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The role of ICT self-efficacy for students' ICT use and their achievement in a computer and information literacy test

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A B S T R A C T

Students' self-efficacy in using information and communication technology (ICT) is among the most important motivational constructs that are related to their ICT acceptance, use, and literacy. The present study attempts to generate new knowledge about the role of ICT self-efficacy for students' ICT use and their computer and information literacy (CIL). Using the Norwegian data obtained from the International Computer and Information Literacy Study (ICILS) in 2013 ($N = 2410$ students in grade level 9), we distinguish between self-efficacy in basic and advanced ICT skills and examine the relations to students' ICT use for different purposes (school-related task learning, study purposes, and recreation) and their achievement in a CIL test. The results show that: (1) self-efficacy in basic ICT skills is positively related to CIL achievement, whereas self-efficacy in advanced ICT skills shows a negative relation; (2) ICT use and ICT self-efficacy are positively correlated for some of the ICT use purposes; (3) there is an indirect effects of ICT use on CIL achievement via ICT self-efficacy; (4) this indirect effect holds for both female and male students. Our findings point to a potential mechanism that links ICT use, self-efficacy, and CIL. Implications for future research and educational practice are discussed.

1. Introduction

Recent research on student learning has identified how students' confidence and expectations about their capabilities to perform are positively related to their persistence, school satisfaction, learning strategies, behavior, and achievement (Schunk, Meece, & Pintrich, 2014; Zimmerman, 2000). As the concept of self-efficacy is often used to understand students' confidence and expectations about success, research has focused on the relations between self-efficacy and achievement on the one hand (Pajares, 1996), and potential sources of self-efficacy on the other hand (Usher & Pajares, 2008). In fact, a growing body of research shows that self-efficacy is an important determinant of learning (Marsh, Dowson, Pietsch, & Walker, 2004). This relation has been identified particularly in the contexts of mathematics (Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014), science (Jansen, Scherer, & Schroeders, 2015), reading and writing (Schunk, 2003). Nevertheless, only limited knowledge exists about its role for students' computer and information literacy and the potential sources of students' self-beliefs in the context of Information and Communication Technology (ICT). For instance, the use of ICT in different

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settings such as the home or school environment and for different purposes such as recreation or working on school-related tasks may provide opportunities for students to gain mastery experience. As such, mastery experiences are considered to be crucial antecedents of students' self-efficacy, which in turn determine their achievement (Usher & Pajares, 2008; Valentine, DuBois, & Cooper, 2004). It therefore seems reasonable to assume that the relation between opportunities to experience mastery, as indicated by the use of ICT in different contexts, and students' computer and information literacy (CIL), as indicated by their achievement in ICT-related tests, may be indirect via self-efficacy in ICT skills.

Against this background, the present study is aimed at generating new knowledge about the role of students' ICT self-efficacy for their computer and information literacy on the one hand and for their use of ICT in different contexts on the other hand. Specifically, we perform structural equation modeling in order to test the hypothesis that ICT use has an indirect effect on CIL via ICT self-efficacy. The Norwegian data of the International Computer and Information Literacy Study (ICILS) 2013 form the basis of our study.

Since 2006, the development of ICT-related competences has been considered to be a key goal in the Norwegian curriculum (Norwegian Ministry of Education and Research, 2006). All the subjects in primary and secondary school have both general descriptions and specific competence goals. The general description emphasizes how to understand the role of ICT when learning the content and methods in each subject. Whereas the specific competence goals deal with what students are supposed to be able to do with technology to enhance their achievement in the subject, the general descriptions in the national framework seem to have many similarities with international frameworks (Binkley et al., 2012; Ferrari, 2013; Fraillon, Schulz, & Ainley, 2013). As such, all of these frameworks emphasize digital information, creating digital content, communication and digital protection or responsibility. Hence, the Norwegian context provides an opportunity of examining CIL from a national, yet general perspective.

2. Theoretical framework

2.1. Conceptualization of ICT self-efficacy

Self-efficacy as a concept builds on the assumption that students are active agents and can influence the directions of their learning process and achievement (Bandura, 1997). The aim of self-efficacy theory is to identify how students' perceive their capability to solve a task or achieve a goal (Sáinz & Eccles, 2012), considering self-efficacy to be about future expectations about success and failure, and the relations of these expectations to students' choices and behavior. Self-efficacy is therefore important for the choice and performance of activities. There is an assumption that when students are confident about being capable to solve a task or a problem, they might be more persistent and concentrated in how they work (Bandura, 2006; Schunk et al., 2014). Hence, self-efficacy generally relates to higher levels of achievement (Schunk et al., 2014; Valentine et al., 2004).

Following Bandura's (1997) distinction between general self-efficacy and domain-specific self-efficacy, Klassen and Mieu (2010) state that the more domain-specific the measurement of self-efficacy is the greater the potential for capturing learning and performance within that specific domain is, as compared with the more general self-efficacy. One reason for this may be that the domain-specific self-efficacy is more relevant for achievement in a specific domain. Another reason claims that it is easier for the students to have realistic expectations about solving a specific task within a specific context ("I can download a program") than a general task ("I am a good with ICT"). In fact, this distinction has encouraged general reflections on the specificity of self-efficacy measures, which, for instance, results in studies on the predictive validity of self-efficacy (specific capabilities) and self-concept (general capabilities) toward school achievement (e.g., Jansen et al., 2015; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2013).

In contrast to other studies narrowing self-efficacy to computers *or* the World Wide Web, ICILS extended self-efficacy toward both, computers *and* the Web (Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014). The concept of *ICT self-efficacy* is therefore used to describe students' confidence in their own capabilities to use the two media successfully. , et al. (2014) and Fraillon, et al. (2014) further distinguish between *self-efficacy in basic and advanced ICT skills*. Whereas the former is used to identify students' self-confidence on more affordable tasks requiring basic skills such as searching the web for information; the latter refers to more demanding tasks such as computer programming and building webpages. The ICILS 2013 results suggest that these forms of ICT self-efficacy are, in fact, distinct and moderately correlated across all participating countries ($\rho = 0.64$; Fraillon et al., 2015, p. 195). This finding was confirmed in a recently published, secondary data analysis for the Norwegian ICILS 2013 teacher sample (Scherer & Siddiq, 2015). A similar approach was taken to distinguish between self-efficacy in solving basic and advanced tasks in the Programme for International Student Assessment (PISA) in 2006 with slightly different labels: Internet versus high-level tasks (Tømte & Hatlevik, 2011). Again, some evidence on their distinction and differential relations to outcome measures was obtained.

To summarize, the concept of self-efficacy can, indeed, be transferred to ICT-related context, and distinguishing between different kinds of ICT tasks may provide a valuable source of considering the construct from a differentiated perspective.

2.2. Conceptualization of computer and information literacy

Computer and information literacy (CIL) can be described as students' achievement with technology in different contexts. Fraillon et al. (2013) define CIL 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*" (p. 17). This definition builds on the broader concept of ICT literacy and focuses specifically on dealing with digital information. According to Fraillon et al. (2013), one main distinction between CIL and ICT literacy is that CIL deals with the computer context, whereas the ICT literacy has a much broader context. Kim, Kil, and Shin (2014) further state that the concept of 'ICT literacy' "considers ICT as a fundamental learning tool" (p. 29). On the basis of previous studies using the concept of ICT literacy (e.g., Ainley, Fraillon, & Freeman, 2007; Lennon, Kirsch, von Davier, Wagner, & Yamamoto, 2003), Kim et al. (2014) conclude that ICT literacy comprises the abilities to process digital information, communicate with others and solve given problems. Developing ICT literacy therefore requires more than fundamental technical knowledge and abilities; it is considered to be a competence of using and dealing with ICT. The same argumentation holds for CIL, which is described as a construct beyond mere technical skills. As such, Fraillon, et al. (2014) operationalize CIL in two strands with seven aspects: The first strand of "Collecting and managing information" comprises three aspects, each of which describes skills that are necessary in order to develop and measure this strand: 1.1) Knowing about and understanding computer use, 1.2) Accessing and evaluating information, and 1.3) Managing information. The second strand refers to "Producing and exchanging information", which was further differentiated into four aspects: 2.1) Transforming information, 2.2) Creating information, 2.3) Sharing information; and 2.4) Using information safely and securely. It is worth mentioning that ICILS 2013 subsumes desktop computers, laptops, and tablets as "computers", but excludes phones or smartphones (Fraillon et al., 2014). Although we are aware that ICT literacy and CIL point to slightly different conceptualizations of being competent with ICT, we will use these two terms interchangeably in the current study.

2.3. The relation between ICT self-efficacy and computer and information literacy

To our knowledge, there are few studies examining the relation between self-efficacy and CIL. Most of these studies identified a positive correlation between performance and computer-related self-efficacy (Wan, Wang, & Haggerty, 2008; Yang & Cheng, 2009); and furthermore showed that ICT self-efficacy is an important predictor of developing digital literacy and competences (e.g., Hatlevik, Guðmundsdóttir, & Loi, 2015). These findings point out that higher self-efficacy is associated with higher achievement in the context of ICT. Of course, these studies do not claim causality in the direction of effects; hence, one may also argue that higher achievement leads to higher self-confidence. Nevertheless, the positive relation between self-efficacy and achievement has also been identified outside the context of ICT (Schunk, 1989; Valentine et al., 2004). As compared to the findings in these domains, a positive relation between ICT self-efficacy and CIL is expected in the present study.

2.4. ICT use as a predictor of ICT self-efficacy

In his self-efficacy framework, Bandura (1997) identified previous personal experience with a given task as probably the strongest predictor of self-efficacy. Specifically, when students engage in specific tasks, they may gain (positive) mastery experience, which may in turn enhance the interpretation of their performance results. We find ample literature supporting this argumentation for general self-efficacy (Usher & Pajares, 2008) and computer self-efficacy (Compeau & Higgins, 1995), that also points to influential factors such as gender, ease of use, and experience with ICT (Tsai & Tsai, 2010; Saleem, Beaudry, & Croteau, 2011; Cassidy & Eachus, 2002).

Within the context of digital technologies, prior successful experience in form of training leads us to categorize ICT use as an important determinant for ICT self-efficacy (Cassidy & Eachus, 2002). By engaging frequently in activities related to ICT, students not only acquire basic skills and competencies, their hands-on-training also helps them develop their ICT self-efficacy. As students increase their capacity of solving ICT-related tasks using previous knowledge and understanding, they can overcome failures, and, through mastery experience, they acquire strong beliefs in their own abilities (Usher & Pajares, 2008).

As argued earlier, ICT use can lead to lower or higher self-efficacy depending on how the students' perceive the usage (Joo, Bong, & Choi, 2000). Nevertheless, it is important to consider the context in which students use ICT and the specific purposes of their ICT use, as students are provided with opportunities to learn about and with ICT, both at and outside school. Fraillon et al. (2014) report that students' use of ICT at home is mainly for communication and information sharing purposes. Though this type of use might not be categorized under "formal education" it presents possibilities to acquire ICT skills and expertise that could be transferred in other contexts and relevant situations. It may therefore be necessary to differentiate between different types of ICT use when studying the ICT use–self-efficacy relation.

Finally, we acknowledge that there might be differences between boys and girls in both their ICT use and self-efficacy, which may also lead to differences in the relations between the two constructs. In fact, although boys were recognized to be more frequent computer users two decades ago, more recent research supports that girls are as frequent users of ICT as boys (Fraillon et al., 2014). One reason for this shift could be that digital technology is becoming the preferred platform and channel for communication of young people today. Regarding ICT self-efficacy, Litt (2013) argued that gender differences exist in the way students' perceive and report their digital literacy. Several studies showed that boys report higher levels of ICT self-efficacy compared with girls (e.g., Tømte & Hatlevik, 2011; Vekiri & Chronaki, 2008). However, according to Aesaert and van Braak (2014), this could be nuanced, as girls seem to have higher levels of self-efficacy than boys with regards to specific domains such as online communication.

In summary, the majority of existing studies reported a positive relation between students' use of ICT and their self-efficacy. Nevertheless, since most studies focused on one aspect of ICT use in *a specific context* and with *a specific purpose* only, disentangling this relation for *different contexts* and *different purposes* of using ICT will provide more detailed information on the role of ICT self-efficacy as a consequence of ICT use. It also seems to be important to address potential gender differences in this perspective.

2.5. ICT use as a predictor of CIL

With rapidly growing investments in ICT infrastructure, students have access to computers and Internet in homes and schools enabling them to become experienced users in digital technologies by gaining ICT knowledge and skills (European Schoolnet, 2013; OECD, 2015). They receive formal instruction, but also gain competencies and experiences outside of school (Tømte & Hatlevik, 2011). As the process of learning is multifaceted, it is rather intricate within the context of ICT use to identify single determinants for achievement. There has been mixed evidence on the impact of computer use on student achievement: In an early meta-analysis, Kulik and Kulik (1991) found that longer use of ICT was associated with students' familiarity and confidence in computers, but it did not automatically assure positive learning outcomes. In a more recent second-order meta-analysis, Tamim, Bernard, Borokhovski, Abrami, and Schmid (2011) identified an average effect size of +0.33, which followed a heterogeneous distribution across more than 20 meta-analyses. This result indicated a positive relation between ICT use and students achievement. Whereas these studies mainly referred on achievement in subjects other than ICT education or computer science, studies providing direct measures of ICT-related competences, also found both positive effects of ICT use on students' achievement (Luu & Freeman, 2011) and very little or no achievement gains in digital competences (Angrist & Lavy, 2002). Supporting the latter finding, Appel (2012) revealed that the use of computers at school and for school work was not related to students' ICT literacy. Even further, in the Norwegian context, the longitudinal study “Monitor” that maps students' digital skills in Norway showed that the time spent on the use of computers at home was positively related to digital literacy (Berge, Hatlevik, Kløvstad, Ottestad, & Skaug, 2009; Hatlevik, Egeberg, Guðmundsdóttir, Loftsgarden, & Loi, 2013). However, the use of ICT at school had a negative correlation with digital competence score in a follow-up study (Hatlevik, Ottestad, & Throndsen, 2015).

Extending on the complexity of the ICT use–achievement relation, we argue that this relation may depend on the specific context and purpose of using ICT. In fact, the use of computers for recreational purposes can be positively associated with learning and achievement (Appel, 2012). One potential explanation for this finding may lie in the fact that the recreational use of ICT is most often focused on engaging in discussion forums or virtual environments, in which students need to perform higher-order thinking and visual-spatial skills (Biagi & Loi, 2012; Steinkuehler & Duncan, 2008). However, there are also opinions that using ICT at home or in informal settings is not sufficient for developing ICT competence; formal education for developing ICT competence is therefore required (Aesaert, van Braak, van Nijlen, & Vanderlinde, 2015).

As noted earlier, it is important to take into account potential differences between boys and girls in ICT use, as these differences may also exist in CIL (Fraillon et al., 2014). Recent research has examined the effect of gender on digital literacy, again providing mixed results. Whereas some studies reported that boys perform better than girls on CIL-related measures (e.g, Calvani, Fini, Ranieri, & Picci, 2012; Van Deursen, 2012), there are results from an international study (Fraillon et al., 2014) and national studies in different countries (e.g., Ainley et al., 2007; Claro et al., 2012) reporting that girls outperform boys in CIL. In addition, there are also studies that could not identify any gender differences (e.g., Hargittai & Shafer, 2006; Van Deursen, Van Dijk, & Peters, 2011). In light of these research findings, it is important for each individual study to account for potential gender differences in CIL.

Taken together, this review of existing research on the relation between students' use of ICT and their computer and information literacy did not provide a clear-cut picture, but pointed to the role of meaningful experiences with ICT for students' digital competences.

2.6. The present study: research question and hypotheses

On the basis of our theoretical considerations, the present study is aimed at answering the following research question: *How does students' ICT self-efficacy relate to the use of ICT for different purposes on the one hand, and the achievement in a computer and information literacy (CIL) test on the other hand?* Addressing this question, we study not only the bivariate relations between these constructs but also test for the indirect effects.

Specifically, we expect a positive relation among ICT self-efficacy and CIL achievement. As pointed out earlier, this expectation is in line with existing research on self-efficacy and achievement, and assumes that positive beliefs about one's capabilities in ICT contexts function as a motivational drive toward increased performance (Christoph, Goldhammer, Zylka, & Hartig, 2015; Fraillon et al., 2014). This argumentation has also been discussed on a more general level outside the ICT context, and positive associations have been identified in numerous studies (Valentine et al., 2004). As a consequence, our first hypothesis reads:

Hypothesis 1. *Self-efficacy in both basic and advanced ICT skills is significantly related to achievement in the CIL test.*

Regarding the relation between ICT use for different purposes and students’ ICT self-efficacy, we expect a positive relation, relying on research on the sources of self-efficacy. We specifically argue that situations in which students use ICT for recreational, learning, or study purposes provide opportunities to develop, perform, and practice their ICT skills. In such opportunities, students may experience how they master specific tasks with the help of ICT. As a consequence, these mastery experiences contribute positively to the development of their self-efficacy, leading to a positive correlation (Usher & Pajares, 2008). As such, the use of ICT can be regarded as a potential predictor of self-efficacy. We note that we do not expect the different types of ICT use to contribute equally to self-efficacy, as they may provide quite different opportunities for mastery experiences. Our second hypothesis reads:

Hypothesis 2. *Frequent use of ICT is significantly and positively related to self-efficacy in both basic and advanced ICT skills.*

Bringing hypotheses 1 and 2 together, we expect an indirect effect of ICT use on CIL achievement via ICT self-efficacy. This expectation draws on research on educational effectiveness outside the context of ICT, which indicated that instructional settings provide sources of positive experiences for students, which may relate to achievement via self-efficacy (e.g., Jansen et al., 2015; Morin, Marsh, Nagengast, & Scalas, 2014). We believe that this argumentation can be transferred to the context of ICT, because opportunities to use ICT for different purposes create mastery experiences that strengthen students' beliefs in their capabilities, which in turn enhance their performance. Nevertheless, we point out that we do not claim causality in this line of argumentation, since there is also evidence that other directions in the relations seem reasonable. Against this background, our third hypothesis is:

Hypothesis 3. *ICT use has an indirect effect on achievement in the CIL test via self-efficacy in basic and advanced ICT skills.*

As a final step, we explore the robustness of this hypothesis by studying the existence of the indirect effect across gender. This seems particularly important, since gender differences have been studied and controversially discussed in the context of ICT (Broos, 2005; Saleem et al., 2011; Sieverding & Koch, 2009). Whereas some research indicated significant differences in students' ICT self-efficacy and literacy in favor of boys (Durndell & Haag, 2002; Lau & Yuen, 2015; Shashaani, 1993), it is unclear whether these differences also apply to the proposed indirect effect; we expect the indirect effect to appear across gender.

In light of these considerations, we see the main contribution of the present study in generating new knowledge about the specific role of ICT self-efficacy for the use of ICT on the one hand, and CIL achievement on the other hand. Rather than studying only bivariate relations, we provide an integrative view on the relations among the three constructs. We combine our hypotheses on these relations in the research model depicted in Fig. 1. Moreover, we take advantage of the ICILS 2013 study, which provides a nationally representative dataset of Norwegian students and psychometrically well-established measures of the constructs.

3. Method

3.1. Sample and procedure

The Norwegian ICILS 2013 sample of 2436 students enrolled in 138 schools in grade level 9 (50.2% girls) formed the basis for the present study. Students' average age was 14.8 years ($SD = 0.3$ years) and ranged between 13.8 and 19.0 years. Due to missing values on all variables under consideration in the present study, we excluded the data of 26 students from the data set. As a consequence, our analyses were based on a final sample of $N = 2410$ students.

In two test sessions, students worked on a CIL achievement test and a questionnaire. The latter comprised two parts, a general one containing background information such as gender and age; a second part consisted of items that assessed ICT-related constructs such as ICT self-efficacy, ICT use for different purposes, and computer experience (Fraillon et al., 2013). Both the CIL test and the questionnaire were administered as computer-based assessments. The subsequent processes of data collection, coding, and reporting were conducted by the International Association for the Evaluation of Educational Achievement (IEA) according to pre-defined quality standards (for details, please refer to Fraillon et al., 2014, 2015).

3.2. Measures

To address our research objectives, we used measures of students' ICT self-efficacy, ICT use, computer experience in years, and their achievement in the CIL test. Except for computer experience, all measures were scaled with the help of item

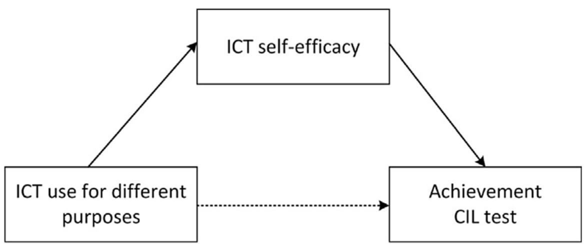

Fig. 1. Conceptual model showing the role of ICT self-efficacy for ICT use and achievement in the computer and information literacy (CIL) test.

response theory (Fraillon et al., 2015, chapters 11 and 12). Warm's weighted likelihood estimates (WLE) served as person estimates (Warm, 1989). For details on the scaling procedures conducted in ICILS 2013, we refer the reader to Fraillon et al. (2015) for more detailed information.

ICT self-efficacy. Students' ICT self-efficacy refers to their confidence in solving basic and advanced computer- and internet-related tasks (Fraillon et al., 2014, 2015). In the current paper, we will use the terms “ICT self-efficacy basic” and “ICT self-efficacy advanced” to indicate the distinction between the two types of self-efficacy

In the ICILS 2013 student questionnaire, students were asked to rate the degree to which they believed how well they performed in 13 computer- and Internet-related tasks on a 3-point scale (*1 = I know how to do this, 2 = I could work out how to do this, 3 = I do not think I can do this*). Six of these tasks were assigned to self-efficacy in basic ICT skills (e.g., “*Create or edit documents [*e.g., *assignments for school]*”, “*Search for and find information you need on the Internet*”); seven tasks belonged to self-efficacy in advanced ICT skills (e.g., “*Change the settings on your computer to improve the way it operates or to fix problems*”, “*Build or edit a webpage*”). Following Bandura's (1997) recommendations, the item stimulus referred to the degree to which students believe they *can do* instead of *will do* the following tasks.

ICT use for different purposes. The three scales of students' use of ICT for task learning, study purposes, and recreation reflect different opportunities for students to acquire ICT-related skills and to gain experience in ICT tasks in their school and home environment. We decided to use the school- and recreation-related ICT use scales, because existing research has indicated that the frequencies of ICT use for leisure and educational purposes are crucial determinants of students' self-efficacy in solving high-level ICT tasks (Tømte & Hatlevik, 2011)

To assess the *ICT use for task learning*, students were asked to indicate whether or not they had learned eight different ICT tasks at school (*0 = No, 1 = Yes*). These items comprised ICT tasks such as “*Accessing information with a computer*”. Students' *ICT use for study purposes* was measured by 8 items, which presented students with a number of school-related purposes of using ICT (e.g., “*Working with other students from your own school*”, “*Completing worksheets or exercises*”). These purposes were rated on a 4-point scale ranging from 1 (*Never*) to 4 (*At least once a week*). Finally, students indicated the frequency of the *ICT use for recreation* by responding to items such as “*Accessing the internet to find out about places to go or activities to do*”. This scale comprised 5 items and was based on a 5-point frequency scale ranging from 1 (*Never*) to 5 (*Every day*).

Achievement in the CIL test. The major focus of ICILS 2013 was on the evaluation of students' CIL, which was organized in two strands and a number of aspects that specified the strands. In total, 27 items were used to assess strand 1, and 53 to assess strand 2 (Fraillon, Schulze, & Ainley, 2013, p. 43). In light of the large number of items that were designed to assess CIL achievement, the assessment was delivered in four test modules. Students had to solve two modules within 60 min. Although such a rotated test module design allows for the inclusion of a large number of CIL items, it requires the application of advanced statistical methods to determine students' overall achievement (Fraillon, Schulze, & Ainley, 2013). Specifically, by means of item response theory (IRT), students' responses were scaled and an overall CIL achievement score (WLE) was obtained (Fraillon et al., 2015, chapter 11). In the present study, we used this overall score as an indicator of students' computer and information literacy. We note that the WLE can be interpreted in the same way as sum scores, meaning that high values indicate high levels of CIL, and low scores indicate low levels of CIL. The reliability of the CIL test obtained from the international ICILS 2013 data set was 0.89 (Fraillon et al., 2015, p. 170)

Computer experience. Students reported their experience with computers as an approximate number of years of computer use five response categories (*1 = less than one year, 5 = more than seven years*). In Norway, almost 96 percent of the students reported 6 years as their average computer experience. In the current study, computer experience serves as a covariate of their ICT self-efficacy and achievement in the CIL test

3.3. Data analysis

In order to test our hypotheses on the relations among ICT self-efficacy, ICT use, and CIL test achievement, we applied structural equation modeling with the statistical package M*plus* 7.3 (Muthén & Muthén, 1998–2014). In particular, using the person estimates obtained from IRT as proxies for the proposed variables (Fraillon et al., 2015, chapter 12), we specified a structural equation model (SEM), which simultaneously linked students' ICT self-efficacy with achievement (Hypothesis 1), and ICT use and self-efficacy (Hypothesis 2). The relations among these variables were reported as path coefficients, which were tested for significant deviations from zero. To address our hypothesis on the indirect effect in this model (Hypothesis 3), we tested the indirect effects for statistical significance. This asymptotic procedure is based on the Delta method which provides an approximate estimate of the standard error of the indirect effect (MacKinnon, Warsi, & Dwyer, 1995). If the corresponding confidence intervals did not contain zero, we had evidence for significant indirect effects (MacKinnon, 2008). Finally, the structural equation model was extended to a multi-group SEM with gender as the grouping variable to test whether the indirect effect existed for both girls and boys. This SEM is estimated for the two gender groups and differences in the path coefficients are tested against zero (Ryu, 2015). This multi-group approach is based on the assumption that the scores of the variables included in the model are comparable between girls and boys, and that they have the same meaning for the two gender groups (Millsap, 2011). We note that we used the person estimates in the current analyses as scores for the constructs involved in this study. Alternatively, we could have specified all constructs as latent variables which are indicated by students' responses or performance on the items. However, in light of the large number of items that would have been used in an item-based approach (see Table 1) and taking into account the missing-by-design setup of the CIL achievement test, the person estimates were obtained in a first step and included in the SEM analyses in a second step. This procedure provides a parsimonious way of analyzing the complex relations among constructs which were measured by large numbers of items (e.g., Little, Rhemtulla, Gibson, & Schoemann, 2013).

In order to evaluate the fit of the structural equation models, common guidelines were applied (i.e., CFI $\geq$ 0.95, TLI $\geq$ 0.95, RMSEA $\leq$ 0.08, SRMR $\leq$ 0.10 for an acceptable model fit; Marsh, Hau, & Grayson, 2005). We note that, given the large sample size in the present study, the χ^2 value may become significant and therefore indicate deviations of the theoretically assumed from the empirical model (Brown, 2015). Whereas this result would be an indication of model misfit, it may also be due to the dependence of the χ^2 value on the sample size. As a consequence, we did not heavily base our evaluation of the model fit solely on this statistic but took into account the indices mentioned earlier.

In our analyses, we applied robust maximum likelihood estimation (MLR) and accounted for the clustering of students in schools by correcting the standard errors and χ^2 value with the TYPE = COMPLEX option in M*plus*. The χ^2 values reported in our study are therefore Satorra-Bentler corrected (SB-χ^2; Satorra & Bentler, 2010). Missing data were handled by the full-information maximum likelihood procedure under the assumption that missing values occurred randomly (Enders, 2010).

Given that ICILS 2013 applied a two-stage random sampling procedure, in which schools were sampled at the first stage, and students within schools were sampled in the second stage, differences in the probabilities of being selected as a study participants may occur (Asparouhov, 2005). In order to adjust for these differences in all analyses, we used students' final weights (M*plus* option WEIGHT = TOTWGTS; Fraillon et al., 2015).

4. Results

4.1. Descriptive statistics and reliabilities

Before testing our hypotheses on the relations between ICT self-efficacy, CIL achievement, and the different types of ICT use, we examined the descriptive statistics and reliabilities of the scales measuring these constructs. The results are shown in Table 1. Given that the means and standard deviations of the ICT self-efficacy and ICT use scales were scaled toward the international scores ($M = 50$, $SD = 10$), the Norwegian data do not show ceiling or floor effects. It is though noteworthy that the variance of students' reported ICT use for recreation was the lowest ($SD = 6.8$), and the variance of students' reported self-efficacy in advanced ICT skills the highest ($SD = 10.0$). The former finding indicates higher homogeneity in students' recreational ICT use reports. For the CIL achievement scores, the descriptive statistics were transformed to a national metric with $M = 150$ and $SD = 10$. Finally, students' computer experience was on average 6.4 years.

Regarding the scale reliabilities, almost all scales showed acceptable values above 0.80. However, Cronbach's α was only substantial for the measurement of 'ICT self-efficacy basic' and 'ICT recreation' (Table 1). For the latter, one potential explanation for the low reliability may lie in the fact that the scale scores show less variation compared to the other scales with higher reliabilities. Nevertheless, we regarded the reliabilities as still sufficient to use the scale scores in a structural equation model.

4.2. Relations among ICT self-efficacy, ICT use, and CIL achievement (Hypotheses 1 and 2)

In order to test our hypotheses on the relations between ICT self-efficacy and CIL achievement (Hypothesis 1), and between ICT self-efficacy and ICT use (Hypothesis 2), we first examined the correlations among these constructs (Table 1). As expected, the results indicated a significant and positive correlation between students' self-efficacy in basic ICT skills and CIL achievement ($r = 0.22$, $p < 0.001$). However, self-efficacy in advanced ICT skills was negatively related to CIL achievement ($r = -0.06$, $p < 0.01$), indicating that the more students feel confident in performing advanced ICT skills, the lower their CIL achievement and vice versa. Regarding the second hypothesis, we found positive and significant correlations among the different types of ICT use and the two ICT self-efficacies. The strongest relations could be established to students' use of ICT for recreational purposes (ICT self-efficacy basic: $r = 0.24$, $p < 0.001$; ICT self-efficacy advanced: $r = 0.26$, $p < 0.001$).

Table 1
Descriptive statistics, reliabilities, and correlations between the ICT use variables, ICT self-efficacy, achievement in the CIL test, and computer experience.

Variables	M	SD	#Items	α	Correlations					
					1.	2.	3.	4.	5.	6.
1. ICT self-efficacy basic	51.5	8.5	6	0.69	–					
2. ICT self-efficacy advanced	49.2	10.0	7	0.83	0.52***	–				
3. Achievement CIL test	150.1	9.9	80	0.89[a]	0.22***	−0.06**	–			
4. Use of ICT for task learning	51.8	9.3	8	0.82	0.08***	0.04*	0.05*	–		
5. Use of ICT for study purposes	52.7	6.8	8	0.81	0.11***	0.11***	0.03	0.12***	–	
6. Use of ICT for recreation	51.1	7.7	6	0.68	0.24***	0.26***	0.06**	0.02	0.34***	–
7. Computer experience [years]	6.4	1.7	1	–	0.17***	0.16***	0.12***	0.02	0.02	0.12***

Notes. #Items = Number of items, α = Cronbach's α. [a]: Due to the rotated multi-matrix design of the CIL test, Cronbach's α cannot be reported as a measure of scale reliability. The reliability reported here refers to the expected-a-posteriori reliability for the entire ICILS 2013 sample (see Fraillon et al., 2015, p. 170).
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

In a second step, we specified a structural equation model which represented our main assumptions on the interplay between the three types of constructs. This model was based on the conceptual framework as shown in Fig. 1. Our basic assumption was that ICT self-efficacy is directly associated with ICT use and CIL achievement, whereas the latter two constructs may show only indirect relations. We therefore established a structural equation model, which represents this assumption (see Fig. 2). Moreover, as students' computer experience served as a covariate in the model, as it may influence students' self-efficacy and CIL achievement. The resulting model showed a very good fit and was therefore accepted, SB-χ^2 [3] = 2.69, $p = 0.44$, RMSEA = 0.000, 90% CI = [0.000, 0.033], CFI = 1.00, TLI = 1.00, SRMR = 0.008 (see Fig. 2).

Testing Hypothesis 1 in the structural equation model, we had support for the assumption of significant relations between ICT self-efficacy and CIL achievement (Fig. 2). Even after controlling for computer experience and allowing for the relations between self-efficacy in basic and advanced ICT skills ($\beta = 0.48$, $SE = 0.02$, $p < 0.001$), we found that self-efficacy in basic ICT skills was positively ($\beta = 0.34$, $SE = 0.03$, $p < 0.001$) and self-efficacy in advanced ICT skills negatively associated with CIL achievement ($\beta = -0.26$, $SE = 0.03$, $p < 0.001$). Moreover, the effect of self-efficacy in basic ICT skills on CIL achievement was indirect via self-efficacy in advanced ICT skills (see Table 2). Hence, the direction of these relations (either positive or negative) confirmed our initial findings obtained from the zero-order correlations.

Finally, we approached Hypothesis 2 in this model and found significant and positive relations among the two ICT self-efficacies and ICT use for recreation, as well as between ICT use for task learning and ICT self-efficacy basic (see Fig. 2). The other relations, although found positive and significant in the correlational analysis (Table 1), were no longer significant. Interestingly, this applied to students' ICT use for study purposes. This result might be due to the fact that we allowed for the relation between self-efficacy in basic and advanced ICT skills in our structural equation model. Nevertheless, the relations that were identified as the strongest in the first step remained in the second step (i.e., concerning *ICT use for recreation*). Hence, we were able to support Hypothesis 2 for students' ICT use for task learning and recreation.

4.3. Evaluation of indirect effects (Hypothesis 3)

Our third hypothesis was concerned with the role of ICT self-efficacy for students' ICT use and their CIL achievement. On the basis of the model proposed to test Hypotheses 1 and 2 (Fig. 2), we examined the indirect effects and tested for the statistical significance (see Table 2). The results indicated that the indirect effect was significant and positive for students' *ICT use for task learning* via ICT self-efficacy basic ($\beta = 0.03$, $SE = 0.01$, $p < 0.001$), but negative via ICT self-efficacy basic and advanced ($\beta = -0.01$, $SE = 0.00$, $p < 0.001$). The latter is due to the negative relation between self-efficacy in advanced ICT skills and CIL achievement. For students' *ICT use for study purposes*, none of the indirect effects were significant, indicating that there was no evidence on significant indirect paths. Finally, the indirect effects for students' *ICT use for recreation* followed the same patterns as the ICT use for task learning. We note that the indirect effects, although significant for two out of three types of ICT use, were rather small. Hence, we found support for indirect effects with respect to students' ICT use for task learning and recreation.

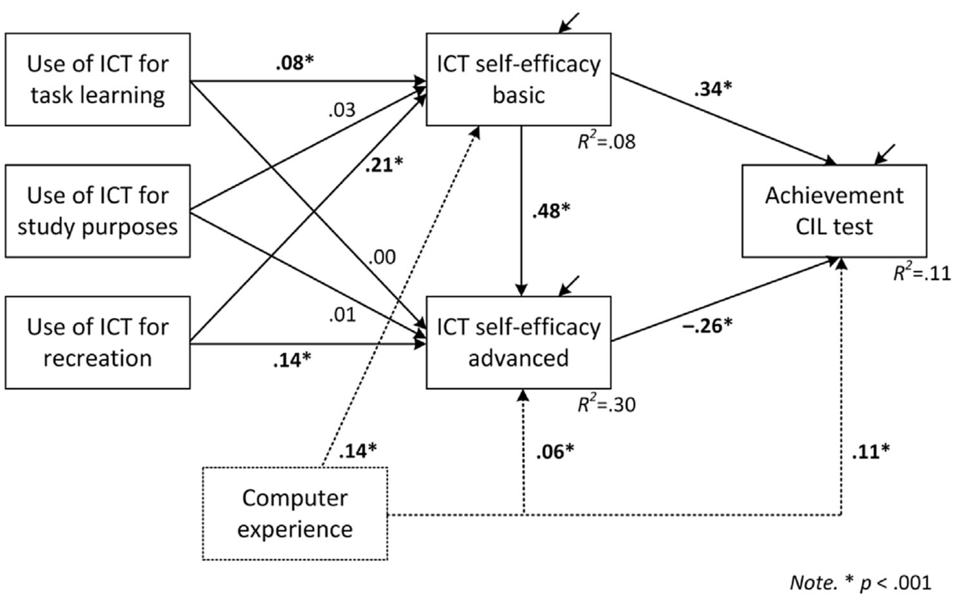

Fig. 2. Structural equation model showing the indirect effects of the use of ICT on the achievement in the CIL test via students' ICT self-efficacies. *Note.* The figure shows the fully standardized results.

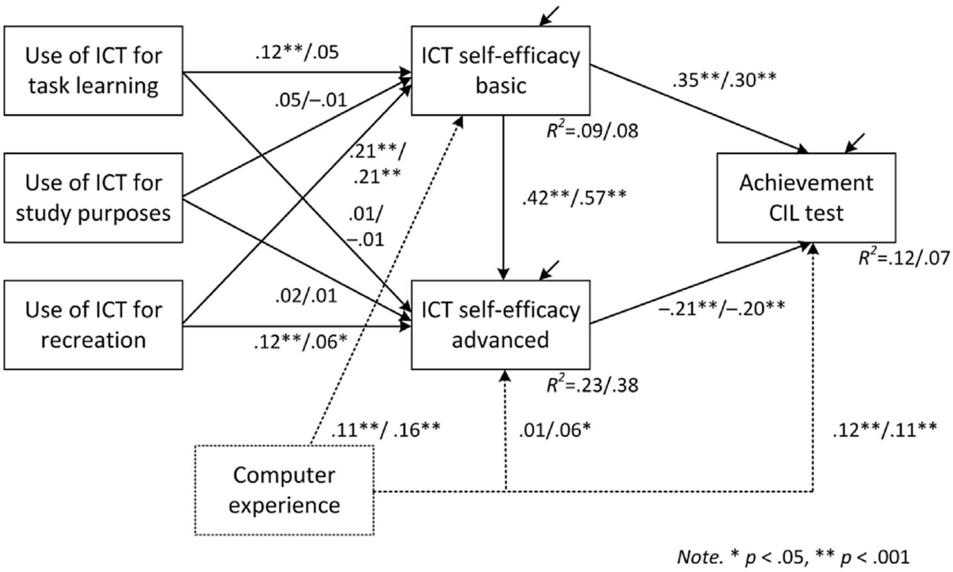

Fig. 3. Results of the multi-group structural equation modeling with gender as the grouping variable. *Notes*. The regression coefficients and variance explanations are shown for girls before and for boys behind the slash. The figure shows the fully standardized results.

To further test whether or not only an indirect effect existed, we added the direct paths between the ICT use variables and CIL achievement to the structural equation model. Since this model was fully identified (degrees of freedom: $df = 0$), the model fitted the data perfectly. The direct effects on CIL achievement obtained from this model were: *ICT use for task learning* $\beta = 0.03$ ($SE = 0.02$, $p = 0.14$), *ICT use for study purposes* $\beta = 0.02$ ($SE = 0.04$, $p = 0.59$), and *ICT use for recreation* $\beta = 0.02$ ($SE = 0.03$, $p = 0.51$). As a consequence, we had strong support for the indirect effect with respect to students' ICT use for task learning and recreation, given the insignificant direct relations between ICT use and CIL achievement.

Finally, we examined whether or not the indirect effects existed across gender by extending the structural equation model shown in Fig. 2 to a multi-group structural equation model with gender as the grouping variable (Fig. 3). In this model, the relations for girls and boys are estimated simultaneously. Examining the model fit, we concluded that the multi-group structural equation model fitted the data very well, SB-χ^2 [6] $= 10.05$, $p = 0.12$, RMSEA $= 0.024$, 90% $CI = [0.000, 0.048]$, CFI $= 1.00$, TLI $= 0.98$, SRMR $= 0.013$.

Regarding the indirect effects, both the recreational use and the use of ICT for study purposes showed similar path coefficients for girls and boys, as Table 3 details. There have only been few exceptions, for instance, with respect to the use of ICT for recreational purposes. With these results in mind, we conclude that there is evidence for the persistence of the indirect effect that has been identified in Hypothesis 3 across gender.

5. Discussion

This study was aimed at examining the relations among students' ICT self-efficacy, ICT use in and out of school, and CIL achievement. In order to address this aim, we developed three hypotheses on the specific relations and tested them with the help of structural equation modeling. The Norwegian ICILS 2013 data formed the basis for our analyses. In the following, we will discuss our findings with respect to the three hypotheses.

The first hypothesis on the positive relation between students' ICT self-efficacy and CIL achievement was supported for self-efficacy in basic ICT skills. Students who believed in their capabilities of solving basic ICT tasks such as searching for information on the internet or editing a document performed better than students with lower self-efficacy. This finding is in line with the positive self-efficacy–achievement relations identified in other domains and samples (Valentine et al., 2004). Hence, our study extends the existing body of research by providing evidence on this relation in the context of ICT-related skills.

Nevertheless, the positive self-efficacy–achievement relation for basic skills may also be due to the design of the measures. Specifically, the self-efficacy items referred to basic ICT skills which were mainly required in the CIL achievement test (Fraillon et al., 2014). This alignment between self-efficacy and achievement resulted in an overlap between the two measures. Following this line of argumentation, the negative relation between students' self-efficacy in advanced ICT skills and their CIL achievement becomes reasonable. As only a limited number of advanced ICT tasks that require higher-order thinking and problem solving skills were administered in the CIL test, there was only little alignment with the ICT self-efficacy advanced measure. According to Bandura (1997), self-beliefs assessments should always be consistent with the achievement measure

Table 2
Indirect effects in the structural equation model (total sample).

Indirect effects	Estimate	SE	p	95% CI
Effect of ICT use for task learning on CIL test achievement				
via ICT self-efficacy basic	0.028	0.008	<0.001	[0.013, 0.044]
via ICT self-efficacy advanced	0.001	0.005	0.78	[−0.008, 0.010]
via ICT self-efficacy basic and advanced	−0.010	0.003	<0.001	[−0.016, −0.004]
Effect of ICT use for study purposes on CIL test achievement				
via ICT self-efficacy basic	0.009	0.009	0.31	[−0.014, 0.026]
via ICT self-efficacy advanced	−0.001	0.006	0.81	[−0.013, 0.011]
via ICT self-efficacy basic and advanced	−0.003	0.003	0.31	[−0.010, 0.003]
Effect of ICT use for recreation on CIL test achievement				
via ICT self-efficacy basic	0.072	0.010	<0.001	[0.053, 0.090]
via ICT self-efficacy advanced	−0.036	0.006	<0.001	[−0.047, −0.024]
via ICT self-efficacy basic and advanced	−0.026	0.004	<0.001	[−0.034, −0.018]
Effect of ICT self-efficacy basic on CIL test achievement				
via ICT self-efficacy advanced	−0.123	0.015	<0.001	[−0.154, −0.093]

Note. The table shows the standardized path coefficients. *CI* = confidence interval.

with which they are compared in order to draw meaningful conclusions on their relations. Since this is not completely the case for the self-efficacy and CIL assessments of advanced ICT skills, it can therefore be questioned, if it is possible for students to have realistic beliefs about their own capabilities in such tasks without prior use and familiarization (Pajares & Schunk, 2001). Besides this measurement perspective, an alternative explanation may lie in the fact that the items demanding advanced skills include less customary curricular activities, yet specialized activities. For example, students' familiarity with complex ICT activities such as programming or creating a database may be limited, as this particular activity is not a part of the curriculum in lower secondary school (Norwegian Directorate for Teaching and Education, 2012).

Taken together, our first hypothesis was supported for students' self-efficacy in basic ICT skills; but there was no evidence on a positive relation for self-efficacy in advanced ICT skills. These findings further point to the importance of nuancing ICT self-efficacy with respect to the different ICT tasks and skills that form the basis for this self-evaluation.

The second hypothesis addressed the relation between ICT use and ICT self-efficacy and was partly supported. For two out of three types of ICT use, a positive relation to self-efficacy in basic and advanced ICT skills was identified. Nevertheless, the effects described in the model were rather small for these two constructs. One reason for this result may be that the ICT use items are more suitable for capturing the *frequency*, but not necessarily the *quality* of ICT use (Luu & Freeman, 2011). Hence, although it is reasonable to use the frequency-based measures of ICT use as proxies for opportunities of mastery experiences, they may not fully reflect these experiences, leading to weak relations.

Specifically, the use of ICT for recreational purposes is the dominant predictor of both types of ICT self-efficacy in our model. Previous research showed that students gain experience in a range of activities using computers and the Internet at home (Mumtaz, 2001). For instance, students might gain positive mastery experience when they use their home computers and the Internet for surfing and emailing (Kuhlemeier & Hemker, 2007). Our results point to the importance of such experience in recreational settings for students' ICT self-efficacy.

The use of ICT for task learning and self-efficacy in advanced ICT skills were weakly related, whereas no significant relation could be identified for self-efficacy in basic ICT skills. Furthermore, the school-related use if ICT did not significantly related to any of the ICT self-efficacies. It seems as if the use of ICT for these two purposes may not necessarily provide students with mastery experiences that help them develop their self-efficacy. Hence, we argue that the use of ICT for school work is necessary in both the intensity and purpose to build up their self-efficacy in demanding skills.

Although our results show that the use of ICT influences students' self-efficacy, we cannot disregard the reverse argument, that is, to assume that ICT self-efficacy influences the use of ICT (Barbeite & Weiss, 2004; Compeau & Higgins, 1995). As efficacy beliefs are self-regulatory and can influence the choice to use or sidestep the use, the relation between ICT use and self-efficacy can best be interpreted as reciprocal (Williams & Williams, 2010). However, in light of the fundamental assumptions on this relation that were developed by Bandura (1997), we proposed a model that appeared most reasonable for describing these relations.

Overall, the analyses of the data supported the third hypothesis about the indirect role of ICT self-efficacy for the relation between ICT use and CIL achievement in part. Our model demonstrates that the indirect effect of the use of ICT for recreation on CIL achievement, and the ICT use of task learning on CIL achievement existed. Students' prior use and experience create opportunities for positive mastery experiences, which are essential for building self-efficacy beliefs (Johnson, 2005). Positive beliefs in turn contribute to the prediction of performance (Pajares & Schunk, 2001).

As self-efficacy is related to both prior use and achievement, we studied its role as an indirect variable to uncover a possible mechanism by which the effects of ICT use in different settings are passed on to CIL achievement. On the basis of our results, we have reasons to believe that the relation between ICT use and CIL achievement operates via self-efficacy in both basic and advanced skills. Interestingly, this mechanism existed for girls and boys. This can be interpreted as first evidence on the robustness of the mechanism against potential gender differences in the three constructs under investigation.

Table 3
Indirect effects in the structural equation model across gender.

Indirect effects	Girls				Boys			
	Estimate	*SE*	*p*	95% *CI*	Estimate	*SE*	*p*	95% *CI*
Effect of ICT use for task learning on CIL test achievement								
via ICT self-efficacy basic	0.043	0.012	<0.001	[0.020, 0.066]	0.015	0.010	0.12	[−0.004, 0.034]
via ICT self-efficacy advanced	−0.003	0.006	0.64	[−0.013, 0.009]	0.002	0.005	0.74	[−0.008, 0.011]
via ICT self-efficacy basic and advanced	−0.011	0.003	<0.01	[−0.018, −0.004]	−0.006	0.004	0.13	[−0.013, 0.002]
Effect of ICT use for study purposes on CIL test achievement								
via ICT self-efficacy basic	0.019	0.012	0.11	[−0.004, 0.042]	−0.002	0.011	0.89	[−0.023, 0.020]
via ICT self-efficacy advanced	−0.003	0.007	0.67	[−0.017, 0.011]	−0.002	0.006	0.71	[−0.014, 0.010]
via ICT self-efficacy basic and advanced	−0.005	0.003	0.12	[−0.011, 0.001]	0.001	0.004	0.89	[−0.008, 0.009]
Effect of ICT use for recreation on CIL test achievement								
via ICT self-efficacy basic	0.072	0.014	<0.001	[0.044, 0.099]	0.063	0.013	<0.001	[0.036, 0.090]
via ICT self-efficacy advanced	−0.026	0.008	<0.01	[−0.042, −0.009]	−0.022	0.007	<0.01	[−0.036, −0.009]
via ICT self-efficacy basic and advanced	−0.018	0.005	<0.01	[−0.029, −0.007]	−0.024	0.006	<0.001	[−0.036, −0.011]
Effect of ICT self-efficacy basic on CIL test achievement								
via ICT self-efficacy advanced	−0.088	0.020	<0.001	[−0.129, −0.046]	−0.113	0.024	<0.001	[−0.162, −0.063]

Note. The table shows the standardized path coefficients. *CI* = confidence interval.

5.1. Limitations and future directions

The present study has some limitations that point to future directions of research on the role of students' ICT self-efficacy: First, our findings are based on the conceptual distinction between self-efficacy in basic and advanced ICT skills, as proposed in ICILS 2013. In fact, we believe that other distinctions may result in slightly different relations between the constructs under investigation. For instance, the negative relation between self-efficacy in advanced ICT skills and CIL achievement may become positive if other skills are used to operationalize self-efficacy. Moreover, given the advancement of ICT and ICT skills, we note that the basic–advanced distinction may be subject to change over time, as researchers may consider today's “advanced” skills to be “basic” in the future. Nevertheless, as the distinction chosen in ICILS 2013 was confirmed empirically (Fraillon et al., 2015), it seems as if it provides a valid operationalization of different types of ICT self-efficacy in the current study.

Second, when comparing the items used to measure ICT use, ICT self-efficacy, and CIL achievement, we noted that they point to quite different ICT-related activities. We believe that a stronger congruence between the measurements of these constructs, particularly with respect to the specific activities and skills, may increase the predictive power of ICT use toward ICT self-efficacy or ICT self-efficacy toward CIL achievement (see Bandura, 1986 for a general discussion). We would therefore like to stimulate future research on the performance of different measures of the three constructs in our proposed model.

6. Conclusion

This study generated new knowledge about the relations between ICT use, ICT self-efficacy, and CIL achievement. ICT self-efficacy plays a particular role for the use of ICT and CIL achievement. We further point to three main conclusions drawn from our findings: First, self-efficacy in basic and advanced ICT skills relate differently to CIL achievement. Specifically, whereas self-efficacy in basic ICT skills relates positively to CIL achievement, self-efficacy in advanced ICT skills relates negatively to CIL achievement. These findings confirm the existence of different forms of ICT self-efficacy, indicating differential validity of the self-efficacy measures. It is therefore important to examine and take into account this distinction when elaborating on the concept of ICT self-efficacy in relation to CIL achievement.

Second, we have shown that the school-related use of ICT does not significantly correlate with ICT self-efficacy, and that the use of ICT for recreation is the more dominant predictor of self-efficacy. According to Bandura (1997), prior experience and meaningful mastery experiences from a domain are important predictors of self-efficacy. In support of prior research, it therefore seems as if students receive considerable opportunities for such mastery experience in recreational rather than school-related contexts (Tømte & Hatlevik, 2011). Hence, together with Luu and Freeman (2011), we encourage educators to not only provide the resources for ICT use but also meaningful learning opportunities, in which students can gain positive mastery experience.

Third, our model suggests a mechanism linking the ICT use, the ICT self-efficacy and the CIL achievement. However, this mechanism has to be nuanced with respect to the different kinds of ICT use and ICT self-efficacy. We obtained some evidence that ICT for recreation would be the most promising predictor of ICT self-efficacy; moreover, compared with self-efficacy in advanced ICT skills, self-efficacy in basic ICT skills has a larger potential to describe a potential mechanism linking ICT use and CIL.

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Authors' contributions

Anubha Rohatgi initiated the paper, developed the model, interpreted the results, and drafted parts of the manuscript. Ronny Scherer participated in the development of the model, conducted the analyses, discussed the results, and drafted parts of the manuscript. Ove E. Hatlevik participated in the development of the model, interpreted the results, and drafted parts of the manuscript.

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