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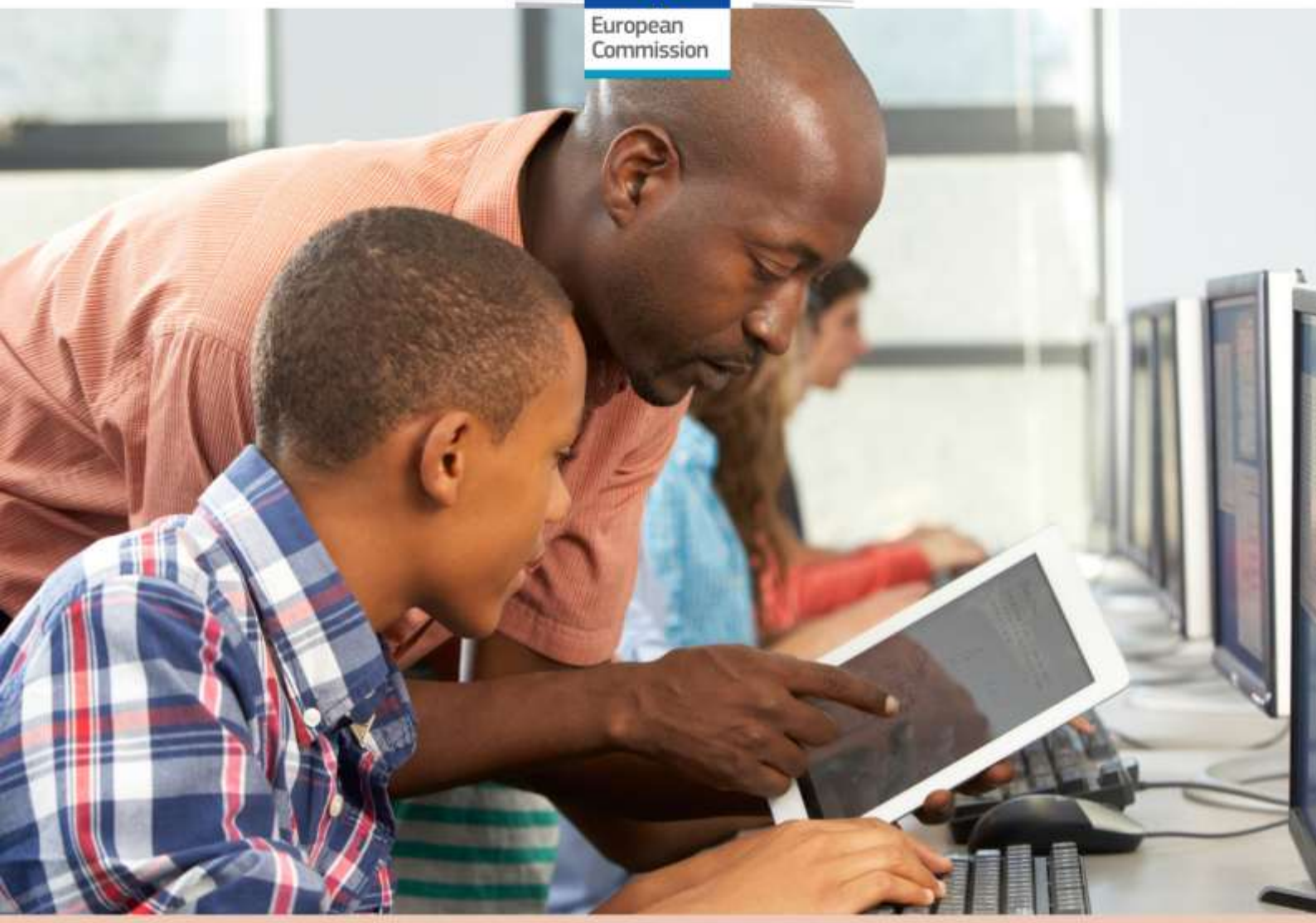

The International Computer and Information Literacy Study (ICILS)

Main findings and implications for education policies in Europe

Education and Training

The International Computer and Information Literacy Study (ICILS)

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Contents

Executive Summary

The 2013 European Commission Communication on Opening up Education[1] underlined the importance of solid evidence to assess developments and take full advantage of the impact of technology on education, and called for sustained effort and international cooperation to improve our knowledge-base in this area.

The International Computer and Information Literacy Study (ICILS) is an important new contribution to this knowledge base on digital competences and the integration of technology in teaching and learning. The study is carried out by the International Association for the Evaluation of Educational Achievement (IEA), and supported by the European Commission's Directorate-general for Education and Culture. ICILS is the first ever internationally comparable study assessing students' computer and information literacy. 60 000 eight graders in more than 3300 schools from 21 education systems, including 9 EU countries, were surveyed and assessed.

Key findings and implications for EU education policy:

- **Many "digital natives" are not digitally competent – school has a key role to play**
  Being born in a digital era is not a sufficient condition for being able to use technologies in a critical, creative and informative way. In the framework of the European Education and Training Strategy (ET2020), the European Commission is working with EU Member States towards enhancing digital literacy, closing digital divides and promoting social inclusion, by means of knowledge exchange and peer-learning. Such objectives are also given priority in the Digital Agenda for Europe.

  The results of ICILS show that in all participating EU countries except CZ and DK, 25% of students demonstrate low levels of computer and information literacy. There is also a risk of a digital divide, with lower average computer and information literacy amongst young people from disadvantaged socio-economic backgrounds. The education system can play a key role in countering such divides and developing the overall CIL amongst young people by embedding digital competences in education institutions, pedagogies, curricula and assessment practices.

- **There is a need to address gender gaps and assure a comprehensive approach to the development of digital competences in school**
  Digital competences cover a varied set of skills, knowledge and attitudes, as defined in the competence reference framework for learners (DIGCOMP) currently being adapted and used by several Member States and regions. ICILS shows that there is a need to examine how boys can be encouraged to develop the less technical aspects of digital competence to the same level as that of girls. On average girls outperform boys in computer and information literacy in all participating EU countries.

  In addition, for both genders it is also important that the education system has a comprehensive approach to digital competences, stimulating the critical and communicative use of ICT as well as attracting young people to develop more technical ICT skills and consider ICT related careers.

- **The pedagogical use of ICT in schools remains constrained, and more emphasis should be given to ICT use that supports active teaching practices**

  In the EU there are many initiatives and policy reforms in the area of innovative use of technology in education, but mainstreaming remains a challenge. Through analyses and exchanges with stakeholders and Member States, the Commission will examine existing

[1] Opening up Education: Innovative teaching and learning for all through new technologies and open educational resources (COM (2013) 654 final).

reforms and initiatives to identify effective models for policy and institutional reform which bring systemic and sustainable change.

ICILS shows that dynamic and interactive pedagogical practices are not widespread in most countries, and many teachers lack confidence and are sceptical about the potential of ICT to support student collaboration on tasks. There is a need to communicate good examples and upscale good practices on active teaching practices and the collaborative use of ICT.

- **Targeted professional development is needed to equip teachers for effective pedagogical use of ICT**

Discussions within the ET2020 process are progressively heading towards the development of competence frameworks not only for learners, but also for educators. In response to 2014 Council Conclusions on Effective Teacher Education, the theme of how to train new teachers at the start of their careers, as well as serving teachers through Continuous Professional Development, is considered as crucial as ever.

The importance the teacher and their attitudes and ICT self-confidence have for the pedagogical use of ICT is highlighted by the ICILS results. Policies need to ensure that digital competences and the pedagogical use of ICT is a core element of initial teacher education, combined with sufficient opportunities for continuing professional development targeted to different needs and prerequisites.

- **Collaborative school environments and channels for cooperation and exchange can act as multipliers for the innovative use of ICT in teaching and learning**

  In order for experience, knowledge and ideas about the pedagogical use of ICT to multiply, it is important that teachers are given opportunities to collaborate and learn from each other. EU tools such as eTwinning, and the forthcoming School Education Gateway, allow schools and teachers to develop a collaborative practice by working together with their peers across Europe. Furthermore, through the OpenEducationEuropa portal the Commission provides a gateway to innovative learning and enables teachers and other practitioners to share content and practices.

  ICILS results underline the importance of collaboration. Teachers who were working in schools they saw as supporting ICT use through a planned and collaborative approach were more likely to use ICT in their teaching and emphasize the development of students' CIL.

1. New evidence on computer and information literacy and the pedagogical use of ICT in schools

The 2013 European Commission Communication on Opening up Education[2] set out a European agenda for stimulating high-quality, innovative ways of learning and teaching through new technologies and digital content, and also stressed the importance of assuring that learners acquire the digital competences needed in a digital world. The Communication underlined the importance of solid evidence to assess developments and take full advantage of the impact of technology on education, and called for sustained effort and international cooperation to improve our knowledge-base in this area.

The International Computer and Information Literacy Study (ICILS) is an important new contribution to this knowledge base. ICILS is carried out by the International Association for the Evaluation of Educational Achievement (IEA) and assesses important aspects of the digital competence of grade eight students (average age 13.5 years). Digital competence is one of the 8 competences defined in the European Key Competences Framework[3], and it is an area where internationally comparable direct assessments of students' competences have been lacking. ICILS therefore contributes to filling a key data gap. ICILS also complements recent assessments in OECD's Survey of Adult Skills (PIAAC) of adults' problem solving skills in technology rich environments and findings from the European Survey of Schools on ICT in Education (European Commission, carried out 2011-12).

What is ICILS?

ICILS gathered data from almost 60,000 Grade 8 (average age 13.5 years) students in more than 3,300 schools from 21 countries or education systems within countries. Main fieldwork was carried out in 2013. ICILS examines the outcomes of student computer and information literacy (CIL) across countries. CIL refers to an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in the community.

The way CIL was conceptualised in ICILS is further elaborated in annex A.

In addition to the assessment part, ICILS also includes a set of questionnaires. The student questionnaire gathers information about computer use in and outside of school, attitudes to technology, self-reported computer proficiency, and background characteristics. Teacher and school questionnaires ask about computer use, ICT self-efficacy, computing resources, and relevant policies and practices in the school context.

Countries covered by ICILS:

EU Countries: Croatia, Czech Republic, Denmark, Germany, Lithuania, Netherlands, Poland, Slovak Republic, Slovenia

Non-EU countries[4]*:* Australia, Chile, Hong Kong SAR, Republic of Korea, Norway, Russian Federation, Switzerland, Thailand, and Turkey

The ICILS computer and information literacy achievement scale and proficiency levels

The proficiency that students showed in the test is reported on a scale with a mean of 500 score points (the ICILS average for the equally weighted national samples), which is divided into proficiency levels: "below level 1" (less than 407 score points), "level 1" (from 407 to 492 score points), "level 2"(from 492 to 576 score points), "level 3" (from 576 to 661 score points) "level 4" (661 score points and more). The higher the level, the more advanced is the proficiency.

Students with proficiency within a given level can be expected to have correctly answered *at least* half of the items that have been mapped to that level of difficulty. Description of proficiency levels and examples of capabilities of students at each of these levels are included in annex B.

[2] Opening up Education: Innovative teaching and learning for all through new technologies and open educational resources (COM (2013) 654 final).

[3] Recommendation 2006/962/EC

[4] In addition ICILS covered two regions of Canada and one region in Argentina. Results for these regions are not included in this paper, but can be found in the ICILS International report.

Selecting from the rich pool of ICILS data, section 2 of this document highlights key findings which have particular relevance for European policies on digital key competences and on embedding ICT in teaching and learning in schools. The section compares computer and information literacy (CIL) of students across and within countries, points to the role schools can play in developing the CIL of students and examines the extent to which the use of new technologies is embedded in teaching.

EU averages are not calculated and European policy implications should be interpreted with care, as the coverage in ICILS is limited to 9 EU Member States out of a total of 21 participating education systems worldwide.

A short final section points to selected areas of future work by the European Commission related to digital competences and ICT in education.

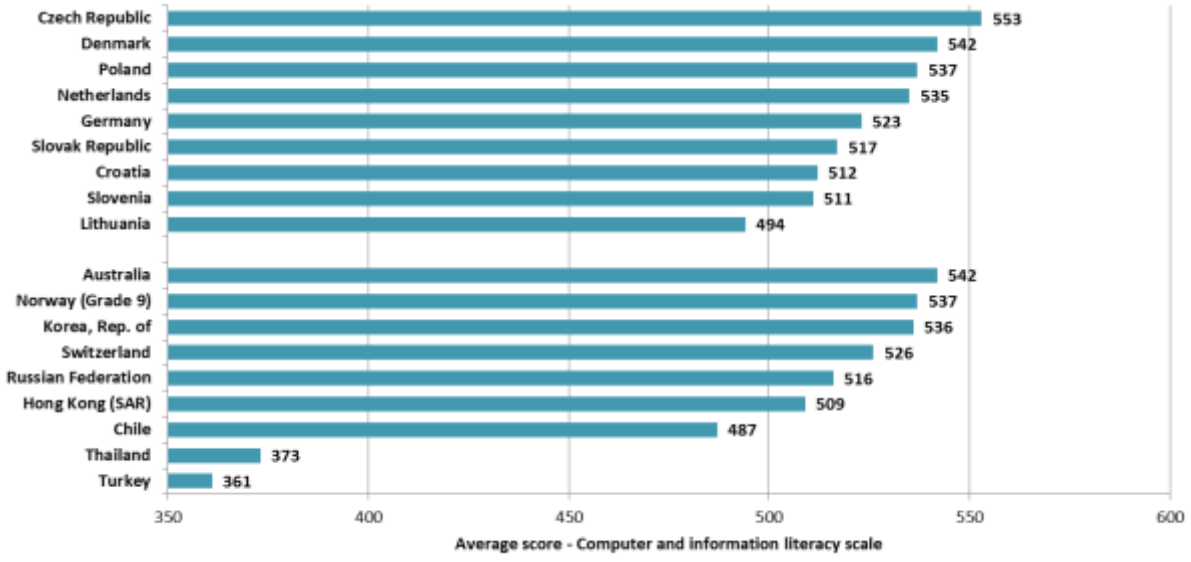
2. Key findings relevant for the EU policy agenda in education

2.1 Are the digital natives digitally competent? - Comparing computer and information literacy across and within countries

ICILS results show high levels of use of computers[5], especially outside schools, by young people. These results confirm findings from previous studies[6]. In the participating EU countries between 96% (Denmark and Poland) and 84% (Germany) of grade 8 students reported having used computers for at least three years, and the average length of time using computers was 6 years. Similar percentages are found for weekly computer use at home, ranging from 88% in Germany to around 95% in the other participating EU countries. This seems to fit well with the description of the young generation of today as a generation of "digital natives". However, ICILS allows us to look further at the extent to which these "digital natives" have self-developed capacity to use digital technology and are truly digitally competent. This section examines variations in computer and information literacy (CIL) proficiency within and across the ICILS countries.

Comparing average student CIL scores across countries, we find a considerable difference of more than 50 score points between the Czech Republic and Lithuania, the highest and lowest scoring of the participating EU countries.

Fig. 2.1 Average student score in computer and information literacy (score points)



Source: IEA (ICILS, 2013).

[5] Desktops, notebooks, netbooks or tablets
[6] e.g. the European Survey of Schools on ICT in Education (European Commission, 2013)

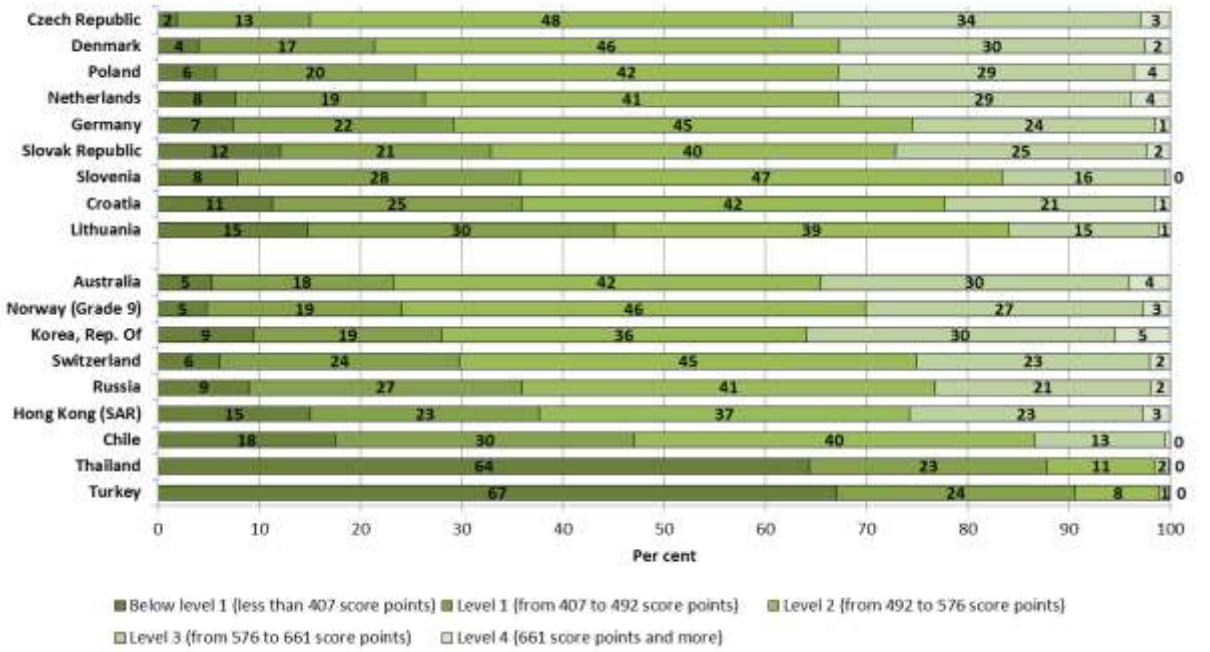
The average CIL score in the Czech Republic is higher than any of the other countries in ICILS. Denmark, Poland and the Netherlands also see relatively high average scores, together with Norway and Korea. Mid-ranking average scores are found in Germany and the Slovak Republic, followed by Croatia and Slovenia. Lithuania has a significantly lower average CIL score than in any other of the participating EU countries, on par with the result in Chile and only above Thailand and Turkey.

Compared with results from assessments of students achievement in other subjects such as mathematics and science (e.g. PISA 2012), we do not see the performance gap between certain Asian countries such as Korea and Hong Kong on the one hand and EU countries on the other.

When examining the distribution of students across CIL proficiency levels we get a more detailed view of whether the generation of "digital natives" in Europe are indeed independent and critical users of ICT. As shown in figure 2.2 a considerable share of the 8th graders in participating EU countries demonstrate a low level of computer and information literacy (level 1 or less). The percentage ranges from 15 per cent in the Czech Republic to 45 per cent in Lithuania. These young people lack the competences for independent use of ICT. While students at level 1 have familiarity with the basic range of software commands that enable them to access files and complete *routine* text and layout editing, they typically can only do so under instruction without independent planning. Amongst EU neighbouring countries, it is striking to note that in Turkey as many as 9 out of 10 students demonstrate only such a basic or even lower level of computer and information literacy.

It is also noteworthy that in none of the countries participating in ICILS do more than 5 per cent score at level 4, the highest proficiency level.

Fig. 2.2 Distribution of students across proficiency levels of computer and information literacy (%)



Source: IEA (ICILS, 2013).

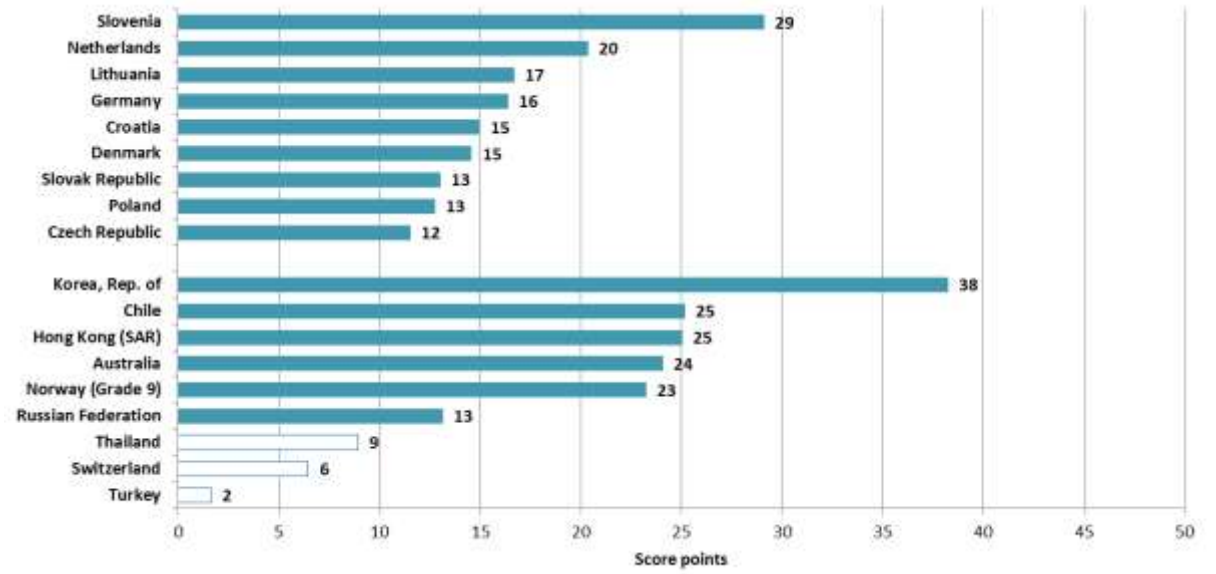
Personal and social background characteristics of students add further insights on how computer and information literacy varies in the student population.

The average gender difference in CIL scores found in ICILS show significantly better results amongst girls than boys in all EU countries. In Slovenia the difference is particularly pronounced with girls scoring on average 29 points higher than boys, whereas in the other EU countries the gap ranges between 20 and 12 points. The Czech Republic combines a high average score with the lowest gender gap amongst the EU countries, but across countries there is not a systematic relationship between the gender gap and average country score.

To understand these gender differences it is important to keep in mind that the CIL assessment construct is much broader than technical ICT skills alone, as it emphasises information literacy and communication skills in the context of computer use. There is thus a close relationship between CIL and Information Literacy which is heavily reliant on text-based reading skills and productive communication skills, areas in which cross-national and national assessments have consistently shown that girls tend to do better than boys.

ICILS also allows for an examination of the association between other student and socio-economic background characteristics and students' CIL score. Such associations are discussed in chapter 4 of the ICILS International Report. The analysis shows that students' educational aspiration is positively associated with CIL scores in all participating countries. Across the EU countries in ICILS the average difference between those students aspiring to complete tertiary education and those aspiring to complete at most lower secondary education ranges from 65 CIL score points in the Czech Republic to 113 CIL score points in the Slovak Republic.

Fig. 2.3 Female-male difference in average student score in computer and information literacy (score points)



Source: IEA (ICILS, 2013). Statistically significant (95% level) differences are shown with the bars fully shaded.

When controlling for the effect of various student characteristics (gender and educational aspiration[7]), socio-economic background indicators (parental education and occupation, number of books in the household) and home ICT resources (number of computers, access to internet), analysis in the ICILS International Report find that the most consistent predictors of students' CIL were tertiary education aspiration, parental occupational status, and home literacy as well as the availability of internet access. The latter was of limited relevance in some EU countries where internet access is available in almost all households.

The results show that personal and social background play a significant part in understanding the student variation in CIL, and it is therefore important to explore the extent to which schools can contribute to mediating such differences.

The international ICILS report underlines that *"the knowledge, skills, and understandings that are the basis of the receptive and productive aspects of CIL can and need to be taught and learned through coherent education programs. The knowledge, skills, and understandings described in the CIL scale show that, regardless of whether or not we consider young people to be digital natives, we would be naive to expect them to develop CIL in the absence of coherent learning programs."*

[7] The highest educational level the student expects to complete

Annex table 1 provides a summary of results across countries from multilevel regression analyses examining the effect on students' CIL score of different predictor variables. Not surprisingly, the table shows that students' years of computer experience and use of computers at home have a positive effect on CIL in a majority of ICILS countries. Likewise, the impact of social background is also reflected in the table. The table furthermore shows that learning experiences about ICT at school is a significant predictor of higher CIL scores in several countries. This underpins that there is a potential for schools in developing the computer and information literacy of students.

Implications for education policies:

- ***Many digital natives are not digitally competent – school has a key role to play***

ICILS provides for the first time direct student assessment results demonstrating that being born in a digital era is not a sufficient condition for being able to use new technologies in a critical, creative and informative way: In participating EU countries, as many as 15 to 45% of eight graders lack basic computer and information literacy and less than 5% demonstrate competence at the highest proficiency level. With a shaky foundation already at a young age, there is a risk that Europe will face severe shortages of skilled citizens in the digital age, thereby hampering growth and competitiveness. There is also a risk of a digital divide, with lower average computer and information literacy amongst young people from disadvantaged socio-economic backgrounds.

The education system can play a key role in countering such divides and developing the overall CIL amongst young people by embedding digital competences in education institutions, pedagogies, curricula and assessment practices. Tackling digital divides is also an important goal of the EU's Digital Agenda, as expressed in its Pillar VI on enhancing digital literacy, skills and inclusion[8].

The European Commission, DG Education and Culture, has with the support of DG JRC-IPTS identified the knowledge, skills and attitudes seen as comprising digital competences[9]. The digital competence reference framework for learners (DIGCOMP) has already been adapted by several regions and Member States, and contributes to the development of curricula and meaningful means for assessment of learning outcomes.

Through the ET2020[10] Working Groups on Transversal Skills an Digital and Online Learning, the Commission supports exchanges and peer learning amongst Member States related to these issues, and further analysis and discussions of ICILS results can provide an interesting angle to such exchanges. Country variations in students' CIL score and the extent to which teachers emphasise development of CIL capabilities in their students highlight the value of peer learning and further analysis: what lessons can e.g. be drawn from experiences in CZ, DK and PL where students on average have a comparatively higher level of computer and information literacy?

- ***There is a need to address gender gaps and assure a comprehensive approach to the development of digital competences in school***

ICILS show that on average girls outperform boys in computer and information literacy. ICILS does not assess advanced technical e-skills, but the gender difference in results points to a need of examining how boys can be encouraged to develop the less technical e-skills aspects of digital competence to the same level as that of girls.

8 http://ec.europa.eu/digital-agenda/en/our-goals/pillar-vi-enhancing-digital-literacy-skills-and-inclusion
9 http://ftp.jrc.es/EURdoc/JRC83167.pdf
10 The EU Education and Training strategy

For both genders it is also important that the education system has a comprehensive approach to digital competences, stimulating the critical and communicative use of ICT as well as attracting young people to develop more technical ICT skills and consider ICT related careers[11].

2.2 Is CIL being taught and is the use of new technologies embedded in teaching practices?

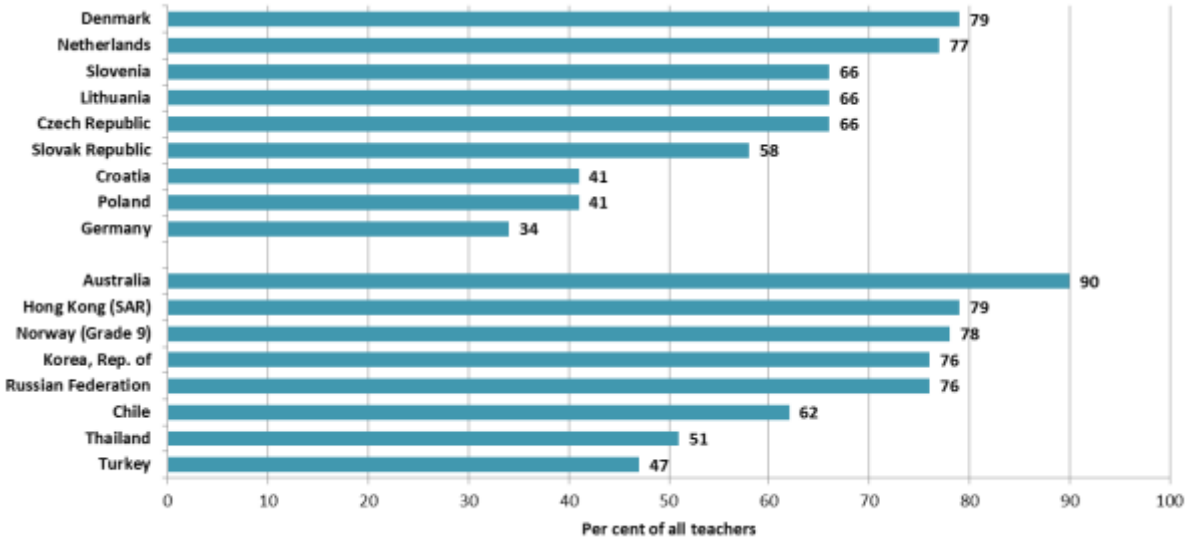
This section examines whether the potential for schools in developing the computer and information literacy of students and making use of new technologies for innovative teaching and learning is being realised. Drawing on results from the teacher questionnaire in ICILS the analysis looks at the way teachers embed the use of ICT in their teaching and the emphasis they give to developing the computer and information literacy of their students.

Are computers frequently used in teaching?

Results from ICILS show that except for Croatia (with 71%), 80% or more of the teachers in participating EU countries report having at least two years of computer experience. However, when we look at the percentage using computers at least once a week at school when teaching, there are considerable variations across countries. Amongst the EU countries in ICILS there are three distinct groups: In Netherlands and Denmark more than three in four teachers report such frequent use[12]; in the Czech Republic, Lithuania, Slovak Republic and Slovenia around or slightly below two thirds are frequent users; finally, less than half of teachers in Croatia, Poland and Germany (as low as one in three in Germany) report weekly use of ICT in their teaching.

Earlier surveys, such as e.g. the European Survey of Schools on ICT in Education have also shown that the uptake of ICT by teachers varies greatly within as well as between countries. ICILS also confirms findings from earlier studies (e.g. TALIS 2013) pointing to variations in the use of ICT across subjects. Not surprisingly the highest prevalence is found when the teacher's reference class was taught regarding information technology or computer studies, but use was in most countries also frequently reported when teaching natural science or humanities. ICT use in teaching was less common in mathematics and creative arts.[13]

Fig. 2.4 Teachers reporting at least weekly use of computers at school when teaching (%)



Source: IEA (ICILS, 2013).

[11] On Commission initiatives for attracting young people to a career in ICT, see e.g. the Grand Coalition for Digital Jobs (https://ec.europa.eu/digital-agenda/en/grand-coalition-digital-jobs)

[12] Amongst the other European countries, a similar share is found in Norway.

[13] For further details about country patterns in subject differences, refer to the ICILS international report table 7.9.

Teachers' views on the use of ICT in teaching and learning – do attitudes matter?

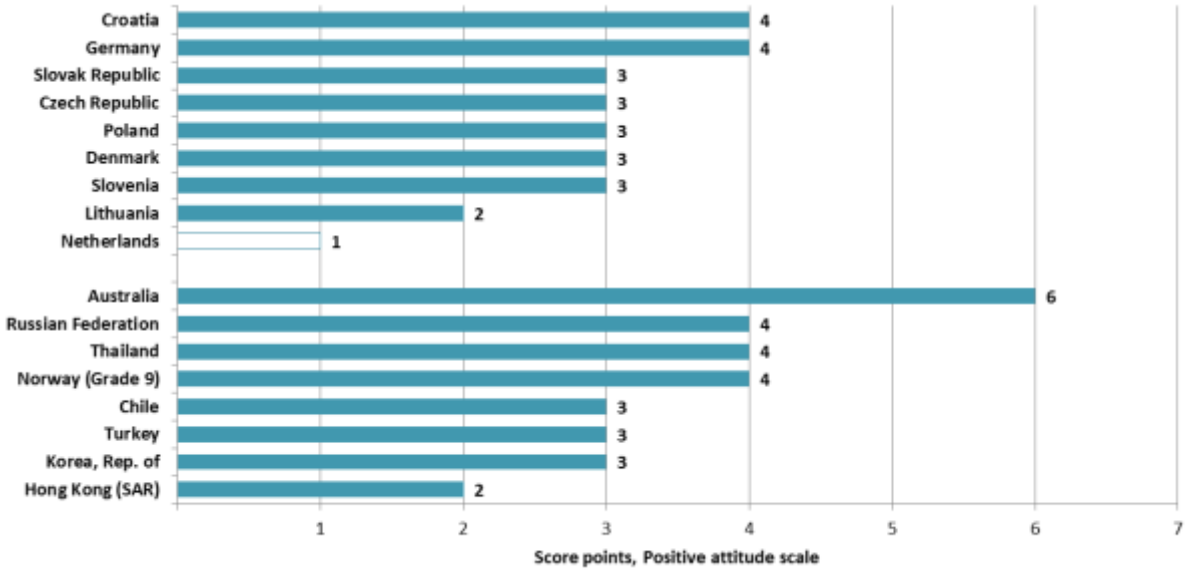
It is also important to investigate teachers' attitudes regarding the use of ICT in teaching and learning at school. In ICILS, teachers were asked to signal their level of agreement/disagreement on a series of statements reflecting both positive and negative views in this regard. The percentages of teachers agreeing with each statement (see table 7.2 of the ICILS International Report) showed that on balance, teachers display generally positive attitudes towards the use of ICT in teaching and learning, especially in accessing and managing information. The data however also show that teachers are sensitive to potential negative aspects (for example related to students' skills in writing, calculation and estimation). Amongst teachers' agreement with negatively worded items, it is particularly interesting to note that with the exception of Denmark, a majority of teachers in all participating EU countries agreed that ICT "limits the amount of personal communication among students".

Based on the replies to different statements, two scales are used in the ICILS International Report: The positively worded items were used to form a scale reflecting "positive views on using ICT in teaching and learning" and the negatively worded items were used to form a scale reflecting "negative views on using ICT in teaching and learning".[14]

On average teachers in Croatia, Czech Republic, Slovenia and Netherlands have a somewhat lower tendency to express a positive view on the value of ICT for teaching and learning. Among all participating countries, such positive views have a particularly low prevalence in Germany.

Teachers may hold simultaneously both positive and negative views on the use of ICT in education. Across countries there is more limited variation in the results on the scale for negative views than on the positive scale, and interestingly German teachers do not hold more negative views than in other participating countries. Teachers in Denmark seem to combine both more positive views and less negative views towards the use of ICT for teaching and learning than teachers across the other participating EU countries.

Fig. 2.5 Average teacher agreement with positive statements about the use of ICT in teaching and learning: Difference between Frequent - Infrequent users of computers when teaching in school (score points on scale of positive attitude)



Source: IEA (ICILS, 2013). Statistically significant (95% level) differences are shown with the bars fully shaded.

[14] These attitude scales were each constructed to have a mean of 50 scale points across all ICILS countries.

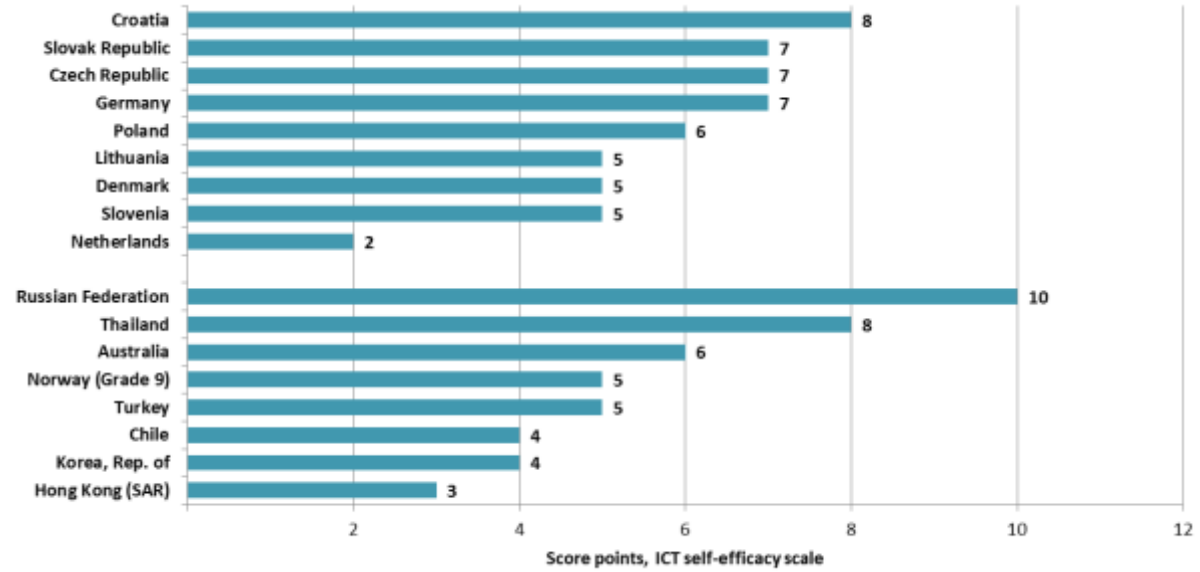
As shown in figure 2.5, frequent pedagogical computer users had on average stronger positive views about the effects of ICT in teaching and learning than did infrequent computer users. This difference was statistically significant in all ICILS countries. Similarly, frequent users also held on average less negative views about the effects of using ICT in school.

Teachers' ICT self-efficacy, collaborative school environment and the effect on the pedagogical use of ICT

There is also a substantial difference between the ICT self-efficacy of frequent and infrequent pedagogical users of ICT, with infrequent users reporting a lower confidence in their own ability to complete different tasks on the computer. Other studies (e.g. SITES 2006 and European Survey of Schools on ICT in Education) have also pointed to the importance of teacher confidence in using ICT for the adoption by teachers of such technologies in their teaching.

The self-efficacy scale is based on a number of tasks for which the responding teachers where asked to rate their confidence. Generally, teachers are confident about their ability to use many computer applications and carry out different tasks, but with a view to innovative learning tools such as learning analytics and collaborative learning resources it is worth noting that the lowest levels of confidence were found for using a computer for "monitoring student progress" and "collaborate with others using shared resources". Amongst the participating EU countries the ICT self-efficacy scale score is highest in Denmark and the Netherlands and lowest in Croatia. In all countries, except Germany, younger teachers were significantly more confident than their older colleagues.

Fig. 2.6 Average teacher ICT self-efficacy: Difference between Frequent - Infrequent users of computers when teaching in school (score points on ICT self-efficacy scale)



Source: IEA (ICILS, 2013). Statistically significant (95% level) differences are shown with the bars fully shaded.

In addition to the link between frequent pedagogical ICT use and attitudes and confidence of teachers, ICILS also show that ICT use by teachers is greatest when teachers work in school environments where there is collaboration about, and planning of the use of ICT and the there are fewer resource limitations to using ICT.

Do teachers emphasize developing students' computer and information literacy?

Teachers who use ICT in their classes can be expected not just to use those technologies to teach their subjects more effectively, but also to develop the more transversal computer and information literacy of their students. Amongst teachers that used ICT in their teaching at least once a week, ICILS investigated the extent to which they had given much emphasis to developing a set of ICT-based capabilities (equivalent to computer and information literacy – CIL). Teachers who said they did not use ICT in their reference class were assigned the category of no emphasis.

The results, as presented in annex table 2, show that in general many teachers do give some or strong emphasis to the development of CIL capabilities in students, but there are important variations across the EU countries. Comparing the EU countries where teachers display the overall highest and lowest emphasis on developing their students CIL capabilities, we e.g. find that 78% of teachers in Denmark vs. 40% and 36% in Lithuania and Germany emphasised "accessing information efficiently" and 70% of teachers in Denmark vs 25% and 29% in Lithuania and Germany emphasised "evaluating the credibility of digital information".

Multiple regression analyses (see the ICILS international report, table 7.11 for details) of predictors of teacher emphasis on developing CIL showed a consistent positive association between such CIL emphasis and teachers' ICT self-efficacy, positive views of ICT and collaborative approach to using ICT in the teachers' school environment. Amongst these, self-efficacy is the strongest correlate. In most countries there is no association between teachers' perceived lack of ICT resources and their emphasis on developing students' CIL. This can be understood as an indication that the development of ICT infrastructure in schools has progressed so that resources are no longer a major constraint on the possibilities of teaching about CIL.

How is the use of ICT being implemented in the classroom?

The effectiveness of the use of ICT for learning does not stem from ICT use per se, but largely depends on how these technologies are implemented in the classroom. In addition to asking ICT-using teachers about their emphasis on developing students' CIL, ICILS also collected further details on the types of ICT tools these teachers used, information on the types of learning activities of their students in which ICT was used and the teaching practices in which ICT was used. The tools that were most frequently reported by teachers are tools concerned with word processing, presentations and computer-based information resources (websites, wikis and encyclopaedia).

The data on those learning activities of students in which ICT was used show that frequent ICT use is most common when students are searching for information, working on short assignments, submitting completed work for assessment and working individually on learning materials at their own pace. These are all learning activities that do not necessarily imply an advanced use of ICT technologies.

Annex table 3 presents figures on teachers' use of ICT for different teaching practices. When looking at such teaching practices in which ICT was used we find that in general, teachers mainly apply practices such as "presenting information through direct class instruction" and "reinforcing learning of skills through repetition of examples". More dynamic and interactive pedagogical practices, including those that support collaboration have a low prevalence in most countries. We find e.g. that in all participating EU countries less than 10% of teachers reported often using practices enabling students to collaborate with other students through ICT.

A recent EU study[15] shows that stakeholders regard continuing professional development as the most relevant area of policy reform for mainstreaming ICT-enabled innovation in education and training. Recent findings from OECD's Teaching and Learning International Study (TALIS 2013) show an imbalance in the provision and demand for teachers' professional development in the use of ICT for learning. Close to 20% of lower secondary

[15] JRC-IPTS (2014), *Mainstreaming ICT-enabled Innovation in Education and Training in Europe* (http://ftp.jrc.es/EURdoc/JRC83502.pdf).

school teachers in the EU indicate that they have a high level of need for continuing professional development in the area of ICT skills for teaching and new technologies in the workplace.[16]. ICILS provides further details on types of training and find that the main forms of professional development in the use of ICT in teaching and learning took place at school level, either through participation in school organised professional development activities or by observing other teachers.

Implications for education policies:

- ***The pedagogical use of ICT in schools remains constrained, and more emphasis should be given to ICT use that supports active teaching practices.***

ICILS show considerable country variation in the percentage of teachers using ICT frequently (weekly) in their teaching at school. Three of the EU Member States (HR, PL, DE) have the lowest frequency of all the countries, both EU and non-EU, participating in the survey. ICILS also show that the pedagogical use of ICT is not embedded in all subjects, with comparatively low use in mathematics and creative arts.

However, the use of ICT teaching tools per se has not been shown to be of primary importance for improving the outcome of educational efforts. The effectiveness of ICT-enabled pedagogies largely depends on how new technology is implemented in the classroom. The ICILS results show that the way ICT is used in teaching is generally rather constrained; dynamic and interactive pedagogical practices are not widespread in most countries.

Increased policy efforts and emphasis are required to stimulate the use of ICT to support pedagogical methods that engage students in active learning on their own or in collaboration. With regards to collaboration it is striking to note that with the exception of Denmark, a majority of teachers in all participating EU countries agreed with the statement that ICT "limits the amount of personal communication among students". This indicates that the potential of ICT to support collaboration on tasks is currently far from being realised in European schools, and there is a need to further identify and communicate good examples and upscale good practices on the collaborative use of ICT.

In the EU there are many initiatives and policy reforms in the area of digitalisation and innovation in education, but only some initiatives and reforms have been successful in going beyond the pilot phase into mainstreaming[17]. Through analyses (e.g. with DG JRC-IPTS) and exchanges with stakeholders and Member States (including in relevant ET2020 Working Groups) the Commission will examine existing reforms and initiatives to identify effective models for policy and institutional reform which bring systemic and sustainable change.

- ***Targeted professional development is needed to equip teachers for effective pedagogical use of ICT***

The importance the teacher and their attitudes and ICT self-confidence have for the pedagogical use of ICT is highlighted by the ICILS results, which establish a positive link between ICT self-efficacy/attitudes and teachers' use of ICT on the one hand and on the other hand their emphasis on imparting computer and information literacy on their students. Not all teachers are confident when it comes to ICT (older teachers have a significantly lower self-efficacy) and lowest levels of confidence relate to innovative and collaborative practices such as using a computer for "monitoring student progress" and "collaborate with others using shared resources".

[16] This is high relative to other training needs. See OECD (TALIS 2013)
[17] See for instance at http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=6362

To raise the relevance and quality of education and training in the digital era, it is pivotal to assure that teachers are equipped with well-developed digital competences. The ICILS international report conclude that findings on barriers to the use of ICT in teaching and learning suggest that more needs to be done in terms of greater pedagogical support. Policies need to ensure that digital competences and the pedagogical use of ICT is a core element of initial teacher education. There should also be sufficient opportunities through continuing professional development for teachers to develop their digital competences and acquire innovative teaching practices. Such professional development should cater in a targeted way to the variation in current competences and needs of teachers, and be based on the latest pedagogical research and proven impact. The EU works with Member States to identify policies that are successful in improving the effectiveness of teachers' continued professional development18 as well as Initial Teacher Education through the ET2020 Working Group Schools (2014/2015).

In most Member States the digital competence that teaching staff should possess are not (yet) clearly described. A European digital competence framework for educators, which will be developed in cooperation with the main educational stakeholders and validated through the relevant ET2020 Working Groups, will contribute to a common understanding of digital competence needs for educators at all levels and will be a resource for educators' professional development.

- ***Collaborative school environments and channels for cooperation and exchange can act as multipliers for the innovative use of ICT in teaching and learning***

In order for experience, knowledge and ideas about the pedagogical use of ICT to multiply, it is important that teachers are given opportunities to collaborate and learn from each other. ICILS show that teachers who were working in schools they saw as supporting ICT use through a planned and collaborative approach were more likely to use ICT in their teaching and emphasize the development of students' CIL.

This suggests a need to encourage not just teachers' digital competences, but also to encourage innovation and digital competences among institutional structures, institutions and administrators. Policy action in key areas which guide educational practice, such as inclusion of digital material and activities in curricula design or allowing and encouraging digital assessment forms, could have a major impact.

In addition to within-school encouragement and collaboration, sharing and collaborating amongst a wider community of teachers are also proven to be successful in changing attitudes and introducing new innovate ways of teaching and learning[19]. The eTwinning online community for teachers and schools allows teachers to develop a collaborative practice by working together with their peers across Europe, and is actively used across Europe, with more than 200,000 registered users and 100,000 schools. Through the School Education Gateway, the EU will further develop this successful tool by providing open educational resources and by extending the dialogue to stakeholders in school education. Furthermore, through the OpenEducationEuropa portal the Commission provides a gateway to innovative learning and enables teachers and other practitioners to share content and practices.

[18] Outputs of the Thematic Working Group on 'Teacher Professional Development' (2010-2013): http://ec.europa.eu/education/policy/strategic-framework/expert-groups_en.htm#schools

[19] See e.g. chapter 4 of European Commission (2013), *Study of the impact of eTwinning on participating pupils, teachers and schools* (*Study of the impact of eTwinning on participating pupils, teachers and schools*).

3. Related future work

ICILS is a valuable source of evidence and information for the policy dialogue between the European Commission and Member States, particularly in the context of the Open Method of Coordination under the European Education and Training strategy. The findings from the survey will feed into exchanges with stakeholders and Member States through ET2020 Working Groups on Transversal skills, Digital and Online Learning and Schools.

The challenges of adapting education to a digital society, and making use of the opportunities offered by technological developments, will be at the heart of discussions in the European High Level Conference "Education in the Digital Era" organised by the European Commission and the Italian Presidency of the EU in Brussels on 11 December 2014.

As a follow-up of the Communication on Opening up Education, the European Commission will, in cooperation with the main educational stakeholders, also develop frameworks/tools in the area of digital competences and innovation in education:

- Follow-up work on the digital reference framework for learners
- Develop a framework for educators' digital competence compatible to EQF levels and accompanied by a self-assessment questionnaire
- Develop a conceptual framework and self-assessment questionnaire for innovative educational organisations making full use of the potential of ICT

The Commission will furthermore initiate analyses to identify effective policy models for ICT-enabled innovation in education in Europe and examine recent research evidence on the use of learning analytics in education and their potential implications for education policies.

Finally, exchange of content and innovative learning practices amongst teachers, other practitioners and stakeholders will be stimulated and facilitated through the School Education Gateway and further development of the OpenEducationEuropa portal.

Annex A: The concept of computer and information literacy as assessed in ICILS

The CIL construct was conceptualized in terms of two strands that framed the skills and knowledge addressed by the CIL instruments. Each strand was made up of several aspects.

Strand 1 of the framework, titled collecting and managing information, focuses on the receptive and organizational elements of information processing and management. It incorporated three aspects:

- *Knowing about and understanding computer use*: This refers to a person's declarative and procedural knowledge of the generic characteristics and functions of computers. It focuses on the basic technical knowledge and skills that underpin our use of computers in order to work with information.
- *Accessing and evaluating information:* This refers to the investigative processes that enable a person to find, retrieve, and make judgments about the relevance, integrity, and usefulness of computer-based information.
- *Managing information:* This aspect refers to the capacity of individuals to work with computer-based information. The process includes ability to adopt and adapt information-classification and information-organization schemes in order to arrange and store information so that it can be used or reused efficiently.

Strand 2 of the construct, titled producing and exchanging information, focuses on using computers as productive tools for thinking, creating, and communicating. The strand has four aspects:

- *Transforming information:* This refers to a person's ability to use computers to change how information is presented so that it is clearer for specific audiences and purposes.
- *Creating information:* This aspect refers to a person's ability to use computers to design and generate information products for specified purposes and audiences. These original products may be entirely new or they may build on a given set of information in order to generate new understandings.
- *Sharing information:* This aspect refers to a person's understanding of how computers are and can be used as well as his or her ability to use computers to communicate and exchange information with others.
- *Using information safely and securely:* This refers to a person's understanding of the legal and ethical issues of computer-based communication from the perspectives of both the publisher and the consumer of that information.

The ICILS International Report contains examples of how these aspects have been operationalised in the assessment instrument, providing details and screenshots of selected tasks the students were asked to carry out.

Annex B: Description of CIL achievement scale

Level 4 (above 661 scale points) Students working at Level 4 select the most relevant information to use for communicative purposes. They evaluate usefulness of information based on criteria associated with need and evaluate the reliability of information based on its content and probable origin. These students create information products that demonstrate a consideration of audience and communicative purpose. They also use appropriate software features to restructure and present information in a manner that is consistent with presentation conventions. They then adapt that information to suit the needs of an audience. Students working at Level 4 demonstrate awareness of problems that can arise regarding the use of proprietary information on the internet.	Students working at Level 4, for example: • Evaluate the reliability of information intended to promote a product on a commercial website; • Select, from a large set of results returned by a search engine, a result that meets specified search criteria; • Select relevant images from electronic sources to represent a three-stage process; • Select from sources and adapt text for a presentation so that it suits a specified audience and purpose; • Demonstrate control of colour to support the communicative purpose of a presentation; • Use text layout and formatting features to denote the role of elements in an information poster • Create a balanced layout of text and images for an information sheet; and • Recognize the difference between legal, technical, and social requirements when using images on a website.
Level 3 (577 to 661 scale points) Students working at Level 3 demonstrate the capacity to work independently when using computers as information-gathering and management tools. These students select the most appropriate information source to meet a specified purpose, retrieve information from given electronic sources to answer concrete questions, and follow instructions to use conventionally recognized software commands to edit, add content to, and reformat information products. They recognize that the credibility of web-based information can be influenced by the identity, expertise, and motives of the creators of the information.	Students working at Level 3, for example: • Use generic online mapping software to represent text information as a map route; • Evaluate the reliability of information presented on a crowdsourced website; • Select relevant information according to given criteria to include in a website; • Select an appropriate website navigation structure for given content; • Select and adapt some relevant information from given sources when creating a poster; • Demonstrate control of image layout when creating a poster; • Demonstrate control of colour and contrast to support readibility of a poster; • Demonstrate control of text layout when creating a presentation; and • Identify that a generic greeting in an email suggests that the sender does not know the recipient.

Level 2 (from 492 to 576 score points) Students working at Level 2 use computers to complete basic and explicit information-gathering and management tasks. They locate explicit information from within given electronic sources. These students make basic edits, and add content to existing information products in response to specific instructions. They create simple information products that show consistency of design and adherence to layout conventions. Students working at Level 2 demonstrate awareness of mechanisms for protecting personal information and some consequences of public acess to personal information.	Students working at Level 2, for example: • Add contacts to a collaborative workspace • Navigate to a URL presented as plain text; • Insert information to a specified cell in a spreadsheet; • Locate explicitly stated simple information within a website with multiple pages; • Differentiate between paid and organic search results returned by a search engine; • Use formatting and location to denote the role of a title in an information sheet; • Use the full page when laying out a poster; • Demonstrate basic control of text layout and colour use when creating a presentation; • Use a simple webpage editor to add specified text to a webpage; • Explain a potential problem if a personal email address is publicly available; • Associate the breadth of a character set with the strength of a password.
Level 1 (from 407 to 491 score points) Students working at Level 1 demonstrate a functional working knowledge of computers as tools and a basic understanding of the consequences of computers being accessed by multiple users. They apply conventional software commands to perform basic communication tasks and add simple content to information products. They demonstrate familiarity with the basic layout conventions of electronic documents.	Students working at Level 1, for example: • Open a link in a new browser tab; • Use software to crop an image; • Place a title in a prominent position on a webpage; • Create a suitable title for a presentation; • Demonstrate basic control of colour when adding content to a simple web-document; • Insert an image into a document; • Identify who receives an email by carbon copy (cc); and • Suggest one or more risks of failing to log out from a user account when using a publicly accessible computer.

Annex Table 1 Predictors of students computer and information literacy scores. Summary of statistically significant effects across countries.

Predictor variables	Number of countries where the predictor had a statistically significant... positive effect	negative effect
Individual-level predictors related to ICT:		
ICT resources at home		
Number of computers	2	0
Internet access	5	0
ICT familiarity of students		
Years of computer experience	16	0
Weekly use of home computers	11	0
Weekly use of school computers	5	0
Index of students' reports on learning CIL tasks at school	7	0
School-level predictors related to ICT:		
ICT resources at school		
Availability of ICT resources	1	0
ICT resource limitations for teaching	0	1
School ICT learning context		
Years of school experience with using ICT for teaching and learning	0	0
School level percentage of students with weekly use of home computers	6	0
School level index of ICT learning at school	5	0
Additional individual-level predictors:		
Students personal and social background		
Gender (female)	13	0
Expected lower-secondary qualification	0	8
Expected post-secondary non-university educ.	7	0
Expected university education	18	0
Socioeconomic background	13	1
Additional school-level predictors:		
School's social intake		
Average socioeconomic background	15	0

Source: IEA (ICILS, 2013). Note: Further description of the predictor variables can be found in the ICILS International Report, chapter 8.

Annex Table 2 Teachers giving strong or some emphasis to developing ICT-based capabilities in their students (%)

	Accessing Information Efficiently	Evaluating the Relevance of Digital Information	Displaying Information for a Given Audience/Purpose	Evaluating the Credibility of Digital Information	Validating the Accuracy of Digital Information	Sharing Digital Information With Others	Using Computer Software To Construct Digital Work Products (e.g., Presentations, Documents, Images, and Diagrams)	Evaluating Their Approach To Information Searches	Providing Digital Feedback on the Work of Others (Such as Classmates)	Exploring a Range of Digital Resources When Searching for Information	Providing References for Digital Information Sources	Understanding the Consequences of Making Information Publically Available Online
Czech Republic	64	55	53	56	49	33	55	43	26	57	54	49
Denmark	78	72	72	70	61	54	68	49	26	55	54	48
Germany	36	28	30	29	23	15	29	27	9	27	32	26
Croatia	62	53	57	54	55	49	58	53	41	47	44	58
Lithuania	40	27	34	25	24	29	35	23	18	38	34	32
Netherlands	49	37	35	34	36	27	52	17	11	43	18	27
Poland	61	49	50	52	52	36	55	56	25	52	44	59
Slovenia	67	45	49	41	40	32	49	40	25	42	39	51
Slovak Republic	66	55	55	55	53	42	58	47	32	57	52	54
Australia	76	66	70	62	58	53	72	53	28	62	58	51
Chile	72	65	63	61	61	55	62	57	47	64	58	54
Hong Kong SAR	53	36	42	36	36	38	51	36	27	33	40	45
Korea, Rep. of	62	55	50	51	50	50	54	48	40	57	56	47
Norway (Grade 9)	72	65	70	67	61	47	72	44	22	49	62	55
Russian Federation	68	54	60	65	65	43	65	51	35	58	51	58
Thailand	59	49	52	50	51	49	52	51	47	52	54	55
Turkey	56	53	53	52	52	50	53	49	45	51	49	47

Annex Table 3 Teachers often using ICT for teaching practices in classrooms (%)

	Presenting Information Through Direct Class Instruction	Providing Remedial or Enrichment Support to Individual Students or Small Groups of Students	Enabling Student-Led Whole-Class Discussions and Presentations	Assessing Students' Learning Through Tests	Providing Feedback to Students	Reinforcing Learning of Skills Through Repetition of Examples	Supporting Collaboration Among Students	Mediating Communication Between Students and Experts or External Mentors	Enabling Students to Collaborate With Other Students (Within or Outside School)	Collaborating With Parents or Guardians in Supporting Students' Learning	Supporting Inquiry Learning
Czech Republic	31	4	7	8	11	14	8	1	3	6	2
Denmark	41	22	23	18	21	16	16	4	4	23	15
Germany	13	4	5	3	4	4	4	1	2	3	4
Croatia	28	10	14	5	8	14	9	3	3	2	12
Lithuania	36	15	15	14	17	19	12	3	5	22	6
Netherlands	44	14	11	15	10	26	11	1	3	8	8
Poland	23	19	10	28	28	24	24	3	5	16	18
Slovenia	35	15	19	7	13	21	12	3	5	5	8
Slovak Republic	29	10	13	9	11	18	10	3	3	6	7
Australia	46	19	18	10	17	20	14	3	7	9	18
Chile	43	20	22	22	33	29	27	6	12	11	28
Hong Kong SAR	38	9	8	12	15	16	8	3	5	3	6
Korea, Rep. of	42	22	10	12	15	20	8	5	8	4	10
Norway (Grade 9)	33	12	9	14	25	11	6	1	5	9	5
Russian Federation	43	21	24	33	16	34	26	5	10	21	19
Thailand	22	13	14	25	19	21	30	10	18	13	31
Turkey	22	15	15	20	17	20	11	7	7	6	13