
Not meeting sample participation requirements	
United States	71(1.1)
Benchmarking participants meeting sample participation requirements	
Moscow (Russian Federation)	65 (1.8)
North Rhine-Westphalia (Germany)	80 (1.3)

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

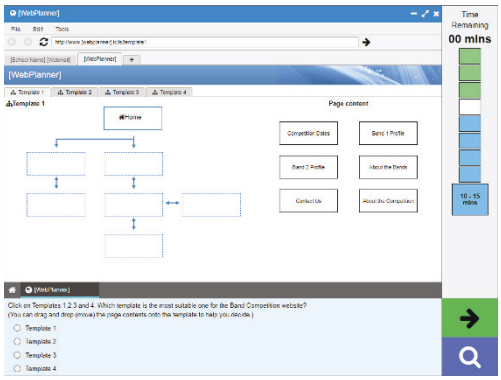
1 National defined population covers 90% to 95% of national target population.

Example Item 3 (Figure 3.3) illustrates student achievement at Level 3 on the CIL scale. It was the fourth task in the narrative sequence of the module and presented the students with four diagrams that represented website structure templates for the band competition website. Each template could be viewed by clicking the template tabs above the diagram.

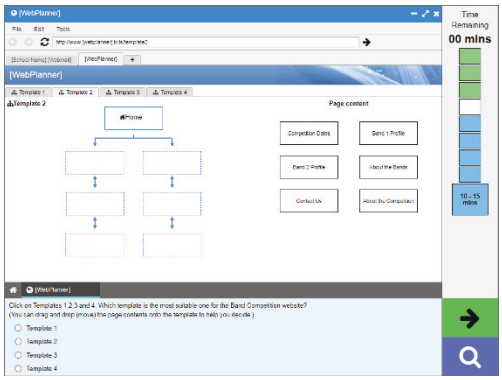
The page content boxes represented the webpages that comprise the band competition website. Students could arrange the page content onto the templates to evaluate the suitability of each template. Each template page had its own set of content boxes which could be arranged independently.

Students that selected Template 3 received credit for this item. On average across all countries, 30 percent of students achieved full credit on this item. The percentages across countries and benchmarking participants varied from 23 to 44 percent.

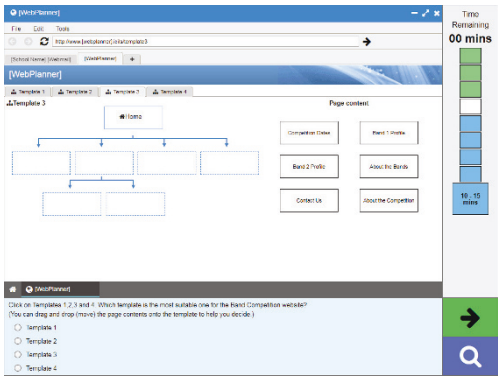
Figure 3.3: Example Item 3 with framework references and overall percent correct



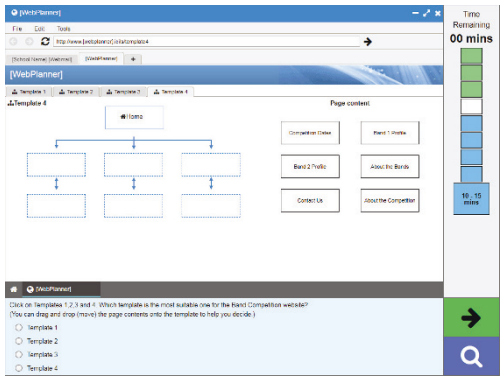
Template 1



Template 2



Template 3



Template 4

Figure 3.3: Example Item 3 with framework references and overall percent correct (contd.)

CIL scale level	CIL scale difficulty	ICILS 2018 average percentage correct responses
3	631	30 (0.5)
Item descriptor		
Compare four website navigation structures and select the most appropriate for given webpage content		
ICILS assessment framework reference		
2.2	Gathering information	
	Managing information	

Country	Percentage of correct responses
Chile	28 (1.7)
Denmark†1	34 (2.2)
Finland	32 (1.6)
France	28 (1.3)
Germany	29 (1.4)
Kazakhstan1	25 (1.8)
Korea, Republic of	35 (1.7)
Luxembourg	27 (0.8)
Portugal††1	36 (1.6)
Uruguay	24 (1.7)
Testing at the beginning of the school year	
Italy	27 (1.5)
Not meeting sample participation requirements	
United States	29 (1.0)
Benchmarking participants meeting sample participation requirements	
Moscow (Russian Federation)	44 (1.8)
North Rhine-Westphalia (Germany)	23 (1.5)

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

1 National defined population covers 90% to 95% of national target population.

Example Item 4 (Figure 3.4) required students to evaluate different issues relating to the publishing of an image on a website. Each of the five issues presented pertained to one of three aspect of content publishing: legal, technical, and social/personal. Students could drag the issues presented in the boxes into the columns to show their answer.

Students received partial credit (one from a possible two score points) if they correctly classified four of the five issues. This level of credit was located at Level 2 on the CIL scale. Students received full credit (two from a possible two score points) if they correctly classified all five of the issues. This level of credit was located at the boundary between Levels 3 and 4 on the CIL scale. On average across all countries, 62 percent of students achieved a score of at least one (i.e., partial or full credit) on this item. The percentages of students achieving a score of at least one across countries and benchmarking participants varied from 37 to 83 percent. On average across all countries, 21 percent of students achieved full credit on this item. The percentages across countries and benchmarking participants varied from 10 to 35 percent.

Figure 3.4: Example Item 4 with framework references and overall percent correct

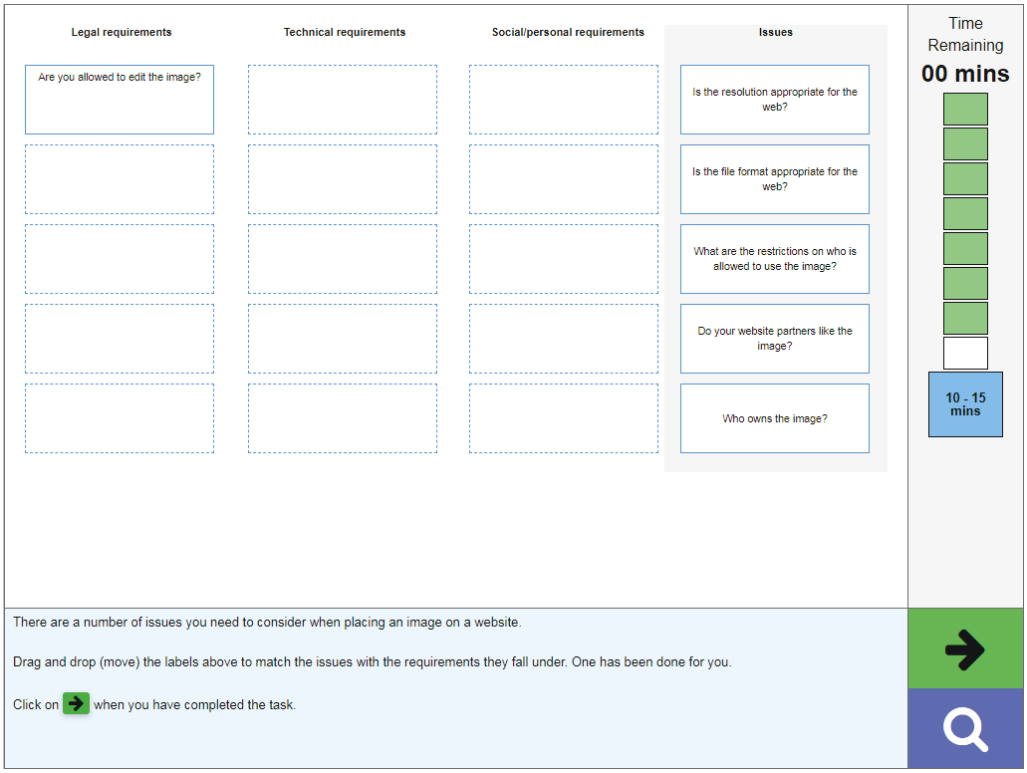


Figure 3.4: Example Item 4 with framework references and overall percent correct (contd.)

Score	CIL scale level	CIL scale difficulty	ICILS 2018 average percentage correct responses
At least one of two points	2	502	62 (1.5)
Two points	4	661	21 (0.4)
Item descriptor (one out of two scale points)			
Recognize four of five distinct legal, technical, and social issues associated with image use on a website			
Item descriptor (two out of two scale points)			
Recognize five distinct legal, technical, and social issues associated with image use on a website			
ICILS assessment framework reference			
4.2	Digital communication		
	Using information responsibly and safely		

Country	Percentage scoring at least one out of two points	Percentage scoring two out of two points
Chile	52 (2.0)	12 (1.4)
Denmark†1	80 (1.6)	27 (1.7)
Finland	77 (1.7)	35 (1.8)
France	58 (1.5)	21 (1.3)
Germany	71 (1.8)	28 (1.6)
Kazakhstan1	37 (1.9)	12 (1.1)
Korea, Republic of	83 (1.4)	25 (1.2)
Luxembourg	55 (1.1)	21 (0.6)
Portugal††1	62 (1.6)	24 (1.5)
Uruguay	46 (2.0)	10 (1.1)
Testing at the beginning of the school year		
Italy	40 (1.6)	16 (1.2)
Not meeting sample participation requirements		
United States	51 (1.1)	20 (1.0)
Benchmarking participants meeting sample participation requirements		
Moscow (Russian Federation)	70 (1.7)	34 (1.6)
North Rhine-Westphalia (Germany)	71 (1.6)	28 (1.6)

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

1 National defined population covers 90% to 95% of national target population.

Example ICILS large-task item

The large task in the band competition test module required students to design a webpage for one of the bands competing in the competition. The page was a sub-page within the band competition website. Students were presented with a description of the task details as well as information about how the task was assessed. This information was followed by a short video designed to familiarize students with the task. The video also highlighted the main features of the software students would need to use to complete the task.

Students saw a task details screen (Figure 3.5) before beginning the band competition large task. Students could view the assessment criteria at any time during their work on the task by clicking the button with magnifying glass icon (Figure 3.6). The criteria presented here were a simplified summary of the detailed criteria used by the expert scorers. The task details screen directed students to create a profile page for the band according to instructions presented in an email using a webpage editor (Figures 3.7 and 3.8).

The band competition large task was presented to students as a blank webpage on which they could create a layout using the software functions. The software functions matched the conventions of basic webpage design applications and included the capability to change the background, change the page border style, add text boxes, add images from an image library, and add icons from an icon library. These software functions were presented as dialogue boxes which included a preview window that students could use to preview their selection before committing the selection to the canvas. The buttons to activate the functions included conventional icons to denote the functionality and were used across all national adaptations of the module. The buttons also included tool tips that described each of the functions and were translated into the language(s) of administration in each country.

The following software functions were available for students to use to create the webpage layout:

- *Change background:* The background dialogue box included a color palette and some styled images suitable for use as a background. Students could style the background as a uniform color from the palette or select one of the images to stretch over the canvas.
- *Borders:* The borders dialogue box included a color palette and style options such as solid, dashed, and line weight (width in pixels).
- *Text:* The text dialogue box presented students with a familiar text editor with conventional text formatting functions. Students could enter text and style any part of the text using font, size, color, bold, italics, underline, alignment, bulleted lists, and numbered lists. When the styled text was added to the canvas the text box element could be moved around the page.
- *Images:* The images dialogue box was a simple gallery of image thumbnails that students could add to the canvas. The images included the band profile photo and band competition logo along with some other generic, primarily decorative images that could likely be found in a typical image library. Images added to the canvas could be moved around the page and resized by dragging the corners or sides of the image's bounding box.
- *Icons:* The icons dialogue box included some simple icons such as a tick, speech bubble, and love heart that could be added to the canvas and manipulated in the same way as the images.

At the top of the screen (see Figures 3.7 and 3.8) were clickable web-browser tabs that allowed the students to toggle between the web-design application and the email with the instructions for creating the webpage. The content of the email included four instructions: add the band's name; add the band's photo; add the band competition logo; and add the description of the band (Figure 3.8). The description of the band was included at the end of the email and could be copied and pasted into a textbox in the webpage editor.

Figure 3.5: Band competition: large task details

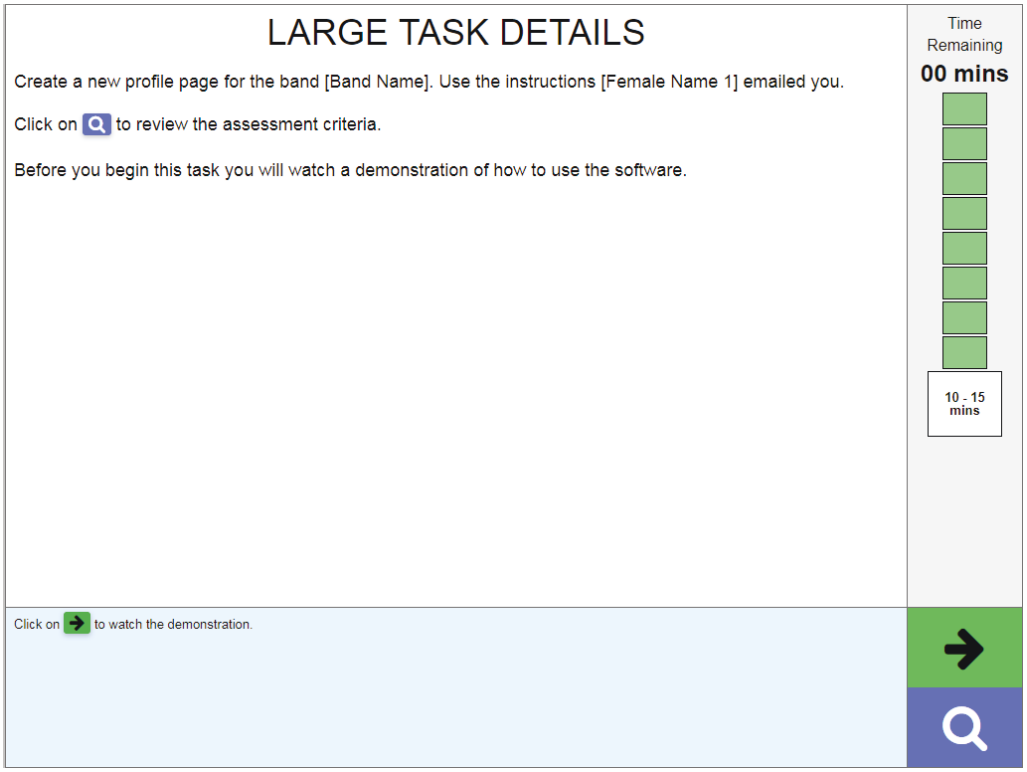


Figure 3.6: Band competition: assessment criteria review

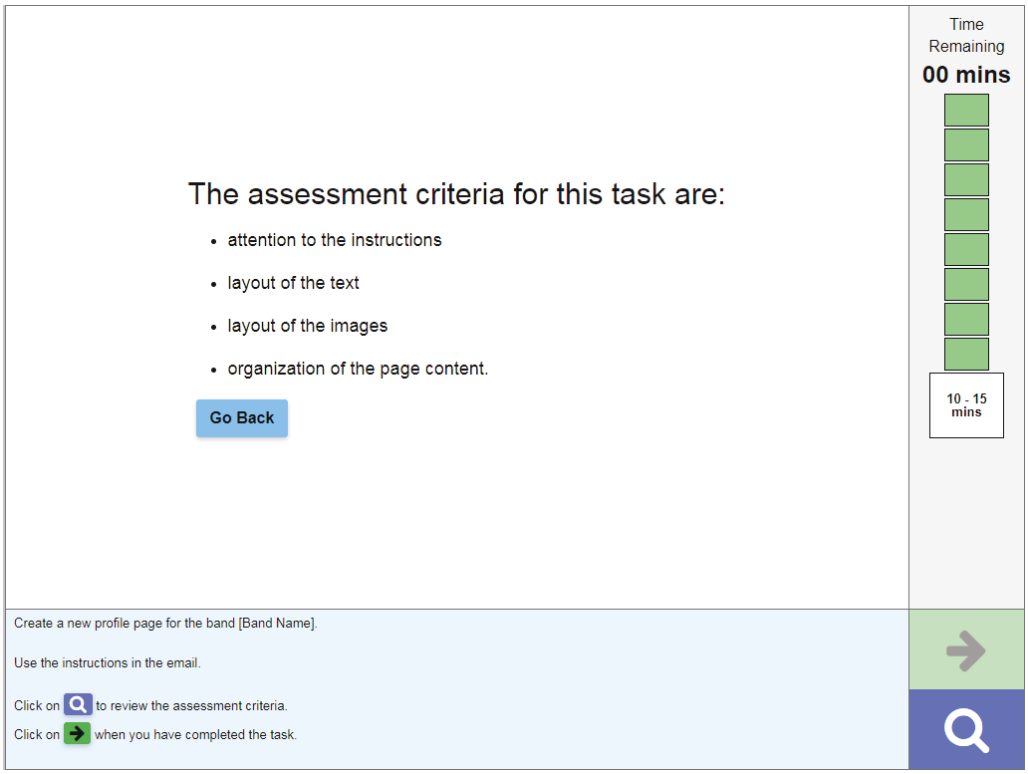


Figure 3.7: Band competition: large task webpage editor software

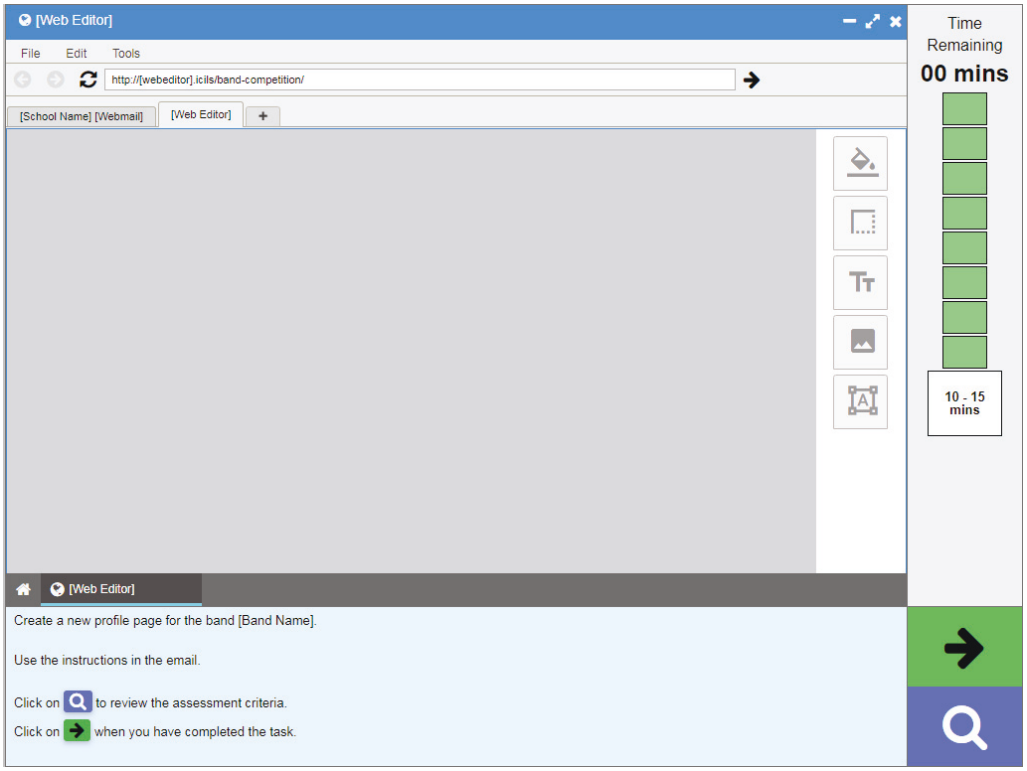
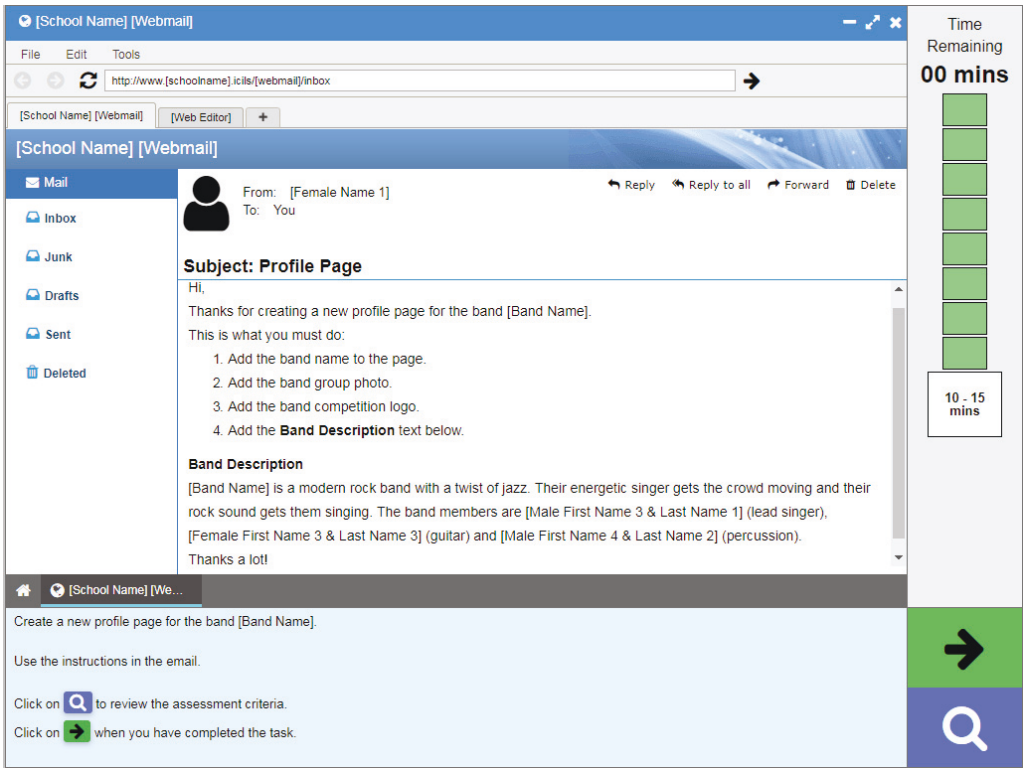


Figure 3.8: Band competition: large task instruction email



When students had completed their webpage, they clicked on the "I've finished" button, an action which saved their webpage as the "final" version. (The test delivery system also completed periodic automatic saves as a backup while students were working on their tasks.) Students then had the option of exiting the module or returning to the large task to continue working.

Once students had exited the module the final version of the webpage was saved in preparation for later scoring by trained scorers within each country. Each webpage was scored according to a set of seven criteria. As was the case for the open response items described previously, data were only included in analyses if they met IEA standards for scoring reliability.

The large tasks in the ICILS test modules were all scored using task-specific criteria. In general, these fell into two categories: technical proficiency and information management. Criteria relating to technical proficiency usually related to elements such as text and image formatting and use of color across the tasks.

Assessment of technical proficiency typically included a hierarchy from little or no control at the lower end, to the use of the technical features to enhance the communicative impact of the work at the higher end. The criteria thus focused on ability to use the technical features for the purpose of communication rather than on simply an execution of skills. Criteria relating to information management centered on elements such as adapting information to suit audience needs, selecting information relevant to the task (or omitting information irrelevant to it), and structuring the information within the task. Some criteria allowed for dichotomous scoring as either zero (no credit) or one (full credit) score points; others allowed for partial credit scoring as zero (no credit), one (partial credit), or two (full credit) score points.

The manifestation of the assessment criteria across the different tasks depended on the nature of each task. For example, information flow or consistency of formatting to support communication in a presentation with multiple slides requires consideration of the flow within and across the slides. The band competition large task comprised a webpage. As such, the scoring criteria related to the necessary elements and content of a webpage.

The scoring criteria used for the band competition's large task are presented according to their levels on the CIL scale and CIL scale difficulties as well as their ICILS 2018 assessment framework references, relevant score category and maximum score, the percentage of all students achieving each criterion, and the minimum and maximum percentages achieved on each criterion across countries (Table 3.3). (Full details of the percentages that students in each country achieved on each criterion appear in Appendix B.)

The design of the large tasks in the ICILS assessment meant that the tasks could be accessed by students regardless of their level of proficiency. The design also allowed students across this range to demonstrate different levels of achievement against the CIL scale, as evident in the levels shown in the scoring criteria (Table 3.3).

Criteria 4, 5, 6, and 7 each occupy a single row because they are dichotomous criteria (scored as zero or one); the description corresponding to a score of one is included for each of these criteria (Table 3.3). Criteria 1, 2, and 3 are partial-credit criteria (scored as zero, one, or two); descriptions corresponding to a score of one and a score of two are included for each of these criteria (Table 3.3). In most cases, the different creditable levels of quality within the partial-credit criteria correspond to different proficiency levels on the CIL scale. For example, the description of a score of one on Criterion 1 is shown at Level 1 (439 scale points) and the description of a score of two on the same criterion is shown at Level 4 (736 scale points).

The lower category for each of two partial-credit scoring criteria for the webpage corresponded to Level 1 on the CIL scale (Table 3.3). These both related to students' control over the role of page elements and reflected students' familiarity with the basic conventions of using one of size,

Table 3.3: Example large-task scoring criteria with framework references and overall percent correct

Level	CIL scale difficulty	Score/ maximum score	ICILS 2018 average percentage of students correct	Maximum percentage achieving criterion	Minimum percentage achieving criterion	Strand	Aspect	Criterion	Descriptor
4	736	2/2	13 (0.3)	19 (1.4)	6 (1.0)	3.2 Producing information	Creating information	1 Logo—Use	Include a logo on a webpage and format its size and location to make its role as an ancillary branding feature of the website clear
3	644	1/1	27 (0.4)	55 (1.8)	2 (0.5)	3.2 Producing information	Creating information	5 Band description text	Transfer specified text from an email to a suitable location on a webpage
3	598	1/1	38 (0.5)	71 (1.6)	15 (1.2)	3.1 Producing information	Transforming information	7 Webpage layout/ alignment	Create a cohesive layout for a webpage
3	586	1/1	41 (0.5)	66 (2.1)	9 (1.2)	3.1 Producing information	Transforming information	6 Band photo and description—Use	Include text and a complementary image on a webpage
2	546	2/2	50 (0.5)	74 (2.2)	9 (1.0)	3.1 Producing information	Transforming information	3 Text—Readability (layout/formatting)	Format and lay out text on a webpage so that it is clear and readable
2	532	1/1	51 (0.5)	78 (1.5)	16 (1.4)	3.2 Producing information	Creating information	4 Text—Contrast	Apply sufficient contrast between text and background colors of most elements on a webpage to support readability
2	526	2/2	56 (0.5)	74 (1.6)	17 (1.6)	3.2 Producing information	Creating information	2 Band name—Use	Format and position text to communicate clearly its role as the title for a webpage
2	510	1/2	61 (0.5)	82 (1.3)	18 (1.5)	3.1 Producing information	Transforming information	3 Text—Readability (layout/formatting)	Format and lay out text on a webpage so that it is generally clear and readable
1	491	1/2	67 (0.4)	87 (1.2)	33 (2.1)	3.2 Producing information	Creating information	2 Band name—Use	Format or position text to communicate its role as the title for a webpage
1	439	1/2	73 (0.5)	87 (1.2)	37 (2.0)	3.2 Producing information	Creating information	1 Logo—Use	Include a logo on a webpage and format its size or location so that it becomes a focal point (rather than an ancillary branding feature) of the page

Notes: Standard errors appear in parentheses.

position, or formatting to denote the prominence of information. For Criterion 1, Logo–Use, 73 percent of students on average across all countries could include the logo as a prominent feature of the webpage. For Criterion 2, Band name–Use, 67 percent of students on average across all countries were able to create a textbox containing the band name and demonstrate some control of the textbox to indicate its role as the title for the webpage. Full credit on this criterion (Band name–Use) was achieved by 56 percent of students on average across all countries. To achieve this, students demonstrated control over the textbox by using both position and formatting to more clearly communicate its role as the title of the webpage representing Level 2 of the CIL Scale.

Three other scoring criteria corresponded to Level 2 achievement on the CIL scale. One of these, Text–Contrast, was dichotomous and appears at Level 2 only. On average across all countries 51 percent of students were able to demonstrate some planning in their use of color and ensure that most text elements in the webpage contrasted sufficiently with the background color to aid readability. The ICILS scoring system automatically generated a suggested score for Text–Contrast based on an adaptation of relevant criteria in the Web Contents Accessibility Guidelines 2.0 (WCAG 2.0; World Wide Web Consortium 2019). The ICILS technical report provides full details of this process (Fraillon et al. 2020). Human scorers reviewed the automatically generated suggested score for each webpage and could either accept or modify the score. Students whose webpages exhibited sufficient color contrast for most text elements to be read clearly received one score point.

Level 2 achievement on the scale was also exemplified by webpages with evidence of the use of the formatting tools (e.g., text size and bolding) to support the readability of text elements (Criterion 3, Text–Readability). Students who could use the formatting tools to support text readability for some elements received one score point while students who could consistently apply formatting to all text elements received two score points. On average across all countries, 61 percent and 50 percent of students achieved one and two score points respectively on this criterion.

At Level 3, students' execution of webpage design shows greater control and independent planning than at Levels 1 and 2. The control over webpage elements typically showed evidence of independent planning extending beyond completion of the procedural aspects of the task. In essence, Level 3 webpages could be considered as complete products that were largely fit for purpose.

Three dichotomous scoring criteria exemplify Level 3 achievement. Each of these criteria required students to demonstrate technical proficiency with an emphasis on information management. Criterion 7, Webpage layout/alignment, required students to include at least two of three specified elements on the webpage[14]: the band competition logo, band description text, and band photo. In addition, students needed to demonstrate control of the overall flow of information by arranging and manipulating the elements to create a harmonious layout. On average across all countries, 38 percent achieved full credit on this criterion.

Criterion 5, Band description text, assessed the accuracy with which students replicated the text describing the band from the email students were provided as part of the task (see Figure 3.8) on to the band webpage. The text could be copied and pasted or (somewhat less efficiently) transcribed from the email to the page. Full credit was awarded on this criterion only when the band description text on the webpage exactly matched that in the email. Students who included the signoff message in the email ("Thanks a lot!") received no credit for this criterion, as the signoff message was deemed to be irrelevant to the webpage. On average across all countries, 27 percent of students achieved full credit on this criterion. Criterion 6, Band photo

14 See Figure 3.8 for the elements described in the email, noting that use of the page title was scored separately.

and description–Use, assessed the degree to which students communicated a clear relationship between the band description text and the band photo on the webpage. This relationship was typically demonstrated by positioning the text and photo close to each other, relative to the other elements on the page. On average across all countries, 41 percent of students achieved full credit on this criterion.

Full credit on Criterion 1, Logo–Use, is an example of Level 4, the highest level of achievement on the CIL scale. Students achieving full credit (two score points) showed careful and deliberate use of position and size to make the role of the band competition logo an ancillary branding feature, rather than a prominent feature, of the webpage. Achievement at this level is evidence of students' understanding the role of the webpage as a subpage of the band competition website and the importance of directing the viewer's attention to the most relevant information given the role of the webpage in the broader context of the website. On average across all countries, 13 percent of students achieved full credit on this criterion.

Comparison of CIL across countries

Distribution of student achievement scores

Across countries, the average student achievement scores on the CIL scale ranged from 395 to 553 scale points, thereby forming a range that spanned a standard of proficiency Below Level 1 to a standard of proficiency within Level 3. This range was equivalent to approximately 1.5 standard deviations (Table 3.4).

Differences in the within-country student score distributions tended to be larger in countries with lower average achievement than in countries with higher average achievement, and the variation in student CIL scores within countries was greater than that across countries (Table 3.4). The distance between the lowest five percent and the highest five percent of CIL scores across countries ranged from 216 to 347 scale points (with a median of 269 scale points), in comparison to a range of average scores across all countries of 157 scale points.

The differences between the average scores of adjacent countries were between two and 18 scale points with the exception of a difference of 55 scale points between the average scores of students in Uruguay and Kazakhstan.

CIL relative to the ICT development index for each country

As additional context, we also calculated the average age of students in ICILS countries and then provide ICT development index (IDI) scores for each country[15] (Table 3.4).

In ICILS 2013, we reported that that higher IDI scores were typically associated with higher CIL scores across countries (Fraillon et al. 2014). In ICILS 2018 the association between CIL achievement and the IDI scores across countries was again strong, with a Pearson's correlation coefficient of 0.72. As in ICILS 2013 it is important to take into account the relatively small number of countries when interpreting these results.

15 The IDI is a composite index that incorporates 11 different indicators relating to ICT readiness (infrastructure, access), ICT usage (individuals using the internet), and proxy indicators of ICT skills (adult literacy, secondary and tertiary enrollment). Each country is given a score out of 10 that can be used to provide a benchmarking measure with which to compare ICT development levels with other countries and within countries over time. Countries are ranked according to their IDI score.

Table 3.4: Country averages for CIL, average age, CIL score, ICT development index score, and percentile graph

Country	Average age of students in years	CIL achievement distribution (100 200 300 400 500 600 700; Below L1 L1 L2 L3 L4)	Average CIL score	ICT development index (IDI) score (and country rank)
Denmark† [1]	14.9		553 (2.0) ▲	8.71 (4)
Korea, Republic of	14.2		542 (3.1) ▲	8.85 (2)
Finland	14.8		531 (3.0) ▲	7.88 (22)
Germany	14.5		518 (2.9) ▲	8.39 (12)
Portugal†† [1]	14.1		516 (2.6) ▲	7.13 (44)
France	13.8		499 (2.3)	8.24 (15)
Luxembourg	14.5		482 (0.8) ▼	8.47 (9)
Chile	14.1		476 (3.7) ▼	6.57 (56)
Uruguay	14.3		450 (4.3) ▼	7.16 (42)
Kazakhstan[1]	14.3		395 (5.4) ▼	6.79 (52)
ICILS 2018 average	14.4		496 (1.0)	
Testing at the beginning of the school year				
Italy	13.3		461 (2.8) ▼	7.04 (47)
Not meeting sample participation requirements				
United States	14.2		519 (1.9)	8.18 (16)
Benchmarking participants meeting sample participation requirements				
Moscow (Russian Federation)[2]	14.8		549 (2.2) ▲	7.07 (45)[2]
North Rhine-Westphalia (Germany)[3]	14.4		515 (2.6) ▲	8.39 (12)[3]

Notes: ICT development index (IDI) score and country rank data relate to 2017 (source: ITU 2019).
Standard errors appear in parentheses. Dotted vertical lines indicate the cut-points between proficiency levels.

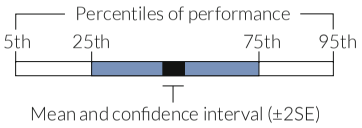
† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

1 National defined population covers 90% to 95% of the national target population.

2 Data relate to all of Russian Federation.

3 Data relate to all of Germany.

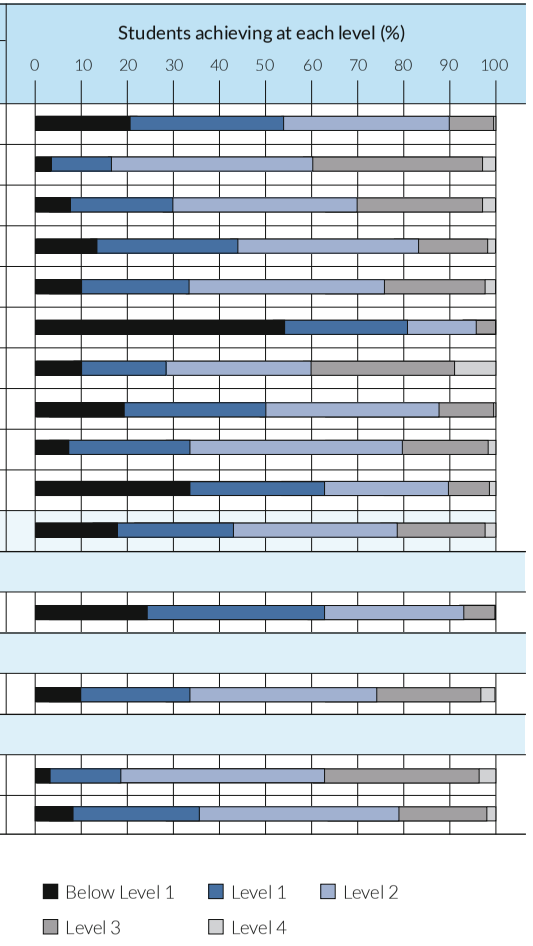


▲ Achievement significantly higher than ICILS 2018 average

▼ Achievement significantly lower than ICILS 2018 average

Table 3.5: Percent of students at each proficiency level across countries

Country	Below Level 1 (less than 407 scale points)	Level 1 (from 407 to 491 scale points)	Level 2 (from 492 to 576 scale points)	Level 3 (from 577 to 661 scale points)	Level 4 (above 661 scale points)
Chile	20 (1.7)	34 (1.3)	36 (1.6)	10 (1.0)	0 (0.1)
Denmark† [1]	3 (0.4)	14 (0.9)	45 (1.3)	36 (1.5)	3 (0.5)
Finland	8 (0.9)	20 (1.1)	43 (1.3)	27 (1.4)	3 (0.4)
France	13 (1.0)	30 (1.2)	40 (1.2)	15 (1.0)	1 (0.2)
Germany	10 (1.1)	23 (1.3)	43 (1.2)	22 (1.1)	2 (0.5)
Kazakhstan[1]	54 (2.1)	27 (1.4)	15 (1.1)	4 (0.8)	0 (0.2)
Korea, Republic of	9 (0.7)	19 (1.2)	32 (1.4)	32 (1.6)	9 (0.8)
Luxembourg	19 (0.5)	32 (0.7)	38 (0.7)	11 (0.4)	0 (0.2)
Portugal†† [1]	7 (0.9)	27 (1.2)	46 (1.1)	19 (1.2)	1 (0.4)
Uruguay	33 (1.6)	29 (1.3)	27 (1.5)	9 (1.0)	1 (0.2)
ICILS 2018 average	18 (0.4)	25 (0.4)	36 (0.4)	19 (0.4)	2 (0.1)
Testing at the beginning of the school year					
Italy	24 (1.3)	39 (1.2)	30 (1.2)	7 (0.7)	0 (0.1)
Not meeting sample participation requirements					
United States	10 (0.6)	24 (0.8)	41 (0.7)	23 (0.8)	2 (0.3)
Benchmarking participants meeting sample participation requirements					
Moscow (Russian Federation)	3 (0.6)	15 (1.2)	44 (1.4)	34 (1.3)	3 (0.4)
North Rhine-Westphalia (Germany)	8 (1.2)	28 (1.4)	44 (1.5)	19 (1.1)	2 (0.4)



Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

[1] National defined population covers 90% to 95% of the national target population.

Achievement across countries with respect to proficiency levels

Across all countries, 80 percent of students achieved scores that placed them within CIL Levels 1, 2, and 3 (Table 3.5). Overall, however, the distribution of student scores across countries and benchmarking participants sits largely within Level 2. The highest percentage of students is in Level 2 in all countries and benchmarking participants except for Uruguay and Kazakhstan.

Although majorities of students in most countries had CIL scores in Level 2, there was some variation in the distribution of percentages across countries. In three countries with the highest percentage of students at Level 4 (Korea, Denmark, and Finland) the proportion of students above Level 2 (i.e., at Levels 3 and 4 combined) is higher than the proportion of students below Level 2 (i.e., at Level 1 or Below Level 1). Across all other countries, the proportion of students above Level 2 is lower than the proportion of students below Level 2.

Trends in CIL achievement

The ICILS 2018 test included three secure CIL test modules from ICILS 2013 comprising 61 items. This meant that we could report student CIL achievement scores for the current ICILS cycle on the scale established in 2013, and also compare changes in CIL achievement across these first two cycles of ICILS. Four of the countries that participated in ICILS 2013 also participated in ICILS 2018. Three of these countries met the necessary sample participation requirements within each cycle to allow valid comparisons of students' CIL achievement across the two cycles.

The differences in average CIL achievement scores in each of the three countries that met the necessary sample participation requirements in each of ICILS 2013 and 2018 were small (11 scale points or less) and not statistically significant (Table 3.6). However, in Chile, the percentage of students achieving at Level 2 or above decreased by seven percentage points between 2013 and 2018 and this difference was statistically significant. The difference in the percentage of students achieving at Level 2 or above in Germany and Korea did not change significantly between 2013 and 2018 (Table 3.6).

Variation in CIL across countries with respect to student background characteristics

In this section we address Research Question CIL 4: What aspects of students' personal and social backgrounds (such as gender and socioeconomic background) are related to students' CIL?

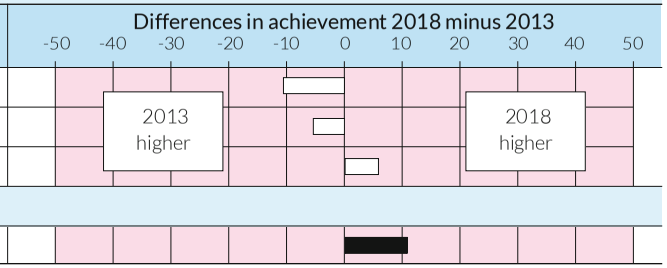
Our focus at this point is on student characteristics that are commonly associated with student achievement as reported in large-scale assessments such as ICILS. In this section we report on the associations between students' CIL and student gender, and between students CIL and variables associated with students' socioeconomic status (SES), whether or not students had an immigrant background, and the language students spoke at home. (See Chapter 7 for a further investigation, based on regression analyses, of the relationships between student CIL and student-level and school-level factors.)

Gender and CIL

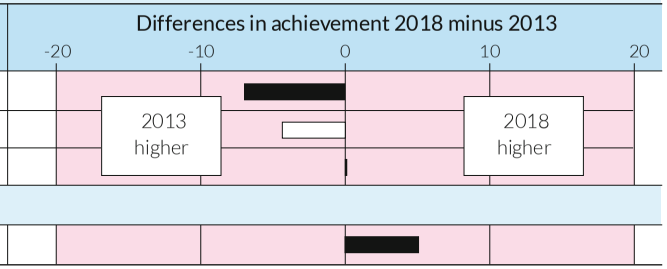
Previous surveys of digital literacies have reported that female students outperform male students. The Australian triennial sample assessments of ICT literacy reported that the average achievement of year 6 and year 10 female students was statistically significantly higher than that of year 6 and year 10 male students in each of 2008, 2011, 2014, and 2017 (ACARA 2018). The US National Assessment of Education Progress sample assessment of Technology and Engineering Literacy reported higher achievement scores for female grade 8 students in ICT in both 2014 and 2018 (US Department of Education, National Center for Education Statistics 2018). In ICILS 2013 it was reported that "the average CIL scale scores of female students were statistically significantly higher than those of male students in all countries except Turkey and Thailand" (Fraillon et al.

Table 3.6: Changes in average CIL achievement scores between 2013 and 2018 and in the percentage of students achieving at Level 2 or above on the CIL scale

Mean CIL achievement scores in ICILS 2013 and ICILS 2018				
Country	**ICILS 2018**	**ICILS 2013**	**Differences between 2018 and 2013**	**Differences in achievement 2018 minus 2013**
Chile	476 (3.7)	487 (3.1)	−11 (6.2)	
Germany	518 (2.9)	523 (2.4)	−5 (5.4)	
Korea, Republic of	542 (3.1)	536 (2.7)	6 (5.6)	
Not meeting sample participation requirements in 2013				
Denmark† [1]	553 (2.0)	542 (3.5)	**11** (5.6)	



Percentage of students achieving at least Level 2 on the CIL scale in ICILS 2013 and ICILS 2018				
Country	**ICILS 2018**	**ICILS 2013**	**Difference between 2018 and 2013**	**Differences in achievement 2018 minus 2013**
Chile	46 (1.8)	53 (1.7)	**−7** (3.2)	
Germany	67 (1.5)	71 (1.6)	−4 (2.6)	
Korea, Republic of	72 (1.5)	72 (1.3)	0 (2.3)	
Not meeting sample participation requirements in 2013				
Denmark† [1]	84 (1.0)	79 (1.9)	**5** (2.5)	



Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent. Statistically signficiant changes ($p < 0.05$) between 2013 and 2018 are shown in **bold**.

† Met guidelines for sampling participation rates in 2018 only after replacement schools were included.

[1] National defined population covers 90% to 95% of national target population.

Difference statistically significant at $p < 0.05$ level

Difference not statistically significant

2014, p. 102) and that in those two countries the difference in performance between male and female students was not statistically significant.

In ICILS 2018, the average CIL scale scores of female students were statistically significantly higher than those of male students in all countries and benchmarking participants except Chile, Uruguay, and North Rhine-Westphalia (Germany). In these three participants, there was no statistically significant difference between the average scores of female students and male students (Table 3.7). On average across all countries, the average score for female students was 505 scale points and for male students it was 488 scale points, an average difference of 18 scale points and equivalent to about one fifth of the ICILS standard deviation.

The magnitude of the statistically significant differences in achievement between female and male students within countries and benchmarking participants ranged from six scale points in Moscow (Russian Federation) to 39 scale points in Korea.[16]

Home background indicators and CIL

Socioeconomic background

Socioeconomic background is a construct regarded as manifest in occupation, education, and wealth (Hauser 1994). While it is widely regarded internationally as an important correlate of a range of learning outcomes (Sirin 2005; Woessmann 2004), there is no scholarly consensus on which measures should be used for capturing family background (Entwistle and Astone 1994; Hauser 1994) and no agreed standards for creating composite measures of SES (Gottfried 1985; Mueller and Parcel 1981). Furthermore, in the context of international studies, there are caveats relating to the validity and cross-national comparability of socioeconomic background measures (Buchmann 2002). In this chapter, our consideration of the influence of socioeconomic background on CIL focuses on within-country associations between indicators of SES and achievement.

In ICILS 2013, "[c]haracteristics reflecting higher socioeconomic status were associated with higher CIL proficiency both within and across countries" (Fraillon et al. 2014, p. 250). To measure and report on socioeconomic background during ICILS 2018, we used responses from the student questionnaire. These related to parental occupational status, parental education, and the number of books in the home, and were the same three socioeconomic background variables used in ICILS 2013.

The ICILS student questionnaire collected data on parental occupational status through questions that allowed students to give open-ended responses. The students' responses were classified according to the International Standard Classification of Occupations (ISCO-08) framework (International Labour Organization 2007). Research indicates relatively high consistencies between data on parental occupation collected from students and from parents (Schulz 2006; Vereecken and Vandegehuchte 2003).

To generate a continuous measure of occupational status, Ganzeboom et al. (1992) coded the ISCO codes in order to derive their international socioeconomic index (SEI). The SEI provides a cross-nationally comparable framework for organizing occupations in a hierarchical order according to their occupational status. We assigned SEI scores to each parent's occupation and then, for each student with two parents, took the higher of the two SEI scores as the indicator score. For students from single-parent families, the one score served as the indicator.

16 The nonsignificant differences were in Chile (eight scale points), Uruguay (five scale points), and North Rhine-Westphalia (Germany) (four scale points).

Table 3.7: Gender differences in CIL

Country	Mean scale score females	Mean scale score males	Difference (females – males)	Gender difference
Chile	480 (4.1)	472 (4.7)	8 (4.8)	
Denmark† [1]	561 (2.2)	545 (2.8)	**16** (3.0)	
Finland	545 (3.2)	516 (3.6)	**29** (3.6)	
France	511 (2.9)	487 (2.8)	**24** (3.3)	
Germany	526 (3.1)	511 (3.6)	**16** (3.3)	
Kazakhstan[1]	399 (5.6)	391 (5.9)	**8** (4.1)	
Korea, Republic of	563 (3.4)	524 (3.9)	**39** (4.3)	
Luxembourg	494 (1.5)	471 (1.3)	**23** (2.3)	
Portugal†† [1]	522 (2.6)	511 (3.2)	**11** (3.0)	
Uruguay	453 (4.9)	448 (4.9)	5 (4.5)	
ICILS 2018 average	505 (1.1)	488 (1.2)	**18** (1.2)	
Testing at the beginning of the school year				
Italy	469 (3.6)	454 (3.1)	**16** (3.7)	
Not meeting sample participation requirements				
United States	531 (2.0)	508 (2.3)	**23** (2.1)	
Benchmarking participants meeting sample participation requirements				
Moscow (Russian Federation)	552 (2.5)	546 (2.7)	**6** (2.7)	
North Rhine-Westphalia (Germany)	517 (3.3)	513 (3.2)	4 (3.8)	

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent. Statistically significant differences ($p < 0.05$) between subgroups are shown in **bold**.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

[1] National defined population covers 90% to 95% of the national target population.

The SEI scale is continuous and ranges from 16 to 90 score points. To describe the parental occupation results in terms of broader categories, we divided the SEI scale into two groups based on international cut-off points. These were "low–medium occupational status" (below 50 score points) and "medium–high occupational status" (50 score points and above).

To measure the educational attainment of each parent (based on the student responses), we used predefined categories denoting educational levels in each country. These categories were constructed with reference to the International Standard Classification of Education (ISCED) and consisted of "ISCED 6, 7, or 8," "ISCED 4 or 5," "ISCED 3," "ISCED 2," and "did not complete ISCED 2" (OECD 1999; UNESCO 2006). When students provided data for both their parents, we used the highest ISCED level as the indicator of parental educational attainment, and when summarizing the association between the highest level of parental education and students' CIL achievement, we used two categories of parental education: "below ISCED 6 (short-cycle tertiary or below)" and "ISCED 6, 7, or 8 (Bachelor's degree or higher)."

As a measure of home literacy resources, we used students' reports of number of books in the home. Number of books was broken down into six categories: "0 to 10 books," "11 to 25 books," "26 to 100 books," "101 to 200 books," and "more than 200 books." When summarizing the relationship between the number of books in the home and students' CIL achievement, we used two categories: "below 26 books" and "26 books and above."

We found statistically significant associations between each of the three socioeconomic background variables and CIL across all countries (Table 3.8). (As a brief explanatory note, the horizontal graphs in these types of tables indicate the magnitude [in CIL scale points], direction, and statistical significance of the differences between the average scores of students in each group. For each of the variables, green bars indicate a statistically significant difference in student CIL in favor of one group, and red bars indicate a statistically significant difference in favor of another group.)

For each of the three socioeconomic background variables in each country, and overall across countries, the average CIL scores of students in the "higher" groups were statistically significantly higher than that of students in the "lower" groups. However, the magnitude of the differences between groups for all three variables varied across countries.

On average across all countries, the difference between students in the highest and lowest parental occupation categories was 36 CIL scale points, with differences ranging from 18 scale points in Korea to 51 scale points in Luxembourg.

The difference between the average CIL scale scores of students in the lower (short-cycle tertiary or below) and in the higher (Bachelor's degree or higher) parental education groups on average across all countries was 31 scale points, with the minimum difference of 15 scale points in Finland and the maximum of 47 scale points in Chile and Uruguay.

Cross-nationally, the difference between the average CIL scale scores of students who reported having 26 or more books at home and those students who reported fewer than 26 books at home on average was 50 scale points, with a minimum difference of 31 scale points in Portugal and a maximum of 63 scale points in Luxembourg.

All three indicators of students' SES contributed to a composite index of SES (this index is included in the multilevel regression analyses presented in Chapter 7).

Table 3.8: Average CIL by category of parental occupation, parental education, and number of books in the home

Country	Average CIL scores by parental occupation (SEI)		Average CIL scores by parental education (ISCED)		Average CIL scores by books in the home	
	SEI below 50	SEI 50 and above	Short-cycle tertiary or below	Bachelor's degree or higher	Below 26	26 and above
Chile	464 (3.4)	**511** (3.7)	465 (4.1)	**512** (4.6)	459 (3.9)	**506** (3.8)
Denmark† [1]	541 (2.8)	**564** (2.1)	546 (2.6)	**566** (2.6)	528 (3.8)	**563** (1.8)
Finland	518 (3.4)	**555** (3.0)	524 (3.7)	**539** (3.7)	500 (4.9)	**544** (2.7)
France	486 (2.8)	**523** (2.9)	492 (2.6)	**522** (3.5)	467 (3.3)	**522** (2.3)
Germany	509 (3.3)	**546** (3.2)	517 (3.8)	**543** (4.4)	476 (7.1)	**536** (2.5)
Kazakhstan[1]	383 (5.3)	**422** (6.4)	380 (5.6)	**422** (6.6)	372 (5.7)	**424** (6.0)
Korea, Republic of	536 (3.3)	**555** (3.7)	526 (4.2)	**548** (3.5)	498 (7.2)	**548** (3.0)
Luxembourg	466 (1.3)	**517** (1.8)	470 (1.4)	**504** (1.5)	437 (1.9)	**500** (1.0)
Portugal†† [1]	505 (3.1)	**534** (2.8)	507 (3.0)	**536** (3.7)	498 (3.6)	**529** (2.6)
Uruguay	444 (3.9)	**490** (5.8)	440 (3.9)	**487** (6.9)	433 (4.2)	**494** (5.7)
ICILS 2018 average	485 (1.1)	**522** (1.2)	487 (1.2)	**518** (1.4)	467 (1.5)	**517** (1.1)
Testing at the beginning of the school year						
Italy	453 (3.0)	**486** (3.8)	453 (3.2)	**482** (3.8)	431 (3.8)	**476** (3.0)
Not meeting sample participation requirements						
United States	507 (2.0)	**545** (2.1)	502 (2.3)	**541** (2.2)	484 (2.7)	**540** (2.0)
Benchmarking participants meeting sample participation requirements						
Moscow (Russian Federation)	536 (3.6)	**557** (2.5)	527 (4.3)	**558** (2.3)	522 (4.4)	**555** (2.5)
North Rhine-Westphalia (Germany)	508 (3.6)	**543** (3.3)	517 (3.5)	**535** (3.8)	482 (4.4)	**533** (2.5)

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent. Score averages that are significantly larger ($p < 0.05$) than those in the comparison group are shown in **bold**. SEI = socioeconomic index.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

[1] National defined population covers 90% to 95% of the national target population.

Difference between comparison groups statistically significant at $p < 0.05$

Immigrant status and language use

Many studies provide evidence of the influence of students' cultural and language background on their educational performance (see, for example, Elley 1992; Kao 2004; Kao and Thompson 2003; Mullis et al. 2007; Stanat and Christensen 2006). Students from immigrant families, especially those families recently arrived in a country, often lack proficiency in the language of instruction and may be unfamiliar with the norms of the dominant culture. Ethnic minorities also tend to have a lower SES, which in turn is often negatively associated with learning and engagement. A number of studies indicate that when socioeconomic background is controlled for, immigrant status and language provide unique predictors of students' literacy achievement (Lehmann 1996).

In ICILS 2013 we reported that the CIL scores in students without immigrant background tended to be higher than those with an immigrant background. Similarly, CIL scores in students who reported speaking the test language at home tended to be higher than those who reported speaking another language at home (Fraillon et al. 2014).

As a means of measuring these aspects of student background, the ICILS student questionnaire asked students about their own and their parents' countries of birth. The questionnaire also asked students to specify which language was spoken most frequently at home.

The question asking where students and their parents were born was first coded to classify each student and any reported parents as "born in country of test" or "not born in country of test." These data were further reduced to form a single variable relating to the student. This variable was coded as "immigrant family" when the student reported all parents[17] as born abroad (regardless of where the student was born) and "non-immigrant family" when at least one parent was born in the country where the survey was conducted. The second question asked students what language they spoke at home most of the time. This variable was coded as "language of test" or "other" for the purpose of the analyses. Nearly all students across most participating countries provided valid responses to these questions.

Students without immigrant backgrounds tended to have higher CIL average scores than those with an immigrant background (Table 3.9). In nine countries and benchmarking participants that met the ICILS technical requirements, the students from non-immigrant family backgrounds had statistically significantly higher average CIL scores than students from immigrant backgrounds. In Chile, Uruguay, and Portugal the difference between the two groups was not statistically significant. On average across countries and benchmarking participants, the difference between students with immigrant backgrounds and those without was 28 CIL scale points. The differences ranged from 19 scale points in Moscow (Russian Federation) to 51 scale points in Finland.

In most participating countries, majorities of students indicated speaking the test language at home. Across countries and benchmarking participants, CIL scores tended to be higher among students speaking the test language at home; the average difference was 38 scale points. For 10 participating countries and benchmarking participants meeting the technical requirements, we recorded statistically significant differences between students speaking the test language and those speaking other languages at home. The statistically significant positive differences ranged from 31 scale points in Luxembourg to 66 in Uruguay.

17 "All parents" refers to both parents when a student reported on the background of two parents or to one parent if the student reported on the background of only one parent.

Table 3.9: Percentages by category of immigrant background and language spoken at home, and comparison of average CIL between categories

Country	Average CIL scores by immigrant backgrond			Average CIL scores by language spoken at home		
	Immigrant family		Non-immigrant family	Other		Language of test
Chile	465	(10.5)	478 (3.5)	426	(17.8)	**478** (3.7)
Denmark† [1]	528	(7.0)	**557** (2.0)	519	(8.1)	**556** (2.0)
Finland	484	(13.4)	**535** (2.8)	489	(8.3)	**535** (2.9)
France	470	(5.6)	**506** (2.2)	452	(9.8)	**506** (2.2)
Germany	494	(7.4)	**531** (3.0)	482	(7.1)	**531** (2.9)
Kazakhstan[1]	375	(10.9)	**400** (5.5)	421	(16.8)	393 (5.2)
Korea, Republic of	^		544 (3.0)	^		543 (3.0)
Luxembourg	470	(1.9)	**495** (1.4)	476	(1.0)	**507** (2.5)
Portugal†† [1]	508	(5.7)	518 (2.8)	513	(8.3)	517 (2.6)
Uruguay	470	(21.1)	453 (4.2)	386	(22.7)	**453** (4.2)
ICILS 2018 average	474	(3.6)	**502** (1.0)	463	(4.2)	**502** (1.0)
Testing at the beginning of the school year						
Italy	444	(6.0)	**464** (3.0)	440	(4.1)	**467** (3.0)
Not meeting sample participation requirements						
United States	501	(7.2)	**522** (1.9)	497	(4.3)	**523** (1.7)
Benchmarking participants meeting sample participation requirements						
Moscow (Russian Federation)	534	(5.9)	**552** (2.3)	509	(8.8)	**551** (2.3)
North Rhine-Westphalia (Germany)	495	(4.5)	**530** (2.9)	484	(5.2)	**530** (2.7)

-100 -80 -60 -40 -20 0 20 40 60 80 100

Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent. Score averages that are significantly larger ($p < 0.05$) than those in the comparison group are shown in **bold**.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

[1] National defined population covers 90% to 95% of the national target population.

^ Number of students too small to report group averages.

Difference between comparison groups statistically significant at $p < 0.05$

Difference between comparison groups not statistically significant at $p < 0.05$

Computers at home and experience using computers

The ICILS 2018 assessment framework explains that the CIL construct assessed in ICILS 2018 was conceptualized with the notion of a computer having sufficient screen size (including available display space) and a keyboard and mouse to support the development of information products that include manipulation of layout elements and the potential for extended text (Fraillon et al. 2019). In ICILS 2018, students were required to complete the CIL test on a device with a minimum screen size of 29 cm and an external keyboard and mouse. While the test could be completed on a tablet device, this was only permitted if the device included an external keyboard and mouse. This conceptual and operational definition of a computer was consistent with ICILS 2013.

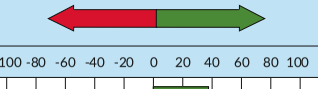
In ICILS 2013, we reported that "students with more computers at home tended to have higher CIL scores" (Fraillon et al. 2014, p. 116) and that students' experience in using computers (in approximate years) was also positively associated with CIL achievement (Fraillon et al. 2014). In ICILS 2018 students were asked to report separately the number of computers (desktop or laptop) and tablet devices (including e-readers) at home as well as the number of years of experience they had using computers and tablet devices. As CIL was conceptualized with the notion of a computer that most closely resembles that defined as desktop or laptop, we report on the relationship between CIL achievement and responses to the two questions (number at home and years of experience using) relating only to desktop or laptop computers. (In Chapter 5, we examine the relationships between CIL and home resources and experience of all digital devices in more detail.)

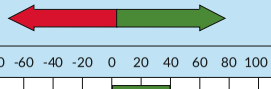
In ICILS 2018, students with more computers at home tended to have higher CIL scores (Table 3.10). On average across countries, the CIL scores of students reporting having two or more computers were 32 scale points higher than those who reported having fewer than two computers at home. This difference ranged from 17 points in Portugal to 48 points in Kazakhstan and was statistically significant in all countries.

Students' years of experience using computers was also positively associated with CIL (Table 3.10). On average, across all countries, the CIL scores of students with five or more years of experience using computers were 32 scale points higher than those with less than five years' experience. The difference was statistically significant in all countries and benchmarking participants except North Rhine-Westphalia (Germany) where the difference was seven scale points. The statistically significant differences ranged from 10 scale points in Germany to 63 scale points in Uruguay.

Table 3.10: Average CIL by category of computer availability at home and years' experience of ICT use

Country	Average CIL by computer availability at home			Average CIL by years' experience of computer use		
	Fewer than two computers		Two computers or more	Less than five years		Five years or more
Chile	457 (4.3)		**492** (3.9)	462 (3.7)		**501** (4.0)
Denmark† [1]	532 (8.1)		**556** (1.9)	543 (2.6)		**562** (2.3)
Finland	513 (3.5)		**539** (3.0)	509 (4.4)		**543** (2.7)
France	480 (3.4)		**510** (2.3)	496 (2.6)		**507** (2.4)
Germany	495 (7.5)		**534** (2.7)	519 (4.0)		**529** (3.3)
Kazakhstan[1]	383 (5.5)		**431** (6.7)	377 (5.3)		**438** (6.5)
Korea, Republic of	526 (3.4)		**554** (3.8)	519 (3.4)		**566** (3.7)
Luxembourg	455 (2.8)		**492** (1.1)	479 (1.2)		**490** (1.6)
Portugal†† [1]	508 (3.4)		**524** (2.8)	502 (2.8)		**525** (3.0)
Uruguay	439 (4.5)		**476** (4.7)	430 (4.1)		**493** (5.0)
ICILS 2018 average	479 (1.6)		**511** (1.1)	484 (1.1)		**515** (1.2)
Testing at the beginning of the school year						
Italy	453 (3.7)		**473** (2.9)	452 (3.3)		**480** (3.2)
Not meeting sample participation requirements						
United States	492 (2.8)		**535** (2.0)	502 (2.2)		**538** (2.1)
Benchmarking participants meeting sample participation requirements						
Moscow (Russian Federation)	534 (3.7)		**557** (2.2)	535 (4.3)		**554** (2.1)
North Rhine-Westphalia (Germany)	500 (4.6)		**530** (2.5)	518 (3.3)		525 (4.1)





Notes: Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent. Score averages that are significantly larger ($p < 0.05$) than those in the comparison group are shown in **bold**.

† Met guidelines for sampling participation rates only after replacement schools were included.

†† Nearly met guidelines for sampling participation rates after replacement schools were included.

[1] National defined population covers 90% to 95% of the national target population.

Difference between comparison groups statistically significant at $p < 0.05$

Difference between comparison groups not statistically significant at $p < 0.05$

References

ACARA. (2012). *National Assessment Program—ICT literacy years 6 and 10 report 2011*. Sydney, Australia: Australian Curriculum, Assessment and Reporting Authority. Retrieved from https://www.nap.edu.au/_resources/NAP_ICTL_2011_Public_Report_Final.pdf.

ACARA. (2018). *NAP sample assessment ICT literacy years 6 and 10 November 2018*. Sydney, Australia: Australian Curriculum, Assessment and Reporting Authority. Retrieved from https://www.nap.edu.au/docs/default-source/default-document-library/2017napictlreport_final.pdf?sfvrsn=2

Binkley, M., Erstad, E., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining 21st century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17–66). Dordrecht, The Netherlands: Springer. Retrieved from http://dx.doi.org/10.1007/978-94-007-2324-5_2.

Buchmann, C. (2002). Measuring family background in international studies of education: Conceptual issues and methodological challenges. In A. Porter, & A. Gamoran (Eds.), *Methodological advances in cross-national surveys of educational achievement* (pp. 150–197). Washington, DC: National Academy Press. Retrieved from https://www.nap.edu/read/10322/chapter/7#153.

Dede, C. (2009). *Comparing frameworks for 21st century skills*. Cambridge, MA: Harvard Graduate School of Education.

Elley, W. B. (1992). *How in the world do students read?* The Hague, The Netherlands: International Association for the Evaluation of Educational Achievement (IEA). Retrieved from https://www.iea.nl/publications/study-reports/international-reports-iea-studies/how-world-do-students-read.

Entwistle, D. R., & Astone, N. M. (1994). Some practical guidelines for measuring youth's race/ethnicity and socioeconomic status. *Child Development*, *65*, 1521–1540.

Fraillon, J., Ainley, J., Schulz, W., Duckworth, D., & Friedman, T. (2019). *International Computer and Information Literacy Study 2018 assessment framework*. Cham, Switzerland: Springer. Retrieved from https://www.springer.com/gp/book/9783030193881.

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). *Preparing for life in a digital age: The IEA International Computer and Information Literacy Study international report*. Cham, Switzerland: Springer. Retrieved from https://www.springer.com/gp/book/9783319142210.

Fraillon, J., Schulz, W., Friedman, T., & Meyer, S. (Eds.). (2020). *IEA International Computer and Information Literacy Study 2018 technical report*. Amsterdam, The Netherlands: International Association for the Evaluation of Educational Achievement (IEA). Manuscript in preparation.

Ganzeboom, H. B. G., de Graaf, P. M., & Treiman, D. J. (1992). A standard international socioeconomic index of occupational status. *Social Science Research*, *21*(1), 1–56.

Gottfried, A. (1985). Measures of socioeconomic status in child development research: Data and recommendations. *Merrill-Palmer Quarterly*, *31*(1), 85–92.

Hauser, R. M. (1994). Measuring socioeconomic status in studies of child development. *Child Development*, *65*, 1541–1545.

International Labour Organization. (2007). *International Standard Classification of Occupations: ISCO-2008*. Geneva, Switzerland: Author.

ITU. (2019). IDI 2017 rank [webpage]. Geneva, Switzerland: International Telecommunications Union. Retrieved from https://www.itu.int/net4/ITU-D/idi/2017/index.html.

Kao, G. (2004). Social capital and its relevance to minority and immigrant populations. *Sociology of Education*, *77*, 172–183.

Kao, G., & Thompson, J. S. (2003). Racial and ethnic stratification in educational achievement and attainment. *Annual Review of Sociology*, *29*, 417–442. Retrieved from https://www.annualreviews.org/doi/abs/10.1146/annurev.soc.29.010202.100019.

Lehmann, R. (1996). Reading literacy among immigrant students in the United States and former West Germany. In M. Binkley, K. Rust, & T. Williams (Eds.), *Reading literacy in an international perspective: Collected papers from the IEA Reading Literacy Study* (pp. 101–114). Washington, DC: National Center for Education Statistics (NCES).

Mueller, C. W., & Parcel, T. L. (1981). Measures of socioeconomic status: Alternatives and recommendations. *Child Development*, *52*(1), 13–30.

Mullis, I. V. S., Martin, M. O., Kennedy, A., & Foy, P. (2007). *PIRLS 2006 international report: IEA's Progress in International Reading Literacy Study in primary schools in 40 countries*. Chestnut Hill, MA: TIMSS &

PIRLS International Study Center, Boston College. Retrieved from https://timss.bc.edu/PDF/PIRLS2006_international_report.pdf.

OECD. (1999). *Classifying educational programmes: Manual for ISCED-97 implementation in OECD countries*. Paris, France: Author.

Rasch, G. (1960). *Probabilistic models for some intelligence and attainment tests*. Copenhagen, Denmark: Nielsen & Lydiche.

Schulz, W. (2006). Measuring the socioeconomic background of students and its effect on achievement in PISA 2000 and PISA 2003. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA, April 7–11, 2006. Retrieved from https://files.eric.ed.gov/fulltext/ED493510.pdf.

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, *75*(3), 417–453.

Stanat, P., & Christensen, G. (2006). *Where immigrant students succeed: A comparative review of performance and engagement in PISA 2003*. Paris, France: OECD.

UNESCO. (2006). *ISCED 1997: International standard classification of education* (Revised ed.). Paris, France: UNESCO Institute of Statistics.

US Department of Education, National Center for Education Statistics. (2018). NAEP Report Card: Technology & Engineering Literacy (TEL): Highlights from the 2018 assessment [webpage]. Washington, DC: Author. Retrieved from https://www.nationsreportcard.gov/tel_2018_highlights/.

Vereecken, C., & Vandegehuchte, A. (2003). Measurement of parental occupation: Agreement between parents and their children. *Archives of Public Health*, *61*, 141–149.

Von Davier, M., Gonzalez, E., & Mislevy, R. (2009). What are plausible values and why are they useful? In M. von Davier, & D. Hastedt (Eds.), *IERI Monograph Series: Issues and Methodologies in Large-Scale Assessments*, *Volume 2* (pp. 9–36). Hamburg, Germany/Princeton, NJ: International Association for the Evaluation of Educational Achievement (IEA)/Educational Testing Service (ETS). Retrieved from http://www.ierinstitute.org/fileadmin/Documents/IERI_Monograph/IERI_Monograph_Volume_02_Chapter_01.pdf.

Woessmann, L. (2004). *How equal are educational opportunities? Family background and student achievement in Europe and the United States* (IZA Discussion Paper 1284). Bonn, Germany: Institute for the Study of Labor (IZA). Retrieved from http://ftp.iza.org/dp1284.pdf.

World Wide Web Consortium. (2019). Web content accessibility guidelines 2.0, W3C World Wide Web Consortium recommendation March, 2016 [webpage]. World Wide Web Consortium. Retrieved from http://www.w3.org/TR/WCAG20/.