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Upgrading the ICT questionnaire items in PISA 2021

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UPGRADING THE ICT QUESTIONNAIRE ITEMS IN PISA 2021

OECD Education Working Paper No. 202

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Abstract

This paper explains the rationale for updating the OECD Programme for International Student Assessment (PISA) 2021 questionnaire on Information and Communication Technology (ICT) and shows how it covers policy topics of current relevance. After presenting key findings based on previous ICT-related PISA data, the paper provides a summary of the PISA 2021 ICT framework guiding the development of the questionnaire. The paper then describes the process followed by the OECD/PISA secretariat for the development of the PISA 2021 ICT questionnaire items. The paper concludes by drawing some lessons that would inform future development of this instrument.

Résumé

Cet article décrit les motivations de l'actualisation du questionnaire du Programme international de l'OCDE pour le suivi des acquis des élèves (PISA) 2021 sur les Technologies de l'Information et de la Communication (TIC) et explique en quoi celui-ci couvre des sujets d'actualité en termes de politiques publiques. Après avoir présenté des résultats clé du PISA portant sur les TIC, cet article propose un résumé du cadre théorique qui a guidé la construction du questionnaire. Il décrit ensuite le processus suivi par le secrétariat de l'OCDE/PISA pour développer les différents items. L'article se conclut par des recommandations pour le développement de futurs questionnaires.

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1. Introduction

Information and communication technologies (ICTs) play an increasingly important role in virtually all aspects of our daily lives. Not only is technology profoundly transforming people's work and professional lives, but it is also altering how people interact, communicate, retrieve and share information, and even how governments provide public services to citizens. ICTs also significantly affect multiple facets of education. They can provide new opportunities for students to learn outside of school, and can change teachers' pedagogical approaches and the learning experience of students in school.

In 2000, the OECD Programme for International Student Assessment (PISA) distributed, for the first time, a questionnaire with the aim of documenting students' familiarity with and use of ICT. Since then the ICT familiarity questionnaire has been offered to countries as an optional part of the PISA assessment. The broad participation in the ICT questionnaire – with 50 countries and economies conducting the survey in 2018 – reflects the growing importance of ICT and digitalisation in the education policy debate. With the role of ICT in education figuring high on the agenda of many PISA-participating countries, the OECD/PISA secretariat – with European Commission funding – launched the development of an ICT conceptual framework, which serves as the basis for upgrading the ICT questionnaire in PISA 2021.

This paper describes the rationale and process that the OECD/PISA secretariat followed in completing this project. The process involved summarising lessons learned from the ICT questionnaires distributed since PISA 2000, reviewing related literature, convening experts to discuss the scope of the PISA ICT questionnaire, developing the ICT conceptual framework, updating the existing ICT questionnaire items, introducing new ICT-related items in the student, school, parent and teacher questionnaires, and testing the student-level questionnaire items in cognitive labs.

The work was undertaken in response to the fact that certain aspects of the existing PISA ICT questionnaire items have become obsolete. For instance, too much emphasis had been placed on the availability of certain technologies and on the intensity of their use. Some of these technologies no longer exist. To address those limitations, the questionnaire was upgraded in a number of ways. First, the new questionnaire documents availability and use simultaneously while focusing on generic digital devices and digital resources likely to affect learning. Second, accessibility and quality of digital resources are now assessed by asking students to describe whether the ICT resources available to them are fit for purpose. Most important, prominence is given to topics of interest to education policy makers, such as students' awareness of the risks of using ICTs, their attitudes towards ICTs, their use of ICTs for learning and for leisure in and out of school, their views on their teachers' abilities and willingness to use ICTs, and their views on the ICT environment at home and at school. The new questionnaire also explores students' self-efficacy and confidence when using ICTs to perform various tasks.

The paper is organised as follows: Section 2 presents results from past PISA ICT questionnaires and highlights the gaps and limitations of existing data and knowledge. Section 3 summarises the conceptual framework guiding the development of the PISA 2021 ICT questionnaire. Section 4 describes the new developments in the PISA 2021 ICT questionnaire. The concluding section presents lessons for the future development of ICT questions in PISA.

1.1. Outputs of the project

1.1.1. The PISA 2021 ICT framework

The main goal of the framework is to paint a comprehensive picture of the availability and use of ICT resources by 15-year-old students and of students' self-reported proficiency in working with ICTs. The framework focuses on three areas:

Quality of ICT resources. Information on whether schools have computers connected to the Internet is not sufficient to understand the relationship between ICT and student performance, since most schools in OECD countries do have these resources. The major differences between schools (and countries) revolve around issues of quality rather than quantity of resources. For instance, Internet speed, whether the Internet is available in every class and for every student, and how it is used to support learning, have all become more important than the simple question of availability.

Detailed use of ICTs. Students use ICTs for various activities (e.g. doing research but also chatting with friends and having fun), some of which, and under certain circumstances, could be distracting. This raises the question of how students spend their time engaging with ICTs, and whether such activities are monitored or structured in a way to foster learning. The existing ICT questionnaire asks about the types of ICT-related activities that students are engaging in. However, it does not provide much information on time spent on different activities or whether the activities are monitored. Furthermore, teachers and school principals can provide important information on detailed usage of ICT in schools. This information includes how ICTs are used in teaching, the types and amount of professional training and support that teachers receive to adapt ICT to their teaching, and school-level policies regarding the use of ICTs in teaching and learning.

Students' self-report on ICT proficiency. ICT literacy and the ability to use technology effectively in today's knowledge economy is a key 21st century skill. Today's environment is characterised by the ease of access to abundant information and by the rapid change in technology. A successful student is someone who is able to use technology as a tool to research, manage, analyse and communicate information while being flexible and able to adopt new ICTs as they arise. Previously in PISA, students were asked basic questions about their self-efficacy in the use of ICTs. The new ICT questionnaire aims to develop these questions to better reflect students' skills and knowledge of ICTs and their effectiveness in using them in their daily life.

1.1.2. The PISA 2021 ICT questionnaire

The PISA 2021 ICT questionnaire was upgraded to cover topics of current relevance for policy makers and to reflect the developments in the field. The lessons drawn from the analysis of previous PISA cycles, and from an extensive review of academic literature and policy reports on the subject, guided the selection of the areas to cover in the questionnaire. Under the guidance of the ICT expert group, the revision of the PISA ICT familiarity questionnaire was seen as an opportunity for a fresh start that will provide a forward-looking model for the assessment of ICTs in education.

1.2. The process

In order to ensure that the ICT framework and questionnaire items covered all topics of current policy relevance, the OECD/PISA secretariat followed a multistage process of development and revisions. The process involved:

1. Developing the ICT conceptual framework based on a review of relevant academic and policy literature and on analyses of existing PISA ICT data.
2. Seeking guidance and advice from a group of experts on the topic. The experts provided valuable input for the development of the conceptual framework and identified key areas to cover in the questionnaires. They also reviewed and commented all outputs throughout the process.
3. Once questionnaire items were selected, they were qualitatively tested in cognitive labs organised and delivered by Statistics Canada.
4. Quality assurance was provided by the OECD/PISA secretariat. Analysts in the OECD/PISA secretariat drafted the outputs and selected the questionnaire items.

1.2.1. The expert group

The expert group consisted of five external experts who provided advice on the development of the ICT framework and the PISA 2021 questionnaire items. The group members were:

- **Jeppe Bundsgaard** (Professor at University of Aarhus, Danish School of Education – Denmark).
- **Cindy Ong** (Senior Specialist, Educational Technology Division, Ministry of Education – Singapore).
- **Michael Trucano** (Senior Education and Technology Policy Specialist and Global Lead for Innovation in Education, World Bank – United States).
- **Patricia Wastiau** (Principal Adviser for Research and Innovation, Schoolnet – France/Belgium).
- **Pat Yongpradit** (Chief Academic Officer, Code.org – United States).

The expert group and the PISA team managing the project met on four occasions (two virtual and two face-to-face meeting). The first virtual and first face-to-face meetings were dedicated to discussing the scope and content of the ICT framework; the following two focused on the development of the ICT questionnaire items.

For the ICT framework, members of the expert group were asked to identify key conceptual areas regarding the use of ICTs to support learning. They also commented on the different drafts of the framework and provided input when needed. Analysts in the OECD/PISA secretariat drafted the framework.

For the ICT questionnaire, the expert group drew a list of key areas to cover, then provided a set of possible questions to include in the questionnaire. Those questions were reviewed internally by the PISA analysts and revisions were made after extensive discussion with the experts. Finally, the chosen questionnaire items were sent to be tested in cognitive labs.

1.2.2. The cognitive labs

The first set of ICT questionnaire items developed by the OECD/PISA secretariat in collaboration with the experts was qualitatively tested in cognitive labs organised and implemented by Statistics Canada. Twenty-four one-on-one interviews were scheduled to take place in Ottawa in both French and English. In the end, a total of fourteen interviews were conducted: seven in each language.

While ICT-related questions for teachers and principals were desk-reviewed, Statistics Canada tested the student-level questionnaire with 15-year-old students from various backgrounds and provided extensive comments on the wording and complexity of the questions.

The objectives of the testing were:

- to obtain feedback from respondents on their overall impressions of and reactions to the proposed content and questions
- to test the cognitive processes of respondents in answering the questions including: a) an assessment of respondents' understanding of the concepts, terminology, questions and response categories; and b) an assessment of the availability of the information requested
- to test respondents' ability and willingness to answer the questions

1.2.3. Quality assurance

All drafts of the PISA 2021 ICT framework and of the corresponding questionnaire were reviewed internally by members of the OECD/PISA secretariat. Comments and inputs were also sought from other OECD colleagues and from colleagues at the European Commission working on topics related to digital literacy and skills, digitalisation and the use of ICTs by young people.

2. Lessons from previous PISA cycles

A critical feature of the ongoing digital revolution is that the landscape of digital technologies and practices is evolving very fast. In a matter of a decade, the development of online storage and computational capacities enabled people to stream movies, to save and share their work online, and virtually replaced local storage devices (e.g. USB sticks and hard drives). Conversely, PISA is relatively "sticky" when it comes to elaborating and updating questionnaire items. Although PISA seeks to inform current education policy issues, it is constrained in timing and flexibility by its simultaneous implementation in more than 70 countries and economies. Moreover, one trade-off that PISA faces is the need to follow trends over time on certain aspects of education policy while keeping the questions up-to-date and relevant for current policy making.

This section highlights the shortcomings and limitations of the previous PISA ICT questionnaire and the need to improve the questionnaire items to ensure relevance and accuracy. It shows how the evolution of digital technologies and practices requires updating the ICT questionnaire for PISA 2021. The data show that some questions covering particular digital resources and practices are not relevant anymore, while other aspects are not documented.

2.1. A rapid but unequal expansion of ICTs

2.1.1. A rapid expansion of ICTs

Most students in most countries have access to generic ICT resources

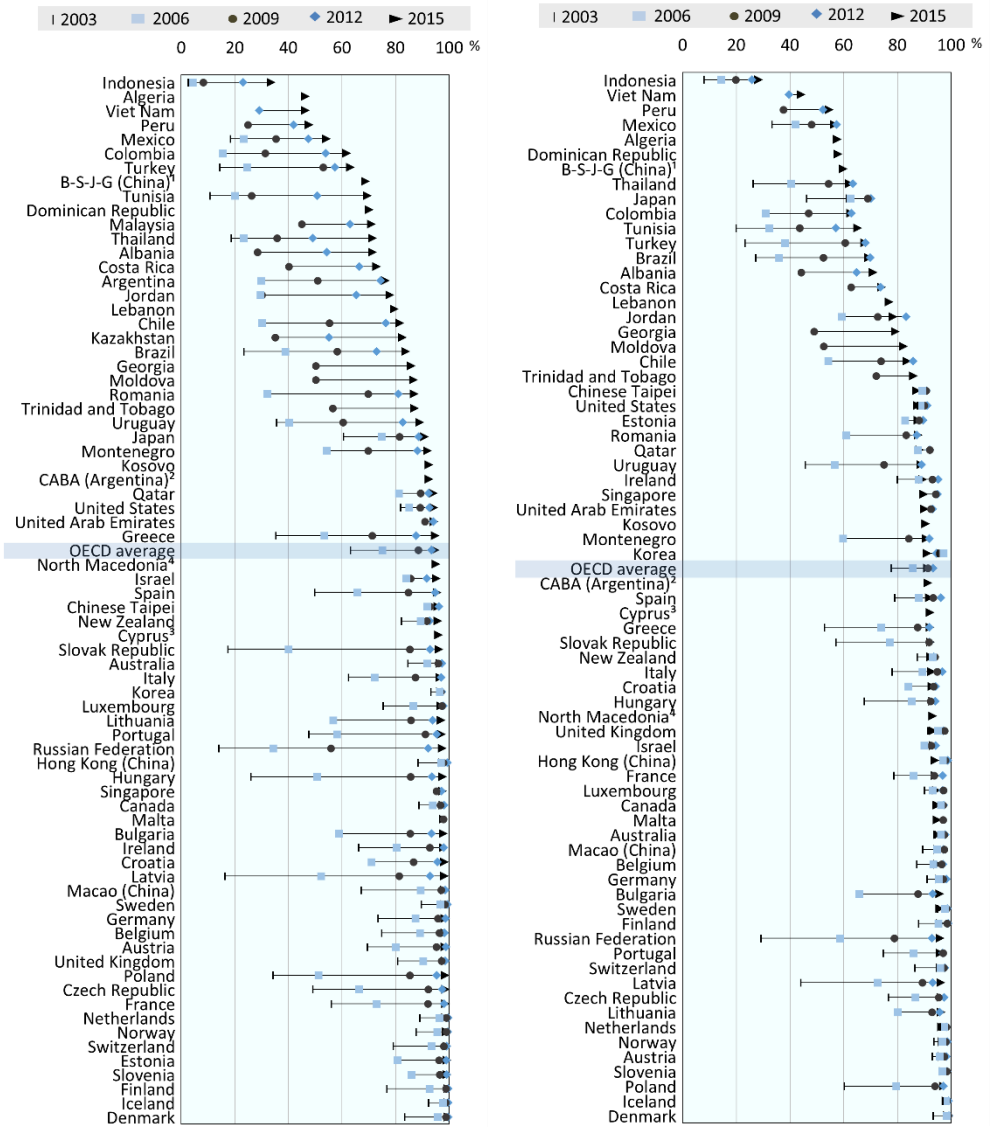
Whether at home or at school, students' access to the Internet and to computers has expanded rapidly enough to become ubiquitous in 2015 in most PISA-participating countries. Among the 40 countries participating in 2003, the share of students with access to the Internet at home increased by 35 percentage points, on average, from 57% in 2003 to 92% in 2015 (

Figure 2.1, Panel A). The bulk of the expansion took place between 2003 and 2009. By that date, the share of students with access to the Internet was already close to 100% in many OECD countries. Students' access to a computer for schoolwork at home expanded less over the same period (17 percentage points, on average), given that possession of a computer was very common in 2003 with about 70% of students, on average, owning a computer (

Figure 2.1, Panel B).

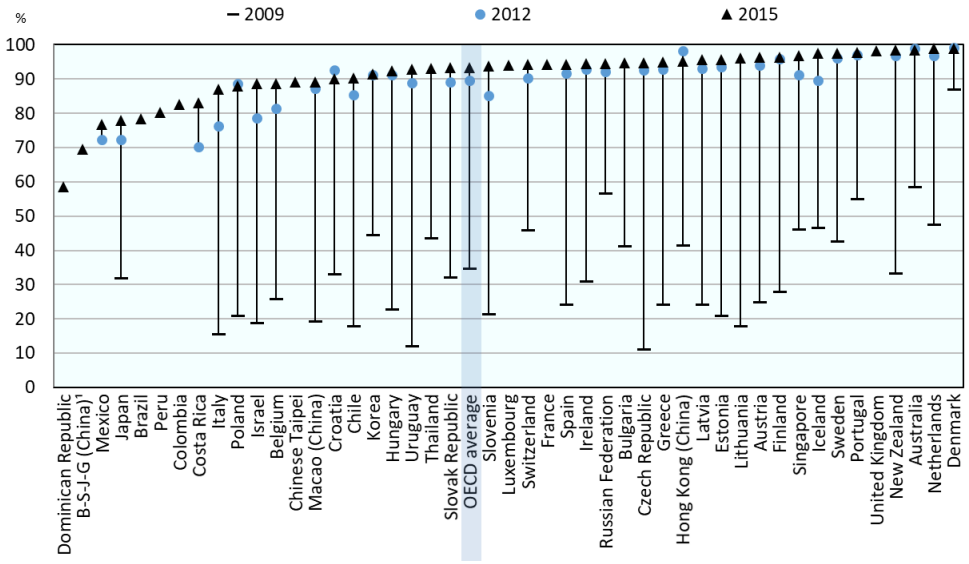
Students' access to the Internet in school has also remarkably increased between 2009 and 2015. In 33 of the 47 countries that distributed the ICT familiarity questionnaire in 2015, more than 90% of students had access to the Internet at school (Figure 2.2). On average, 91% of students had access to the Internet at school in 2015, a slightly higher percentage than that in 2012 (89%, based on all countries with data in 2012) but much higher than the percentage in 2009 (33%, based on all countries with data in 2009).

Figure 2.1. Access to the Internet (Panel A) and a computer available for schoolwork (Panel B) at home (2003-15)



1. B-S-J-G (China) refers to the four PISA-participating Chinese provinces of Beijing, Shanghai, Jiangsu and Guangdong.
2. CABA (Argentina) refers to the adjudicated region of Ciudad Autónoma de Buenos Aires (CABA).
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4. North Macedonia refers to the Republic of North Macedonia.
Notes: Only countries and economies with available data in 2015 are shown in the figure.
(Panel A) Countries and economies are ranked in ascending order of the percentage of students who had access to the Internet at home in 2015. (Panel B) Countries and economies are ranked in ascending order of the percentage of students who had a home computer available for schoolwork in 2015.
Source: OECD, PISA 2003, PISA 2006, PISA 2009, PISA 2012 and 2015 Databases (http://www.oecd.org/pisa/data/ - accessed on 10 December 2018).

Figure 2.2. Access to the Internet at school (2009-15)



1. B-S-J-G (China) refers to the four PISA-participating Chinese provinces of Beijing, Shanghai, Jiangsu and Guangdong.
Notes: Only countries and economies with available data in 2015 are shown in the figure.
Countries and economies are ranked in ascending order of the percentage of students who had access to the Internet at school in 2015.
Source: OECD, PISA 2009, PISA 2012 and PISA 2015 Databases (http://www.oecd.org/pisa/data/ - accessed on 10 December 2018).

2.1.2. Heterogeneity between and within countries in access to ICTs

ICT resources are not yet ubiquitous in emerging and developing countries

Internet and computers are not yet available for a large proportion of students in developing and emerging countries. Of the 74 countries and economies that participated in PISA 2015, the proportion of students with no access to the Internet at home was below 50% in 4 countries (Algeria, Indonesia, Peru and Viet Nam) (

Figure 2.1, Panel A) and ranged between 50% and 80% in 13 countries.

Similarly, in 2015 the share of students with access to a computer was below 50% in Indonesia and Viet Nam and between 50% and 80% in 16 countries including, in ascending order, Peru (55%), Mexico (57%), Japan (62%), Tunisia (65%) and Lebanon (77%) (

Figure 2.1, Panel B). The spread of computers and Internet access is still an ongoing process in these countries as shown by the continuous increase in the proportion of students' accessing these resources. Those countries are progressively catching up with wealthier OECD economies where students' access to computers and the Internet is widespread (

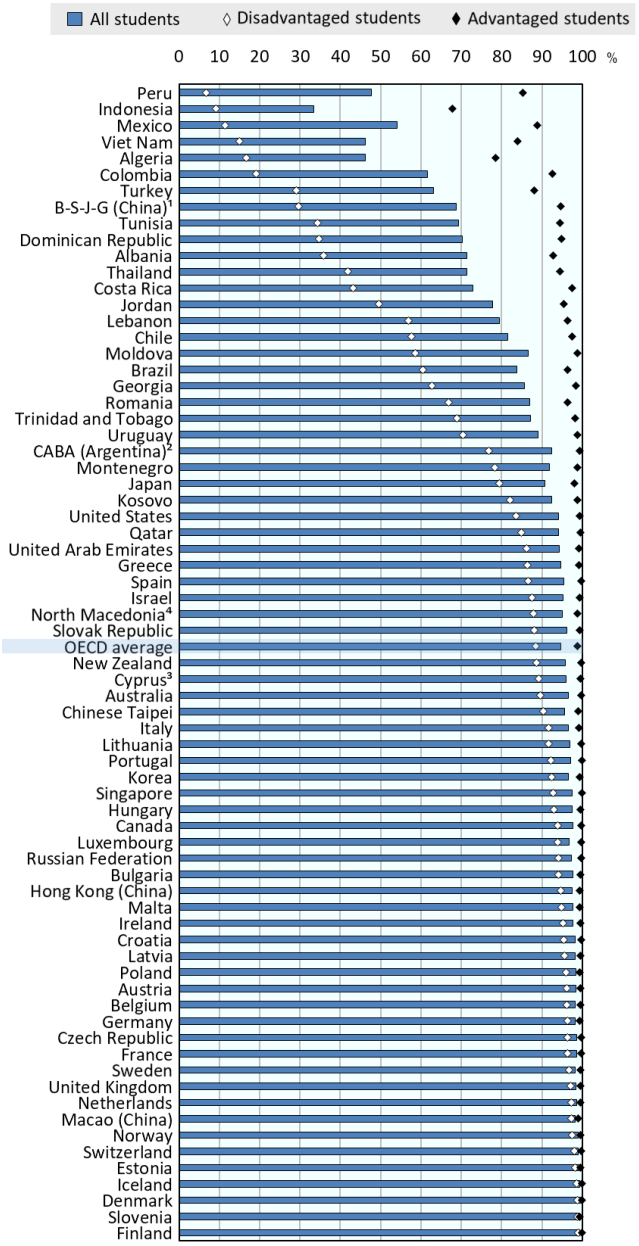
Figure 2.1).

Within-country differences in ICT access remain strong

The "first digital divide" remains a serious issue in many PISA-participating countries. Across OECD countries that participated in PISA in 2015, 88% of

disadvantaged students (i.e. students who belong to the bottom quarter of the index of economic, social and cultural status) had access to the Internet at home in comparison with almost 100% of their advantaged counterparts (Figure 2.2). This divide is much greater across OECD partner countries and economies, and remains a major policy concern in Indonesia, Mexico, Peru and Viet Nam, where less than 15% of disadvantaged students had access to the Internet at home. In contrast, as much as 99% of disadvantaged students in Denmark, Finland, Iceland and Slovenia had access to the Internet at home, and the availability of basic digital resources is now universal.

Figure 2.3. Students with an Internet connection at home, by socio-economic status



1. B-S-J-G (China) refers to the four PISA-participating Chinese provinces of Beijing, Shanghai, Jiangsu and Guangdong.
2. CABA (Argentina) refers to the adjudicated region of Ciudad Autónoma de Buenos Aires.
3. See note 3 in Figure 2.1.
Source: OECD, PISA 2015 Database (https://www.oecd.org/pisa/data/2015database/ - accessed on 10 December 2018).

Those results suggest that documenting access to basic ICT resources and to the Internet does not provide additional information for OECD countries since access and availability are now universal. While the use of computers and the Internet by 15-year-old students was not very common in 2003, by 2015 both computers and Internet access were widely available. However, two considerations arise. First, the issue of access to basic ICT

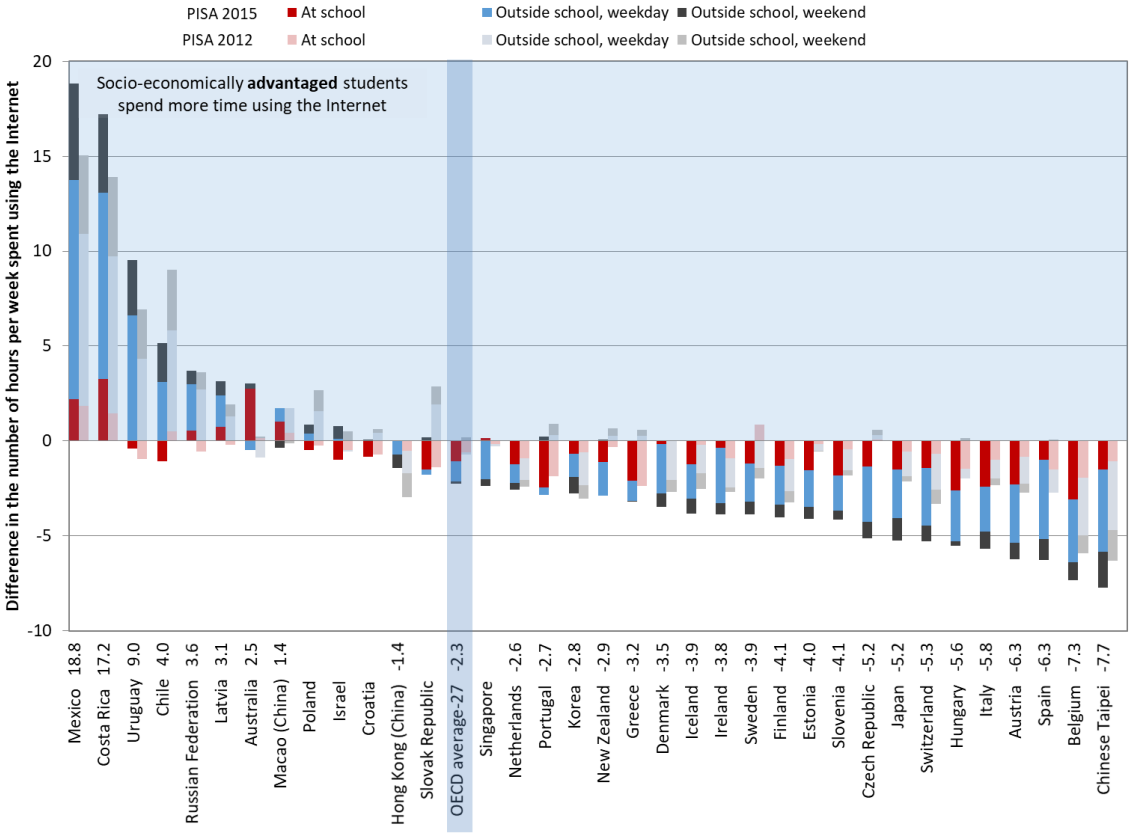
resources remains important for PISA partner countries and economies and therefore should be covered in future PISA ICT familiarity questionnaires. Second, for OECD countries, the questionnaire should go beyond documenting the simple availability of basic ICT resources. This could be achieved by focusing on more sophisticated resources, their quality, the modalities of their use, and on students' competencies in using them.

2.1.3. Students' use of ICTs is increasing and is getting more diversified

Students spend more and more time online, both at home and at school. While most students in OECD countries already had access to the Internet at home in 2012, the increase in students' Internet use between 2012 and 2015 was remarkable (Figure 2.4). Over these three years, the time students spent online increased from 21 to 29 hours per week, on average across the 27 countries that distributed the ICT questionnaire in 2012 and 2015 (OECD, 2018[1]). In Costa Rica – the country that experienced the largest increase – students spent almost twice as much time online in 2015 (37 hours per week) than in 2012 (19 hours). While two-thirds of the increase in time spent using the Internet happened outside of school (5.4 hours per week), on average across OECD countries, students also spent 2.7 hours more per week online at school in 2015 than they did in 2012. This rapid increase in the time spent online reflects the greater connectivity following the expansion of access to the Internet. This trend is likely to continue in the near future and therefore should be documented in the upcoming cycles of PISA data collection.

The modalities of Internet use are diverse. In countries and economies where access to the Internet is almost universal, disadvantaged students spend more time online in comparison with their advantaged counterparts (Figure 2.4). On average, disadvantaged students spent 2.3 hours more online each week. Those in Chinese Taipei spent up to 7.7 hours more, those in Belgium 7.3 hours more, and disadvantaged students in Austria and Spain spent 6.3 hours more. However, the traditional digital divide persists in countries where access is still not widespread. Thus, advantaged students in Mexico spent 18.8 hours more per week online than their disadvantaged peers. In Costa Rica, such students spent 17.2 hours more per week, and in Uruguay, 9 hours more per week. Hence, depending on the situation the time students spend online takes on a different meaning. Documenting precisely how students use ICTs is therefore of primary interest. Moreover, disadvantaged students are more likely to have simple, repetitive skill based experiences while their advantaged peers might have more experience with problem solving and creating digital solutions.

Figure 2.4. Differences between advantaged and disadvantaged students in time spent using the Internet



Notes: To obtain the weekly average, the response categories were recoded with the middle value (e.g. "31-60 minutes per day" being coded as "45.5 minutes per day") and then multiplied by 5 if they refer to a school day and by 2 if they refer to a weekend day.
Countries and economies are ranked in descending order of the difference between advantaged and disadvantaged students in the time spent using the Internet in 2015.
Source: OECD (2018) PISA in Focus 2018/83.

2.2. A fast-changing ICT environment: From digital resources to digital practices

In the past decade, the fast-changing digital and technological environment has modified peoples' digital practices and habits. The omnipresence of smartphones in one's daily life is a good example of how people's habits have radically changed because of technological progress. For example, people can now use their smartphones to listen to music, access the Internet and make a phone call. These tasks were originally done separately using multiple devices, but now they can be performed on a single device that has become essential to own.

The rapid expansion and diversity of digital technologies challenges the ICT familiarity questionnaire in different ways. It makes it difficult for the ICT questionnaire to cover the full breadth and diversity of digital devices and practices. Moreover, as digital technologies develop, some become ubiquitous and universal while others become obsolete. This would require adapting and updating the questionnaire for each PISA cycle. In practice, different generations of digital devices fulfill similar roles (e.g. desktop, laptop and tablet computers), which complicates even further the documentation of their availability and the

evolution of their use. Moreover, PISA occurs every three years and questionnaires are prepared well in advance of data collection. This means that technologies might change within this timeframe, rendering some of the questionnaire items irrelevant. Therefore, ICT questions should not be too specific and should not focus on a particular device or software but rather on the role they fulfill.

2.2.1. Evolution of digital technologies

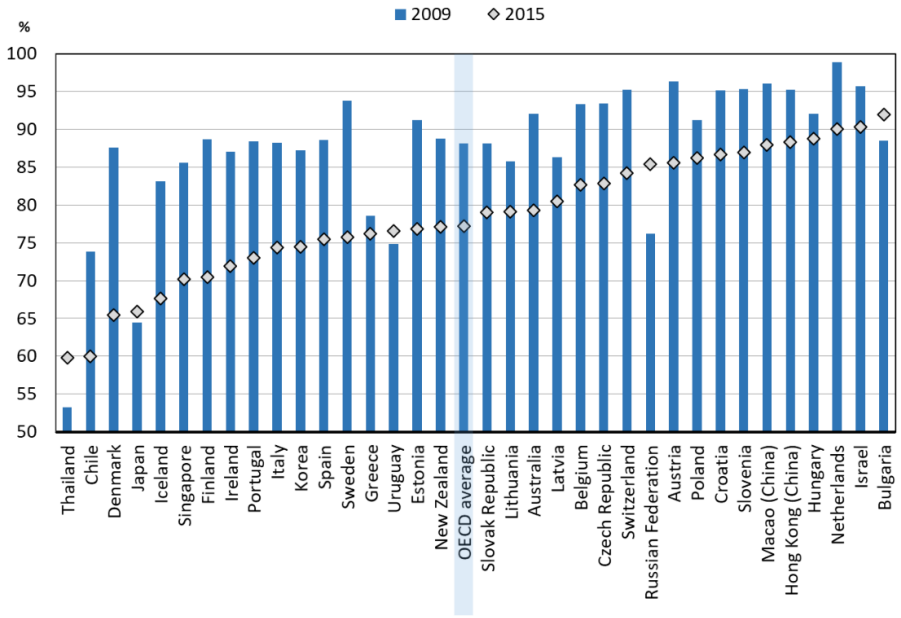
Relevance of ICT resources

The coverage of ICT resources has evolved over PISA cycles in an attempt to better capture the changing digital landscape. Between 2000 and 2006, the ICT familiarity questionnaires covered only students' access to a computer and the Internet and their use of video games, educational software and generic tools, such as text editors and spreadsheet software. From PISA 2009 onward, coverage of the ICT questionnaire was extended to include newly available digital devices, such as laptops, printers, memory sticks and mp3 music players, and school-specific digital resources, such as school-provided storage space, projectors and interactive whiteboards. From 2015, students were asked how frequently they conduct specific tasks at and outside of school using digital devices. The tasks ranged from playing multi-player video games, to writing e-mails and chatting online to browsing the Internet for schoolwork.

Yet in spite of this evolution, the ICT familiarity questionnaire still documents digital devices that will no longer be relevant in 2021. The PISA 2018 ICT familiarity questionnaire documents students' access to portable music players (e.g. MP3/MP4, iPod or similar), a printer and a memory stick. These digital devices are deemed not relevant to document students' exposure to new or modern digital resources. Indeed, most students use their smartphones to listen to music, and the possession of a memory stick is not necessarily relevant to students' educational experiences in 2021 since possession has become universal and data storage is shifting to new platforms (e.g. cloud-based applications). Some of these ICT resources were covered in the 2018 questionnaire in order to maintain trends across PISA cycles. However, this is conceptually problematic because using a memory stick in 2009 has a different meaning than doing so in 2018. Today, it would indicate that a student is using an old technology in an era where everything is stored online. Therefore, a decision was made to give precedence to updating the coverage of the PISA 2021 ICT questionnaire rather than maintaining trends that are no longer useful.

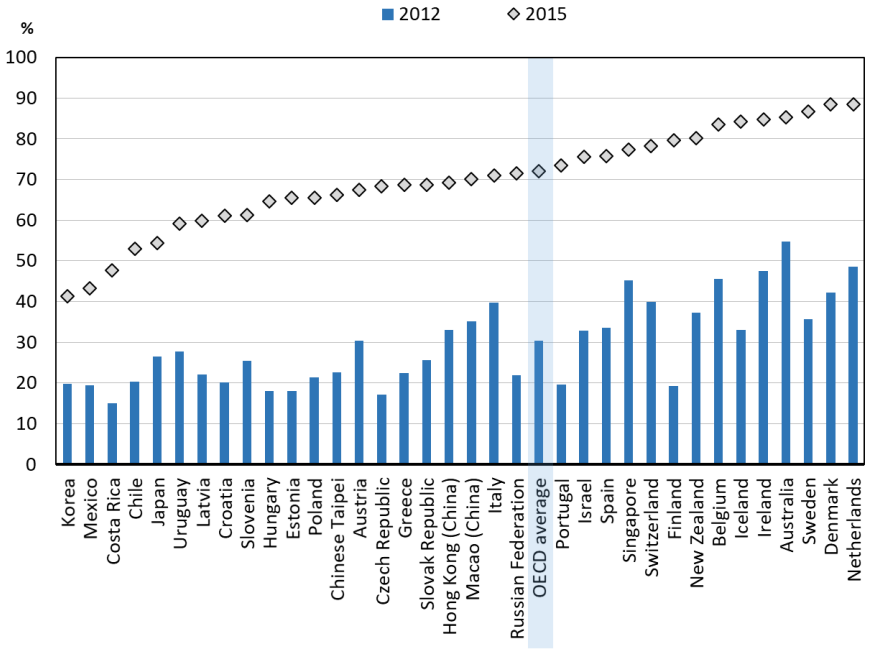
Technological change over time adds a layer of complexity to the PISA ICT questionnaire. The rapid replacement of desktop computers by laptop and other forms of computers shows how the fast-changing ICT environment can affect ICT questionnaire validity and relevance. Indeed, between 2009 and 2015, PISA data documents a 10% drop (from about 87% to 77%) in the share of students having access to a desktop computer at home (Figure 2.5). At first, this result could be interpreted as a decrease in access to ICT resources. Yet, this decrease was more than compensated by the rise (from around 30% to 70%) in the share of students having access to a tablet computer at home between 2012 and 2015 (Figure 2.6). This evolution (i.e. common digital devices being replaced by new ones) constitutes a serious challenge for investigating ICT access and usage. Indeed, while tablet computers are not fundamentally different from desktop computers – at least in their potential contribution to learning – they are still not exactly similar and involve a specific cognitive experience.

Figure 2.5. Change between 2009 and 2015 in the availability of desktop computers at home



Note: Countries and economies are ranked in ascending order of the percentage of students who had access to a desktop computer at home in 2015.
Source: OECD, PISA 2009 and PISA 2015 Databases (https://www.oecd.org/pisa/data/ - accessed on 10 December 2018).

Figure 2.6. Change between 2012 and 2015 in the availability of tablet computers at home



Note: Countries and economies are ranked in ascending order of the percentage of students who had access to a tablet computer at home in 2015.
Source: OECD, PISA 2012 and PISA 2015 Databases (https://www.oecd.org/pisa/data/ - accessed on 10 December 2018).

Moreover, the digital landscape is becoming even more complex due to the consolidation of devices and uses. For instance, in the past decade, a plethora of new devices and services, such as smartphones, connected watches, programmable vacuum cleaners and drones, have emerged. Some, like smartphones, have consolidated multiple functions that were separate some years ago. Not only do they include high-quality digital cameras and allow accessing the Internet almost everywhere, they are also more powerful than older laptop computers. The frontier between a laptop, a tablet and a smartphone is now blurry and is not necessarily related to the use of each digital device. In this context, it becomes difficult and even counterintuitive to focus on one particular type of digital device – especially given the overlapping nature of these devices and their unpredictable evolution.

Therefore, continuously updating the PISA ICT questionnaire to include new ICT devices seems unrealistic. Rather than measuring the degree of sophistication of students' ICT resources, the questionnaire should focus on the relationship between digital resources and learning. Consequently, the PISA 2021 strategy focuses on the use of digital devices that are expected to influence learning outcomes. The strategy is articulated around the function of the device rather than its nature.

Covering software and online resources

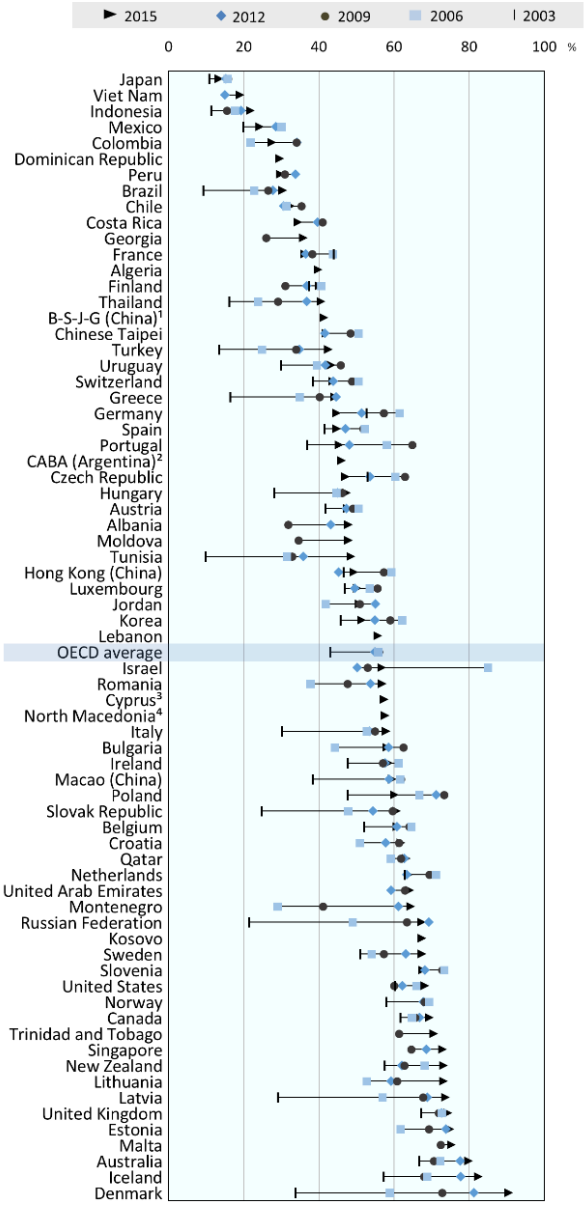
As mentioned earlier, in a context of almost universal access to computers and the Internet, documenting students' access to ICT resources requires going beyond the mere availability of digital devices to exploring how students use them. This suggests investigating the availability and use of software and online resources in general, which proves to be challenging for different reasons. One specific challenge in covering software lies in the fact that students do not need to possess these resources per se. Having access to the Internet is sufficient to ensure access to a wealth of online resources and software, many of which are free or have a free equivalent.

Second, online resources and software are virtually infinite, and it is extremely difficult to define and classify them in a way that is relevant to all PISA-participating countries and economies while maintaining coherence over time. Following the same logic discussed above, it seems realistic to document students' access to online resources and software specifically designed to support learning instead of mapping all types of software. Students' access to educational software at home has been documented in the PISA ICT questionnaire starting in 2003. Unlike computers and access to the Internet, educational software is not widely available (see below) and as such, documenting its availability in future PISA cycles is warranted. However, the range of digital learning resources covered in the questionnaire should be extended to include new types of resources, including learning apps, games and various online education tools, such as school platforms and learning management systems. Again, the objective is not to extensively cover all types of digital learning resources but rather to identify the main categories. The reason is that they differ widely in quality and purpose, and because their potential effects on students' cognitive outcomes depend on how they are used in practice.

Students' access to digital resources for learning purposes is not widespread in all countries. On average across OECD countries, the proportion of students with access to educational software at home increased from 43% in 2003 to 56% in 2006 and remained stable since then until 2015 (Figure 2.7). The share of students with access to educational software at home in 2003 varied greatly across countries, ranging from 12% in Japan, 19% in Viet Nam, 36% in France and 40% in Finland to 75% in Estonia, 82% in Iceland and 91% in Denmark. Interestingly, even countries where more than 90% of students had access

to the Internet and a computer at home (such as France and Finland) showed relatively low access to educational software at home.

Figure 2.7. Access to educational software at home (2003-15)



1. B-S-J-G (China) refers to the four PISA-participating Chinese provinces of Beijing, Shanghai, Jiangsu and Guangdong.
2. CABA (Argentina) refers to the adjudicated region of Ciudad Autónoma de Buenos Aires.
3. See note 3 in Figure 2.1.
4. North Macedonia refers to the Republic of North Macedonia.

Notes: Only countries and economies with available data in 2015 are shown in the figure.
Countries and economies are ranked in ascending order of the percentage of students who had access to educational software at home in 2015.
Source: OECD, PISA 2003, 2006, 2009, 2012 and 2015 Databases (https://www.oecd.org/pisa/data/ - accessed on 10 December 2018).

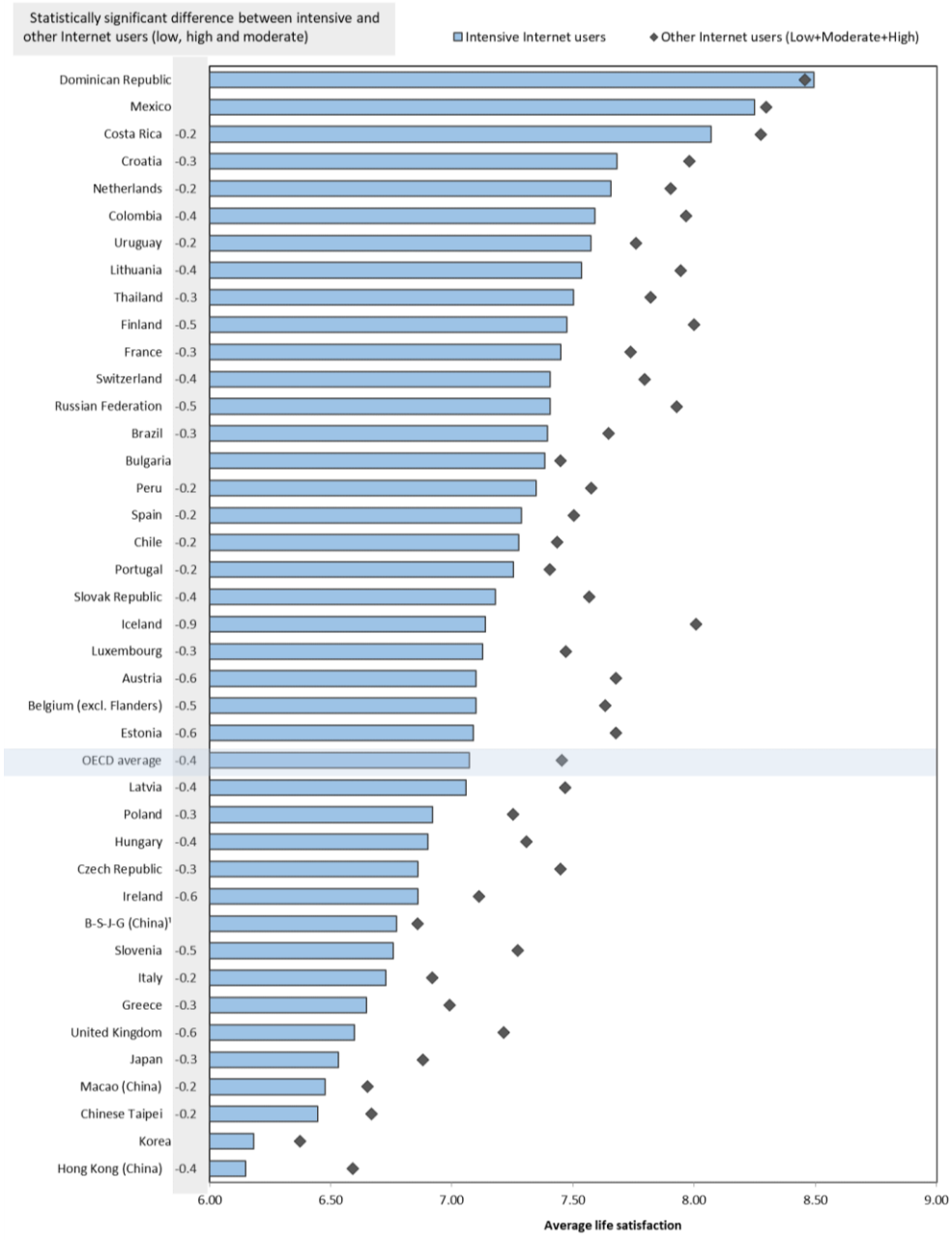
2.2.2. Evolution of digital practices

Time spent online and risks related to ICT use

Digital practices and habits have evolved together with the spread of ICTs. As mentioned earlier, one implication of the spread of Internet and smartphone use is a sharp increase in the time students spend online. Between 2012 and 2015, the time students spent online increased from 21 to 29 hours per week, on average in OECD countries (OECD, 2018[1]). Given the importance of the intensity of students' use of ICTs in the policy debate, it is crucial for the ICT familiarity questionnaire to explore this upward trend. In fact, it will be necessary to propose more response categories regarding the time spent online. Eventually, the evolution towards a world of constant connection to the Internet will shed doubt on the usefulness of the current classification of high vs. low Internet use. Thus, documenting carefully when, where and why students are online might be necessary to provide a more insightful account of time spent online.

The more time students spend online, the greater their exposure to online opportunities and risks (Hooft Graafland, 2018[2]). Students can benefit from many opportunities online, ranging from e-learning classes to seeking personal advice on gender, sex, health, identity and other issues (Hooft Graafland, 2018[2]). Furthermore, the PISA 2015 ICT questionnaire reveals that disadvantaged students spend more time online than their advantaged counterparts (OECD, 2018[1]). This suggests that they might be more engaged in excessive Internet use or "binge gaming" for example. This can have adverse effects on students' well-being as intensive Internet users are less likely to be satisfied with their lives (Figure 2.8). Other online risks include exposure to inappropriate content (e.g. pornographic, violent or dangerous content) and online bullying. The ICT familiarity questionnaire should cover more extensively both online risks and opportunities.

Figure 2.8. Average life satisfaction, by time spent on the Internet outside of school during weekend days



1. B-S-J-G (China) refers to the four PISA-participating Chinese provinces of Beijing, Shanghai, Jiangsu and Guangdong.

Notes: Categories of Internet users are based on students' responses to questions about how much time they spend online, outside of school, during a typical weekend day. Low Internet users: one hour or less; moderate Internet users: 1 to 2 hours; high Internet users: 2 to 6 hours; intensive Internet users: more than 6 hours.

Statistically significant differences in life satisfaction between intensive Internet users and other Internet users are shown next to the country/economy name.

Countries and economies are ranked in descending order of the average life satisfaction of intensive Internet users.

Source: OECD, PISA Database (https://www.oecd.org/pisa/data/2015database/ - accessed on 10 December 2018).

Mastery of basic technical and routine ICT tasks is now widespread

The dissemination of new digital technologies also affects how students use ICTs and consequently how the ICT familiarity questionnaire should document it. For example, the 2018 ICT familiarity questionnaire assesses the frequency with which students "use e-mails" and "chat on line". Yet, writing e-mails is not common anymore among 15-year-old students and has been gradually replaced by a range of different communication tools and modes (e.g. Messenger, Whatsapp, Snapchat, etc.). Moreover, many activities that once were considered as technical digital tasks, such as downloading and installing apps, are now part of students' routine digital practices. This stresses the need to focus the ICT familiarity questionnaire on current digital habits.

Attitudes and dispositions towards ICTs

For similar reasons, some questions regarding students' attitudes and dispositions towards ICTs are often outdated in the current version of the ICT questionnaire. Asking students whether they "like using digital devices" or whether "the Internet is a great resource for obtaining information" might have been relevant to document students' interest in digital devices when they were not widespread. Nowadays, these technologies are taken for granted and are part of everyday activities.

Moreover, students' self-efficacy as assessed in the 2018 questionnaire focuses mainly on whether students feel comfortable using digital devices or can provide advice to their friends. As such, this definition does not reflect the diversity nor the depth of the digital competencies that students should possess in the 21st century. The 2021 ICT familiarity questionnaire should reflect the growing importance of major digital competencies, such as how to access and assess information, communicate effectively, create digital content or solve digital problems. Some of these competencies overlap with broader areas of interest for PISA, such as global competence and problem solving.

2.3. ICT use and students' cognitive outcomes

Policy makers are increasingly concerned with how ICTs affect education. Most education systems have launched ICT plans and policies to help schools and teachers integrate the latest digital technologies into teaching while coping with potential disruptive effects (Conrads et al., 2017[3]). Indeed, ICTs hold great promise for enhancing teaching, supporting school management and developing students' digital skills for the 21st century. Yet, both international surveys and the recent policy evaluation literature provide mixed evidence on the contribution of ICTs to education outcomes (Fraillon et al., 2014[4]; Escueta et al., 2017[5]). The findings from PISA are not different. A more frequent and diverse use of ICT in the classroom is not associated with higher performance in mathematics, reading or science in general. In fact, PISA results show a bell-shaped relationship between ICT use and students' performance (OECD, 2015[6]). This unclear relationship between ICT use and students' cognitive outcomes warrants further investigation of how and why students use ICTs in the classroom.

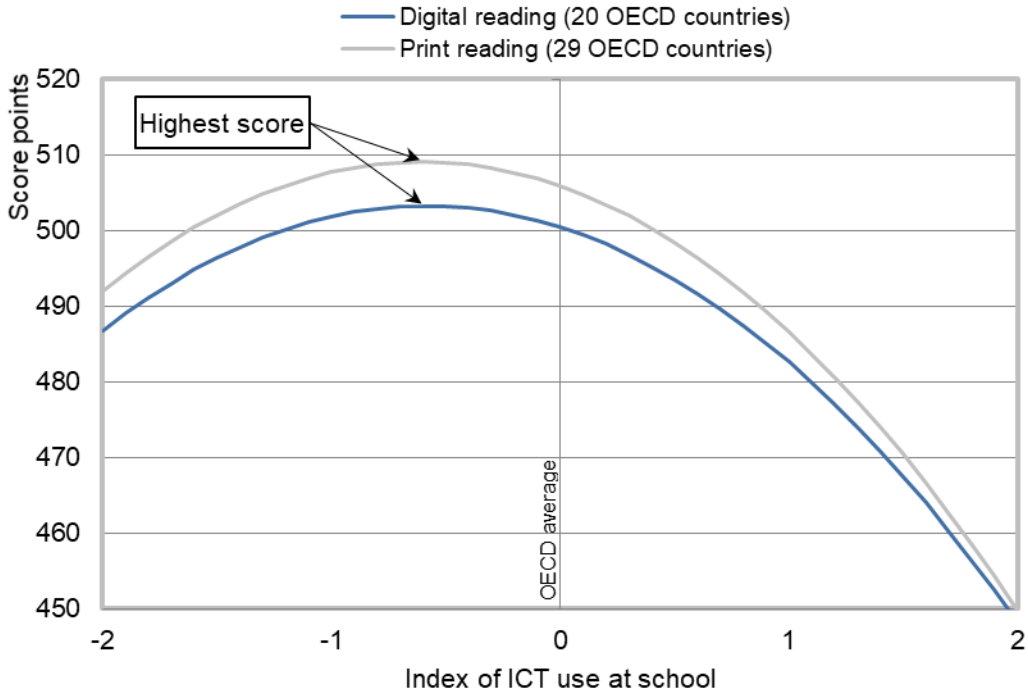
2.3.1. A bell-shaped relationship between ICT use and students' cognitive outcomes

The PISA 2009 ICT familiarity questionnaire documents how frequently students conduct specific tasks with digital devices both at school and at home. Based on these data, an index of ICT use was constructed. It was based on the frequency with which students chat online,

use e-mails, browse the Internet for schoolwork, play simulations, and use learning apps and websites. Findings from PISA 2012 and 2015 showed an overall negative correlation between the index of ICT use at school and students' performance in mathematics, science and reading (OECD, 2015[6]; OECD, forthcoming[7]). Figure 2.9, based on PISA 2012 results, shows the overall relationship between this index and students' performance in reading. Students with the highest performance in both reading and digital reading use ICT slightly less than the average OECD student does. The bell-shaped relationship suggests that moderate use of digital devices at school may be better than no use at all, but ICT use above the OECD average is associated with significantly lower results.

Figure 2.9. Students' skills in reading, by index of ICT use at school

OECD average relationship, after accounting for the socio-economic status of students and schools



Notes: The lines represent the predicted values of the respective outcome variable, at varying levels of the index of ICT use at school, for students with a value of zero on the PISA index of economic, social and cultural status, in schools where the average value of that index is zero.
Source: OECD, PISA 2012 Database (https://www.oecd.org/pisa/data/pisa2012database-downloadabledata.htm/ - accessed on 10 December 2018).

2.3.2. Those indecisive results require updating the questionnaire

Overall, the current ICT questionnaire does not provide sufficient information to interpret this bell-shaped relationship. While using ICTs can have a direct positive impact on performance, using it excessively may lead to unintended negative consequences.

For instance, students may lack attention or may engage in non-learning activities during lessons. Spending too much time using ICTs may also reduce the amount of time students spend on other useful learning activities. Moreover, low performers might also be adversely affected by the intensive reliance on ICTs in school. These are, of course, hypothesised relationships that require in-depth investigation. The PISA 2021 ICT familiarity questionnaire aims at providing more data that should help answer some of these questions.

3. Summary of the PISA 2021 ICT Framework

This section presents a summary of the conceptual framework guiding the development of the PISA 2021 ICT questionnaire items. The framework provides a comprehensive strategy to document how students access and use ICT resources in and outside of school for learning and for leisure activities. It identifies how teachers, schools and education systems integrate ICTs into pedagogical practices and learning environments and explores students' experiences with ICTs. It also examines students' attitudes towards ICTs, their self-efficacy and their awareness of safety issues when using ICTs.

3.1. Overall objective and conceptual approach

3.1.1. Why develop a framework on the integration of ICTs in teaching and learning?

ICTs affect individuals in many ways, including their education: how they learn, how they are taught in school and what they learn. Consequently, it raises important policy questions about students' access to and use of ICTs at and outside of school. Despite the growing body of literature exploring the relationship between students' engagement with ICTs and education outcomes, there is no consensus on the contributions ICTs make to students' educational attainment or cognitive performance in general.

Do students have sufficient access to quality digital resources? How do teachers integrate ICTs into teaching practices and what are the best practices using ICTs? What are the effects of integrating ICTs on students' cognitive performance and well-being?

ICTs play an increasingly important role in many facets of our daily lives. They transform people's work and professional life, but also how they socialise, communicate, and retrieve and share information. Education is no exception and is affected in many ways by the expansion of ICTs. ICTs can provide new opportunities for students to learn outside of school, and can change teachers' pedagogical approaches and students' learning experience in school. Moreover, education systems are increasingly embedding digital competencies in their curricula.

ICTs can affect learning in three major ways:

- Students' use and engagement with ICTs (both in and outside of school) can affect their cognitive processes and their well-being, and eventually what they learn.
- Teachers are increasingly using ICTs for instruction, and administrative and communication purposes, with numerous implications for classroom management, instructional practices, pedagogical approaches and time use.
- Competence in using ICTs and digital literacy are being recognised as skills that students need to acquire if they are to flourish in the digital age.

Yet, the ICT familiarity questionnaires in previous PISA cycles were developed in an ad-hoc manner without a comprehensive ICT assessment framework to guide their development. This resulted in a number of shortcomings. For example, questionnaires covered mainly hardware and access to the Internet while software and digital learning resources were covered to a lesser extent. The quality and accessibility of these resources were not systematically documented; and, more important, the use of ICT resources was

only partially documented, with limited coverage of teachers' pedagogical practices related to ICT. In addition, differences in questionnaires across PISA cycles offered limited possibilities for examining ICT-related trends over time.

3.1.2. Objectives of the PISA 2021 ICT framework

This framework provides a comprehensive strategy to document how students access and use ICT resources in and outside of school, and to identify how teachers, schools and education systems integrate ICTs into pedagogical practices and learning environments. The framework allows for an exploration of how system-level factors influence schools' and students' experiences with ICTs, how the availability and use of ICTs interact with various teaching practices, and how these associations correlate with students' performance in mathematics, reading and science, and with other outcomes, such as students' ICT skills and well-being.

Importantly, while the framework is not exhaustive, it provides an in-depth discussion of the diverse ways in which ICTs and education interact. This aims to provide a structure for the development of the ICT questionnaire items in PISA 2021 but also in future cycles. However, ICT questionnaires cannot cover such large ground and will only reflect partially the framework, with the objective of shedding light on aspects of prime interest for policy makers. As such, the focus of the ICT questionnaire is likely to evolve with the changing policy priorities.

This ICT assessment framework covers the dimensions listed below while ensuring consistency and comparability across countries:

- **access to ICTs**, which encompasses availability, accessibility and quality of ICT resources with a special focus on (connected) technologies that can support learning (e.g. digital learning resources, learning management systems, etc.)
- **use of ICTs**, which covers the types and modalities of ICT use by students in an informal and possibly unsupervised environment for learning and leisure, and in a supervised situation in the classroom, notably through teachers' pedagogical practices with ICTs;[1] it also includes alternative uses of ICTs by teachers to support teaching
- **students' ICT competencies,** which include attitudes towards ICT use (for learning and for leisure), self-efficacy measures in the use of ICTs, and questionnaire-based assessments of ICT skills.

3.1.3. Overall approach

At the heart of the PISA 2021 ICT framework is the relationship between two major dimensions of ICT – access and use – and students' outcomes (cognitive performance, well-being, and ICT-related attitudes and competencies). However, the framework also aims to identify how these links depend on contextual factors and background characteristics, and

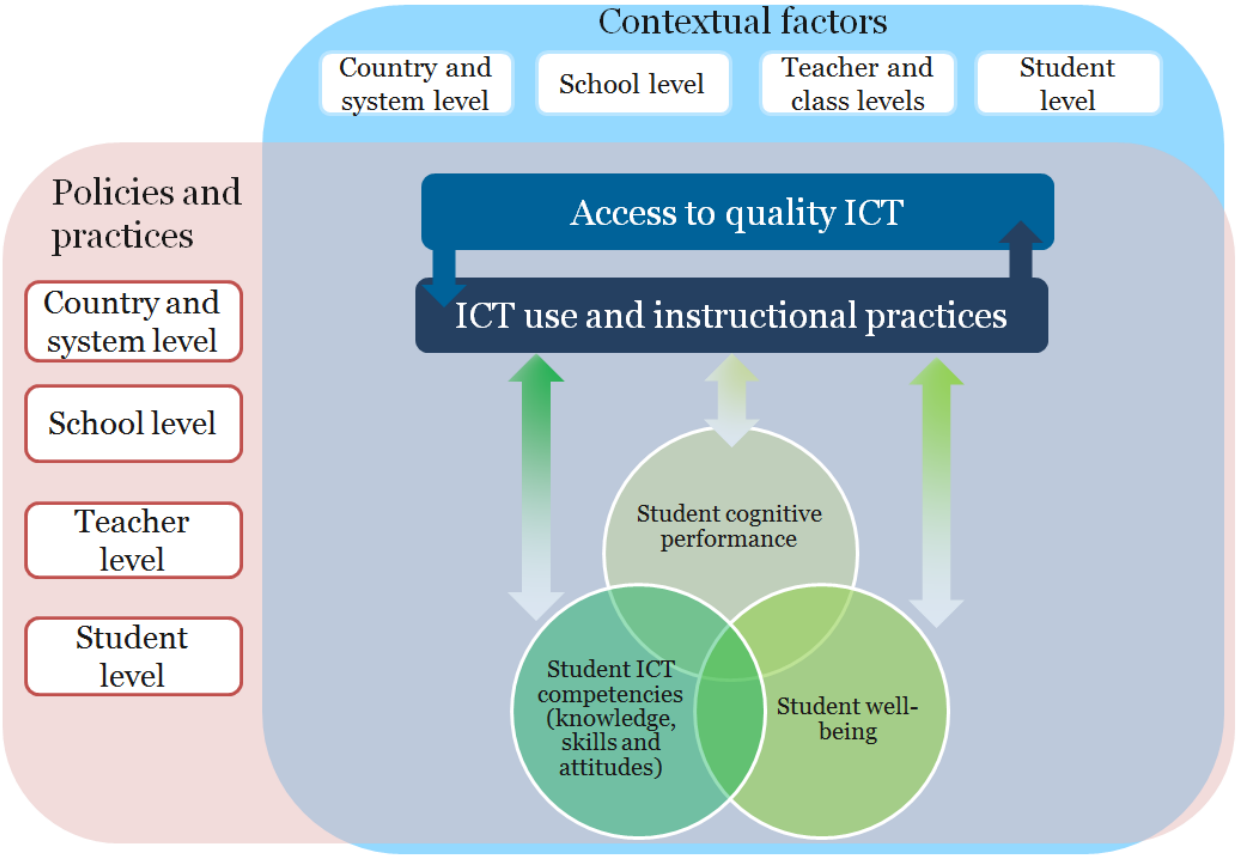
[1] The framework distinguishes between student use of ICT resources during classroom lessons (and therefore under the supervision of at least one teacher) and ICT use outside of the classroom, which includes ICT use at home and ICT use outside of class but not at home (whether in a school computer lab, a library, or at any other location except home). For the sake of simplicity, ICT use subsumes all of the above situations in the remainder of this text, unless otherwise noted.

on existing policies and practices related to ICTs. Figure 3.1 provides an overview of the underlying logic used to elaborate the PISA 2021 ICT framework.

Students' use of ICT resources is conditional upon the availability, accessibility and quality of those resources. Similarly, the amount and type of ICT resources made available to students and teachers depends on their use. Therefore, the framework documents whether human and physical ICT resources are available and are of sufficient quality; but most important it sheds light on how ICTs are used by students and teachers.

The framework also acknowledges the influence of contextual factors, policies and practices on both access to and use of ICT resources, and on students' outcomes. Contextual factors include the general background characteristics of the education system, schools and students' households. In addition, specific ICT-related policies and practices could directly influence access to and use of ICT resources. Such policies include, for example, the availability of specific funding for ICT resources, principals' attitudes towards ICT use as an instructional tool, and guidelines and support for teachers in using ICTs in the classroom.

Figure 3.1. PISA 2021 ICT Framework



Source: OECD (2019), PISA 2021 ICT Framework.

3.2. Access to quality ICTs

Previous PISA cycles mainly documented the type of ICT resources available at home or in school. This framework broadens the focus and proposes a systematic and consistent approach to measuring 15-year-old students' access to ICT resources. Availability, accessibility and quality are documented.

- The **availability** of ICT resources documents the presence of a specific ICT resource, which can be used either in class or during students' free time.
- The **accessibility** of ICT resources describes the set of elements that characterises the ease and flexibility with which ICT resources can be accessed. Therefore, it refers to existing rules, norms, configurations and arrangements guiding access to ICT resources both in and outside of school.
- The **quality** of ICT resources is a multi-faceted concept that refers primarily to the functionality, technical capacity and capability of ICT resources. Quality measures describe the extent to which ICTs function smoothly – without flaws, delays or security issues – and are compatible with other ICT resources (hardware or software). In addition, some aspects of availability and accessibility also contribute to the definition of quality, such as the diversity of ICT resources and the quantity available per student. Moreover, dimensions such as the relevance and usability of ICT resources – notably in the context of their use by 15-year-olds for learning purposes – are also important for defining quality. These correspond to the degree to which the ICT resources are relevant to the curriculum, create interest among students who can easily work with them, and can be used for a variety of purposes under different education settings.

3.3. Using ICTs in the classroom

As pointed out in recent literature reviews, merely providing ICT resources is not enough to ensure that they are used effectively to improve students' cognitive achievements, well-being and ICT competencies (Bulman and Fairlie, 2016[8]; Escueta et al., 2017[5]). Although the positive impact of ICT use on student achievement remains subject to debate, there is a consensus that the specific purpose, context and pedagogical practices surrounding ICTs are central to their effect on students.

3.3.1. Learning with ICTs

Teachers' use of ICTs for teaching

Teachers' pedagogical practices and teaching strategies with ICTs largely determine the extent to which their use in the classroom will result in improved cognitive achievement. Research stresses the promising potential of computer-assisted learning to bolster student achievement (Roschelle et al., 2016[9]; Pane et al., 2013[10]; Karam et al., 2016[11]; Campuzano et al., 2009[12]). Thus, using ICTs for teaching and learning in the classroom does not minimise teachers' role. On the contrary, as the primary actors for implementing the curriculum and orchestrating learning activities, teachers are likely to be even more central to learning with the adoption of ICTs. Indeed, the success of using ICTs for educational purposes relies heavily on teachers' abilities to select, create and manage adequate digital resources in order to implement innovative and inclusive teaching strategies in a specific context (Redecker, Punie and European Commission. Joint Research

Centre., 2017[13]). Integrating ICTs into teaching may encourage teachers to modify their approaches to teaching itself, which, in turn, could affect students' use of ICTs for learning.

In addition to implementing pedagogical practices, teachers could also use ICTs for management purposes, such as planning teaching sessions, assessing students, and taking part in communication and collaboration activities with colleagues, parents and the students themselves.

After a preliminary period of investing time to become acquainted with new technologies, ICTs might help teachers prepare their lessons, regardless of whether ICT-based activities will be conducted during class or not. In fact, the preparation of teaching activities constitutes the most frequent ICT-based activity conducted by teachers in EU countries, with 30% to 45% of students taught by teachers who declare doing this every day, almost every day, or at least once a week (European Commission, 2013[14]).

Teachers use of ICTs for management

Teachers also spend a non-negligible amount of time communicating and co-operating with parents and students, in addition to collaborating with other teachers (OECD, 2014[15]). These activities may enhance the school climate and improve classroom environments (OECD, 2014[15]). Moreover, teachers' beliefs about the nature of teaching and learning determine their choice of which pedagogical practices to use in the classroom (OECD, 2014[15]).

Students' use of ICTs for learning in the classroom

Using ICTs in the classroom is likely to affect instructional time, the curriculum to be taught, and teaching and learning practices. These factors have been documented as important predictors of student achievement (Scherff and Piazza, 2008[16]; Schmidt and Maier, 2009[17]; OECD, 2017[18]). Analysing those relationships requires documenting the frequency and modalities of students' use of ICTs in addition to assessing teaching and learning strategies.

Based on this, existing PISA constructs on teaching and learning practices can be complemented with ICT-specific information. This includes data on classroom arrangements when ICTs are used, and students' opinions of teachers' ICT competencies.

- **Intensity and modalities of students' use of ICTs:** The integration of ICTs in teaching and learning can affect instructional time in many ways. Teaching with ICTs takes more time as it often requires changing the classroom layout and may require frequently altering pedagogical practices (Trucano, 2005[19]). Moreover, when using certain ICT tools, students' attention could be drawn away from learning; they might be tempted to use the ICT resources for leisure activities (e.g. games, browsing the Internet, social media, etc.). Yet ICT-assisted instruction may also increase the overall time students spend learning. Therefore, it is important to document not only how frequently students use ICT for learning, but also the modalities: length of time they use ICTs in each class, whether they use them continuously or recurrently, in which classes, whether they bring their own devices or not, whether they have to change rooms and other classroom dynamics regarding ICT use.

- **Learning experiences with ICTs**:
  - The PISA student questionnaire highlighted different dimensions in assessing instructional quality: structure and classroom management, teacher support and student learning practices (OECD, 2017[20]). Each of these dimensions was found to be correlated with students' cognitive achievements (OECD, 2017[20]; OECD, 2013[21]). Each can also be altered significantly by integrating ICTs in the classroom (although probably not all to the same extent).
  - Several features of ICT can affect the way teachers provide feedback to students, personalise instruction, develop collaborative projects and rely on group-work assignments. Indeed, findings from previous PISA cycles show that "students using ICT in mathematics class" are more likely to describe their teachers as frequently using structuring practices (e.g. setting clear goals, asking questions to verify understanding), student-oriented practices (e.g. giving different work to students who have difficulties or who can advance faster, having students work in small groups), formative assessments (e.g. giving feedback on strengths and weaknesses), and cognitive activation (e.g. proposing exercises that require students to apply what they have learned to new contexts and/or proposing exercises that can be solved in different ways) (OECD, 2016[22]).
  - Although students' ICT use in school is positively correlated with effective instructional strategies in PISA, it is not clear how students use ICTs for learning and, in particular, whether ICTs are used in ways that are related to quality instruction. Detailed documentation of whether and how frequently the instructional processes described above actually involve ICT would help fill this knowledge gap.

Enabling environments for teaching and learning with ICTs

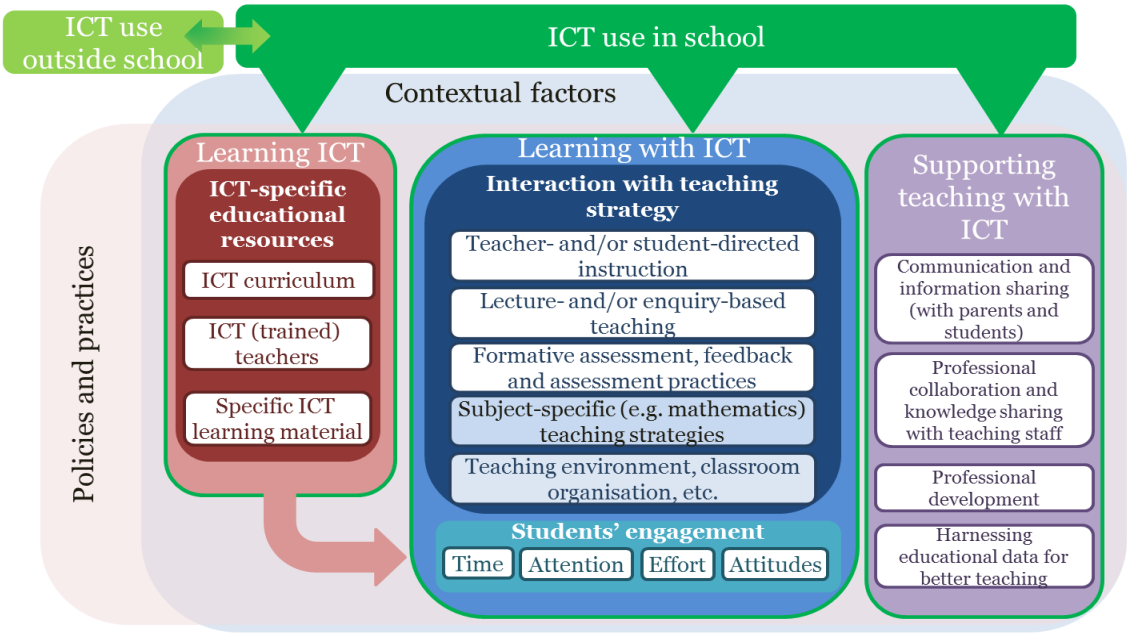
Teachers' capacity to use ICT resources for teaching and learning depends on several contextual factors and practices, which could be referred to as the enabling environment for ICT use in school. In addition to the availability and quality of ICT resources (described in the previous section), enabling factors include contextual information on students' background, school-level policies and practices regarding the governance of ICT use for learning (notably incentives and support for teachers), and teachers' attitudes towards and competencies in using ICT for teaching. The enabling environment partly determines whether and how teachers use ICT resources in the classroom. The adequacy of that environment can be assessed by asking teachers to report the extent to which these factors aid or impede ICT use for learning.

3.3.2. ICT-related practices and policies at the school level

Although numerous aspects related to ICT use in school are decided at the national level, schools often retain some leeway in organising the integration of ICTs into teaching. Schools, for instance, often define the policies related to the use of ICTs within school to support teaching and learning. They also play a role in determining how ICTs are used for communication and for sharing information with teachers, parents and students and in implementing assessments. Schools also play a role in defining the type of incentives given to teachers to encourage them to adopt ICTs in their practices.

School principals' and teachers' attitudes also play an important role in enabling the integration of ICTs into school as these influence their general level of engagement. Indeed, in the OECD Teaching and Learning International Survey (TALIS), teachers identify "teaching with ICT" and "using new technologies in the workplace" as the second and third most important professional development needs (OECD, 2014[15]).

Figure 3.2. Detailing ICT use in school



Source: OECD (2019), PISA 2021 ICT Framework.

3.4. ICT use outside of the classroom

Over the past decade, the number of 15-year-olds with access to the Internet has grown (OECD, 2015[6]). The amount of time spent on the Internet outside school also increased by 40 minutes between 2012 and 2015 to reach two and a half hours (OECD, 2017[18]). Consequently, policy makers are expressing greater interest in understanding how students engage with ICTs outside of the classroom and how their use of ICTs is affecting their well-being, cognitive outcomes and acquisition of ICT skills. One of the important advantages of integrating ICTs into the education system is bridging the divide between school and home, and allowing for more continuity between the two.

3.4.1. ICT use for learning

Since teaching and learning is not limited to formal instruction in the classroom, the PISA 2021 questionnaire framework considers students' after-school opportunities to learn as an integral part of education (OECD, 2018[23]). ICTs can be a catalyst for learning outside the classroom, notably through their potential effect on students' engagement with learning activities and by providing a powerful tracking and monitoring tool for teachers and parents.

In addition, the development of a wealth of digital learning resources, providing students with more and better learning opportunities, such as educational games, Massive Online

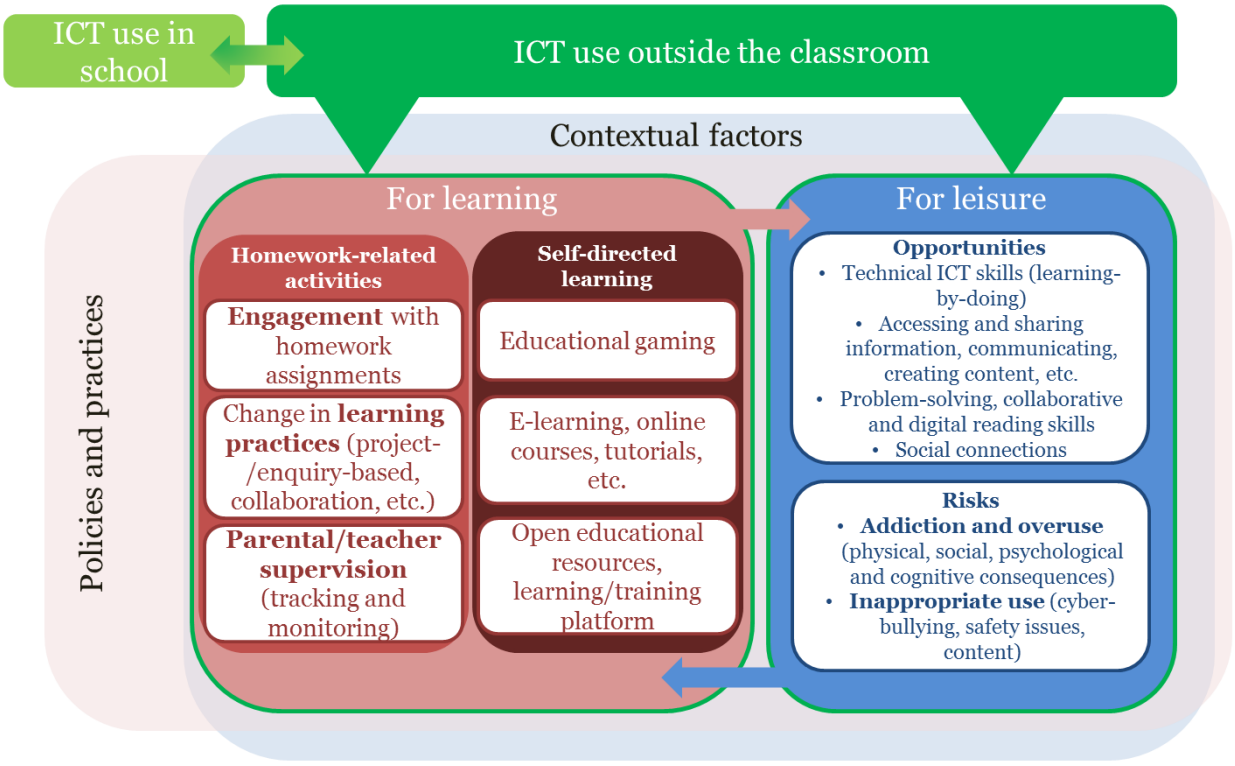
Open Courses (MOOCs), and a variety of topic-specific media content, such as video and audio podcasts, tutorials, etc., may spark students' interest in using ICTs for learning outside the classroom.

3.4.2. ICT use for leisure

Most of the time students spend using ICTs outside the classroom is dedicated to leisure activities. The extent to which ICT use for leisure is potentially related to students' cognitive performance, ICT skills and well-being depends on the frequency, the diversity and the type of activities students engage in (van Deursen and Helsper, 2015[24]). ICT use for leisure provides an opportunity for students to acquire ICT knowledge and skills but could also be a source of distraction.

As mentioned earlier, students' use of ICT for leisure also involves risks, and is a source of concern among parents and policy makers (Hooft Graafland, 2018[2]). Inappropriate or unsafe Internet use can expose students to harmful content or to cyber-bullying. Students also face an enormous amount of information online that might help them develop online reading skills, but can also have adverse effects if the students are not able to distinguish fact from fake news and verify their sources. Additional risks, such as overuse of video games and compulsive use of social media, can have serious physical, social, psychological and cognitive consequences (OECD, 2017[18]; Smith et al., 2008[25]; Currie et al., 2012[26]).

Figure 3.3. ICT use outside of the classroom



Source: OECD (2019), PISA 2021 ICT Framework.

3.5. Digital competencies: Attitudes and dispositions

The PISA 2021 ICT framework aims to assess the relationship between students' access to and use of ICTs and three distinct outcomes: students' cognitive achievement, students' well-being and students' competencies in ICTs. These three outcomes are defined based on the PISA frameworks on cognitive achievement in mathematics, science and reading, as well as student well-being. Moreover, students' ICT competencies are defined in a broad sense to encompass digital literacy as a specific domain as well as students' attitudes and dispositions towards ICT use in various contexts. While proposing a fully-fledged assessment framework for digital (or ICT) literacy is beyond the scope of this work, a roadmap for such an assessment is suggested.

3.5.1. Students' cognitive achievement and well-being

PISA's approach to measuring students' cognitive achievement consists "in assessing not only whether students can reproduce knowledge, but also whether they can extrapolate from what they have learned and apply their knowledge in new situations. It emphasises the mastery of processes, the understanding of concepts, and the ability to function in various types of situations" (OECD, 2017[20]). Thus, rather than assessing mathematics, science and reading *per se*, PISA aims to document mathematics literacy, science literacy and reading literacy, where literacy refers to students' capacity to apply knowledge and skills in key subjects, and to analyse, reason and communicate effectively as they identify, interpret and solve problems in a variety of situations (OECD, 2017[20]).

Adolescents' well-being can be defined as the quality of students' lives and their standards of living. Well-being is a multi-dimensional construct with both objective, material components and subjective, psychological facets. The PISA 2018 framework for the assessment of well-being integrates these different perspectives. In addition to students' overall perceived quality of life or life satisfaction, the well-being framework covers three other dimensions, each of which incorporates both objective and subjective components: self-related well-being, well-being in school environments, and well-being outside of school environments (OECD, 2016[22]).

3.5.2. Students' digital literacy

The growing importance of students' ICT literacy is reflected in the frequent inclusion of a variety of ICT competencies in curricula (European Commission, 2013[14]). As measures of ICT competencies become more widely recognised, education systems are shifting from teaching ICT skills in isolation towards a more horizontal approach, integrating specific ICT tasks and competencies across subjects (European Commission, 2013[14]). This highlights the crosscutting and complex nature of ICTs, which are often used as a tool to support instruction, but are also recognised as a subject of learning in themselves.

Although the PISA 2021 ICT framework does not provide a full-fledged assessment of ICT competencies, it proposes the foundations for integrating ICT literacy as a specific domain in future PISA cycles. It relies on existing assessments of ICT literacy to identify the main methodological challenges and key competency areas that should guide the development of such an assessment.

The feasibility study for the PISA ICT literacy assessment defines ICT literacy as "the interest, attitude and ability of individuals to appropriately use digital technology and communication tools to access, manage, integrate and evaluate information, construct new knowledge and communicate with others in order to participate effectively in society"

(Lennon et al., 2003[27]). This definition shares many similarities with the approach developed in other ICT literacy assessment framework, such as the International Computer and Information Literacy Study (ICILS) and Australian Curriculum, Assessment and Reporting Authority (ACARA) ICT Literacy, among others (Fraillon, Schulz and Ainley, 2013[28]; Fraillon et al., 2015[29]).

A comprehensive approach to assessing ICT competencies should focus on five main competency areas (Redecker, Punie and European Commission. Joint Research Centre., 2017[13]; Fraillon, Schulz and Ainley, 2013[28]; Fraillon et al., 2015[29]):

- accessing, evaluating and managing information and data
- sharing information and communicating
- transforming and creating digital content
- individual and collaborative problem solving in a digital context and computational thinking
- appropriate use of ICTs, which embeds knowledge and skills related to security, safety and risk awareness

Competency area 1: Accessing, evaluating and managing information and data

Accessing information and data focuses on the extent to which individuals can identify the desired information, data or digital content, and understand how to find and recover computer-based information from various sources by using ICTs (ACARA, 2014[30]; Fraillon et al., 2015[29]). Evaluating information and data is an integral step in accessing information and even more so with the development of search engines and artificial intelligence. This involves the process of filtering through multiple information sources, and assessing their relevance, integrity and usefulness (Fraillon, Schulz and Ainley, 2013[28]; ACARA, 2014[30]).

Managing information and data refers to the ability to organise and store various types of digital information (ACARA, 2014[30]). It involves the ability to adopt and develop systems for organising and classifying information in such a way that the information can be retrieved and reused efficiently (Fraillon, Schulz and Ainley, 2013[28]).

Competency area 2: Sharing information and communicating

Sharing information and communicating refers to one's ability to exchange information, share knowledge, and customise such communication for a specific audience, context and medium (Fraillon, Schulz and Ainley, 2013[28]; ACARA, 2014[30]). This includes detailed knowledge regarding the real and digital contexts in which information is shared and thus requires awareness about ICT-based communication platforms, including e-mail, instant messaging and group chat, media sharing and social-networking websites, among others. Given the wide range of ICTs for communication, those who want to communicate effectively with ICTs need to understand information-based social conventions and be able to adapt and modify selected modes of communication depending on the intended recipients.

Competency area 3: Transforming and creating information and digital content

Transforming and creating information involves the use of ICTs and ICT-based data, digital content and information to develop new information or knowledge. Successful individuals

can take existing information and derive new understandings by adapting, applying, designing, inventing or authoring (Fraillon, Schulz and Ainley, 2013[28]). Individuals may transform information with ICTs, either to produce or expand upon existing information, by modifying its presentation for improved understanding in specific contexts. This process often requires the ability to use ICT-based formatting, graphics and multimedia to simplify and enhance the communication of information. Information transformation and creation are also related to the quality of information, specifically with regards to how structure, layout and design are used to support overall comprehension.

Competency area 4: Problem-solving in a digital context and computational thinking

PISA 2012 defines problem solving as individuals' capacity to engage in cognitive processing to understand and resolve problem situations where a solution is not immediately obvious. In the context of ICT literacy, the focus should be on solving technical problems, identifying technical responses and solutions, and creatively using digital technologies to solve a problem.

According to ICILS 2018, computational thinking can be defined as the "ability to identify a problem, break it down into manageable steps, work out the important details or patterns, shape possible solutions and present these solutions in a way that a computer, human or both can understand" (IEA, 2017[31]). Although computational thinking and problem solving in a digital environment strongly overlap and share many thought processes, one key difference can be that computational thinking focuses on how to rely on digital and computing possibilities to solve problems.

Competency area 5: Appropriate use of ICTs (online security, safety and risk awareness and skills)

Online safety and security issues incorporate the appropriate use of ICTs across multiple contexts and platforms. Using ICTs appropriately requires making critical and thorough assessments of ICTs use while considering the social, legal and ethical issues in different settings (Fraillon et al., 2015[29]). With increased information sharing, students must be aware of methods for handling and protecting information.

3.5.3. Students' attitudes and dispositions towards ICTs

The assessment of students' and potentially parents' ICT-related attitudes and dispositions rely extensively on existing measures developed for previous PISA cycles. More precisely, it follows the PISA 2021 taxonomy, which revolves around six dimensions: i) attitudes; ii) values and beliefs; iii) task performance; iv) emotional regulation; v) collaboration; vi) and open-mindedness and engagement with others (OECD, 2018[23]).

Although all dimensions listed above are not equally relevant to ICT use, they are related to ICT literacy in two different ways. First, students' attitudes, behaviours, beliefs and aspirations related to ICTs are likely to be correlated with ICT literacy and students' ability to use ICTs for learning and leisure. This suggests exploring how students feel or behave when using ICTs in general, but also when using ICTs in specific contexts, including learning and leisure.

Second, the use of ICTs for teaching and learning can alter students' attitudes and dispositions towards learning in general or for a specific subject. This is often one of the

reasons why ICTs are used for learning. These two relationships between students' ICT use and dispositions are investigated in the following ways:

Self-efficacy refers to students' beliefs regarding their ability to execute a specific task or to achieve a given goal. Research suggests that higher levels of ICT self-efficacy are associated with higher levels of learning outcomes (Fraillon et al., 2014[4]). In the absence of a proper assessment of ICT competencies, self-efficacy constitutes the primary source of information about students' ICT skills. It would therefore be of great value to ask students to evaluate their own abilities based on a set of tasks and situations that reflect the five competency areas mentioned above.

Interest, enjoyment and intrinsic motivation in a particular subject are in general positively associated with learners' achievements in that subject. Results from the International Computer and Information Literacy Study (ICILS) 2013 suggest similar conclusions for ICTs. In parallel, research suggests that ICT use in the classroom can also affect students' motivation and interest in learning a specific subject (Lajoie and Azevedo, 2006[32]).

Emotional regulation and task performance cover aspects of students' emotions and emotional control (i.e. their capacity to curb anxiety, handle stress, develop and maintain positive expectations, etc.), and aspects related to students' diligence and commitment, including setting high standards, working hard and avoiding distractions (OECD, forthcoming[7]). Knowing whether students are anxious or stressed when using ICTs, and whether they are committed to understanding how to conduct specific tasks with ICTs in different contexts would provide insights into their abilities to use ICTs, particularly for learning purposes.

In addition, emotional-regulation and task-performance items could be constructed with the intention to document students' risky behaviours with ICTs. Notably, aspects related to students' self-control, dependence and abilities to regulate their engagement in specific ICT activities (including addiction and overuse of ICTs).

Collaboration, open-mindedness and students' engagement with others cover students' approaches to connecting with other people and the perceived value of those connections; openness to new experiences, perspectives and eagerness to learn and experience; and enjoyment of social connections and assertiveness in voicing their own views (OECD, 2018[23]).

Metacognition refers to students' knowledge of learning strategies for a specific subject. For example, metacognition in reading refers to students' awareness and ability to use a variety of appropriate strategies when processing texts in a goal-oriented manner (OECD, 2009[33]). Metacognitive reading strategies have been positively associated with students' reading proficiency (Waters and Schneider, 2010[34]; OECD, 2017[20]). When ICTs serve as a means to learn reading, science or mathematics, students are exposed to new learning strategies and practices. Thus, it seems important to document students' awareness about the effectiveness of ICT-based learning techniques.

4. Upgrading the ICT questionnaire items for PISA 2021

The development of the ICT framework serves as a basis for a thorough revision of the scope and focus of ICT-related questions for PISA 2021. The lessons drawn from the analysis of previous PISA cycles (Section 2), and from an extensive review of the academic literature, and policy reports and surveys on ICTs in education, guided the selection of key policy issues to document in PISA 2021. Under the guidance of the ICT expert group, this revision process was perceived as an opportunity to consider the ICT-related questions with a fresh eye, with the objective of providing a new, forward-looking model for the ICT questionnaire and its future iterations.

This section details the main changes to the questionnaire and explains the reasons guiding them. The revisions concerned the three main areas of the questionnaire: access to ICTs, use of ICTs and students' self-reported proficiency in the use of ICTs.

Three major constraints affect the revision of the ICT questionnaire items. First, limited space and time is available for ICT questions in the ICT familiarity and the student, parent, teacher and school questionnaires. Administering the ICT familiarity questionnaire should not take more than 15 minutes in the field trials and no more than 10 minutes during the actual data collection. Moreover, since ICT is one among many areas to cover in the student, parent, teacher and school questionnaires it is only possible to include a limited number of ICT-related items in these questionnaires. Second, the ICT familiarity questionnaire should maintain a certain degree of continuity over time, particularly to show trends on key measures; at the same time it should give priority to new developments affecting the use and spread of ICTs in education. Therefore, the relevance of a question was the main criterion in the decision to keep or drop an item and was given precedence over the opportunity to preserve trends. Third, the questionnaire should remain relevant to a large number of countries and economies with various ICT experiences and environments.

Engaging in an in-depth revision of ICT items for PISA 2021 provided useful lessons that can guide the development of ICT questions for future cycles. A structural challenge for the development of the ICT questionnaire is to keep up with a fast-changing and unpredictable digital environment. The schedule for developing new ICT questions and items is slower than ICT evolution. Therefore, the ICT familiarity questionnaire had to identify and prioritise documenting stable and long-lasting ICT constructs. The pervasiveness of ICTs in education also raises questions on the role of the ICT questionnaire in future PISA cycles. The ICT familiarity questionnaire could become a laboratory for uncovering innovative uses of ICTs for learning and teaching while mainstream aspects of ICT in education would enter the core contextual questionnaires as they become universal.

4.1. Access to ICTs

With the rapid development of new digital technologies, documenting the availability of ICT resources for students in 2021 proved challenging and required making some important changes in the approach to the ICT questionnaire. Importantly, the mere availability of digital resources was deemed insufficiently informative about the digital practices and needs of the 21st century student. Therefore, the questionnaire had to go beyond availability to put the emphasis on ICT use. Moreover, the range of ICT resources

documented in the questionnaire had to be adjusted and complementary information on the "quality of resources" was sought.

4.1.1. Availability and use to be documented simultaneously

In previous versions of the questionnaire, students were asked whether a list of ICT resources (or digital devices) is "available to them for use". The analysis of PISA data revealed that having access to ICT resources (whether at school or at home) does not necessarily imply that students actually use them (OECD, 2015[6]). Moreover, in a context of universal availability of ICTs, access to digital resources is less of a constraint for students.

As a result, the new questionnaire focuses on the frequency with which students use a set of digital resources at and outside of school while including a response option (i.e. "This resources is not available to me") to document the availability of the ICT resource. This option also has the advantage of reducing the space devoted to a full set of ICT availability questions. The cost of this change is that the new question is slightly more complex and would increase the cognitive load on students to answer the questionnaire.

4.1.2. Focus on main digital devices and educational digital resources

The scope of ICT resources investigated in the questionnaire changed in two ways: It narrowed the coverage to document only students' use of generic digital resources and gave special attention to "digital learning resources" expected to be particularly relevant to students' learning outcomes.

Instead of aiming at full coverage of a variety of ICT resources, the PISA 2021 ICT familiarity questionnaire focuses on generic digital devices and technologies. It documents the availability and use of "desktop and laptop computers", "smartphones", "the Internet", "tablet devices or e-book readers" and "video games".

This choice was guided by several considerations:

- In a context of rapid technological innovation and integration of several digital technologies into single devices, it becomes increasingly difficult to interpret the results based on how frequently students use each device or generation of technologies. For example, what does infrequent use of portable music players reveal about a student in the era of smartphone technology? Similarly, how could one interpret a student's intense use of a desktop computer when laptops are the universal option? Since the primary objective of PISA is not to report the evolution of students' use of different technologies but rather to document how ICTs are related to learning outcomes, there is little additional value in documenting students' use of specific devices compared with the general availability and frequency of use of generic ICT resources.
- Moreover, given the rapid evolution of digital technologies and practices, it is not possible to identify the digital resources that will make a significant difference years from now.
- Generating a classification of digital devices and resources is cumbersome as similar devices can be used in different ways and different devices can serve a similar purpose.

- Given the limited space available in the questionnaire, investigating students' practices with digital resources rather than how frequently they use a specific device was deemed more cost-effective.

However, the questionnaire highlights digital learning resources. Those specific resources are of special interest compared with other digital resources because they might have a strong effect on students' learning outcomes. Moreover, documenting the extent to which students engage with digital learning resources at school and at home could inform how much a country's student population relies on those new learning technologies. Therefore, the questionnaire documents three broad types of digital learning resources: "school portals", "educational software, apps and games" and "learning management systems".

4.1.3. Accessibility and quality of resources

Another consequence of the rapid technical change and expansion of ICTs is the diversification of ICTs in terms of quality. Having access to the latest generation of computers – that embed brand new technologies and allow using the latest software without slackening – improves learning possibilities far beyond what students could do with slow and outdated computers. Nowadays, the major differences between students, schools (and countries) revolve around issues of quality rather than quantity of ICT resources. In this context, quality not only refers to the technical capacities of ICTs but also include aspects such as whether the resources are fit for purpose and flexible enough to be used in various contexts. Moreover, the degree of accessibility of ICT resources at school is also important in determining how they are used to support learning (Redecker, Punie and European Commission. Joint Research Centre., 2017[13]). For example, PISA 2015 data shows that out of the 81% of students across OECD countries with access to a desktop computer at school, only 58% actually use it.

Thus, the PISA 2021 ICT familiarity questionnaire investigates the quality of students' access to ICTs at school. It does so by asking students' their opinion about different quality-related dimensions:

- *the technical capacity of ICT resources*, covering aspects such as the speed of the Internet connection, whether digital resources are connected to the Internet or function properly
- *the modality of access to ICTs*, comprising the availability of sufficient digital resources per students, but also whether the digital resources are easily available within the classroom
- *the relevance of ICTs and overall guidance on how to use them,* which documents whether the students find digital learning resources engaging, whether they have sufficient support to use ICTs and consider teachers to be motivated and skilled to use ICT resources

Adding this new question in the ICT familiarity questionnaire helps document important policy topics. It provides information on the association between the quality of ICT resources and students' learning outcomes, which could subsequently inform policy on how education authorities should invest in and select ICT resources. In particular, it could help answer the question: to what extent should authorities invest in providing average ICT resources or providing less ICT resources but of better quality? Moreover, teachers and students might also be more willing to use ICT resources for learning purposes if they meet higher quality standards.

4.2. Use of ICTs

A critical finding from the literature on ICTs and education is that increasing students' access to and use of ICTs does not generally improve their cognitive performance. There is a consensus that the potential positive effect of ICT use on learning depends on how students use ICTs. The analysis of PISA data from previous cycles is in line with these conclusions. Therefore, documenting in detail how students use ICTs, particularly for learning, constitutes the major additional contribution of the revised PISA ICT familiarity questionnaire. Two components of ICT use have been updated in the questionnaire: the intensity of use in different places and for different purposes, and the modality of ICT use for supporting teaching activities.

4.2.1. Intensity and frequency of use in different contexts

An important lesson from PISA 2015 is that students spend an increasing amount of time using ICTs. While most students already have access to ICTs, one can expect the intensity of ICT use to keep increasing in the coming years. As such, it is very important to track the evolution of ICT use across countries and ensure that the trend is carefully monitored over PISA cycles.

Yet, the previous measurement of the time spent online or using digital resources suffered from an important drawback. Although the latest versions of the ICT questionnaire documented the intensity of ICT use for different tasks, it did not distinguish systematically between ICT use for learning or for leisure. Students' constant access to the Internet requires making this distinction in order to capture students' ICT use in more detail. Indeed, in some countries students are increasingly using ICT resources during class for leisure. The two types of ICT use in class might have opposite effects on learning outcomes and could explain the unclear connection between ICT use and students' performance.

Thus, the new ICT questionnaire was developed in several ways to account for the evolution of ICT practices:

- With the increasing amount of time students spend using digital resources, new categories of ICT use were added to the response scale in order to accurately capture higher levels of ICT use.
- The coverage of the time students spend using digital resources now distinguishes between ICT use for learning and leisure activities at school, before and after school and on weekends.[2] This allows for tracking how long students use ICT resources in total and therefore maintains a trend with previous PISA cycles while distinguishing between the different types of use. This question is included in the student main questionnaire rather than the ICT familiarity questionnaire. The former covers all participating countries and economies.
- The previous version of the ICT questionnaire documented in detail how frequently and how long students used digital resources in different subjects. The updated version of the questionnaire focuses only on the frequency of ICT use in the subjects assessed in PISA (i.e. mathematics, science and reading). While this

[2] Note that the questionnaire does not distinguish between the use of digital resources at school during class and after class as it might be too cumbersome for students to recall this information. Yet, this distinction could be of importance if students' use of ICT for leisure during class is particularly detrimental to learning.

version provides less information on the time students spend using ICTs in different courses, it still documents the relationship between ICT use in a specific subject and performance in that subject.

4.2.2. Detailed coverage of learning activities with ICTs

As mentioned above, PISA data reveal an ambiguous bell-shaped relationship between ICT use and students' cognitive performance. Students' performance in mathematics, science and reading is the highest when students use ICTs moderately (everything else held equal). The results hold for both ICT use at school and outside of school. One of the main objectives for the revision of the PISA ICT familiarity questionnaire is to disentangle these puzzling results. To do so, the selected approach will cover in detail how students use ICT resources in relation to specific teaching practices.

Previous versions of the ICT familiarity questionnaire documented various types of ICT tasks related to different learning contexts, such as "chatting on line", "using e-mail", "browsing the Internet for schoolwork" and "practicing and drilling". The revised questionnaire takes a different route and focuses on the support function of ICTs in learning. ICTs have a great potential for widening learning possibilities, by enabling enquiry-based learning, providing more autonomy to students and facilitating group work, formative assessment, and feedback and communication between students and teachers. Thus, the revised questionnaire investigates whether students use ICTs in association with specific teaching practices, including teacher-directed, student-centered and enquiry-based teaching, and for teacher feedback. This approach has the advantage of linking ICT-related practices to teaching strategies documented in the student and teacher questionnaires.

Students are asked how frequently they use ICTs while engaging with particular teaching practices. The question on students' use of digital resources for teacher-directed activities focuses on mathematics (the core subject in PISA 2021) and is included in the core student questionnaire. It includes activities such as using digital resources to "solve equations", "draw geometric figures or functions", "read an explanation of mathematical concepts" and "coding". The ICT familiarity questionnaire investigates classroom activities related to enquiry-based teaching, receipt of teacher feedback, formative assessment and school-related activities after class. Enquiry-based teaching activities include items such as "create a multi-media presentation", "write or edit text for a school assignment", and "analyse data that you have collected yourself". The activities do not specifically refer to mathematics lessons and can be relevant to science and reading.

Another question documents modalities of teacher feedback. It provides information on whether the students "read or listen to feedback sent by teachers, by other students or automatically selected by a learning app" and whether students "revise their work based on feedback" or "work on practice exercises using educational software". The ICT familiarity questionnaire documents another potentially important contribution of ICTs to education: the capacity to enhance out-of-school learning in effective and innovative ways. Hence, the questionnaire examines how frequently students "browse the Internet for schoolwork", "receive or download assignments or instructions from their teachers" and "communicate with their teachers".

Most of the time students spent using digital resources outside of school is dedicated to leisure activities (OECD, 2017[18]). Using ICTs for leisure can also contribute to learning. For example, social media provides students with opportunities to develop reading and comprehension skills, and certain video games might encourage collaborative problem solving. Frequent users of digital technologies may also become more efficient in using

digital resources for learning purposes. However, excessive engagement in certain activities might deter students from doing their homework or engaging in activities of higher learning value. Therefore, the questionnaire examines how much time students spend doing various digital activities ranging from playing video games, to browsing social networks or looking for practical information online, for example, both during a weekday and on a weekend day.

4.3. Attitudes and disposition towards ICTs

Most PISA-participating countries and economies are increasingly concerned with developing students' digital competencies so they will be able to thrive in the knowledge economy. Indeed, most education systems include ICT or digital literacy in their national curriculum, either as a stand-alone discipline or integrated within other subjects (Conrads et al., 2017[3]). A successful 21st century student should be able to use ICTs to research, manage, analyse and communicate information online, understand how to solve problems and adopt new ICTs as they arise while ensuring that they use ICT resources safely. Moreover, students should be able to shift between digital platforms and combine different ICT tools to achieve their objectives. Previous versions of the ICT familiarity questionnaire included basic questions about students' attitudes, dispositions and self-efficacy in the use of ICTs. The new ICT questionnaire develops questions on self-efficacy in order to reflect the diversity of digital competencies identified in the ICT framework. Moreover, it investigates students' opinions about school rules for ICT use, their attitudes towards the accuracy of information online, their experience with inappropriate digital content and their general interest in acquiring ICT skills.

4.3.1. Students' opinion about ICT use for learning

ICTs bring great learning opportunities to the classroom but also entail some risks. In particular, students' constant connection to the Internet and to social media via their smartphones can interfere with their learning activities. When working with ICTs, students might divert ICT resources from their initial learning purposes to either play, communicate via social media or simply browse the Internet. They can also use their smartphones to communicate at any time during class hours, thus creating noise and disorder. Since distraction caused by ICT use during lessons is becoming an increasing concern, the ICT questionnaire included a question on students' opinions about school rules regarding ICT use. The question provides information about the degree of autonomy students have when using digital resources in class. For example, it asks students whether they should be allowed to bring their mobile phones or laptops to class, whether the school should set up filters on the Internet, and whether teachers and students should jointly decide on the rules for using ICTs. Moreover, two items on the potential effects of ICT use have been included in the classroom-climate question in the main student questionnaire.

4.3.2. Students' exposure and response to ICT risks

Facing safety issues when using ICTs is an inevitable by-product of the increased exposure to digital resources (Hooft Graafland, 2018[2]). The more time students spend online, the more likely they are to encounter inappropriate digital content (i.e. violent or pornographic content), to come across discriminatory content, and to face cyber-bullying. The ICT familiarity questionnaire covers those risks and asks students whether they faced such situations and how upset they were when they did. In this way, the questionnaire will

provide information on the frequency of student exposure to these situations and on the emotional consequences of this exposure.

Today's students also have to deal with a plethora of information coming from different sources. Being able to assess the quality and accuracy of the different types of information is one of the core digital competencies students should acquire. In order to address this question, the ICT questionnaire examines how much students trust the information available online, whether they have opportunities to discuss its accuracy, and how they react when they encounter false or inaccurate information.

4.3.3. Students' interest in ICTs and ICT self-efficacy

Ensuring that students possess an adequate set of digital skills has become an important objective of education systems; yet, there are only few sources of information on the actual performance of students in terms of ICT or digital literacy. The International Computer and Information Literacy Study (ICILS) of the International Association for the Evaluation of Educational Achievement (IEA) and ACARA's ICT literacy assessment are among the few nationally representative tests that rely on a well-defined assessment framework. The DigComp.2.1 digital competency framework identified a set of digital competencies. The PISA 2021 approach draws on this framework and proposes a self-efficacy assessment of students' digital competencies that encompasses a broad range of skills.

The self-efficacy questions included in the 2015 and 2018 versions of the questionnaire were general in scope. They documented students' overall confidence, independence, interest and collaboration when using, helping relatives or learning about digital devices. While these questions can be positively correlated with students' digital abilities, they mainly reflect their technical digital skills. The questionnaire items document whether students feel comfortable "using digital devices", "solving a problem with a digital device", "installing a software" and "selecting an application".

Several components of digital competencies omitted in previous versions of the questionnaire are now accounted for. The self-efficacy questions document students' ability to perform a variety of tasks that refer to the competency areas identified in the ICT framework. Students' self-reported ability to "search and find relevant information on line" and to "assess the quality of information" is document competency area 1 (i.e. accessing, evaluating and managing information and data). Competency area 2 corresponds to the ability to share information and communicate, and is documented by students' perception of their ability to "use digital resources to share practical information with a group of students", "use digital resources to collaborate with other students on a group assignment" and "explain to other students how to share digital content on line or on a school platform". Competency area 3 corresponds to students' ability to transform and create information and digital content, and assesses students' capacity to "edit digital photos or images", "write or edit text for a school assignment", "collect and record data", "create a multimedia presentation" and "create, update and maintain a webpage". Students' self-efficacy in problem-solving in a digital context and computational thinking (i.e. competency area 4) is documented through students' ability to "change the settings of a digital device to improve the way it operates", "select the most efficient program or app to carry out a specific task" and "create a computer program". Finally, students' ability to use digital resources appropriately (i.e. aware of online safety and security risks) is assessed by their ability to "change the settings of a device or app in order to protect their data and privacy" and by the question on their attitudes towards information quality descried in the previous sub-section.

Defining relevant items for all aspects related to digital problem solving and computational thinking proved to be challenging. A self-efficacy assessment requires simple but well-defined tasks that would make sense to all students, regardless of their engagement with complex digital tasks. Yet, computational thinking abilities are usually assessed in a context and by a succession of activities. Thus, these aspects of digital competencies are not well-reflected in the self-efficacy questions. Another important challenge when defining a self-efficacy measure is to ensure that it is associated with students' actual digital literacy. Previous studies suggest that such measures might not be correlated with students' ICT skills (Fraillon et al., 2014[4]). The coverage of a relatively broad range of digital competencies should reduce this risk. Moreover, a large number of items will be tested during the field trials, and will eventually lead to the selection of the most relevant ones.

5. Lessons for the future development of ICT questions in PISA

Findings from the analysis of ICT questions in previous PISA cycles, together with a thorough review of the literature on the subject and the inputs from the expert group, guided the development of the PISA ICT framework and subsequently the revision of the ICT questions for PISA 2021. Overall, the new updated ICT questions are more reflective of current digital practices and concerns. In particular, the PISA 2021 ICT familiarity questionnaire accounts for the fact that access to ICTs is now almost universal, and therefore the questions of interest for policy making revolve around issues of quality of ICT resources and students' use of those resources. The questionnaire also examines the possible negative side effects of ICT use, students' attitudes towards the accuracy of online content and online risks, and their opinions about their own digital skills.

This in-depth revision process revealed opportunities and challenges regarding the future development of ICT questions in PISA. In terms of opportunities, some of the important dimensions identified in the PISA ICT framework are not covered extensively due to constraints related to questionnaire length. For example, the selection and quality of digital learning resources, the role of parents and teachers, and a full test-based assessment of digital competencies might deserve more thorough coverage in future questionnaires. Upgrading ICT items also unveiled significant challenges for documenting ICTs in the context of PISA. The challenges include the rapid, unequal and irreversible expansion of ICTs, the international nature of PISA, the long time needed to prepare for a cycle of data collection and the difficulty to cover countries in different stages of ICT development.

The set of ICT questions selected for the PISA 2021 field trials does not cover all relevant aspects of ICT in education and would need to be revised in the future to cover new developments in the field. With the expansion of ICTs, access becomes less important and the quality of resources takes central stage. In particular, future questionnaire items should assess the quality of ICT resources and how they were chosen by schools and teachers. A comprehensive assessment should examine the suitability of the digital resources for learning, that is, whether they are adequate for diverse education settings and are fit for purpose. For example, the Norwegian Centre for ICT in Education assesses the quality of digital resources for education along three dimensions: the quality of the interface between users and the resources (e.g. the digital resources should generate interest and be accessible and inclusive); the possibilities and limitations of the digital resources (e.g. adaptability to different contexts); and the education and evaluation potential (e.g. relevant for the curriculum, enable relevant evaluation, suitable to different education contexts) (Norwegian Center for ICT in Education, n.d.[35]).

Regarding ICT use, the modalities surrounding the use of digital resources for learning at school could be further examined. For example, it would be interesting to understand exactly how students use ICT resources during class. Do they use ICT resources many times in a single lesson for various purposes at different times or do they have an entire class during which they practice on digital devices? To what degree are students independent when using digital resources? Do they follow the teachers' instructions? Do they have to solve problems by themselves, or in groups?

The PISA ICT framework highlights how ICTs can support teaching activities by enabling parents and teachers to monitor students' work both at and outside of school. There is a great potential for ICTs to contribute to enhancing students' engagement with their home

assignments and ensuring continuity between school and home learning activities. These types of practices could be investigated in more detail in future ICT questions as they are likely to become very common in the near future. The role of parents in shaping their children's ICT practices is also important and is not investigated in detail in the questionnaire. Moreover, ICT co-ordinators might play an increasingly important role in schools by selecting and maintaining ICT equipment and by providing support and training to teachers. Future questionnaires should reflect these organisational changes.

The increased use of digital learning tools is likely to trigger another phenomenon that could affect education in the future: the harnessing of education data to enhance teaching. Although collecting data on students raises ethical and security concerns, it is not surprising that in the near future some education systems might decide to equip schools with educational software to better track their students' strengths and weaknesses.

An increasingly important concern for policy makers is students' digital literacy. Developing a proper assessment of students' digital skills beyond self-efficacy could be very valuable. Yet, as digital competencies become increasingly essential, developing an optional assessment tool for one PISA cycle may not be the best option. Instead, digital competencies could be tested as part of the mathematics, science and reading assessments. Indeed, many components of digital literacy are similar to reading, science and mathematics literacy in a digital environment. The assessment of digital reading in PISA 2012 is a good example. Moreover, computational thinking involves processes that are very close to problem solving and collaborative problem solving assessed in PISA. Therefore, the suggested approach consists in developing test items within the assessments of reading, science and mathematics that would cover digital literacy. This approach coincides well with PISA's definition of skills, which are more about practical knowledge in real-life contexts.

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