EQUATING FROM A NATIONAL TO AN INTERNATIONAL ASSESSMENT

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ABSTRACT

Australia will be a participant in the inaugural IEA International Computer and International Literacy Study (ICILS) and, at a national level, Australia has been involved in a National Assessment Project in Information and Communication Technology Literacy (NAP-ICTL) that has taken place every three years since 2005. The assessments of ICILS and NAP-ICTL are very similar in nature. However, the assessments are targeted at different year levels (Year 8 in ICILS versus Year 6 and Year 10 in NAP-ICTL) and the two assessments do not have common tasks.

In order to link the assessments, two modules from the NAP-ICTL assessment were included in the Australian ICILS field trial. This provided a unique opportunity to investigate equating a national to an international assessment. The equating procedure consisted of four steps and resulted in a plausible growth curve from Year 6 to Year 10 on the international ICILS scale. This suggests that similar equating steps can be applied to equate the NAP-ICTL 2011 scale to the official ICILS 2013 main study scale. As a result, a wider range of skills can be described along the proficiency scale as well as more accurate growth patterns. Equating to the ICILS main study will enable exploring the performance of Year 6 and Year 10 Australian students from ICT literacy when benchmarked against the international ICILS assessment scale.

Key words: test equating, item response theory, computer and information literacy, large-scale assessment, international assessment

INTRODUCTION

Information and Communication Technology (ICT) has had wide ranging impacts across many areas of society, in the workplace, at home and in schools. ICT skills are necessary to become an active participant in a technology-based and knowledge-intensive society.

The Australian Education Ministers acknowledged the place of technology in society and the necessity "to enable all young people to engage effectively with an increasingly complex world. This world will be characterised by advances in information and communication technologies" (MCEETYA, 1999). The commitment of the Australian Governments to ensure young Australians have the necessary skills and knowledge to fully participate in society was further recognised in the declaration of the educational goals for young Australians. Two goals were identified with the aim of achieving higher standards in Australian education. One of the goals was that "all young Australians become successful learners, confident and creative individuals, and active and informed citizens" (MCEETYA, 2008, p.8), and that successful learners "have the essential skills in literacy and numeracy and are creative and productive users of technology, especially ICT, as a foundation for success in all learning areas" (MCEETYA, p.8).

The National Assessment Project for Information and Communication Technology Literacy (NAP-ICTL) was developed to monitor and report progress of ICT literacy towards the achievement of goals for young Australian, on a nationally comparable basis. On an international scale, International Association for the Evaluation of Educational Attainment (IEA) has previously surveyed information technology in the Computers in Education Survey and the Second Information Technology in Education Study (SITES), and is currently assessing computer and information literacy in the International Computer and Information Literacy Study (ICILS).

NATIONAL ASSESSMENT PROJECT FOR ICT LITERACY[1]

NAP-ICTL is a national sample assessment that assesses the confidence, creativity and skill development in the use of ICT literacy-related competencies, for students at Year 6 and Year 10. The first assessment took place in 2005 and is repeated every three years so that changes over time can be measured. NAP-ICTL adopted the MCEETYA (2005) definition of ICT literacy as *the ability of individuals to use ICT appropriately to access, manage, integrate and evaluate information, develop new understandings, and communicate with others in order to participate effectively in society* (as cited in ACARA, 2012, p. 3).

The NAP-ICTL framework comprises a set of six integrated key processes: accessing information, managing information, evaluating, developing new understandings,

[1] Information about ICT Literacy has been taken from the *National Assessment Program ICT Literacy Years 6 and 10 Report 2011*.

communicating and using ICT appropriately. NAP-ICTL is assessed in relation to three ICT literacy processes:

- working with information
- progressing from (1) using key words to retrieve information from a specified source, through (2) identifying search question terms and suitable sources, to (3) using a range of specialised sourcing tools and seeking confirmation of the credibility of information from external sources
- creating and sharing information
- progressing from (1) using functions within software to edit, format, adapt and generate work for a specific purpose, through (2) integrating and interpreting information from multiple sources with the selection and combination of software and tools, to (3) using specialised tools to control, expand and author information, producing representations of complex phenomena
- using ICT responsibly
- progressing from (1) understanding and using basic terminology and uses of ICT in everyday life, through (2) recognising responsible use of ICT in particular contexts, to (3) understanding the impact and influence of ICT over time and the social, economic and ethical issues associated with its use

As in previous assessment cycles, the assessment instrument of NAP-ICTL in 2011, consisted of items and tasks embedded in seven 20-minute test modules, each of which had its own unifying theme. Each student was randomly assigned four modules.

The modules typically followed a basic structure in which the students were first presented with details of the *context and purpose* of the module and then complete simulation, multiple-choice and short-constructed response items in the lead-up to a large task using at least one live software application. Typically, the lead-up tasks required students to: manage files; perform simple software functions (such as inserting pictures into files); search for information; collect and collate information; evaluate and analyse information; and perform some simple reshaping of information. When completing the large tasks, students needed to select, assimilate and synthesise the information they have been working with in the lead-up tasks and reframe the information to fulfill a specified communicative purpose. The audience and software related communicative context were specified to the students as part of the communicative purpose of the large task. Students spent between 40 per cent and 50 per cent of the time allocated for a module on the large task

Following is a description of two of the NAP-ICTL modules, Friend's PC and Sports Picnic.

- *Friend's PC*. Students help to plan a school sports picnic. They use a Blog web-site and a comparative search engine to identify a venue and to select sports' equipment that

meet given criteria. They used tailored graphics software to produce invitations to the picnic that include a map generated using embedded mapping software
- *Sports Picnic*. Students help a friend to manage software on a PC. They search for and install specific photo management software, change settings for antivirus software, organise a photo collection and edit a photo according to given instructions

The main studies of NAP-ICTL have taken place every three years since 2005. The most recent assessment is the main study of 2011.

INTERNATIONAL COMPUTER AND INFORMATION LITERACY STUDY[2]

ICILS is the first international comparative study assessing the ways in which young people (Year 8 students in Australia) are developing Computer and Information Literacy (CIL) for life in the digital age. The following definition of CIL is used in ICILS: *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 & Ainley, in press, p.10).

The ICILS framework comprises two strands:

- *Collecting and managing information.* This strand focuses on the receptive and organisational elements of information processing and management, including the fundamental and generic skills and understandings that are associated with using computers. This strand comprises three aspects: knowing about and understanding computer use, accessing and evaluating information and managing information.
- *Producing and exchanging information.* This strand focuses on using computers as productive tools for thinking, creating and communicating. This strand comprises four aspects: transforming information, creating information, sharing information and using information safely and securely.

The assessment instrument of ICILS consisted of four 30-minute modules with each test module comprising a series of tasks assessing different CIL skills which were unified by a theme and narrative. The modules were similar to the NAP-ICTL modules in structure. Each module followed a basic structure in which the students were first presented with details of the *context and purpose* of the module and then complete simulation, multiple-choice and short-constructed response items in the lead-up to a large task using at least one live software application. Students from Year 8 will complete two of the four modules.

The first main study of ICILS is being conducted in 2013. The field trial of this study was held in 2012 and data were available for use in this paper.

[2] Information about ICILS has been taken from the International Computer and Information Literacy Study Assessment Framework.

NATIONAL VERSUS INTERNATIONAL ASSESSMENT

Not many countries have participated in both a national and an international study that assess the similar. The Australian situation provides an opportunity to link the two assessments, and then establish how the Year 6 and Year 10 students who completed the NAP-ICTL assessment would have performed compared to the ICILS population.

ICILS reflects many of the characteristics of NAP-ICTL. The constructs CIL and ICT literacy, together with the related term of digital literacy, have increasingly become regarded as a broad set of capabilities that can be generalised and transferred to manage and communicate cross-disciplinary information using computer technology.

The perspective adopted is that these two constructs are so similar that the measures based on them are expected to align as one dimension. The analyses are therefore based on principles of one-dimensional measurement and item response theory was used to evaluate how well the tasks derived from different assessments fit the one-dimensional model and to evaluate the relative difficulties of those items. On that basis it is possible to equate the two scales through the common tasks that were completed by students in ICILS.

The paper explores whether a combination of common item and common person equating methods can be used to link the national ICT literacy to the international assessment scale of CIL. One purpose of this exercise is to better understand the CIL skills of Australian students by enabling comparisons with other year levels within Australia. In addition, if a link between the assessments can be established, Australia would be able to incorporate the international study data into their national evaluation and monitoring system of ICT literacy.

METHOD

In 2012, Australia participated in the field trial of ICILS together with 19 other countries. Four modules were developed for this study, each consisting of multiple tasks (or items). In addition, all Australian students in the ICILS field trial test were administered one of two modules from NAP-ICTL after the international test.

Data from both assessments were used for this study. For the NAP-ICTL study, 5710 Year 6 and 5313 Year 10 students were tested from all states and territories. The assessment consisted of 121 items, grouped in seven themed modules. One-hundred and five out of 121 items were used to estimate student abilities: 60 for both year levels, nine for Year 6 students only and 36 for Year 10 students only. To calibrate the items, the two year levels were jointly scaled using item response theory (IRT) methodology, resulting in 105 unique item difficulties.

The field trial of the international ICILS 2013 study was conducted one year later. For this trial a convenience sample of 445 Year 8 students from three out of eight states and territories

was tested for their proficiency in ICT. The test consisted of four modules that were developed for the international study. Seventy-eight items were calibrated on an international field trial sample and used to estimate student abilities. In addition, two modules from the national study (NAP-ICTL) were included: Friend's PC (FPC) and Sports Picnic (SPN) in order to equate the national Year 6 and Year 10 scale to the international Year 8 scale.

EQUATING PROCEDURE

Prior to estimating equating parameters to transform the national scale to the international scale, dimensionality of the ICILS and NAP-ICTL items was explored. The hypothesis was that the items from the two studies measure the same construct. If the two tests measure the same construct, the correlation between abilities estimated on one set of items and the other set of items should be close to 1, suggesting a uni-dimensionality between the two tests. In case the items were not uni-dimensional, the data were further explored to find a set of NAP-ICTL items that were most similar to the ICILS items as indicated by a high correlation.

Once items of the NAP-ICTL test were selected as link items between the two assessments, the equating procedure, based on IRT methodology, to transform the national NAP-ICTL scale to the international ICILS scale was disentangled into four separate steps:

1. Year 6 & 10 ICTL all items ➠ Year 6 & 10 ICTL link items
2. Year 6 & 10 ICTL link items ➠ Year 8 ICTL link items
3. Year 8 ICTL link items ➠ Year 8 national ICILS
4. Year 8 national ICILS ➠ Year 8 international ICILS

First, because the subset of NAP-ICTL items that link the two assessments may behave somewhat differently than the items that were not selected as link items, the NAP-ICTL 2011 data were rescaled using only the link items. For each year level, the difference between the population means on all items and on the link items only and the ratio of the population standard deviations were used to transform the distribution of student performance on the complete test to the distribution of student performance on only the link items.

Second, the average difficulty of the link items when calibrated on the NAP- ICTL sample was compared with the average difficulty when calibrated on the ICILS sample. The difference between these mean difficulties was used to shift the Year 6 and Year 10 ICTL abilities to the Year 8 ICTL scale.

Third, the performance of Year 8 students was estimated separately on the ICILS items and the NAP-ICTL items that were selected for linking the assessments. Given that each student received one ability estimate for each set of items and assuming that the two sets of items measure the same construct, the difference between the two population means and the

ratio between the two population standard deviations were used as equating parameters from the Year 8 NAP-ICTL scale to the Year 8 ICILS scale. In this step, ICILS item difficulties were calibrated on the national sample.

Fourth, the performance of Year 8 students was compared on ICILS items using national and using international item parameters. The difference in mean performance and the ratio of the standard deviations were the transformation parameters to equate from the national to the international ICILS scale.

If the linear transformation within each step is expressed as $Y = aX + b$, with X being the original scale or the scale from the previous step and Y the transformed scale, the equating parameters are defined as in Table 1.

TABLE 1: TRANSFORMATION PARAMETERS FOR EACH EQUATING STEP

	Scale X	Scale Y	Equating parameter
Step 1	*Year 6 & 10 ICTL all items*	*Year 6 & 10 ICTL link items*	
	SD population X	SD population Y	$a_1 = SD_Y / SD_X$
	Mean population X	Mean population Y	$b_1 = MN_Y - MN_X$
Step 2	*Year 6 & 10 ICTL link items*	*Year 8 ICTL link items*	
	-	-	$a_2 = 1$
	Mean difficulty X	Mean difficulty Y	$b_2 = MN_Y - MN_X$
Step 3	*Year 8 ICTL link items*	*Year 8 national ICILS*	
	SD population X	SD population Y	$a_3 = SD_Y / SD_X$
	Mean population X	Mean population Y	$b_3 = MN_Y - MN_X$
Step 4	*Year 8 national ICILS*	*Year 8 international ICILS*	
	SD population X	SD population Y	$a_4 = SD_Y / SD_X$
	Mean population X	Mean population Y	$b_4 = MN_Y - MN_X$

When all equating parameters were computed, the transformations were applied to the NAP-ICTL student abilities on the logit scale. The transformed distributions of Year 6 and Year 10 students were then compared with the distribution in logits of Year 8 students.

RESULTS

First, the hypothesis that the NAP-ICTL and the ICILS items formed a uni-dimensional scale was tested. When defining the items from the two NAP-ICTL modules – Friend's PC and Sports Picnic – as one dimension and all the ICILS items as another dimension, the latent correlation between the two dimensions was .78, which is low for items that are supposed to measure the same construct. For comparison, the correlation between the 2009 OECD's PISA

reading and mathematics domains was .86 in Australia and between science and mathematics .90.

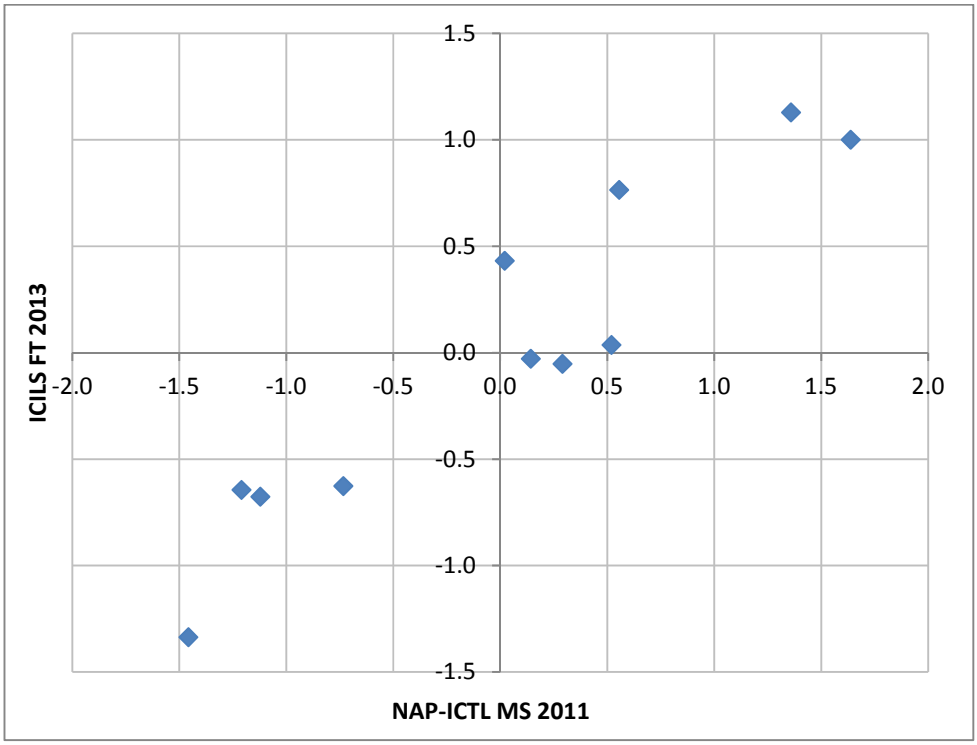
The next step was to identify items in the two NAP-ICTL modules that cause the low correlation between the two sets of items. Two hypotheses were explored. (1) The items within a large task at the end of each module correlate more with each other than with items outside the large task. In other words, the items within large tasks have correlated errors and show local dependence. One reason for this local dependence can be that the items within a large task measure a specific ICT skill. (2) One of the two NAP-ICTL modules correlates better with the ICILS items than the other.

To test the first hypothesis, the large tasks were excluded from the NAP-ICTL items. This substantially increased the correlation to .93 between performance on the ICILS and NAP-ICTL items. The second hypothesis was tested by including only items from one of the two NAP-ICTL modules. The correlation between ICILS and Friend's PC was .88 and between ICILS and Sports Picnic was .72. Clearly, the large tasks and the module Sports Picnic diminish the correlation of NAP-ICTL items with ICILS items. The module Sports Picnic consisted of 17 items of which 12 were part of the large task.

As a result, the module Friend's PC was chosen to link the two assessments. The large task was included, because a correlation of .88 seemed reasonable for the field trial data and because there were not enough link items in the Friend's PC module without the large task. Friend's PC consisted of 17 items with four items in the large task at the end of the module. Three items were dropped from the NAP-ICTL scale because of bad performance and could therefore not be used for linking to two assessments. In addition, two items were not used to estimate Year 6 abilities and one item was not used to estimate Year 10 abilities. This resulted in 11 items to link the two assessments.

Figure 1 shows a scatter plot with the relative item difficulties of the eleven link items by centering the difficulties around zero within each assessment. Although some items seem to function somewhat differently between the two assessments, it was decided to use all items as link items for this trial because of the small number of available link items and because the convenience field trial sample of the ICILS study is not necessarily representative of the full population of Year 8 students in Australia.

FIGURE 1: RELATIVE ITEM DIFFICULTIES OF LINK ITEMS BETWEEN NAP-CC AND ICILS



After selection of these link items steps 1 to 4 of the equating process were undertaking. The equating parameter estimates are included in Table 2.

TABLE 2: TRANSFORMATION PARAMETERS FOR EACH EQUATING STEP

	Scale X	Scale Y	Equating parameter
Step 1	*Year 6 & 10 ICTL all items*	*Year 6 & 10 ICTL link items*	
Year 6	SD_X = 1.22	SD_Y = 1.33	a_1 = 1.08
	MN_X = -0.21	MN_Y = -0.28	b_1 = -0.07
Year 10	SD_X = 1.21	SD_Y = 1.28	a_1 = 1.05
	MN_X = 1.09	MN_Y = 1.21	b_1 = 0.12
Step 2	*Year 6 & 10 ICTL link items*	*Year 8 ICTL link items*	
	-	-	a_2 = 1
	MN_X = -0.77	MN_Y = -1.02	b_2 = -0.24
Step 3	*Year 8 ICTL link items*	*Year 8 national ICILS*	
	SD_X = 1.01	SD_Y = 1.03	a_3 = 1.02
	MN_X = 0.32	MN_Y = -0.26	b_3 = -0.58
Step 4	*Year 8 national ICILS*	*Year 8 international ICILS*	

$SD_X = 1.03$	$SD_Y = 1.09$	$a_4 = 1.05$
$MN_X = -0.02$	$MN_Y = -0.01$	$b_4 = 0.02$

The total transformations that were applied to the student abilities on the complete 2011 NAP-ICTL test was

$$L^* = 1.05 * (1.02 * ((1.08 * L + -0.07) + -0.24) + -0.58) + 0.02 \quad \text{for Year 6}$$

$$L^* = 1.05 * (1.02 * ((1.05 * L + 0.12) + -0.24) + -0.58) + 0.02 \quad \text{for Year 10}$$

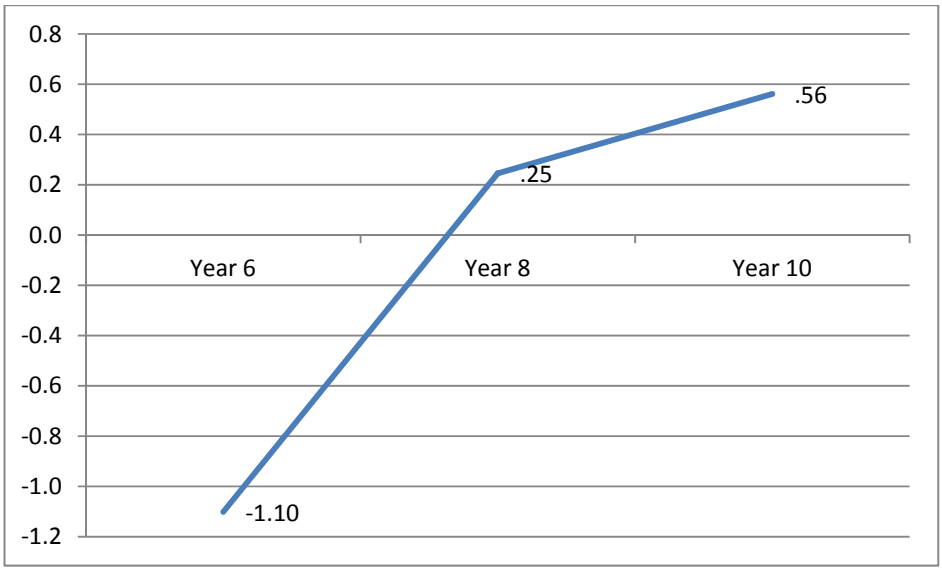
where L is the student ability in logits on the NAP-ICTL 2011 main study scale and L^* the student ability on the ICILS 2013 field trial scale.

Table 3 shows the distributions of proficiencies for each year level on the ICILS FT 2013 scale. The mean performance is graphically displayed in Figure 2. The mean performance of Year 8 students is probably somewhat higher than expected from a typical growth curve. However, the mean performance of Year 8 students is probably overestimated due to the nature of the sample for the ICILS field trial. Students were only sampled from three states and remote areas were under-represented.

TABLE 3: PROFICIENCY DISTRIBUTIONS BY YEAR LEVEL

	Mean	Standard deviation	Data source
Year 6	-1.10	1.39	NAP-ICTL MS 2011
Year 8	.25	1.06	ICILS FT 2013
Year 10	.56	1.34	NAP-ICTL MS 2011

FIGURE 2: MEAN PERFORMANCE BY YEAR LEVEL



This bias in the sample is also expected to cause an under-estimation of the variance in performance. Indeed, Table 3 shows that the standard deviation is smaller in Year 8 than in the other year levels.

CONCLUSION

Taking into account the bias in the field trial sample of the ICILS study, the results suggest a plausible and typical growth curve. This indicates that the equating process was successful and that similar equating steps can be applied to equate the NAP-ICTL 2011 scale to the ICILS 2013 main study. As a result, a wider range of skills can be described along the proficiency scale as well as more accurate growth patterns. Equating to the ICILS main study will enable exploring the performance of Year 6 and Year 10 Australian students from ICT literacy when benchmarked against the international ICILS assessment scale.

Both NAP-ICTL modules will be used again in the ICILS main study sample. In addition to choosing one module or excluding the large tasks, similar to the procedures that were undertaken for this study, treating each large task as a partial credit item could also be explored in relation to the dimensionality of the two assessments. In addition, more attention will be given to differential item functioning of individual link items when selecting the most appropriate set to link the two assessments. Finally, dimensionality within the ICILS item pool will be explored in order to better understand the relationship between the national and the international assessments.

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