Chapter 3
Student Achievement and Beliefs Related to Computer and Information Literacy

Abstract The 2013 International Computer and Information Literacy Study (ICILS) showed that female students demonstrated higher achievement in computer and information literacy (CIL) than male students in 12 of the 14 countries considered, with an average 19 scale points (or one-fifth of a standard deviation) difference across those 12 countries. An analysis of differential item functioning indicated that female students generally performed relatively better on tasks that involved communication, design, and creativity, while male students generally performed relatively better on more technical tasks, and those concerned with security. Female students took a little longer to complete the test than male students; this may have contributed to their better scores. While there were few differences between female and male students' basic information and communications technologies (ICT) self-efficacy, on average, male students recorded higher specialized ICT self-efficacy than female students in all 14 countries, and the difference was moderate to large in 12 of the 14 countries. General ICT self-efficacy was positively associated with both male and female CIL achievement to a similar extent in all 14 countries. Advanced ICT self-efficacy, however, was less strongly and less consistently related to CIL achievement.

Keywords Achievement · Computer and information literacy (CIL) · Differential item functioning · Gender differences · Information and communications technologies (ICT) · International Computer and Information Literacy Study (ICILS) · International large-scale assessments · Self-efficacy

3.1 Introduction

As noted in Chap. 1, many large-scale assessments in a range of countries have reported that, on average, female students achieve higher scores than male students on computer, digital, or ICT literacy assessments (the terminology varies but the constructs are similar). These results differ from what might be expected, given the preponderance of males working in information technology and enrolled in computer science courses. These results also differ from the reports of self-reported competencies in the early stages of the introduction of computer technology to school (Cooper 2006; Volman and van Eck 2001). Punter et al. (2017) suggested

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that there has been a change in the relative performance of female and male students that has accompanied a broader societal change in computer use, from technical to applications incorporating information management and communications that make use of the internet. They argued that the performance of female and male students on different types of task should be investigated. We begin this chapter with an overview of the gender differences reported in the ICILS 2013 international report (Fraillon et al. 2014), and then summarize some detailed analyses of differences between female and male students overall and on different types of task, as well as reported differences in self-efficacy.

3.2 Gender Differences in Overall Performance

As reported in the ICILS 2013 international report (Fraillon et al. 2014), the performance of female students was substantially higher than that of male students in 12 out of the 14 ICILS 2013 countries for which adequate data were collected (Table 3.1). The size of the difference ranged from small in the Czech Republic (12 scale points) to moderate in the Republic of Korea (38 scale points). In the remaining

Table 3.1 Differences in mean performance in computer and information literacy between male and female students

Country	Mean CIL scale score for male students	Mean CIL scale score for female students	Difference in scale scores (males − females)
Republic of Korea	517 (3.7)	556 (3.1)	−38* (4.1)
Slovenia	497 (2.8)	526 (2.8)	−29* (3.6)
Chile	474 (3.9)	499 (3.9)	−25* (4.8)
Australia	529 (3.3)	554 (2.8)	−24* (4.0)
Norway	525 (3.1)	548 (2.8)	−23* (3.5)
Lithuania	486 (3.8)	503 (4.2)	−17* (3.4)
Germany	516 (3.2)	532 (2.9)	−16* (3.8)
Croatia	505 (3.6)	520 (3.1)	−15* (3.5)
Russian Federation	510 (3.4)	523 (2.8)	−13* (2.4)
Slovak Republic	511 (5.1)	524 (4.8)	−13* (4.1)
Poland	531 (3.1)	544 (2.9)	−13* (3.7)
Czech Republic	548 (2.8)	559 (2.0)	−12* (2.7)
Thailand	369 (5.3)	378 (5.7)	−9 (5.6)
Turkey	360 (5.4)	362 (5.2)	−2 (3.8)

Notes Standard errors in parentheses. Because some results are rounded to the nearest whole number, some totals may appear inconsistent. *Significant differences ($p < 0.05$)
Source Fraillon et al. (2014)

two countries (Thailand and Turkey; in both these countries achievement levels were very low), the differences were negligible.

3.3 Gender Differences in Specific Skills

The probability of responding correctly to an item is generally assumed to be dependent only on a student's ability and not on any other characteristics of the students, such as gender. If an item is easier for a male student than a female student with the same ability, the item is showing differential item functioning (DIF) and will advantage male students in general. The sum of the DIF estimates over all items is zero. The sum of the DIF for certain groups of items may not always add up to zero, however, and can thus reveal that some types of items are easier for male students and others for female students, after taking their ability into account. Items that display large DIFs are usually excluded from the measurement scale during calculation of ability estimates. It is not possible to remove all items that show any DIF, however, and so most remaining items show smaller levels of DIF. DIF values for females were estimated for each of the items in the ICILS 2013 CIL assessment for each of the computer literacy domains/strands, and the estimates over the group of items were summed (Table 3.2).

On average, female students performed better than male students of the same ability when asked to create information and, to a lesser extent, when asked to transform information. Male students outperformed female students of the same

Table 3.2 Differential item functioning for male and female students by ICILS 2013 strand

Strand		Sum of DIF (female)	Gender DIF favors	Number of items
2.2	Creating information	−1.08*	Females	18
2.1	Transforming information	−0.45	Neither	11
2.3	Sharing information	−0.17	Neither	3
1.2	Accessing and evaluating information	−0.06	Neither	9
1.3	Managing information	0.09	Neither	4
1.1	Knowing about and understanding computer use	0.70	Males	10
2.4	Using information safely and securely	0.97*	Males	10
Total DIF		0.00	Neither	65

Note *DIF estimates > 0.5 of a logit

Table 3.3 Differential item functioning for male and female students by ICILS 2013 item type

Item type	Sum of DIF (female)	Gender DIF favors	Number of items
Large task	−1.72	Females	34
Multiple choice	0.48	Males	7
Constructed response	1.24	Males	24
Total DIF	0.00	Neither	65

ability on items that required knowledge about and understanding of computer use, and on items that concerned using information safely and securely.

These findings agree with those reported in Punter et al. (2017), who examined item bias using different methods; they concluded that overall, ICILS 2013 items showed little gender DIF.

The ICILS 2013 test consisted of three types of items: multiple response items, constructed response items, and large tasks. The large tasks ask students to create an information product, such as a poster, presentation, or website. For instance, students might be asked to use a simple website builder to plan and create a webpage, or to use online database tools to select and adapt information in order to create an information sheet for their peers. DIF was also explored for these item types (Table 3.3). Large tasks were found to be relatively easier for female students. Constructed response and, to a lesser extent, multiple choice items were found to be relatively easier for male students. This pattern was true within each of the domains of CIL.

Individual assessment items that favored female students generally required skills involving communication, design, and creativity. In comparison, those items favoring male students generally required less creative skills, but more technical skills and greater knowledge of security issues, such as knowing the purpose of a captcha and recognizing spam emails (Table 3.4).

3.4 Gender Differences in CIL Self-efficacy

To examine self-efficacy in ICILS 2013, students were asked to report how well they could do each of the following general CIL skills:

- Search for and find a file on a computer;
- Edit digital photographs or other graphic images;
- Create or edit documents (for example assignments for school);
- Search for and find information needed on the internet;
- Create a multimedia presentation (with sound, pictures, or video); and
- Upload text, images, or video to an online profile.

Table 3.4 ICILS 2013 assessment items with a gender differential item functioning estimate favoring male or female students of at least 0.1 of a logit, and the skills required by each item

ICILS 2013 item code	ICILS 2013 test unit	Item difficulty	Gender DIF estimate	Gender DIF favors	Description of skill
S08F	School trip	1.06	−0.17	Females	Create balanced layout of text and images for an information sheet
A10A	After school exercise	−0.37	−0.15	Females	Create an appropriate title design for a poster
B07B	Band competition	−3.01	−0.15	Females	Use software to make an image brighter
A10I	After school exercise	1.03	−0.15	Females	Exclude irrelevant information in a poster
A03Z	After school exercise	−2.84	−0.14	Females	Identify information that is risky to include on a public profile
S08B	School trip	0.14	−0.14	Females	Locate required times on website pages
A10D	After school exercise	0.15	−0.12	Females	Text and background colors contrast to support readability
B09D	Band competition	0.08	−0.12	Females	Text and background colors contrast to support readability
S01Z	School trip	−1.48	0.10	Males	Open a link in a new browser tab
A09Z	After school exercise	−0.31	0.10	Males	Modify the sharing settings of a collaborative document
A02Z	After school exercise	−0.10	0.11	Males	Navigate to a URL given as plain text
B03Z	Band competition	0.13	0.12	Males	Navigate to a text-based URL
S07Z	School trip	2.50	0.15	Males	Interpret and choose a search result based on two criteria
B02Z	Band competition	−0.70	0.16	Males	Explain the features that make one of two passwords more secure
S08D	School trip	0.65	0.17	Males	Convert a description of directions into a visual route on a map
A06C	After school exercise	2.27	0.17	Males	Identify that a link's URL does not match the URL displayed in the link text
B08Z	Band competition	0.46	0.19	Males	Recognize legal and technical issues associated with image use
A06A	After school exercise	1.70	0.20	Males	Identify that an email does not originate from the purported sender
A04Z	After school exercise	−0.16	0.32	Males	Identify the purpose of a captcha form

Notes Further explanation of the ICILS 2013 item codes, units, item difficulties, and skills required can be found in Fraillon et al. (2014)

In ICILS 2013, student responses to this set of items were combined into a self-efficacy scale for basic CIL skills. The scale was constructed to have a mean of 50 and a standard deviation of 10.

Female students reported significantly higher levels of general self-efficacy, on average, than male students in six countries (Table 3.5). In Chile and the Republic of Korea, the differences were significant but small, while in the Russian Federation, Croatia, Australia, and Thailand, the differences were negligible (although statistically significant). In the remaining eight countries there were no significant gender differences.

Similarly, in ICILS 2013, students were also asked to rate the level of their skills for a set of specialized CIL skills, and a self-efficacy scale for specialized CIL scales was constructed (again with a mean of 50 and a standard deviation of 10). The specialized skills were:

- Use software to find and get rid of viruses;
- Create a database (for example, using [Microsoft Access®]);
- Build or edit a webpage;
- Change the settings on the computer to improve the way it operates or to fix problems;

Table 3.5 National averages and gender differences for students' self-efficacy in basic CIL skills, as reported by students participating in ICILS 2013

Country	National averages for students' self-efficacy in basic CIL skills		
	Males	Females	Difference (males − females)
Chile	52 (0.3)	54 (0.3)	−2* (0.3)
Republic of Korea	48 (0.3)	50 (0.3)	−2* (0.3)
Russian Federation	51 (0.3)	52 (0.2)	−1* (0.3)
Croatia	52 (0.3)	53 (0.3)	−1* (0.3)
Australia	51 (0.2)	52 (0.2)	−1* (0.3)
Thailand	39 (0.4)	40 (0.4)	−1* (0.4)
Slovenia	53 (0.3)	54 (0.3)	−1 (0.4)
Slovak Republic	51 (0.3)	51 (0.4)	−1 (0.5)
Norway	52 (0.3)	51 (0.2)	1 (0.3)
Germany	50 (0.3)	49 (0.4)	1 (0.5)
Poland	54 (0.2)	54 (0.3)	0 (0.3)
Czech Republic	51 (0.2)	51 (0.2)	0 (0.3)
Lithuania	49 (0.3)	49 (0.3)	0 (0.4)
Turkey	44 (0.4)	44 (0.5)	0 (0.6)

Notes Standard errors in parentheses. Because some results are rounded to the nearest whole number, some totals may appear inconsistent. *Significant differences ($p < 0.05$)
Source Fraillon et al. (2014)

- Use a spreadsheet to do calculations, store data, or plot a graph;
- Create a computer program or macro (for example, in [Basic, Visual Basic]); and
- Set up a computer network.

In contrast to the findings for general CIL skills, on average, male students showed higher self-efficacy when rating their ability in specialized CIL skills than female students in all 14 countries (Table 3.6), and the gender differences were much larger. The size of this difference was large in Germany, Norway, the Slovak Republic, the Czech Republic, Poland, Slovenia, and Lithuania, and moderate in Croatia, Australia, Turkey, the Russian Federation, and the Republic of Korea. Only in Chile and Thailand were the differences rated as small.

In order to examine the association of students' CIL with ICT self-efficacy beliefs for this report, we computed correlation coefficients for each ICILS country by gender for basic skills (Table 3.7) and for specialized skills (Table 3.8), and calculated Cohen's *d* to provide an estimate of the strength of the association. Self-efficacy in basic skills was found to be strongly positively related to achievement for male students in six countries (Australia, Chile, Croatia, the Republic of Korea, the Slovak Republic, and Turkey) and for female students in four countries (the Republic of Korea, Lithuania, the Slovak Republic, and Turkey). In most other countries the association was found to be moderate, while the effect was small for female students in the Czech Republic and Germany. This finding is in contrast to previous studies that

Table 3.6 National averages and gender differences for students' self-efficacy in specialized CIL skills, as reported by students participating in ICILS 2013

Country	National averages for students' self-efficacy in specialized CIL skills		
	Males	Females	Difference* (males − females)
Germany	51 (0.3)	44 (0.4)	7 (0.5)
Norway	52 (0.3)	46 (0.3)	6 (0.4)
Slovak Republic	54 (0.3)	47 (0.4)	6 (0.5)
Czech Republic	51 (0.3)	45 (0.3)	6 (0.4)
Poland	52 (0.3)	46 (0.3)	6 (0.4)
Slovenia	54 (0.4)	49 (0.3)	5 (0.4)
Lithuania	53 (0.3)	48 (0.3)	5 (0.4)
Croatia	55 (0.3)	50 (0.3)	4 (0.4)
Australia	50 (0.3)	46 (0.2)	4 (0.3)
Turkey	52 (0.4)	48 (0.4)	4 (0.5)
Russian Federation	54 (0.3)	50 (0.3)	4 (0.3)
Republic of Korea	53 (0.2)	50 (0.2)	3 (0.3)
Chile	53 (0.3)	51 (0.4)	2 (0.4)
Thailand	48 (0.4)	46 (0.4)	2 (0.5)

Notes Standard errors in parentheses. Because some results are rounded to the nearest whole number, some totals may appear inconsistent. *All differences were significant ($p < 0.05$)
Source Fraillon et al. (2014)

Table 3.7 Correlation between student self-efficacy for basic skills and CIL achievement, by gender

Country	Correlations between student self-efficacy for basic skills and CIL achievement*			
	Males	Cohen's *d*	Females	Cohen's *d*
Australia	0.38 (0.03)	0.8	0.34 (0.03)	0.7
Chile	0.37 (0.03)	0.8	0.32 (0.03)	0.7
Croatia	0.37 (0.03)	0.8	0.30 (0.04)	0.6
Czech Republic	0.24 (0.03)	0.5	0.21 (0.03)	0.4
Germany	0.23 (0.04)	0.5	0.19 (0.04)	0.4
Republic of Korea	0.42 (0.02)	0.9	0.40 (0.03)	0.9
Lithuania	0.35 (0.03)	0.7	0.41 (0.03)	0.9
Norway	0.22 (0.04)	0.5	0.27 (0.03)	0.6
Poland	0.33 (0.02)	0.7	0.34 (0.03)	0.7
Russian Federation	0.30 (0.02)	0.6	0.26 (0.03)	0.5
Slovak Republic	0.36 (0.03)	0.8	0.38 (0.03)	0.8
Slovenia	0.30 (0.03)	0.6	0.24 (0.03)	0.5
Thailand	0.27 (0.03)	0.6	0.32 (0.03)	0.7
Turkey	0.36 (0.04)	0.8	0.38 (0.03)	0.8
Average for all countries	0.32 (0.01)	0.7	0.31 (0.01)	0.7

Notes Standard errors in parentheses. *All correlations were significant ($p < 0.05$). Effect sizes using Cohen's *d* are regarded as insubstantial if $d = 0.2$, moderate if $d = 0.5$, and strong if $d = 0.8$

have suggested that self-efficacy is not related to performance in CIL (for example, Siddiq et al. 2016).

Self-efficacy in specialized skills, however, was less consistently and less strongly related to CIL achievement (Table 3.8). While a number of the correlations for both male and female students reached statistical significance, the relationship was only found to be of moderate strength for males in Turkey. The strength of the relationship in all other countries was insubstantial.

These differences were noted in the ICILS 2013 international report (Fraillon et al. 2014). The report explains that the finding is not unexpected given the nature of the CIL assessment construct, which is framed around computer and information literacy skills that are not necessarily related to the more technical skills described in the specialized skills construct. Punter et al. (2017) also investigated ICT self-efficacy differences between male and female students, and concluded that the differences may arise as males tend to overestimate their abilities while females tend to underestimate their abilities.

Table 3.8 Correlation between self-efficacy for specialized skills and CIL achievement, by gender

Country	Correlations between self-efficacy for specialized skills and CIL achievement			
	Males		Females	
	Correlation	Cohen's *d*	Correlation	Cohen's *d*
Australia	0.10* (0.03)	0.2	0.05 (0.03)	0.1
Chile	0.10* (0.03)	0.2	−0.06* (0.03)	−0.1
Croatia	0.18* (0.03)	0.4	0.09* (0.04)	0.2
Czech Republic	0.04 (0.03)	0.1	0.04 (0.03)	0.1
Germany	0.05 (0.03)	0.1	−0.04 (0.04)	−0.1
Republic of Korea	0.20* (0.03)	0.4	0.16* (0.03)	0.3
Lithuania	0.12* (0.03)	0.2	0.09* (0.03)	0.2
Norway	0.01 (0.04)	0.0	−0.05 (0.04)	−0.1
Poland	0.12* (0.03)	0.2	0.04 (0.03)	0.1
Russian Federation	0.08* (0.02)	0.2	−0.02 (0.03)	0.0
Slovak Republic	0.11* (0.04)	0.2	0.06* (0.03)	0.1
Slovenia	0.03 (0.04)	0.1	0.02 (0.03)	0.0
Thailand	0.05 (0.04)	0.1	−0.04 (0.04)	−0.1
Turkey	0.24* (0.04)	0.5	0.17* (0.04)	0.3
Average of all countries	0.10* (0.01)	0.2	0.04* (0.01)	0.1

Notes Standard errors in parentheses. *Correlations were significant ($p < 0.05$). Effect sizes using Cohen's *d* are regarded as insubstantial if $d = 0.2$, moderate if $d = 0.5$, and strong if $d = 0.8$

3.5 Gender Differences in Time Taken to Respond to the Test

Another consistent finding in ICILS 2013 across all 14 countries was that male students spent less time responding to the test items, on average, than female students. On average, female students spent one to four seconds longer on each item than male students (Table 3.9).

Germany, the Republic of Korea, and Slovenia had relatively higher gender differences in the time taken to respond to items and also higher differences between male and female students' average performance on the assessment (Table 3.9). Thailand, Lithuania, and the Russian Federation recorded much smaller (though still statistically significant) differences in average response times for male and female students, but varied somewhat in the size of their gender differences in achievement; this was small in Lithuania (17 points) and the Russian Federation (13 points), and non-significant in Turkey (see Table 3.1). These results suggest that response times for items may be a factor in the stronger average performance of female students on the ICILS 2013 CIL assessment. Taking more time to respond to these CIL items may be reflective of more careful and thoughtful responses, rather than being less

Table 3.9 Average time in seconds taken to respond per ICILS test item, by gender

Country	Average time (s) for students to respond to test items*		
	Mean response time males	Mean response time females	Difference (males − females)
Australia	34 (0.4)	37 (0.4)	−3 (0.4)
Chile	35 (0.5)	38 (0.4)	−2 (0.5)
Croatia	36 (0.6)	39 (0.5)	−3 (0.5)
Czech Republic	40 (0.5)	43 (0.4)	−3 (0.4)
Germany	37 (0.6)	40 (0.4)	−4 (0.6)
Republic of Korea	27 (0.5)	31 (0.6)	−4 (0.7)
Lithuania	33 (0.6)	34 (0.6)	−1 (0.4)
Norway	36 (0.5)	39 (0.5)	−3 (0.5)
Poland	39 (0.4)	41 (0.4)	−2 (0.4)
Russian Federation	37 (0.5)	38 (0.5)	−1 (0.4)
Slovak Republic	36 (0.7)	38 (0.5)	−2 (0.4)
Slovenia	35 (0.5)	39 (0.5)	−4 (0.5)
Thailand	31 (0.6)	33 (0.7)	−2 (0.5)
Turkey	23 (0.6)	24 (0.6)	−1 (0.3)

Notes Standard errors in parentheses. *All differences were significant ($p < 0.05$)

familiar or less confident in their responses, or needing more time to identify the correct response, as is often the case in other assessments.

3.6 Summary

Research question RQ1 (Sect. 1.4) asked: What is the magnitude of the difference between male and female students in measured computer literacy overall, and for particular types of items?

The findings of ICILS 2013 clearly indicated that, on average, female students achieved higher scores for CIL than male students. This difference was statistically significant in 12 of the 14 countries considered, and averaged 19 scale points (or one-fifth of a standard deviation) across the countries reported here.

Within this overall pattern, we found that differential item functioning analyses indicated that female students generally performed relatively better on tasks that involved communication, design, and creativity skills. In contrast, male students generally performed relatively better on more technical tasks and those concerned with security, such as knowing the purpose of a captcha and recognizing spam emails. In addition, female students took a little longer to complete the test than male students; each item took students an average time of 35 seconds to complete, and female

students took between one and four seconds longer to respond to items than male students.

Research question RQ2 (Sect. 1.4) asked: To what extent do female and male students differ in computer self-efficacy overall, and in particular aspects of computing?

We found few differences worthy of note between female and male students' basic ICT self-efficacy. Differences were significant in only six countries, and of small size in two of these countries. However, on average, male students recorded higher specialized ICT self-efficacy than female students in all 14 countries, and the difference was moderate to large in 11 of the 15 countries. General ICT self-efficacy was positively associated with CIL achievement similarly for both sexes in all 14 countries. Advanced ICT self-efficacy, however, was less strongly and less consistently related to CIL achievement.

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