# Chapter 1
# Introduction to Gender Differences in Computer and Information Literacy


**Abstract** As computer and information technologies increasingly dominate modern life, educators and policymakers recognize the importance of ensuring that all students are able to use computers to investigate, create, and communicate effectively. Intriguingly, results from IEA's International Computer and Information Literacy Study (ICILS) of grade eight students, undertaken in 2013, indicated that female students generally had higher computer and information literacy (CIL) scale scores than male students. This book further analyzes the data collected by ICILS 2013, providing an in-depth investigation of the gender differences in the CIL abilities of students and their teachers. After establishing how CIL (and other similar constructs) are assessed, this chapter reviews the existing research into gender differences in students' CIL; this is based mainly on data collected by large-scale assessments. Patterns in students' use of information and computer technologies, their perceptions of computer technology, and their sense of competence in using computer technologies reveal gender differences that might be associated with the differing development of students' CIL. Gender differences among teachers, in their confidence in the use of computer technologies and their attitudes to the pedagogical use of those technologies, are also examined.

**Keywords** Computer and information literacy (CIL) · Gender differences · Information and communications technologies (ICT) · International Computer and Information Literacy Study (ICILS) · International large-scale assessments

## 1.1 Introduction

Information and communications technologies (ICT) have significantly changed how people interact with each other, and the ways people live and work around the world. The evolution of ICT has also affected teaching and learning in schools, and education systems have recognized the importance of developing their students' capacity to use these technologies for a range of purposes beyond basic ICT skills. IEA's International Computer and Information Literacy Study (ICILS) was designed to establish how well students around the world were prepared for study, work, and life in the digital age. ICILS 2013 referred to these capacities as computer



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and information literacy (CIL). CIL was 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 society" (Fraillon et al. 2014, p. 17). The ICILS 2013 CIL construct comprised two strands: (1) using computer technologies to collect and manage information, and (2) using computer technologies to produce and exchange information.

Educators and systems have also recognized the importance of ensuring that both male and female students develop those capacities. Many large-scale educational assessments in a range of countries have reported that, on average, female students score higher than male students on ICT-related assessments, such as national studies in Australia (ACARA [Australian Curriculum, Assessment and Reporting Authority] 2015), Chile (Claro et al. 2012), and the Republic of Korea (Kim and Lee 2013; Kim et al. 2014). These results are intriguing because they defy commonly held expectations and do not reflect the gender balance in employment patterns in computer-related industries or participation in further studies in computing and information technology.

In this report, we aim to provide a systematic investigation of gender differences in computer literacy, computer usage, and attitudes to computer technology, based on the data collected by ICILS 2013 (Fraillon et al. 2014). In the early days of computing in schools it was evident that computer use was dominated by male teachers (for example, see Reinen and Plomp 1993). However, the use of ICT has become more prevalent since the days of the Computers in Education study (COMPED; see IEA 2019a), and so to gauge changes, we investigate the use of computer technologies in the classroom by female and male teachers. Teachers' personal use of, and attitudes to, computer technologies in the lower secondary school years may also have an effect on their students, either directly, through their instructional practices or frequency of use of ICT in the classroom, or indirectly, through modeling of behavior. The associated teacher questionnaires delivered as part of ICILS 2013 thus provide a rich data resource that may better explain student achievement (Fraillon et al. 2014). While previous research has certainly investigated gender differences in student and teacher capabilities and their use of digital technologies, the literature for students is more extensive than that for teachers (Heemskerk et al. 2005; Volman and van Eck 2001).

In this chapter, we review the relevant research literature on gender differences in CIL among students, beginning with a summary of findings for measured CIL (and similar constructs) drawn mainly from large-scale assessments. We then consider studies reporting gender differences in factors that might be associated with the development of students' CIL: namely patterns in students' use of ICT, and their perceptions of computer technology and sense of competence in using computer technologies. We also consider gender differences in teachers' confidence in using computer technologies and teachers' attitudes to the pedagogical use of those technologies. After reviewing the existing literature, we formalize a set of research questions to guide our investigation.

## 1.2 Students and Computer Technologies

Knezec and Christensen (2018) noted that, while competencies in computer technologies, computer use, and computer-related attitudes were once considered separate but related aspects of the field, they have come to be seen as integrated. It is thus important that we not only review literature concerned with gender differences in these aspects of student computer literacy but also review information about gender differences in CIL and related constructs, patterns of computer use, and perceptions of computer technology (including consideration of student attitudes to computer technologies and their perceptions of their capacities to use those technologies).

### *1.2.1 Students' Computer and Information Literacy*

Large-scale assessments of students' CIL have reported that, on average, female students perform better than male students on computer, digital, or ICT literacy assessments (the terminology varies, but the constructs remain similar). Results from IEA's ICILS 2013, conducted in 21 countries,[1] indicated that female grade eight students achieved significantly higher CIL scores than male students (Fraillon et al. 2014). The difference between the international average scores for female and male students was equivalent to about one-fifth of the ICILS standard deviation. As part of the Organisation for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) in 2009, 19 countries participated in an option that focused on assessing the digital reading capabilities of 15-year-old students (OECD 2011). Female students scored higher than male students on that assessment of digital reading, with the average difference being one-quarter of a standard deviation.

Similar results have been reported across a range of national assessments of computer literacy. In the 2014 National Assessment of Educational Progress in the United States, female grade eight students scored higher than male grade eight students in the ICT content area of the assessment of technological and engineering literacy by approximately one-sixth of a standard deviation (NCES [National Center for Educational Statistics] 2016a, b). In Australia, over four cycles of national assessment of ICT literacy at grades six and 10, the difference between the performance of female and male students averaged one-fifth of a standard deviation (ACARA 2015). Similar size differences (that is, about one-fifth of a standard deviation) were reported between female and male students at elementary and middle levels of school in the Republic of Korea's national assessment of ICT literacy (Kim

[1] In this report, educational systems are sometimes referred to as "countries." This is for ease of reading, but it should be noted that there are a number of systems that are not countries as such, but are provinces or regions within a country with a degree of educational autonomy that have participated following the same standards for sampling and testing.

and Lee 2013; Kim et al. 2014). Aesaert and van Braak (2015) reported similar differences for upper primary school students in the Netherlands, while Hatlevik et al. (2015) reported statistically significant, but slightly smaller differences in favor of female students in a study of a sample of upper primary students in Norway.

There have been some large-scale studies that reported no gender differences in computer literacy. ICILS 2013 identified only two countries, Thailand and Turkey, where there were no significant gender differences in achievement (Fraillon et al. 2014). Among the 19 countries that took part in the OECD PISA 2009 study of digital reading, only Colombia reported no gender differences in student achievement (OECD 2011). In a large-scale assessment of the ICT literacy of Chilean 15-year-olds, there were no significant differences found between female and male students (Claro et al. 2012). Hatlevik and Christophersen (2013) also reported no significant gender differences in digital literacy among senior secondary students in Norway.

Some have argued that gender differences vary across different types of computer task. Punter et al. (2017) used data from ICILS 2013 to identify three subscales of CIL: technical functionality, evaluating and reflecting on information, and sharing or communicating information (such as through an information product). They found that female students performed better than male students on both evaluating and reflecting on information (nine countries) and sharing and communicating information (nine countries), with these two subscales being highly correlated. On the subscale of technical functionality, however, the differences between female and male students were not significant in four countries, in favor of male students in five countries, and in favor of female students in five countries. A study of upper grade students in Finnish comprehensive schools reported a very small, but statistically significant, difference in favor of female students on overall ICT literacy, with male students performing better on technical-oriented items and female students performing better on "school work-oriented and social interaction" items (Kaarakainen et al. 2018). The argument put forward by Punter et al. (2017) provides a plausible explanation of why the relative computer literacy achievements of female and male students might have changed over time, as there has been a change in computer use from the more technical to a focus on applications incorporating information management and communications that make use of the internet. Changes in the balance of assessment items focusing on different domains or subskills of CIL could contribute to explanations of why some assessments generate different results to the majority (differences in the balance of items across assessments). Accordingly, the current report examines not only the overall CIL scale scores of male and female students, but also item-level performance data.

### *1.2.2 Gender Differences in Student Technology Use*

When computer technologies were being introduced into schools, the use of ICT was more extensive among male than female students (Lockheed 1985). However, as the use of computer technologies became more prevalent, the overall differences

in computer use between male and female students appeared to decrease (Colley and Comber 2003). Potential gender differences in computer usage have remained of interest because computer use at home has been identified as a predictor of measured CIL, although the association may not be linear (Bundsgaard and Gerick 2017; Fraillon et al. 2014). More recently, the differences between female and male students in terms of the percentages who report using computer technologies on a daily basis appear to have been negligible. Analyses of ICILS 2013 data showed that 57% of male students and 52% of female students used computers at home at least once each day (Fraillon et al. 2014). While this overall difference may be viewed as negligible, the magnitude of the difference between the proportions of male and female students who reported daily use of computers varied across countries (Fraillon et al. 2014). In the Australian national assessment of ICT literacy, there were no significant differences between the percentages of female and male students who reported daily computer use at home or school, either in primary or secondary school (ACARA 2015).

However, there are some differences between male and female students in the types of computer use. According to ICILS 2013, female students made slightly greater use of computer technologies for schoolwork or study purposes than male students, while male students used ICT more frequently for exchanging information and for recreational purposes (Fraillon et al. 2014). Similar findings were reported in PISA 2009 (OECD 2011).

### *1.2.3 Gender Differences in Student Perceptions of Computer Technology*

Punter et al. (2017) noted that many studies have attributed the lower use of computer technologies among female students and lower levels of female participation in computer-based industries to differences in attitudes. Research in this area focused mainly on gender differences in computer-related attitudes, such as liking computers, perceived usefulness of computers, self-confidence in computer use, and anxiety in using computers (Meelissen 2008). These differences identified in the early literature appear to have remained largely unchanged in recent years. In ICILS 2013, male students expressed greater interest and enjoyment in using computer technology than did female students, although this finding varied across countries (Fraillon et al. 2014). Similarly, PISA 2009 reported that male students showed more positive attitudes than female students towards computers (OECD 2011).

The Australian national assessment of ICT literacy indicated that students in late primary and mid-secondary school expressed high levels of interest and enjoyment in working with computers (ACARA 2015). However, interest and enjoyment were higher among male than female students at both stages of schooling, and interest was higher among primary students than secondary school students. Positive associations between ICT literacy and interest and enjoyment in working with

computers were identified in both late primary and mid-secondary stages of school, with the associations being stronger among male students than female students (ACARA 2015).

In general, research has indicated that gender differences in students' attitudes towards computer technologies run counter to the gender differences in achievement in CIL. We thus aimed to explore gender differences in interest in and enjoyment of computer and information technologies, patterns of particular use (i.e., for social communication, for exchange of information, for recreation, and for study purposes), and potential associations between these differences and CIL.

### *1.2.4 Students' ICT Self-efficacy*

Many studies of computer, digital, or ICT literacy have made use of self-reports, where students are asked to evaluate how well they believe they can perform on ICT-related tasks. The construct measured by these self-reports is called ICT self-efficacy. Studies of self-efficacy from the early stages of the introduction of computer technology to schools have consistently found that male students rate their competence more highly than their female peers (Cooper 2006; Volman and van Eck 2001). Rohatgi et al. (2016) analyzed the Norwegian ICILS 2013 data, and noted that ICT self-efficacy may not be a unidimensional construct. They distinguished general ICT self-efficacy from specialized ICT self-efficacy (sometimes referred to as self-efficacy with basic and advanced skills) and determined that general ICT self-efficacy was positively related to computer literacy, whereas specialized ICT self-efficacy was negatively, but minimally associated with computer literacy. ICILS 2013 found that female students, on average, reported slightly higher levels of ICT self-efficacy than male students in relation to basic ICT tasks (about one-tenth of a standard deviation), whereas male students reported much higher levels of ICT self-efficacy in relation to advanced ICT tasks (by about half a standard deviation) (Fraillon et al. 2014). Similar results have been reported for grade six and grade 10 students in Australia (ACARA 2015). This variability in self-confidence in performing tasks with different levels of difficulty has become more apparent over time, likely in line with increasing use of ICT both inside and outside the classroom. For basic ICT self-efficacy tasks there is now a very strongly skewed distribution of responses; most students report that they can perform simple basic tasks. Thus, what is now being observed in the factor structure may be a distinction between tasks that almost all students think they can perform, and tasks that only some students think they can perform. For example, while 87% of students participating in ICILS 2013 agreed that they could search for and find a file on a computer and 89% agreed that they could search for and find information on the internet, only 30% agreed that they could create a database and only 38% agreed that they could build or edit a webpage (Fraillon et al. 2014).

Siddiq et al. (2016) cautioned that measures of self-confidence or self-efficacy do not provide sound measures of ICT literacy because they correlate poorly with measured competence. It is thus important to distinguish between computer literacy

and self-confidence in using those technologies, and most studies have concluded that the two constructs are distinct. The Australian National Assessment Program for ICT literacy also found that measures of ICT self-efficacy were not equivalent for male and female students: male students were more confident than female students about using ICT, but this confidence was not reflected in measured computer literacy (ACARA 2015). In PISA 2009, 15-year-old male students reported greater levels of self-confidence in completing high-level ICT tasks than female students, but female students recorded higher average scores on digital reading, which is a form of computer literacy (OECD 2011).

## 1.3 Teachers and Computer Technologies

### *1.3.1 Gender Differences in Teacher Confidence in Using ICT*

One of the enduring research issues involved in the study of the differential use of computer technologies in teaching concerns teacher confidence or ICT self-efficacy. Indeed, among the many purposes of professional learning in computer technologies is to enhance teacher expertise and confidence in computer technologies and their pedagogical applications. The Second Information Technology in Education Study 2006 (SITES 2006; see IEA 2019b) surveyed the role of ICT in science and mathematics in grade eight teaching in 22 countries and reported that the use of ICT was greater when teachers had a higher level of confidence in using ICT, when teachers had participated in ICT-related professional development, and when there were fewer contextual obstacles (infrastructure, digital learning resources, ICT access) (Law et al. 2008). The European Commission (2013) also reported that teachers who were confident users of ICT were more likely to adopt ICT as part of their teaching. However, the results from SITES 2006 also suggested that the relationship between ICT self-efficacy and the use of digital technologies was not determinist, and that there were variations in the relationship across countries and among environments within countries. Among the possible reasons for the apparent differences in results concerning the relationship between gender and computer self-efficacy could be that the self-efficacy construct is multifaceted and the strength of (or even the direction of) the relationship depends on the facet that is being addressed by the instrument.

Scherer and Siddiq (2015) analyzed ICILS 2013 teacher data from Norway and identified three aspects of teacher ICT self-efficacy: in basic operational skills, a combination of advanced operational and collaborative skills, and in using computers for instructional purposes. This was a similar structure to that reported from SITES 2006. Scherer and Siddiq (2015) found that the structure was the same for male and female teachers, although there were differences found on some aspects. Male teachers had higher self-efficacy with respect to both basic and advanced operational

skills, but there were no significant gender differences in confidence in using computers for instructional purposes. Markauskaite (2006) reported differences in the self-reported technical ICT capabilities of male and female preservice teachers. In contrast, Sang et al. (2010) reported that gender was unrelated to teacher ICT self-efficacy, their attitudes to computing, or teacher prospective computer use after mediating variables were taken into account.

Most studies that have reported on teachers' ICT competencies have relied on self-report data. However, one of the few performance assessments of ICT skills among teachers identified three ICT skill factors: basic digital skills, advanced technical skills, and professional ICT skills (Kaarakainen et al. 2018). Interestingly, these dimensions appear to be similar to those reported from studies of ICT self-efficacy. Results from this assessment indicated that male teachers outperformed female teachers in the assessment of ICT skills that they used; these results mirror the patterns found among assessments of students.

### *1.3.2 Teacher Perceptions About and Use of Digital Technologies*

There are conflicting claims about the influence of gender on the pedagogical use of ICT (Teo 2008). Some argue that male teachers tend to be more interested in learning about and using digital technologies (Schumacher and Morahan-Martin 2001; Yuen and Ma 2002). However, more recent studies suggest that the differences are neither large nor consistent across varied contexts.

SITES 2006 stressed the importance of the reciprocal relationships between teachers' pedagogical orientations and their use of ICT in teaching (Law et al. 2008). Ertmer et al. (2012) reported on the importance of teachers' general beliefs about teaching, and on their interest in technology itself, for the extent and manner of technology use in classrooms. ICILS 2013 included a set of questions asking teachers about the benefits of ICT in school education. Data based on responses to these questions were used to identify two orthogonal dimensions: positive views and negative views (Fraillon et al. 2014). The implication was that it was possible to hold both sets of views simultaneously. The level of use of computer technologies in teaching was higher among those teachers who had positive views of the roles of these technologies in school education and lower among those who held negative views about ICT (Fraillon et al. 2014). Gender differences on these scales were not reported.

Studies of teacher use of computer technologies have drawn attention to the importance of the environment in which teaching takes place. One aspect of the teaching environment is the learning or subject area in which teaching takes place. SITES 2006 found that the pedagogical use of ICT was greater in science classrooms than in mathematics classrooms (Law et al. 2008). ICILS 2013 also reported that the pedagogical use of ICT varied across learning areas. Aside from teaching in computer

studies classes, the pedagogical use of ICT was considerably greater in the sciences and the humanities than in mathematics and the creative arts (Fraillon et al. 2014). As the distribution of male and female teachers across learning areas is not uniform, these findings suggest that comparisons of the pedagogical use of computer technologies by female and male teachers need to take into account the subject areas in which they are teaching.

## 1.4 Research Questions

We derived a set of research questions designed to systematically investigate the gender differences in computer literacy, computer usage, and attitudes to computer technology in the ICILS 2013 data. These research questions can be divided into two groups. The first set of questions focus on students.

RQ1 *What is the magnitude of the difference between female and male students in measured computer literacy overall, and for particular types of items?*
RQ2 *To what extent do female and male students differ in computer self-efficacy overall, and in particular aspects of computing?*
RQ3 *To what extent do female and male students differ in their patterns of computer use and in their attitudes to computer technology?*

The second set of research questions concerned teachers.

RQ4 *To what extent do female and male teachers differ in computer self-efficacy overall and in relation to particular aspects of computing?*
RQ5 *To what extent do female and male teachers differ in their attitudes towards the use of computer technologies in school education?*
RQ6 *To what extent do female and male teachers differ in the ways in which they use computer technologies in their teaching?*

## 1.5 Structure of This Report

The chapters that follow this introduction address our six research questions in Sect. 1.4. Chapter 2 provides an overview of the ICILS study, describes the instruments and data, discusses the methods of analysis and variables used, and measures of significance and effect. Chapter 3 addresses research question RQ1 (measured computer literacy) and research question RQ2 (computer self-efficacy). It discusses each of these measures and the relationship between them for female and male students. Chapter 4 addresses research question RQ3 and examines differences between female and male students in their patterns of computer use and their attitudes towards computer technology. Research questions RQ4, RQ5, and RQ6, concerned with differences between female and male teachers of grade eight students

in computer self-efficacy, attitudes to the pedagogical use of computer technology, and the uses made of computer technology in teaching, are the focus of Chap. 5. Chapter 6 provides an overview and interpretation of gender differences in computer literacy and computer use in schools.

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