CHAPTER 2

Computer and information literacy framework

2.1 Overview

The ICILS CIL framework was initially developed for ICILS 2013. At the time, it was noted that there was a variety of terms relating to CIL in the research literature (see, for example Virkus 2003) and that the development of context-specific constructs related to CIL had led to a proliferation of frequently overlapping and confusing definitions (Fraillon et al. 2013, p. 15). Since the development of ICILS 2013, the range of concepts associated with students' use of digital technologies has further increased. For example, Siddiq et al. (2016, p. 60) listed nine different names for "concepts for describing what and how students acquire, use, adapt to and learn with technology," ranging from "internet skills" through to "21st century skills"; these include the ICILS 2013 conceptualization of CIL. This evolving breadth of conceptualizations of competencies associated with the use of digital technologies is, in part, a function of the range of local contexts (including local curriculum needs) as countries develop their own approaches to having students both learn how to use digital technologies and use digital technologies to support learning across other domains.

When the CIL construct was first defined and described for use in ICILS 2013, it was necessary to locate CIL within the existing broad suite of constructs related to digital literacy and to clearly articulate the scope of the CIL construct. The reasoning underpinning this process is outlined in detail in the ICILS 2013 assessment framework (Fraillon et al. 2013). The following is a summary of the key decisions in this process with some reflection on their continued relevance for ICILS 2018.

The CIL construct was formulated during a period when there was a tension in the research literature between beliefs in the need to develop new constructs to describe and measure new skills being demonstrated with changes in technology and beliefs that the new skills should be assimilated into existing constructs. This tension is ongoing, and was described by Voogt and Roblin (2012, pp. 301–302) in their comparative analysis of international frameworks for 21st century skills as an "ongoing controversy on whether these terms are actually used to designate new competences, or rather to give greater emphasis to a specific set of long known competences that are considered as especially relevant to the knowledge society."

One of the conceptual challenges for ICILS 2013 was to decide whether the construct of CIL should address a new set of competencies or emphasize its connection to existing ones. The research team, in consultation with external experts, eventually opted for the second approach.

Furthermore, the ICILS conceptualization of CIL needed to take into account two fundamental parameters of ICILS:

- ICILS targets school-aged children (in their eighth year of schooling)
- The assessment is completed using computers and focuses on computer use.

The second of these parameters has necessitated the establishment of a working definition of *computer* for ICILS. In the final decades of the 20th century, the predominant concept of the computer associated with school-aged children was either as a desktop or laptop computer (but not a smartphone or tablet). These devices could be used for a range of educational purposes, including but not limited to: program development, use of productivity tools (such as word processing or spreadsheet tools), tuition applications, art and design tools, data collection, the conduct of simulations, and searching for information (such as from an encyclopedia). As the

J. Fraillon et al., *IEA International Computer and Information Literacy Study 2018 Assessment Framework*,
https://doi.org/10.1007/978-3-030-19389-8_2

internet evolved, many learning and information resources became internet delivered rather than residing on personal devices or local networks, and electronic communication was added to the suite of activities associated with computer use in schools. In the early part of the 21st century, the concept of the computer in education has broadened, largely due to the proliferation of portable digital technologies, in particular tablet devices and smartphones, which can access the internet and run applications (see, for example, Hwang and Tsai 2011; Martin and Herzberger 2013). In particular, the ICILS 2018 study team had to determine how best to accommodate the use of tablet devices, which, since the inception of ICILS 2013, have become increasingly prevalent in schools and are now part of the discourse relating to ICT use in schools.

For ICILS, the concept of the computer was developed with reference to the primary use of the device in the context of education rather than with reference to the size and portability of the device. However, in doing this, it was acknowledged that the properties of a device do impact on the purposes for which it can best be used. Haßler et al. (2016), following an extensive literature review of reported use of tablet devices in school, suggested that:

> "Unsurprisingly, certain technologies are more appropriate for particular tasks than others and this is also true when considering uses for tablets: for example, keyboards, larger screens and specialized software (perhaps only available for certain operating systems) may be needed to support specialized tasks such as extensive writing, mathematical constructions and computer programming" (Haßler et al. 2016, p. 148).

The ICILS test of CIL contains tasks that require students to act as both information consumers and producers. While tablet devices are well suited for information consumption, the conclusions of Haßler et al. (2016) suggest that information production tasks are best performed on tablet devices with sufficiently large screens to manage layout. Screen size can be considered in terms of both the physical size of the screen and the available space on the screen. For tablet devices, the latter is maximized by the use of an external keyboard, which consequently prevents an on-screen keyboard from displaying and greatly reducing the visible screen space. For ICILS 2018, the concept of the *computer* was operationally defined as any device able to run the assessment software with a minimum screen size of 29cm and an external keyboard and mouse. This included conventional desktop computers, portable computers and tablet devices with an external keyboard and mouse.

For ICILS 2018, the CIL construct was consequently conceptualized with reference to this concept of computer rather than the broader device contexts implicit (although not always measured in practice) in constructs relating to digital literacy, ICT literacy, and digital competence (Carretero et al. 2017; Janssen and Stoyanov 2012; MCEECDYA 2010; Pangrazio 2016; Wilson et al. 2015).

The CIL construct also embraced information literacy (for a discussion of this in contrast to media literacy see Fraillon et al. 2013, p. 16), which emphasizes the processes of information management including the evaluation of the veracity of information (Catts and Lau 2008; Christ and Potter 1998; Livingstone et al. 2008; Ofcom 2006; Peters 2004).

At the time ICILS 2013 was in its planning and development stage, the concept of 21st century skills was emerging as an umbrella term to account for skills that are broadly regarded as necessary for successful participation in life, work and education in the 21st century. Definitions of and conceptualizations of 21st century skills in the research literature are varied, but largely influenced by six prominent frameworks (Chalkiadaki 2018). Some scholars have attempted to identify the common elements of the broad suite of 21st century skills. For example, van Laar et al. (2017, p. 583) listed core 21st century digital skills as: technical; information management; communication; collaboration; creativity; critical thinking; and problem solving. They further listed contextual 21st century digital skills as: ethical awareness; cultural awareness; flexibility; self-direction; and lifelong learning. Chalkiadaki (2018, p. 6) classified 21st century skills into four sets: personal skills; interpersonal and social skills; knowledge and information management

skills; and digital literacy. What is common across the different conceptualizations of 21st century skills is that they comprise a broad range of skills that typically include a sub-set of skills common to CIL as defined in ICILS, but also extending well beyond the reach of what can be assessed in a study such as ICILS. CIL should be regarded as fitting neatly under the broader umbrella of 21st century skills, but with a focus on one of its dimensions.

ICILS was established to investigate the competencies associated with computer and information literacies as the enabling components of digital competence and representing aspects of the broader suite of 21st century skills. The ICILS research team developed the CIL construct independently of specific curriculum goals; the construct focused on what Lampe et al. (2010, p. 62) referred to as technology-mediated educational priorities for middle-school students. These include finding and synthesizing relevant resources, connecting to people and networks, and knowing how to present and express oneself online in general and through online systems in particular.

2.2 Defining computer and information literacy

ICILS defined CIL for use in ICILS 2013 with reference to definitions and constructs associated with information literacy and computer literacy. Information literacy constructs developed first through the fields of librarianship and psychology (Bawden 2001; Church 1999; Homann 2003; Marcum 2002) and are acknowledged as having the following processes in common: identifying information needs, searching for and locating information, and evaluating the quality of information (Catts and Lau 2008; Livingstone et al. 2008; UNESCO 2003). Information literacy constructs evolved to include the ways in which the collected information can be transformed and used to communicate ideas (Catts and Lau 2008; Peters 2004).

Early conceptualizations of *computer literacy* in education typically focused not on the logical reasoning of programming (or the syntax of programming languages) but rather on declarative and procedural knowledge about computer use, familiarity with computers (including their uses), and, in some cases, attitudes toward computers (Richter et al. 2000; Wilkinson 2006). Since that time, the concept of CT has gained increasing prominence across education systems, with perhaps some of the inevitable "definitional confusion" (Grover and Pea 2013, p. 38) that comes with new (or renewed) curriculum areas. While ICILS acknowledges that, conceptually, CT may be included in the broader concept of computer literacy (see, for example, diSessa 2000), ICILS 2018 distinguishes the functional aspects of computer literacy that support the use of digital devices when managing digital information from the problem solving and algorithmic thinking features of computer literacy that are core to CT. The former are part of the CIL construct established in the first ICILS cycle in 2013, while the latter are part of the CT construct developed for ICILS 2018 as an international option.

The assumption that information is received, processed, and transmitted underlies the CIL construct. Computer literacy constructs typically attribute less importance than is attributed by information literacy constructs to the nature and constituent parts of the information processing that happens between reception and transmission. In essence, computer literacy focuses on a more direct path between reception and transmission than information literacy, which emphasizes the processual steps involved as information is evaluated and transformed (Boekhorst 2003; Catts and Lau 2008). Over time, the originally distinct constructs of computer literacy and information literacy converged into a broader dimension reflecting ICT literacy and digital literacy.

Some scholars have emphasized the potential for information literacy and ICT skills to develop independently of each other. Catts and Lau (2008, p. 7) observed that "people can be information literate in the absence of ICT," and Rowlands et al. (2008, p. 295) commented that "the information literacy of young people, has not improved with the widening access to technology: in fact, their apparent facility with computers disguises some worrying problems." The CIL skills

measured and reported on in ICILS, however, address computer literacy skills in the context of information literacy as applied to digital information sources. They reflect a combination of skills that, given the pervasiveness of digital information, continue to have a high profile in contemporary frameworks. For example, as mentioned already, the revised DigComp framework (DigComp 2.0) described digital competence in terms of five competences: information and data literacy; communication and collaboration; digital content creation; safety; and problem solving (Vuorikari et al. 2016). The US NAEP TEL framework also described ICT proficiency in terms of five, albeit different, sub-areas: construction and exchange of ideas and solutions; information research; investigation of problems; acknowledgement of ideas and information; and selection and use of digital tools (NAGB 2013).

The definition of CIL established for ICILS 2013 was derived with reference to pre-existing definitions of ICT and digital literacy that illustrated the convergence between information literacy and computer literacy skills in practical real-world applications.

These definitions were:

- "ICT literacy is using digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (ETS 2002, p 2).
- "ICT literacy is the ability of individuals to use ICT appropriately to access, manage and evaluate information, develop new understandings, and communicate with others in order to participate effectively in society" (MCEETYA 2007, p. 14).
- Digital literacy is "… the ability to use digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (Lemke 2003, p. 22).

Common to these definitions is the assumption that individuals have the technical skills needed to use the technologies. All three definitions also list very similar sets of information literacy and communication processes. Each also maintains that individuals need to acquire these forms of literacy in order to participate and function effectively in society. Binkley et al. (2012, p. 52) postulated six categories under which ICT literacy knowledge, skills, attitudes, values and ethics can be classified: access and evaluate information and communication technology; analyze media; create media products; use and manage information; apply technology effectively; and apply and employ technology with honesty and integrity.

The definition of CIL established in ICILS 2013 and maintained as the definition in ICILS 2018 is:

> Computer and information literacy refers to 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.

This definition relies on, and brings together, technical competence (computer literacy) and intellectual capacity (conventional literacies including information literacy) to achieve a highly context-dependent communicative purpose that presupposes and transcends its constituent elements. This view of CIL is congruent with Audunson and Nordlie's (2003) conceptual model of information literacy and is most closely aligned with the ICT literacy construct evident in the first of the ICT and digital literacy definitions cited above.

2.3 Revising the structure of the computer and information literacy construct

According to the ICILS 2013 assessment framework (Fraillon et al. 2013), CIL was described as comprising two strands each of which was specified in terms of a number of aspects.

Strand 1 collecting and managing information comprises three aspects:

- Aspect 1.1: Knowing about and understanding computer use
- Aspect 1.2: Accessing and evaluating information
- Aspect 1.3: Managing information.

Strand 2 producing and exchanging information comprises four aspects:

- Aspect 2.1: Transforming information
- Aspect 2.2: Creating information
- Aspect 2.3: Sharing information
- Aspect 2.4: Using information safely and securely.

The structure described above did not presuppose an analytic structure although, at the time of its development, the ICILS research team anticipated the possibility that Strands 1 and 2 might lead to separate measurement dimensions. Analyses of the ICILS 2013 main survey data included an investigation of the dimensionality (for details regarding the analytic approach see Gebhardt and Schulz 2015) but the very high latent correlations between the two strands led to the decision to report CIL achievement as a single dimension.

Following ICILS 2013, the project team together with ICILS 2013 national researchers evaluated the CIL construct with reference to its use throughout the full life-cycle of study. While the content of the construct was deemed to be appropriate, they identified potential improvements that could be made to the structure of the CIL construct. Firstly, positioning *knowing about and understanding computer use* (Aspect 1.1) within Strand 1 (the receptive strand) and *using information safely and securely* (Aspect 2.4) within Strand 2 (the productive strand) was problematic because it undermined the stated acknowledgement that each of these aspects was applicable across both the receptive and productive strands. At the time the CIL construct was specified this problem was acknowledged with the caveat that the aspects were included in the strands in which they were deemed to have the greatest applicability. However, on reflection, the ICILS research team decided that it would be better to remove any implication that either aspect was better associated with receptive or productive skills.

Furthermore, in a time of increasing opportunity for young people to act as information creators and publishers, it became apparent that Aspect 2.3 (*sharing information*) should be afforded greater prominence in the structure of the CIL construct.

In response to these concerns, and in consultation with ICILS national researchers, the project team established a revised structure for the CIL construct for ICILS 2018. It is important to note that the restructuring of the CIL construct was undertaken to better communicate the contents and emphases of the construct and to minimize overlap across the aspects of the construct. The change in structure neither means a change in ICILS assessment content nor presupposes a change to the analytic structure of the CIL construct.

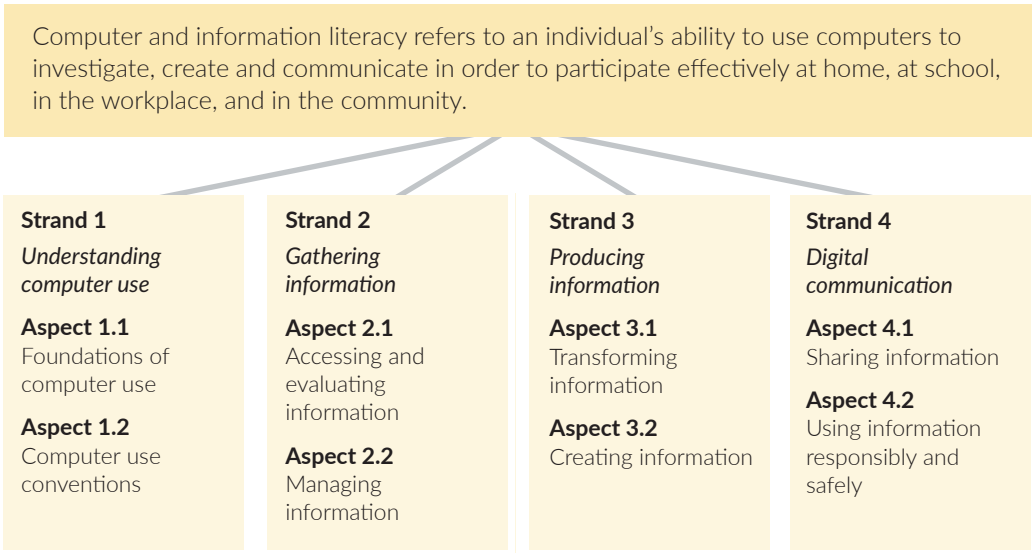
2.4 Structure of the ICILS 2018 computer and information literacy construct

The CIL construct includes the following elements:

- Strand: This refers to the overarching conceptual category for framing the skills and knowledge addressed by the CIL instruments.
- Aspect: This refers to the specific content category within a strand.

The construct comprises four strands, which each contain two aspects (summarized in Figure 2.1 and described in detail in section 2.5). The aspects encompass the set of knowledge, skills, and understandings held in common by the range of definitions of ICT literacy and digital competency discussed previously.

Figure 2.1: ICILS 2018 CIL framework



2.5 Strands and aspects of computer and information literacy

2.5.1 Strand 1: Understanding computer use

Understanding computer use refers to the fundamental technical knowledge and skills that underpin the operational use of computers as tools for working with information. This includes a person's knowledge and understanding of the generic characteristics and functions of computers. Early constructs of ICT and digital literacies typically focused on the receptive and productive elements of information literacy and de-emphasized generic computing technical knowledge and skills (see, for example, ETS 2002). However, it soon was acknowledged that fundamental knowledge and skills when using technology could be blended with information literacy in conceptualizations of ICT literacy (see Catts and Lau 2008), and ICILS 2013 included understanding computer use as an aspect of CIL to reflect the evolution of the domain (Fraillon et al. 2013). The role of basic technological skill in digital literacy continues to be prevalent. The DigComp 2.1 framework included skills associated with solving technical problems and identifying needs and technological responses as part of the problem solving competence area (Carretero et al. 2017). The 2014 US NAEP TEL framework included ICT as a major area of assessment and "understanding technological principles" as a practice. Understanding technological principles "focuses on students' knowledge and understanding of technology and their capability to think and reason with that knowledge" (NAGB 2013, p. 10) and the constituent understanding and reasoning is deemed to be applicable across all areas of TEL.

Understanding computer use comprises two aspects:

- Foundations of computer use
- Computer use conventions.

Aspect 1.1 Foundations of computer use

Foundations of computer use includes the knowledge and understanding of the principles underlying the function of computers rather than the technical detail of exactly how they work. This knowledge and understanding underpins effective and efficient computer use including basic troubleshooting. At a declarative level, a person should know that computers use processors and memory to run programs, or that operating systems, word processors, games, and viruses are examples of programs. They should be able to demonstrate knowledge that computers can be connected and so can "communicate" with one another through networks, and that these can be local or global. They should understand that the internet is a form of computer network that is run through computers and that websites, blogs, wikis, and all forms of computer software are designed to meet specific purposes. They should further be aware that information (such as files) can be stored across a range of locations including locally on a device, on removable devices (such as USB drives, SD cards and portable hard drives), and on local or remote networks (such as in cloud storage), and be aware that the range of storage locations are associated with a range of user benefits, risks and procedures.

The following examples reflect tasks that provide evidence of an individual's knowledge and understanding of the foundations of computer use:

- identifying that computers require physical memory, and that this is finite but may be expanded
- suggesting basic strategies to improve the performance of a computer that is running slowly
- explaining why the content of a completed web-based form might be lost if a user navigates away from the page and then returns to the page
- recognizing strategies to identify the part of a computer network that might be malfunctioning if a network connection has been lost.

Aspect 1.2 Computer use conventions

Computer use conventions include the knowledge and application of the software interface conventions that help computer users make sense of and operate software. This knowledge supports the efficient use of applications, including the use of devices or applications that are unfamiliar to the user. Accordingly, at the procedural level, a person may know how to execute basic, generic file and software functions, such as opening and saving files in given locations, resizing images, copying and pasting text, and identifying file types by their extensions, or modifying settings such as screen resolution or enabling accessibility options. The procedural knowledge included in Aspect 1.2 is thus limited to generic basic commands that are common across software (including operating system) environments.

The following examples reflect tasks that provide evidence of an individual's ability to apply computer use conventions:

- Editing an image using an interface with icons and controls that follow software interface conventions
- Clicking on a hyperlink to navigate to a web-page
- Saving an existing file to a new location with a new name
- Opening a file of a specified type
- Adding users to a collaborative web-based workspace.

2.5.2 Strand 2: Gathering information

Gathering information embraces the receptive and organizational elements of information processing and management. This strand comprises two aspects:

- Accessing and evaluating information
- Managing information.

Aspect 2.1: Accessing and evaluating information

Accessing and evaluating information refers to the investigative processes that enable a person to find, retrieve, and make judgments about the relevance, integrity, and usefulness of computer-based information. The proliferation of information sources that use the internet as a communication medium means that users are required to filter the vast array of information to which they gain access before they can make use of it. However, the process of filtering, in combination with the increasing intuitiveness of computer-based information search programs[3], is producing an ever greater integration of the processes of accessing and evaluating information. For this reason, accessing and evaluating information are regarded as sufficiently integrated to warrant their inclusion as a single aspect, rather than as separate aspects, of the digital information dimension of the CIL construct.

The importance of accessing and evaluating information is also a direct result of the increasing quantity and range of available unfiltered computer-based (and delivered) information. Computer-based information is not only increasing in volume, but also is constantly changing. While accessing and evaluating information are rooted in conventional literacies, the dynamic multimedia and multimodal nature of computer-based information means that the processes of accessing and evaluating that contribute to the CIL construct are different from those that relate only to conventional literacies. The dynamic context of computer-based information therefore necessitates the use of an amalgam of a range of skills (i.e., those typically associated with digital and media literacies) that differ from, and are broader than, the range employed with conventional literacies.

The following examples reflect tasks that provide evidence of an individual's ability to access and evaluate computer-based information:

- Selecting information from within a website or file list that is relevant to a particular topic
- Describing and explaining the functions and parameters of different computer-based information search programs
- Suggesting strategies for searching for information and/or adjusting the parameters of searches to target information better
- Recognizing and explaining characteristics of computer-based information (such as hyperbole and unsubstantiated claims) that detract from its credibility
- Recognizing that published information may serve other purposes than simply the sharing of information
- Suggesting and implementing strategies to verify the veracity of information (such as cross-checking information from multiple sources).

Aspect 2.2: Managing information

Managing information refers to the capacity of individuals to work with computer-based information. This information can be in the form of files that can be stored and opened using applications for later use or data that can be organized within files (such as data within fields in a database). The process of managing information includes ability to adopt and adapt information classification and organization schemes in order to arrange and store information so that it can

3 These include search engines that tailor search results to individual searchers based on location, previous search behavior, and even internet-use behavior of "friends" in a social network.

be used or reused efficiently. Managing information can include applying procedures to make use of alternative file storage locations (such as local, local or remote network or cloud-based locations) to support user access and to back-up information to protect against loss.

The following examples reflect tasks that provide evidence of an individual's ability to manage information:

- Creating a file structure in a directory according to given parameters
- Sorting or filtering information on an internet database
- Explaining the use of tags when storing images in an image library
- Recognizing the most efficient data structure for a given purpose within a simple database.

2.5.3 Strand 3: Producing information

This strand, which focuses on using computers as productive tools for thinking and creating, has two aspects:

- Transforming information
- Creating information.

Aspect 3.1: Transforming information

Transforming information refers to a person's ability to use computers to change how information is presented so that it is clearer for specific audiences and purposes. This process typically involves using the formatting, graphics, and multimedia potential of computers to enhance the communicative effect or efficacy of (frequently text-based or numerical) information.

The following examples reflect tasks that provide evidence of an individual's ability to transform information:

- Reformatting the titles in a document or presentation so as to enhance the flow of information
- Using, modifying, or creating images to supplement or replace text in a document (such as with a flow chart or diagram)
- Creating a chart to represent a table of data
- Transferring data (such as temperature or velocity data) from a data logger and displaying it in ways that illustrate patterns of change
- Creating a short animated sequence of images to illustrate a sequence of events.

Aspect 3.2: Creating information

Creating information refers to a person's ability to use computers to design and generate information products for specified purposes and audiences. These original products may be entirely new or may build upon a given set of information to generate new understandings.

Typically, the quality of information created relates to how the content is structured (whether or not the flow of ideas is logical and easy to understand) and the way in which layout and design features (such as images and formatting) are used to support understanding the resulting information product. Even though information design and layout design are executed together in an information product, they are typically conceptualized and assessed as discrete elements of creating information.

The following examples reflect tasks that provide evidence of an individual's ability to create information:

- Using a simple graphics program to design a birthday card
- Designing and writing a presentation that explains the key elements of an historical event
- Using a given set of information to make recommendations in a report that integrates text, data, and graphics.

2.5.4 Strand 4: Digital communication

Digital communication focuses on the competencies associated with information sharing in social networking (and broader web-based information sharing space) together with the social, legal and ethical responsibilities associated with information sharing. This strand includes responsibilities associated with information production, as well as mechanisms for protection against improper use of information by others. This strand has two aspects:

- Sharing information
- Using information safely and securely.

Aspect 4.1: Sharing information

Sharing information refers to a person's understanding of how computers are and can be used, as well as his or her ability to use computers to communicate and exchange information with others. Sharing information focuses on a person's knowledge and understanding of a range of computer-based communication platforms, such as email, wikis, blogs, instant messaging, sharing media, and social networking websites. Given the rapidly changing nature of this area, Aspect 4.1 focuses on knowledge and understanding of information-based social conventions and, at the higher end of the achievement spectrum, the social impact of sharing information through computer-based communication media.

The following examples reflect tasks that provide evidence of an individual's ability to share information:

- Recognizing some key differences between computer-based communication media
- Using software to disseminate information (such as attaching a file to an email or adding or editing a social media post)
- Evaluating the appropriateness of information for a specified audience
- Evaluating the best communication platform for a particular communicative purpose
- Creating or modifying information products to suit a specified audience and purpose.

Aspect 4.2: Using information responsibly and safely

Using information responsibly and safely refers to a person's understanding of the legal and ethical issues of computer-based communication from the perspectives of both the publisher and the consumer. Internet-based communication platforms increasingly are providing the facility for users to share information. With this facility comes the potential for misuse, particularly when dealing with personal information. Using information safely and securely also includes risk identification and prevention, as well as the parameters of appropriate conduct, including awareness of and prevention of cyberbullying. It furthermore focuses on the responsibility of users to maintain a certain level of technical computer security, such as using strong passwords, keeping virus software up to date, and not submitting private information to unknown publishers.

The following examples reflect content and contexts relating to responsible and safe use:

- Identity theft
- Unauthorized access and impersonation
- Identity concealment
- Phishing
- Malicious software distribution
- Automatic collection of internet usage data
- Social network posts
- Provision and use of personal information
- Attribution and copyright.

The following examples reflect tasks that provide evidence of an individual's ability to use information safely and securely:

- Identifying the characteristics that influence the strength of passwords
- Explaining the consequence(s) of making personal information publicly available
- Describing protocols for appropriate behavior on a social media site
- Suggesting ways to protect private information
- Understanding how internet advertising targets users
- Explaining the techniques used in a phishing email scam.