Measuring Computer and Information Literacy across Countries

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Abstract

This paper describes the properties and content of the Computer and Information Literacy (CIL) achievement scale based on the responses of 8933 students from 20 countries to the International Computer and Information Literacy (ICILS) field trial test items. The paper briefly outlines the process of generating the described scale before presenting and examining the substance of the scale. The scale is based on data from the 83 test items used in the ICILS field trial. The described scale comprises four discrete described achievement levels that are further articulated by examples of achievement. Key aspects of the cognitive differences between the levels are discussed and some questions are raised about the way in which the achievement of students below Level 1 and at or above Level 5 will be dealt with in the main survey.

Keywords: *ICILS, Computer and Information Literacy, ICT, Achievement Scale, Progress Map*

Introduction

The purpose of the International Computer and Information Literacy Study (ICILS) is to 'investigate, in a range of countries, the ways in which young people are developing computer and information literacy (CIL) to support their capacity to participate in the digital age' (Fraillon, Ainley & Schulz, forthcoming). The study will be based on data collected from a suite of international instruments with reference to the study's Assessment Framework (Fraillon, Ainley & Schulz, forthcoming). The instruments comprise a computer-based student test, a student questionnaire, teacher, school ICT-coordinator and principal questionnaires, and a survey of the overarching context for CIL education in each participating country.

Recent decades have seen rapid developments in information and computer technologies (ICT) with concomitant reductions in the cost of computing devices. Together these factors have contributed to the current (and increasing) pervasiveness of the use of ICT in societies across the world. Many countries have recognized the importance of education and training in ICT to provide citizens with the necessary skills to access information and participate in transactions through these technologies (Kozma, 2008). In ICILS, these skills are measured as CIL, which is defined 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 the community' (Fraillon, Schulz and Ainley, Forthcoming).

The ICILS student test of CIL has been developed to assess the contents of the ICILS Assessment Framework (Fraillon, Schulz & Ainley, forthcoming). According to the framework, CIL comprises two strands each of which is 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; and
- 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; and
- Aspect 2.4: Using information safely and securely.

The strands describe CIL in terms of its two main purposes (receptive and productive) and the aspects further articulate CIL in terms of the main (but not exclusive) constituent processes used to address purposes. This structure is used primarily as an organisational tool to ensure that the full breadth of the construct is included in its description and to make clear the nature of the construct. The ICILS framework does not presuppose that CIL will necessarily be a multidimensional construct.

In early 2012, 20 countries participated in the field trial of the ICILS instruments. This paper focuses on ICILS field trial data from the test instrument that will be used to measure the CIL achievement of students within and between countries.

Methodology and Data Sources

Data sources

The described achievement scale presented in this paper is based on data from the field trial data analysis for ICILS which was carried out in 20 participating countries between February and May 2012. In each country a minimum of 25 schools were selected with 20 students then randomly selected from the target grade. The target grade corresponds to the eighth year of schooling provided that the minimum age of students is 13.5.

The ICILS test instrument comprised questions and tasks delivered in 30 minute modules. In total there were four test modules and each student completed two of these modules. The modules were randomly allocated to students according to a fully balanced rotated design.

A test module is a set of linked questions and tasks built around an authentic theme and driven by a plausible narrative. Each module had a series of five to eight smaller tasks (that each typically take students less than one minute to complete) leading up to a single large task. The large tasks required students to create an information product (such as a presentation or website) and were designed to take 15 to 20 minutes to complete.

The field trial test data were derived from the responses of 8933 students to 68 tasks which made up 83 score points. Forty-two of the score points were generated by tasks that were automatically scored (such as multiple choice questions (MCQ) and the execution of simple basic computer commands) and 41 score points were generated by tasks that required scoring by trained scorers in each country. These latter tasks comprised a mixture of short-constructed response tasks (in which the students would typically write one or two sentences) and criterion-based scoring of aspects of the information products generated in response to the large tasks.

Data Analysis

One parameter (Rasch) IRT was used for scaling the test items. A number of analyses were conducted as part of the scaling process (for further details of these see Schulz and Sibberns, 2004).

Constructing the Scale

Item descriptors were written for each item (or each score category in the case of partial-credit items). These item descriptors detail the CIL knowledge, skills and understandings (with reference to the ICILS Assessment Framework) demonstrated by a student correctly responding to the item. When paired with the scaled threshold (difficulty) of the matching item, the item descriptors can be ordered to produce a scaled item map.

The usefulness of this item map is limited because the item content is a "sample" of all possible items that could be used to assess CIL knowledge skills and understandings and because the specificity of the item descriptors can make it difficult for readers to generalise about student achievement across the scale. The solution to these problems is to identify what is common (both in the content and the processes) within different sections (levels) of the scale and to create summary descriptions of the levels of achievement. These summary level descriptors can then be illustrated by examples of the test items to ensure common understandings of the nature of achievement at each level on the scale.

It must be remembered that the process of constructing levels is a somewhat artificial division of a continuous scale into discrete elements. The number, breadth (in scale points) and positioning of the levels ideally depends only on the substantive congruence of the items

within the levels. However, at a practical level the accepted approach is to consider levels of equal breadth (in terms of difficulties) such that differences between levels represent differences in the substance of what students can do. The final process of identifying and describing the content of the achievement levels is typically a balance between the substantive and empirical content of the scale. The empirical aspect of this process relies both on the distribution of items and of student achievement across the scale and can also be established in terms of the response probability (RP) of the scale (OECD, 2005). The substantive aspect of this process relies on judgment of the conceptual similarity of items grouped within levels.

Based on the substantive and empirical analysis of the item map and student data, the levels of the ICILS draft achievement scale were set to be 0.8 logits wide with category boundaries at -1.3, -0.5, 0.3 and 1.1 logits.

Findings and Discussion

Empirical Achievement Scale

Figure 1 shows the person item distribution map for the 80 score points and approximately 9,000 students in the ICILS field trial. The digits on the left edge of Figure 1 are scale points (in logits) for the CIL ability/ difficulty scale. Each number to the right of the vertical dashed line represents an item used to construct the described scale. The vertical positions of the items represent the scaled difficulty of the item. The different score categories (1 or 2) for the open-ended response items are shown by the suffix ".1" or ".2", for example "48.2" refers to the score code 2 for item 48. The "X"s to the left of the vertical dashed line show the distribution of student achievement on the scale. The horizontal lines on the picture indicate the approximate positions of the level categories established from the field trial data and item descriptors. Because the contents of the ICILS instruments are still secure, the item descriptors used to construct the scale have not been included in this paper.

<Insert Figure 1 here>

Broadly, Figure 1 shows that the test is well targeted with the difficulties of the items listed on the right largely matching the distribution of student abilities on the left. Figure 1 also shows that the bulk of the students and items are located within levels 1, 2, 3 and 4 on the achievement scale. Currently a "Below Level 1" category has been allocated. From Figure 1 it can be seen that only six items are in this category and a small percentage of students are achieving at this level. This observation will be discussed in greater detail later in this paper. The item locations shown in Figure 1 together with their descriptors were used to compile the draft described ICILS cognitive achievement scale.

Draft Described Achievement Scale

Table 1 contains the draft described achievement scale based on the ICILS field trial data. Six levels of achievement have been defined and each level is further described through examples of student achievement on the test indicative of each level.

<Insert Table 1 here>

The draft described achievement scale explicates the development of CIL proficiency demonstrated in the ICILS field trial. The scale is hierarchical in the sense that CIL student achievement progresses up the scale and the scale is developmental with the assumption that any given student is most likely to also be able to demonstrate achievement of the content below his or her measured level of achievement. This section will further describe the underlying characteristics of the levels shown in Table 1, and speculate on the fundamental differences between achievement at each level and achievement of the levels above each given level. Ultimately, such differences could inform pedagogies aimed at supporting student learning to progress through the levels.

Students working at Level 1 of the scale 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 recognise some basic conventions used by electronic communications software and demonstrate awareness of fundamentals of information security. A key factor that differentiates Level 1 from achievement below Level 1 is the size and breadth of the range of fundamental software commands used by students. It is unlikely that such students below Level 1 would be able to generate digital information products. Key factors that differentiate Level 1 achievement from that of higher levels are the degree to which students can independently search for information and plan their information use.

Students working at Level 2 demonstrate basic use of computers as information resources. They locate explicit information in simple electronic resources, select and add content to information products, and begin to control layout and formatting of text and images in information products. Key factors that differentiate Level 2 achievement from that of higher levels are the degree to which students work autonomously and with an evaluative perspective on information they access and use.

Students working at Level 3 make selective, purposeful judgements about the information they use. They edit and create information products using conventionally recognised software functions with controlled layout and design. Key factors that differentiate Level 3 from achievement at the higher levels 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 judgement when searching for information and creating information products. They demonstrate awareness of audience and purpose when searching for information, when selecting information to include in information products and in the formatting and layout of information products they create. Key factors that differentiate performance at Level 4 from Level 5 are the efficiency of student information searches and the overarching coherence of their information products with respect to audience and purpose.

Level 5 represents the highest level on the described scale and could be regarded as an aspirational achievement level for students in the target grade. A very small number of students demonstrated achievement at this level. Students working at Level 5 use software features to make information searching faster and more efficient. They demonstrate awareness of context-specific layout conventions when creating information products and adapt information to suit audience and purpose. Students working at Level 5 are discerning users of ICT to collect information and communicate with others.

Conclusion and Implications

The draft described achievement scale and examples give substance to the empirical student achievement data collected in the ICILS field trial. The draft scale represents a model of process and substance for the development of a described student achievement scale for the ICILS main survey. Analysis of the field trial data indicated that the 83 items used to describe this scale represent a uni-dimensional achievement construct. It is possible that the ICILS main survey data may support the identification and reporting of CIL subscales. This question will be revisited in light of the ICILS main survey data. The draft described scale contains five levels.

One further question highlighted by the described scale and field trial data relates to the students achieving at the extreme ends of the scale (below Level 1 and at or above Level 5). This is not a unique problem in international studies in which the achievement range of students across countries is often far greater than it is practical to target with a finite set of assessment items allocated to students independently of any preconceptions of the matching of item difficulties to students' abilities. Overall, the targeting of the ICILS achievement items to the students appears to be very good, and the achievement of the great majority of students can be well described using the 83 field trial items. It would of course be possible to shift the position and alter the width of the achievement levels based on the main survey data, although any such changes must also be supported by the substance of the items in the scale. There is

also a question of whether, if there is a very small proportion of students achieving at or above Level 5, there is any value in reporting student achievement at this level separately from that of Level 4.

Based on the experience of the ICILS field trial it appears that the cognitive test items and student data will provide ample resources for the construction of a described student CIL scale that will account for the achievement of the bulk of students in all countries. Ideally such a described scale will be used both to understand better the nature of student CIL achievement and to assist in the planning and provision of educational resources and programs to contribute to the ongoing challenge of improving CIL achievement outcomes.

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Tables and Figures

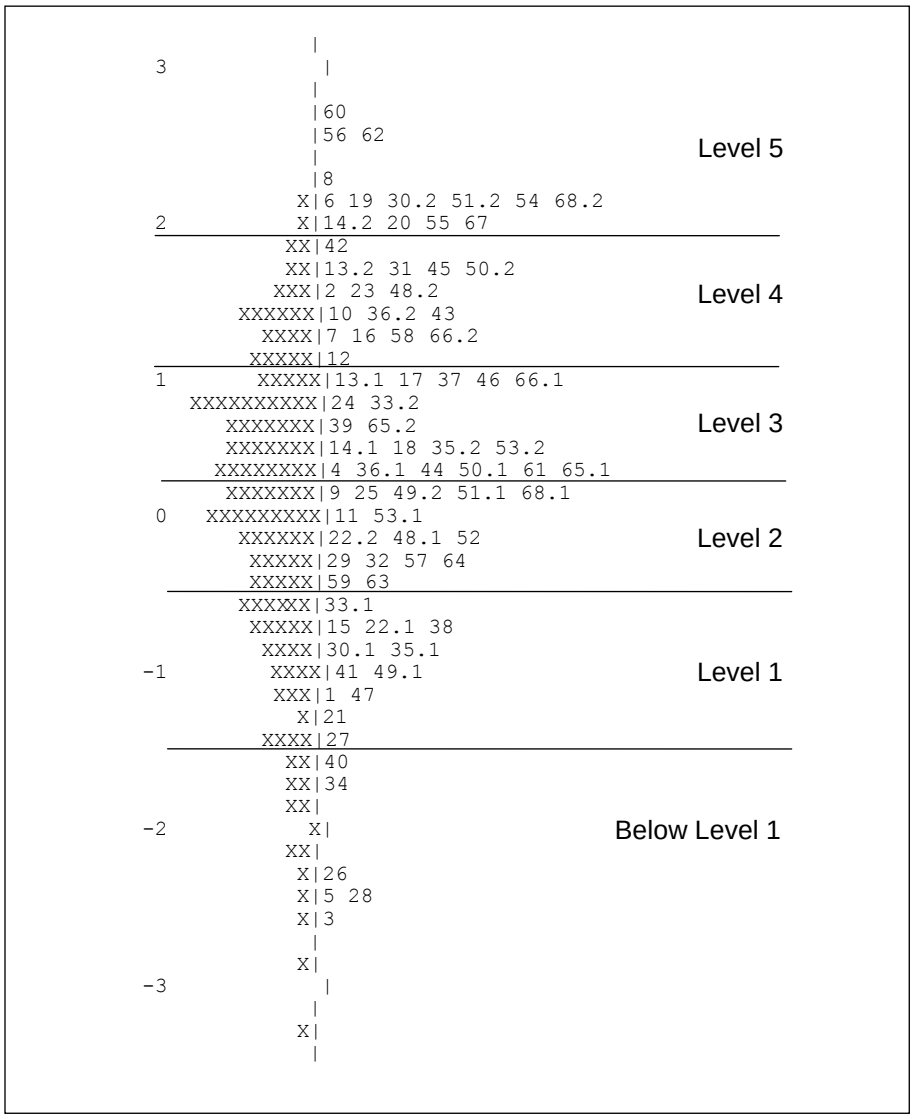

Figure 1: Person/Item Distribution Map for ICILS Field Trial including Draft Levels

Table 1: Draft ICILS described cognitive achievement scale based

Level 5 Students working at level 5 use simple software features to increase the efficiency of information searches and select the most relevant information to use for specific communicative purposes. They create information products that show clear evidence of planning and technical competence. They use software features to reshape and present information consistent with presentation conventions and area aware of different categories of problems that can arise regarding the use of propietrory information on the internet.	Students working at Level 5, for example: ▪ show clear control of the design and layout text in a poster; ▪ adpat text from sources to suit an specified audience and purpose; ▪ select relevant images from electronic sources to demonstrate a simple process; ▪ demonstrate clear control to balance the layout of text and images on an information sheet; ▪ select, from a large set, a search result that meets two requisite search criteria; ▪ apply filtering features to increase the efficiency of a search; ▪ select and adapt source information to create a poster with persuasive purpose; and ▪ recognises the difference between legal, technical and social requirements when using images on a website.
Level 4 Students working at level 4 generate refined, well target searches for information and evaluate the reliability of information based on its content and likely origin. They create information products that demonstrate consideration of audience and communicative purpose.	Students working at Level 4, for example: ▪ create a website page to match a given set of instructions; ▪ demonstrate clear control of colour to support the communicative purpose of a presentation; ▪ generate search terms that target specific attributes of the desired search results. ▪ demonstrate clear control of text layout when creating a presentation; ▪ use generic mapping software to represent

	text information as a map route; ▪ evaluate the reliability of information provided on a commercial website; and ▪ identify that a generic greeting in an email indicates that the sender does not know the recipient.
Level 3 Students working at Level 3 demonstrate some autonomy when using computers as information gathering and management tools. They select the best information source to meet a specific purpose, retrieve information from given electronic sources to answer specific, concrete questions and follow instructions to use conventionally recognized software commands to edit and reformat information products. They recognise that the credibility of web-based information is relient on the creators of the information.	Students working at Level 3, for example: ▪ distinguish between paid and organic search results on a search engine; ▪ include all specified necessary information on a web-page; ▪ create and implement an appopriate title design for a poster; ▪ evaluate the reliability of information presented on a crowdsourced website; ▪ select an appropriate website navigation structure for given web page content; ▪ create a balanced layout of a webpage; ▪ recognise the purpose of a captcha form; ▪ save a presnetation with a new filename; and ▪ select relevant information according to given criteria to include in a website.
Level 2 Students working at Level 2 use computers as tools to complete very basic and explicit information gathering and management tasks. They locate simple, explicit information from within given electronic sources and add content to and make simple	For example, students working at level 2: ▪ insert information to a specified cell in a spreadsheet; ▪ use software to crop an image; ▪ locate explicitly stated information on website pages;

changes to existing information products when instructed. They edit information products and create products that show limited consistency of design and information management.	▪ select relevant images to include in a presentation; ▪ select some relevant information from web-based sources to include in a presentation; ▪ demonstrate basic control of text layout and colour use when creating a presentation; and ▪ explain a potential problem if a personal email address is publicly available.
Level 1 Students working at Level 1 demonstrate a functional working knowledge of computers as tools to complete tasks. They implement the most commonly used file management and software commands when instructed. They apply conventional software commands to perform basic communication tasks and demonstrate awareness of prortecting privacy of electronic information.	Students working at Level 1 for example: ▪ recognize that there are different file types used by computers; ▪ add given text to a web-document; ▪ demonstrate basic control of layout of images and text when adding content to a simple web-document; ▪ identify who receives an email by carbon copy (Cc); ▪ relate passowrd complexity to password security; ▪ suggest a risk of failing to log out from a user account when using publicly accessible computer.