youth SKILLS

Children's and young people's digital skills: a systematic evidence review

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Children's and young people's digital skills: a systematic evidence review

Work Package 2 – Deliverable 2.1

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Executive summary

What do we know about children's and young people's digital skills?

Given the considerable policy and practical importance of digital skills and literacies for young people's life chances, especially as regards inequalities and digital inclusion, and the increasing reliance on digital technologies for learning, employment and civic life, a systematic evidence review was conducted to answer this question.

The review was informed by the International Telecommunication Union's (ITU) definition of digital skills: "the ability to use ICTs in ways that help individuals to achieve beneficial, high-quality outcomes in everyday life for themselves and others" and to "reduce potential harm associated with more negative aspects of digital engagement" (2018, p.23).

A preliminary rapid evidence mapping found that relatively little research was published in the early years of mass internet use (2000–09). Hence the systematic evidence review encompassed all research published between 2010 and 2020, thus representing the large majority of available studies. The search protocol, registered on PROSPERO, included studies of moderate to high quality (judged using the Weight of Evidence approach) that used quantitative methods, were published in the English language, and related directly to the digital skills of 12- to 17-year-olds.

The results of 110 studies were analysed to identify what is known about youth digital skills, and to examine the evidence for the antecedents (or factors influencing the acquisition) of digital skills, and the consequences of having digital skills. They were also scrutinised for research gaps and to generate questions and hypotheses for future investigation. In addition, they were examined for the many ways in which digital skills have been conceptualised and measured in the research literature.

Highlights from the many findings are summarised below.

How are youth digital skills conceptualised and measured?

- Both broad and narrow conceptions of "digital skills" are used in the literature, with some researchers conceiving of multiple dimensions of digital skills and others focusing on particular skills (e.g. information literacy or computer programming) as befits their topic. Moreover, the definition of digital skills is not much discussed, making it difficult for the field to come to a consensus. The plethora of definitions in use means that comparing study findings is a bit like comparing apples and oranges.
- It is important to distinguish demonstrated or claimed digital skills from digital self-efficacy. The former are revealed through performance tests or self-report surveys that ask direct and factual questions. Self-efficacy ("I am good at…" or "I am confident about…") is subject to social desirability biases, and we place less weight on such studies. We also excluded studies that infer skills from methods that measure digital uses or activities, but do not measure digital skills directly.

The studies analysed were conducted in 64 different countries, with the USA and Europe generating most of the available research. Most of the studies used self-report surveys, but a minority (almost one-third) conducted performance tests, involving some form of task-based assessment. Most performance tests were used to examine the antecedents rather than the consequences of digital skills.

Findings on the antecedents of youth digital skills are summarised below.

- There is strong evidence that children's digital skills improve with age, as expected.

- Contrary to popular belief, the evidence regarding gender differences is inconsistent. Boys appear to claim better digital skills than girls, but when performance tests are used, there are no gender differences.
- Ethnicity is examined by a handful of studies as a potential source of digital inequality, with mixed results.
- A few studies suggest that better cognitive skills are associated with better digital skills.
- The higher a child's academic achievement, the better their digital skills. Motivation also plays a role and, possibly, learning style.
- Children with positive attitudes towards information and communication technology (ICT) have higher digital skills.
- Children from higher socioeconomic status (SES) households are found to have higher digital skills in around half of the studies that examine this relationship.
- When parents practise restrictive mediation, this is linked to lower digital skills for their children, while enabling mediation is generally linked to better digital skills, although some studies found no relationship.
- When ICT is more available in schools, children's digital skills tend to be better. Also, those with earlier or broader access to ICT, including at home, have better digital skills. Most studies do not examine possible underlying causes (such as household SES).

Studies of the consequences of youth digital skills are scarcer than studies of the antecedent factors that may lead to better skills. Nonetheless, the consequences of youth digital skills were found to be as follows:

- Few studies examined whether digital skills improve wellbeing, and even fewer found that they do.
- There is clearer evidence that greater digital skills are linked to better learning outcomes for children, although again, the evidence base is small.
- Of the few studies that looked for a relationship between digital skills and youth civic engagement (offline and online), all found it to be positive.
- Children with higher levels of digital skills may be better able to protect their privacy online.
- There is evidence that better digital skills are linked to more online risk, although the evidence also suggests that the type of skills matters: critical digital skills, for instance, are not linked to online risk. Moreover, better digital skills are not linked to more harm, and may even reduce harm, possibly because children with better digital skills appear better able to cope with online risks.

Twelve studies sought to model the relation between the antecedents and consequences of youth digital skills, using statistical modelling techniques. Their findings are complex, and bear careful investigation, in crucial ways questioning the simple bivariate relationships between antecedents or consequences and digital skills. Notably, they show that:

- The association between better digital skills and more online risk is indirect, as better skills are linked to more online opportunities, and those, in turn, are linked to more risk.
- Relatedly, it seems that enabling parental mediation has only an indirect association with digital skills, through its role in facilitating online opportunities.
- Efforts to model the relations among factors to understand digital inclusion suggest that the online and offline disadvantages that girls and children with lower level education face can

be countered if efforts are made to improve their digital skills. SES and age are independently associated with outcomes, but again, improving digital stills can mitigate inequalities.

In addition to generating many specific insights that can improve the future evidence base, the review concluded with the following hypotheses and recommendations:

- As regards research methods, factual questions ("I know how to…") are preferable to self-evaluative questions ("I am good at…") because they introduce less measurement bias and help distinguish digital skills from self-efficacy. Performance tests should be preferred to self-report studies when social desirability biases are likely to be particularly strong (e.g. in relation to gender).
- Since it appears that children acquire better digital skills when they are younger and the process slows with age, future research should seek to identify when, and under what circumstances, children are more receptive to learning particular types of digital skills.
- Girls also seem to have better digital skills than boys when they are younger, and these differences disappear with age. Research could explore whether this is because girls fall behind with age, or boys catch up, or whether other factors are relevant.
- Scattered studies examine a range of personal and social factors that may influence youth digital skills, but if these are held to be important, a stronger rationale and concerted effort will be needed for clear results.
- SES matters, insofar as it tends to result in differential ICT access and use, but more research is needed on how it may continue to matter when children from different backgrounds gain similar digital access and how such inequalities can be mitigated.
- It may seem surprising that some factors relating to teachers or schools show little association with youth digital skills, and this bears further investigation.
- It is intriguing that certain online activities accorded little value by society (e.g. gaming, communication) are linked to digital skills, while digital learning activities are not consistently linked to digital skills. Clearly the process by which children and young people gain better skills needs more exploration,
- While studies suggest that digital skills can benefit children's wellbeing, more research is needed to examine this relationship, to establish more clearly which digital skills are worth promoting in relation to which desired outcomes.
- Similarly, although available studies suggest that better skills bring benefits to children's learning, participation and other outcomes, more research is needed to conclude with confidence, and to explore the factors that matter.
- The available research suggests that better skills are linked to more risk, although it also supports the view that better skills help children cope and so, reduce harm. However, the evidence base is weak, and further research is greatly needed given the importance of equipping children to cope with online risk so as to reduce harm.

Finally, we note that, while the internet is increasingly available world-wide, most research reviewed here was conducted in the Global North. In terms of future research methods, more studies should undertake statistical modelling to examine the indirect as well as the direct relations among multiple variables. Most important, although we (and the evidence base) have interpreted studies as having causal implications (differentiating the antecedents and consequences of digital skills), most of the studies reviewed use cross-sectional designs, and longitudinal research is greatly needed in the future.

ySKILLS highlights

There is substantial evidence showing that digital skills play an important role for children's and young people's learning, participation and other opportunities. The benefits apply offline and also online, potentially affecting multiple dimensions of children's lives in a digital world.

There is some evidence that better digital skills can also protect children from the online risk of harm, although the evidence is still weak and needs to be strengthened.

Not all children learn all digital skills, and the literature is inconsistent and not always clear about the nature or level of the digital skills being investigated. Crucially, however, the gaps in children's knowledge, some of which reflect structural inequalities in society, are crucial for their life outcomes.

More research is needed, particularly in relation to consequences from digital skills, causality and the relationship among different factors, and the review proposes a range of specific hypotheses to be tested in future research.

Little is known about the processes whereby children gain digital skills or how best adults (teachers, parents, others) can scaffold their learning and ensure that their digital skills do result in beneficial outcomes.

1. The ySKILLS project

The ySKILLS (Youth Skills) project is funded by the European Union's (EU) Horizon 2020 programme. It involves 15 partners from 13 countries to enhance and maximise the long-term positive impact of the information and communication technology (ICT) environment on multiple aspects of wellbeing for children and adolescents by stimulating resilience through the enhancement of digital skills. Starting from the view that children are **active agents in their own development**, ySKILLS examines how digital skills mediate the risks and opportunities related to ICT use by 12- to 17-year-olds in Europe (see www.ySKILLS.eu).

The overarching aim of ySKILLS

To enhance and maximise the long-term positive impact of the ICT environment on multiple aspects of wellbeing for all children by stimulating resilience through the enhancement of digital skills.

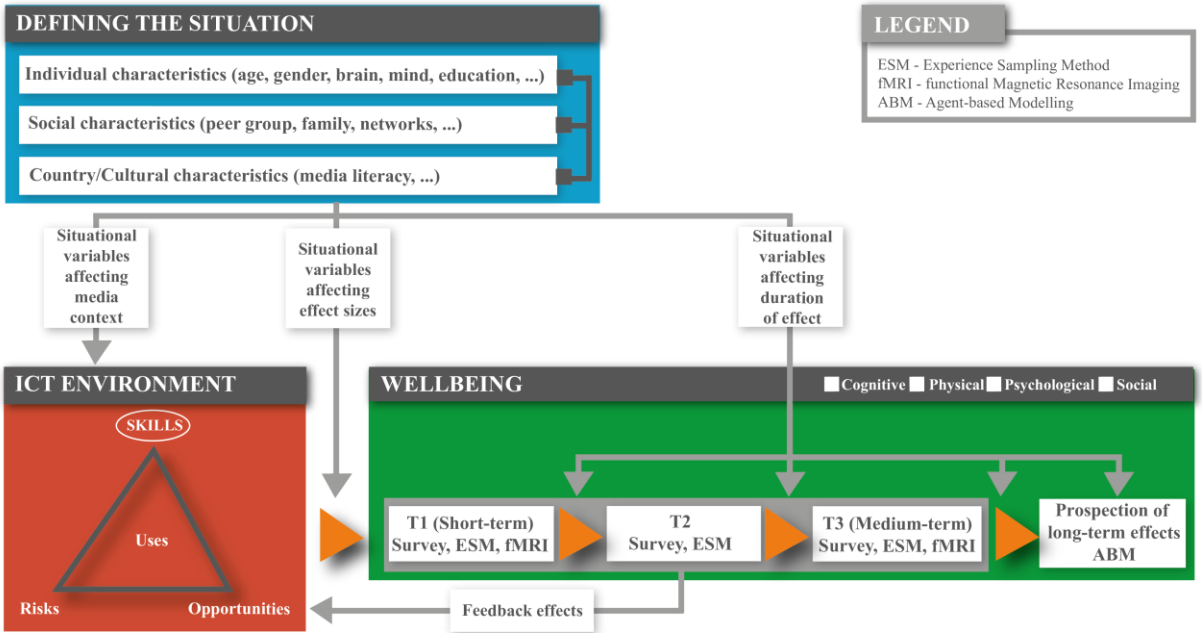
ySKILLS will i**dentify the actors and factors** that undermine or can promote **children's wellbeing** in a digital age. The relations between ICT use and wellbeing will be critically and empirically examined over time.

ySKILLS' research objectives

1. ***To acquire extensive knowledge and better measurement of digital skills.***
2. ***To develop and test an innovative, evidence-based explanatory and foresight model predicting the complex impacts of ICT use and digital skills on children's cognitive, physical, psychological and social wellbeing.***
3. ***To explain how at-risk children (as regards their mental health, ethnic or cultural origin, socioeconomic status and gender) can benefit from online opportunities despite their risk factors (material, social, psychological).***
4. ***To generate insightful evidence-based recommendations and strategies for key stakeholder groups in order to promote European children's digital skills and wellbeing.***

ySKILLS has proposed, and will continue to develop, **its conceptual model**. This review aims to contribute to the model development by exploring the evidence on the relationships between the different elements.

Figure 1. ySKILLS CONCEPTUAL MODEL



2. Task 2.1: Reviewing the research literature

In order to advance ySKILLS Objective 1 (to acquire extensive knowledge and better measurement of digital skills) and to inform the other objectives, Task 2.1 of ySKILLS was to undertake a systematic evidence review of the available research on the nature and measurement of children's and young people's digital skills, focusing on identifying their antecedents and consequences. It contributes to ySKILLS Work Package 2 (Integration of Theories and Methods Towards a New Theoretical Model), which aims to identify what is already known, and important gaps in the evidence on children's digital skills, by reviewing the relevant literature and through secondary analysis of data. Through methodological, empirical and theoretical integration, the aim is to propose a new theoretical model.[1]

The aims of this evidence review are to:

(1) Reveal evidence gaps by assessing what is known and not known about youth digital skills – that is, to identify which antecedents and consequences need to be further investigated because their hypothesised relations with digital skills have not yet been confirmed by empirical research, or have not generated consistent findings and why.

(2) Identify how youth digital skills are conceptualised and measured by the existing studies – in order to assess which conceptualisations and measurements ensure a deeper understanding of the antecedents and consequences of digital skills, thus informing new research in this area.

(3) Identify the antecedents and consequences that shape children's and adolescents' digital skills and their outcomes – in order to contribute to the design of future survey instruments and performance tests, and also to inform policy initiatives aimed at improving children's digital skills.

[1] Task 2.1 was originally planned as a systematic mapping of the evidence followed by a rapid evidence assessment of the available research on children's and young people's digital skills. However, the importance of this task in underpinning the wider ySKILLS project led to the decision to undertake a systematic mapping followed by a systematic evidence review. A systematic evidence review offers a thorough and robust analysis that encompasses and improves on a rapid evidence assessment (Grant & Booth, 2009), thereby providing a solid basis for the work of ySKILLS.

(4) Generate a series of hypotheses and priority research questions, as well as the information needed to critically review the ySKILLS conceptual model and prepare the integration of theories.

This is to be achieved through:

- **A systematic mapping of the evidence** identified and compared research by country, DESI ranking,[2] year (2000–20), research discipline, country, language and publication outlet (a proxy for research quality). This identified available research and research gaps (Aim 1) and informed the definition of inclusion criteria for the systematic evidence review. It revealed that the vast majority of research on youth digital skills has been published in the last decade. It was therefore decided to focus the systematic evidence review on research published from 2010 onwards.[3]
- **A systematic evidence review** to identify and examine the antecedents and consequences of youth digital skills, as well as the ways in which digital skills themselves have been defined and measured. Following an in-depth search, screening and analysis of the publications on youth digital skills, this generated an in-depth account of what is known and not known about youth digital skills, enabling the formulation of a series of hypotheses to be tested in future research (Aims 2–4).

This review resents our methods, results and recommendations for further research.[4]

3. The context: Researching youth digital skills

Digital skills gained the status of an established object of investigation in the field of digital inclusion/exclusion when it became obvious that digital inequalities involved more than a binary opposition between those who had access to the internet and those who did not, which was the focus of debates in what is now called the first-level digital divide. After initial hopes, it became clear that digital inequalities could not simply be bridged by providing everyone with a computer and internet connectivity.

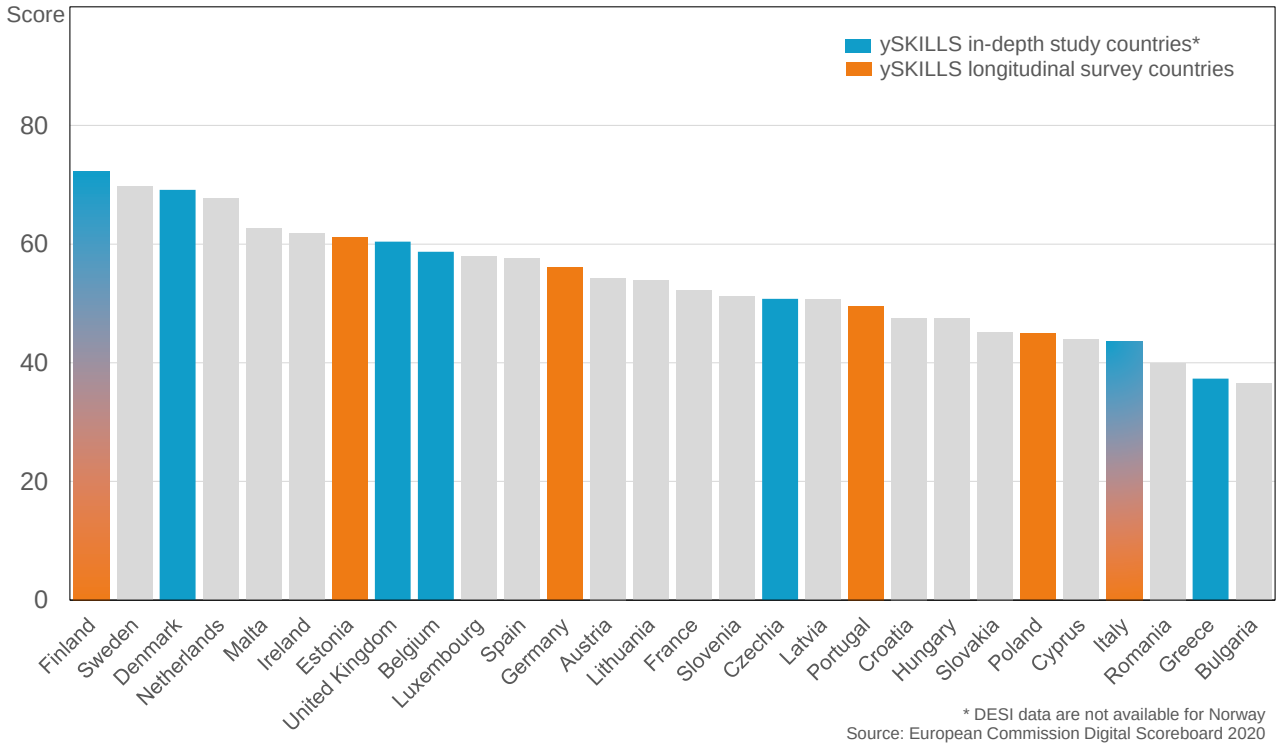
The concept of the second-level digital divide (Hargittai, 2002) was formulated to overcome the limitations of the first-level digital divide and to recognise that, even when young people in the Global North gain internet access, inequalities are likely to persist regarding young people's ability effectively to use digital technologies in ways that benefit their wellbeing. At the individual level, research has long shown that social inequalities (based on gender, age, education, income, ethnic group etc.) explain variations in how and why the internet is used. At the country level, digital inequalities persist across (as well as within) countries, as shown by the European Commission's Digital Economy and Society Index (I-DESI) (Figure 2).

[2] The International Digital Economy and Society Index (I-DESI, 2018) measures the digital economy performance of EU-28 Member States through five dimensions: connectivity, use of internet services, integration of digital technology, digital public service, and human capital (in terms of digital skills). The design of ySKILLS methodology – especially the choice of countries where the three waves of survey will be administered – was based on DESI. In the systematic evidence review we consider the current DESI rating, not that of the year when the study was conducted, which sometimes is hard to establish and different from the year of publication. Note that the systematic mapping was originally intended to distinguish primary and secondary-aged school children, but this proved impractical. Children's age is therefore addressed as part of the systematic evidence review.

[3] The search took place at the end of January 2020, so only the start of this year is included.

[4] This task was designed to contribute to theory development in ySKILLS (Task 2.4) by identifying the actors and factors that shape 12- to 17-year-olds' digital skills and their outcomes and generating priority research questions and hypotheses for further research. Task 2.4 will then undertake a critical review of ySKILLS' conceptual model and prepare the integration of theories based on this and other research carried out across ySKILLS.

Figure 2. DIGITAL ECONOMY AND SOCIETY INDEX 2020, BY COUNTRY



* DESI data are not available for Norway
Source: European Commission Digital Scoreboard 2020

To account for persisting inequalities and differences, a third-level digital divide has been theorised, which acknowledges how inequalities in digital skills and digital engagement translate into diverse tangible outcomes of internet use in the field of education, culture, identity, sociality, occupation and socioeconomic status (SES), health and wellbeing (van Deursen et al, 2017; van Deursen & Helsper, 2018). In other words, digital skills have been shown to have both online (digital engagement) and offline consequences (tangible outcomes of internet use). Research also shows that internet use itself not only reproduces social inequality but also accelerates pre-existing exclusion (van Deursen & van Dijk, 2014).

Scholars interested in the topic of digital inclusion/exclusion have therefore elaborated models that explain the relationship between the antecedents and consequences of digital skills, whereby digital skills are understood as either the consequence of differences in sociodemographic and internet use factors, and/or the antecedents of digital engagement and other (typically, offline) tangible outcomes such as social, economic and cultural inclusion. Digital skills may also be the mediator or moderator in these relationships among factors, for example reducing or strengthening the effect of sociodemographics and internet use on digital and social inclusion.

Since consensus has been reached on the central role played by digital skills in digital and social inclusion, the measurement of digital skills has become more and more crucial. Earlier studies tended to measure only self-report skills ("I know how to…") or used self-efficacy or even online activities as proxies for skills and competences – assuming that if someone is comfortable with something or regularly performs certain online activities, then they have developed the necessary skills. More recently, effort has been devoted to developing more sophisticated measures of skills that not only encompass different sets of abilities – including operational, information navigation, social and content creation skills (van Deursen, Helsper & Eynon, 2017) – but that combine performance tests with multi-dimensional self-report survey measures, including functional ("I know how to…"), critical ("I understand..") and strategic ("I can apply…") elements of digital skills.

While the very definition of digital skills is still contested, and the measurement of digital skills is subject to continuous refinement, here we draw on the notion of the third-level digital divide, defining

digital skills as "**the ability to use ICTs in ways that help individuals to achieve beneficial, high-quality outcomes in everyday life for themselves and others**" while also being able to "**reduce potential harm associated with more negative aspects of digital engagement**" (ITU, 2018, p.23).

Compared with the above literature on digital inclusion, which typically focuses on the adult population, research into children's digital skills remains relatively scattered, both because of the dominant preoccupation with the risks and harm that the internet could pose to children, and because of the myth of the digital natives as naturally able to use digital media and equipped with all the necessary skills (Gasser & Cortesi, 2017). Furthermore, the media panic around internet risks favours a narrow conceptualisation of children's digital skills as the ability to use the internet safely and responsibly, resulting in a narrow and highly normative equation between online safety and digital citizenship (Cortesi et al., 2020). The literature on education takes a different approach but also, problematically, tends to regard digital skills in purely technical or operational terms, reinforcing the idea of a generational digital divide, and neglecting the wider dimensions of children's agency and wellbeing in a digital world.

However, in the past decade digital skills have become of growing importance among policy-makers concerned with children's online safety, educators and parents alike. Research has dismantled a series of myths associated with children and the internet (the digital native, the generational digital divide and the celebration of everyone as not only a consumer but also a producer of digital content). Increasingly, attention has shifted to the need for a better understanding of what makes children more vulnerable or, conversely, more resilient to online risks. This shift in policy attention is evident in the evolution of the EU's Safer Internet Programme (SIP) into the Better Internet for Kids (BIK) Programme.

One of the most notable contributions of the EU Kids Online research, funded by SIP, has been precisely to demonstrate that risks and opportunities are correlated – the more children engage in online activities, the more they are likely to encounter some kind of risk – and, also importantly, that exposure to risk online does not necessarily translate into a harmful experience (Livingstone, Mascheroni & Staksrud, 2018). Children who are more vulnerable to the harmful consequences of online risk situations are usually those who are psychologically and socially vulnerable offline, and also those who have fewer digital skills. Accordingly, the main goal for academics and policy-makers alike is to understand under what conditions and for which children online opportunities can result in tangible benefits, or online risks turn into harm, and simultaneously, how to foster children's resilience to online problematic situations by reinforcing their digital skills (Livingstone, Mascheroni & Staksrud, 2018).

It is in this context, characterised by a renewed attention to children's digital skills, that the ySKILLS project was designed to provide an explanation of the antecedents and consequences of digital skills that help maximise the beneficial outcomes of internet use in children's (cognitive, physical, psychological and social) wellbeing and strengthen resilience through the enhancement of digital skills. The first step involves understanding how digital skills have been conceptualised and measured in relation to children, and identifying the antecedents at the individual and social level that explain differences in children's digital skills, as well as exploring whether and how digital skills have been shown to contribute to children's learning, socialisation, identity formation, emotional wellbeing, digital engagement (civic and political), participation, etc. The systematic review of the literature reported here responds to this task and will help the ySKILLS project design new measures of skills to be included in the survey and a performance test. Moreover, it aims to advance our understanding of children's digital skills beyond the narrow focus on online safety, to include children's rights and children's wellbeing in a multi-dimensional sense.

3.1 Research questions

Taking into account the research context, and the aims of ySKILLS, as explained above, the systematic evidence review in this study was guided by the following research questions:

(1) How are children's digital skills conceptualised and measured?

(2) What factors and actors influence the nature or extent of children's digital skills as an outcome?

(3) What is the role of children's digital skills as a predictor, moderator or mediator of wellbeing?

(4) What is the relationship between children's digital skills and other actors and factors influencing children's wellbeing?

4. Methodology

4.1 The selection of review methods

Systematic mapping reviews are used to plot and categorise the existing literature, identifying gaps from which to commission further reviews or primary research (Grant & Booth, 2009). They usually characterise the quantity and quality of literature based on some criteria (e.g. by study design) and do not entail a formal quality assessment (Grant & Booth, 2009). We selected a "rapid version" of this review using the existing classifications and in-built evidence analysis functionality of a large database (Web of Science Core Collection). This allowed a quick screening of a large number of results and fast-paced identification of gaps (for details see Appendix 2).

In contrast, systematic evidence reviews involve a much more methodically robust search, appraisal and synthesis of the research evidence, often adhering to established guidelines on review protocols (Grant & Booth, 2009). Regarded as the highest quality approach to reviewing evidence, the strengths of systematic reviews lie in their rigorous and transparent methods, which can be replicated (Sutherland, 2004). They entail a clear definition of a research question, a comprehensive search strategy, explicit eligibility criteria, a systematic assessment of the methodological quality of the included studies and the exclusions made, synthesis of the data establishing claims that can be made from the research, and a summary of the results in an unbiased manner (Gough, 2007; Gough et al, 2012; Sutherland, 2004).

As systematic reviews have grown in number and in terms of the fields they cover, they have diversified, including in the terminology used. Therefore, there have been attempts to specify major dimensions by which systematic reviews differ (Gough et al, 2012) and to develop typologies of reviews.[5] However, these overviews concede that in practice there are overlaps between and combinations of these different dimensions, and "currently, there is no internationally agreed set of discrete, coherent and mutually exclusive review types" (Grant & Booth, 2009, p.104).

4.2 The search protocol

The search protocol was developed through an expert consultation with ySKILLS members at an in-person project workshop in January 2020 and through subsequent online meetings. It was designed to be *comprehensive* in its coverage of relevant databases and search terms, *consistent* in its application of the same search word strings across databases, and **efficient** in minimising the number of irrelevant results.

[5] For example, Grant and Booth (2009) list 14 types of review.

Four types of search terms were needed: terms that would identify articles about studies with children, since this is the target group; terms that would identify quantitative studies, since this is the type of evidence being considered in the review; terms that would identify different types of technologies, since the project is interested in the digital aspects of children's experiences and skills; and terms that would identify the various types of skills and competences that are the focus of the project. The search terms were identified based on previous evidence reviews, several consultations with the project members and test searches of several databases.

This resulted in the following groups of search terms:

- **Group 1, child terms:** child* OR youth OR teen* OR adolescen* OR minors OR kid* OR girl* OR boy* OR pupil* OR "school student".
- **Group 2, method terms:** survey* OR questionnaire OR meta-analys* OR quantitative OR empirical OR performance OR test* OR study OR studies OR finding* OR result* OR exam OR "measur*" OR scale OR instrument OR cohort OR sample OR validate.
- **Group 3, technology terms:** digital* OR mobile* OR internet OR online OR "social media" OR cyber* OR app OR technolog* OR comput* OR information OR coding OR programming OR gaming OR ICT OR e- (searched in combination with Group 4).
- **Group 4, skills terms:** skill* OR competen* OR resilien* OR literac* OR literate OR coping OR efficacy OR confiden* (searched in combination with Group 3).

After further testing, it was discovered that skills terms on their own produce a substantial amount of irrelevant results (e.g. skills not related to the digital environment). Combining the digital terms with the skills terms in search phrases reduced the level of noise and yielded more relevant results. Hence, all combinations of Group 3 and 4 words were used, for example: "digital* skill*" OR "mobile* skill*" OR "internet skill*" OR "online skill*" OR "social media skill*" OR "cyber* skill*" OR "app skill*" OR "technolog* skill*" OR "comput* skill*" OR "information skill*" OR "coding skill*" OR "programming skill*" OR "gaming skill*" OR "ICT skill*" OR "e-skill*".

The final search string took the form: child terms AND methods terms AND a digital skill phrase (i.e., digital term +skill term). For more details of how the search protocol was developed, see Appendix 1.

This search protocol was used for both review methods.

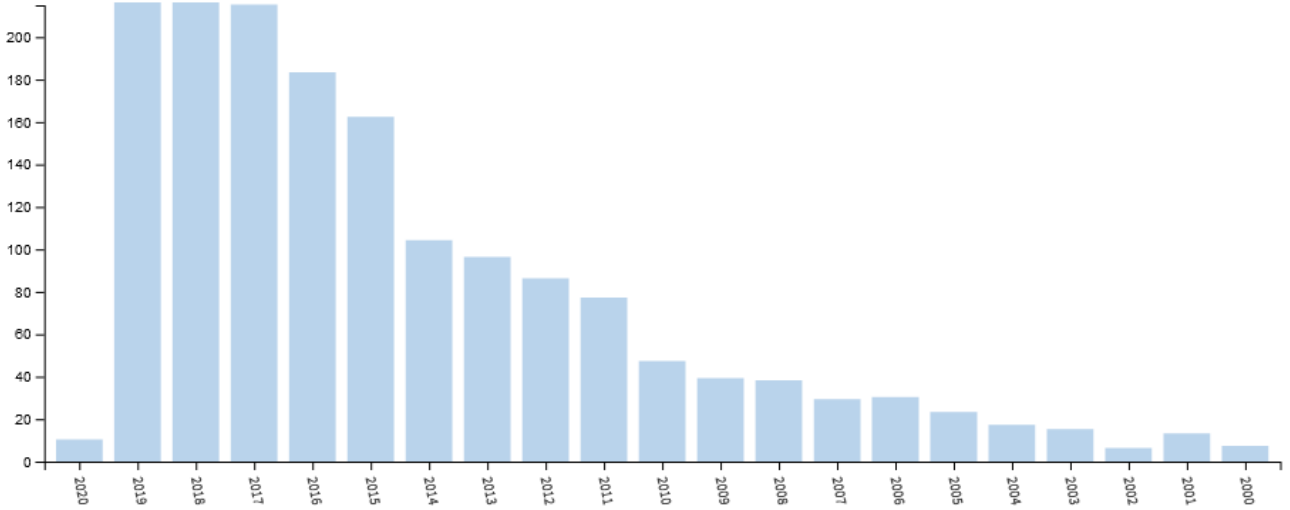
4.3 The systematic rapid mapping review of the evidence on youth digital skills

The large database aggregator, Web of Science, was used for this rapid mapping review because it includes an automated analysis of a very large number of search results by year, academic discipline, publication type, country and so forth. The mapping review encompassed and compared research from the last two decades, identifying how the field has developed and what gaps remain.

The results revealed that most studies on youth digital skills were published in the second decade compared with the first: 207 in 2000–09 compared to 1,401 in 2010–20, a sevenfold increase (see Figure 3). Visually, it is clear that starting from six sources in 2000 there is at first a steady linear increase, but then 2011 saw the start of the rising curve as publications rapidly increased, stabilising toward the end of decade, with 214 studies in 2017 and 215 studies in each of 2018 and 2019.

Based on these results, a decision was made to focus the systematic evidence review on the last decade. For detailed results of the mapping review, see Appendix 2.

Figure 3. WEB OF SCIENCE SEARCH RESULTS: NUMBER OF STUDIES ON YOUTH DIGITAL SKILLS BY YEAR OF PUBLICATION



4.4 The systematic evidence review on youth digital skills

4.4.1 Databases

Drawing on the research team's expertise and through consultation with the specialist subject librarian at the London School of Economics and Political Science (LSE) and ySKILLS project members, it was decided that two international research database aggregators, Web of Science and Scopus, would offer the most sources. This would be supplemented with additional material from specialised databases: International Bibliography of the Social Sciences (IBSS), Communication & Mass Media Complete (CMMC), Education Resources Information Center (ERIC), PsychINFO, Embase and SocINDEX.

These databases can be searched for terms in the abstract, in the keywords section, in the title and in the full text. They include texts in languages other than English, but these usually have an English abstract. For more details, see Appendix 1.

4.4.2 Inclusion criteria

We applied the following inclusion criteria in searching for evidence:

(1) **Studies of children's digital skills:** this choice was informed by the scope of the project. Exclusions here comprise of studies that are not based on research with children (e.g. studies with parents or teachers) or that do not measure skills. Digital skills were defined broadly in order to retain all relevant material that considers skills, however implicitly. For example, studies on information searching or resilience to cyberbullying were retained, but studies measuring internet use, rather than skills, were excluded.

(2) **Studies using quantitative methods:** due to the aims of the evidence review, we sought to retain studies that generate measures of children's digital skills, whether through use of a survey, experiment, evaluation or intervention or secondary data analysis.

(3) **Studies of children aged 12–17:** studies that included children anywhere within this age range were retained; younger children were excluded due to the scope of the project.

(4) **Studies involving high-quality, methodologically robust research:** this follows the requirement of systematic evidence reviews and was applied during the choice of the databases, the screening process and the application of the eligibility criteria.

(5) **From any country but published in English:** the search originally included any languages as the bibliography was shared with members of the project, hence we included publications that could inform their work. The non-English publications were removed during the screening process and not included in the review.

(6) **Studies published since 2010:** this decision was informed by the rapid mapping review, which demonstrated that the vast majority of publications were produced after 2010. The more recent sources were deemed more relevant for the ySKILLS project due to the rapid technological changes. The year of publication limits were applied to the database search.

4.4.3 PROSPERO registration

PROSPERO is an international database for publicly registering systematic reviews, and that process involves a form of quality control where all the steps and precautions taken are described in some detail to make sure reviews reach a recognised standard. The team submitted the review protocol and successfully engaged in this process; the PROSPERO registration number is CRD42020172272.

4.4.4 Search results

The total number of search results from the 2010–20 database search was 4,811. The bibliographic information and abstract for each source were downloaded into a combined EndNote library. The duplicates were removed (n=1,748),[6] resulting in 3,064 unique results. Further filtering exclusions relate to non-English sources, books, reports and theses. This resulted in 2,640 studies (N_1) that were then screened for eligibility.

[6] Duplicates includes "near duplicates", e.g. a conference paper with the same content as a journal article. In such cases, the entry that had been through a more rigorous peer-reviewing process that was fuller or newer was kept. Some duplicates were identified later in the process – during the eligibility stage, their number (n=49) was added to the overall number of duplicates.

Table 1. RESULTS OF THE SEARCH		
Database	**Database description**	**Number of search results**
Scopus	Among the largest abstract and citation databases of peer-reviewed literature including scientific journals, books and conference proceedings. It includes research outputs from across the world in the fields of science, technology, medicine, social sciences, and arts and humanities.	**1,978**
Web of Science Core Collection	A very large database, this contains peer-reviewed, high-quality scholarly journals published worldwide (including Open Access journals) in over 250 sciences, social sciences, and arts and humanities disciplines. Conference proceedings and book data are also available.	**1,396**
PsychINFO	A specialist database of the American Psychological Association providing abstracts of articles relevant to all fields of psychology. One of the largest resources in behavioural science and mental health, this includes coverage from the 17th century, with extensive coverage from the 1800s to the present.	**471**
Education Resources Information Centre (ERIC) (via EBSCO)	An authoritative database of indexed and full-text education literature and resources. Sponsored by the Institute of Education Sciences of the US Department of Education; coverage from 1966.	**427**
Embase	Indexes medical, biomedical and neuroscience journal articles published since 1947. Data from over 95 countries.	**218**
International Bibliography of the Social Sciences (IBSS)	Has bibliographic references to journal articles, books, reviews and selected chapters from 1951. Has broad coverage of international material and incorporates 100+ languages and countries.	**118**
Communication & Mass Media Complete (CMMC) (via EBSCO)	Communication studies database providing full-text, indexing and abstracts for many top communication journals covering all related disciplines, including media studies, linguistics, rhetoric and discourse; coverage from 1900.	**116**
SocINDEX (via EBSCO)	Database for sociology research with indexed records from top sociology journals including gender studies, criminal justice, social psychology, racial studies, religion and social work.	**87**
	Combined search results (N_0)	**4,811**
	Duplicates	1,748
	Non-English sources	278
	Books, reports and theses	145
	Final search results (N_1)	**2,640**

4.4.5 Eligibility screening

The screening occurred in two steps: applying the eligibility criteria first to the title and abstract and then to the full text. Exclusions based on the different criteria were made:

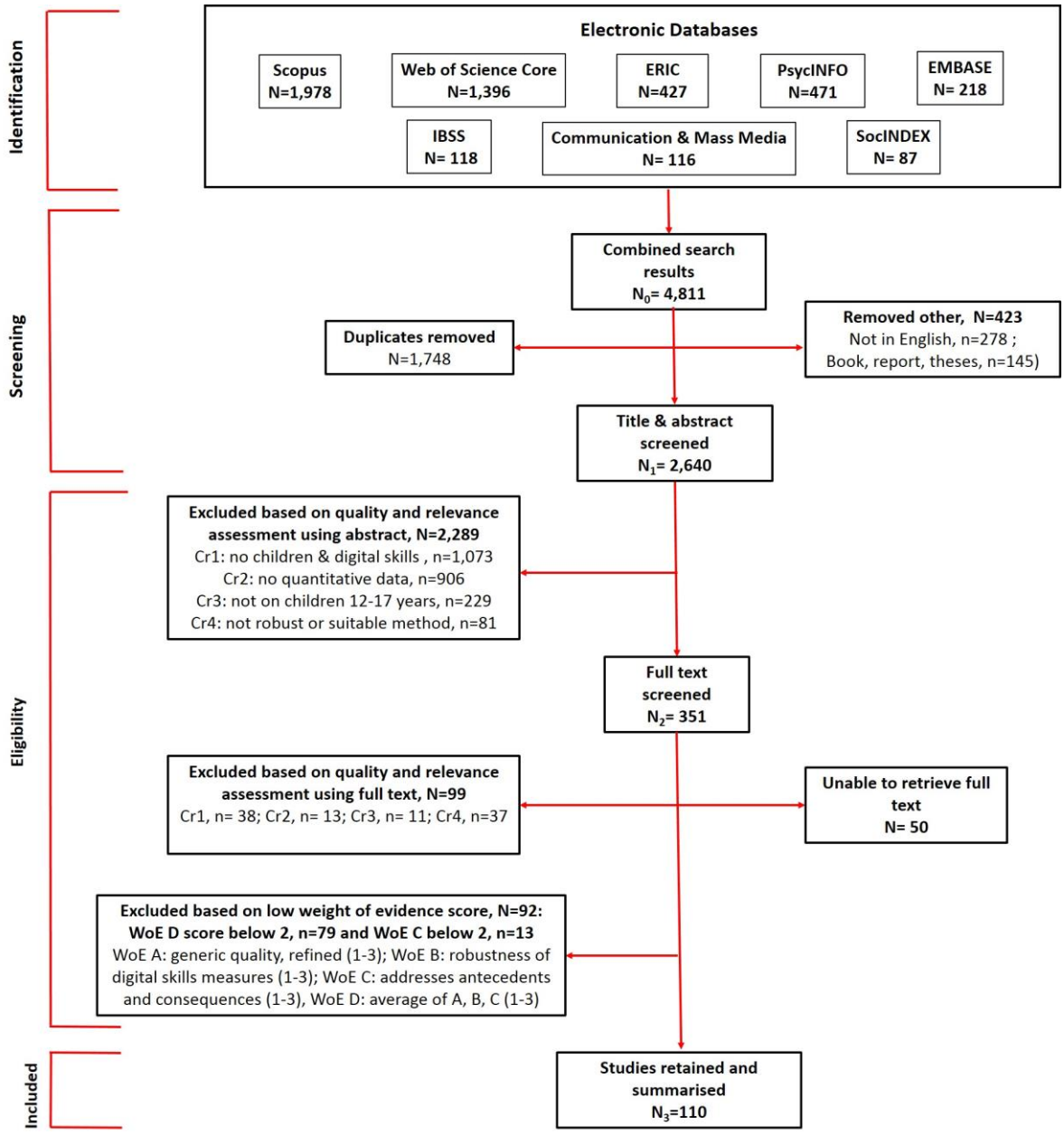
- **Criterion 1, studies of children's digital skills:** here studies involving parents' and teachers' perceptions of children's digital skills were excluded since they were not a direct measure of children's skills. Other exclusions occurred when, for example, the source was clearly discussing reading skills, library search skills or media literacy – in the sense of critical engagement with media texts.
- **Criterion 2, using quantitative methods:** sources with an abstract that only included recommendations for future research or referred to a literature review without including full study information were deemed ineligible.
- **Criterion 3, studies of children aged 12–17:** this included studies of elementary school children who were mainly younger but included some 12-year-olds, and studies of college students who were mainly adult but included some 17-year-olds. Studies outside this age range were excluded.

- **Criterion 4, methodological rigour:** this meant excluding small sample surveys, research designed to develop a measure rather than report on children's digital skills and pilot research.

The criteria for eligibility were applied in a hierarchical cascading fashion – each source was first checked against criterion 1; if it passed, it was checked against criterion 2, and so on. In cases where the available information was insufficient, the source was retained. A total of 2,640 studies were screened based on title, excluding 2,289 studies that did not meet the four criteria (see Figure 4 for the number of exclusions per each criterion). The remaining 351 studies were screened based on full text. Further exclusions were made because the full text was not available (n=50) or the study did not meet the four criteria (n=99). The remaining 202 studies underwent an in-depth quality appraisal and relevance assessment using a Weight of Evidence (WoE) framework.

This process was undertaken by six team members. Notes were kept to document issues likely to inform the next stage of the work, and to account for how decisions were reached in tricky cases. Initially, retained sources were categorised as "include" or "unsure". After discussing the reasons for classifying some sources as "unsure", the team was able to assess them all according to the four criteria.

Figure 4. FLOW DIAGRAM OF THE SCREENING AND QUALITY APPRAISAL PROCESS



4.4.6 Reliability of screening

The research team trained by appraising a sample of sources together, to ensure inter-rater reliability. A 10% sample of sources judged ineligible by each team member was then checked by another researcher from the team. The logic behind examining the reliability of excluded sources was that this was the more significant decision (since wrongly including a source would merely mean it could be excluded later). Checking 270 sources[7] revealed disagreement over the exclusion of 3%[8] of

[7] The sources for the reliability check were allocated to second reviewers at the time when N was 2,640, as shown in Figure 2.
[8] In part this was a qualitative judgement. Some of the boxes involved comparing texts. There was also a long checklist of antecedents and consequences, and for any one study most would not apply. This means the two coders would usually agree most of these did not apply and that, in turn, would automatically produce a high reliability score if using tests like Cohen's Kappa.

sources; that is, the process was 97% reliable.[9] This reliability check also showed that some sources could have been excluded for a different (usually a higher-ranked) criterion.[10]

4.4.7 Quality appraisal and relevance assessment: Weight of Evidence

An important distinction between systematic evidence reviews and other forms of review is the in-depth and review-specific quality appraisal and relevance assessment (Gough, 2007). For this purpose, we used a Weight of Evidence (WoE) framework. It weights studies that are particularly relevant to the review and are fit for purpose as pieces of evidence when addressing the questions being considered (Gough, 2007).

WoE involved evaluating the studies by three different criteria (A, B and C), giving them a score of 1=poor, 2=fair and 3=good, and then assigning them an average score (D) between 1 and 3. For details on how the different scores were operationalised, see Appendix 3. The WoE criteria used were:

- **WoE A, overall study method quality:** the previous criteria were expanded to include more in-depth considerations. Examples are whether the study used controls for confounding effects, randomised representative sampling, longitudinal designs, how the data are used to test hypotheses, and whether data on children are reported separately or by different age groups of children.
- **WoE B, appropriateness of that form of evidence for answering the review question:** in this review, criterion B was applied in relation to the conceptualisation and measurement of digital skills. This involved consideration of the complexity of the definition of digital skills allowing multiple dimensions (e.g. information, social, technical) and if the different dimensions were measured robustly; whether there is a model which explains how the dimensions fit together; and if the study reports on the reliability and validity of scales.
- **WoE C, relevance of the focus of the evidence for the review question:** in this review, criterion C was operationalised in relation to how the study addresses the antecedents or consequences of digital skills. For example, if the study includes a substantial and in-depth discussion of antecedents and/or consequences; if it has some (even simple) theoretical or statistical model to explain antecedents and/or consequences (pathways); and if it reports how these measures influence or are influenced by digital skills.
- **WoE D, overall rating:** the average of A, B and C.

Each study was rated on each criterion (A–C) and received an average overall rating (WoE D). This allowed the prioritisation of studies with a higher overall rating and those that were particularly relevant for the task. The WoE appraisal was also used to take notes on the antecedents and consequences used by the studies that then informed the development of a coding framework developed for the analysis.

Based on the WoE, two types of exclusions were made: first, studies with an average score less than 2 (in effect, meaning they had scored "poor" in at least one of the three areas) were removed (n=79); second, studies that scored "poor" on WoE C were removed as they had made little contribution to the analysis of antecedents and consequences (13). This produced a final sample for analysis N_3 of 110 studies.

[9] For the sample checked, those wrongly excluded were added to N_2. These were mainly borderline age decisions, e.g. elementary school studies where the upper age was initially unclear from the abstract but further checks showed that 12-year-olds were included.
[10] Of the 270 sources in the reliability check, 19 should have been excluded on criterion 1 but were excluded on a lower-ranked criterion.

4.4.8 Reliability of eligibility judgements

As at earlier stages, the team members first trained by coding and discussing the same five studies in order to ensure they would code in the same way. After the coding, 10% (35 studies) were examined by reviewers other than the first coder in order to test inter-coder reliability. While scores sometimes varied a little as regards particular criteria, there was more often agreement and very often agreement that a particular study on average either had a score over 2 or under 2 on WoE D. In only two cases of the sample tested (6%) were there different evaluations about whether a study should be excluded or not.

4.4.9 Coding and analysis of the results

The final sample of 110 studies were coded and analysed using a coding framework. The framework was developed based on the observations made during the WoE appraisal that produced a long list of antecedents and consequences used in the studies and following a consultation with the ySKILLS network. The list of antecedents and consequences were grouped and synthesised into broader and more analytical categories improving the opportunities for cross-study comparisons while retaining the nuances and differences of the individual studies. The antecedents include factors related to personal attributes, the social context, ICT environment, online activities and country-level differences. The consequences range from those related to wellbeing, to approach to learning and leisure, learning outcomes, offline activities, online activities, approaches to digital activities and risk of harm. The coding process also involved recording the direction of effects on digital skills and significance thresholds for each measured antecedent and consequence.

The coding framework incorporated information about the study's geolocation (countries covered), methods (whether the studies involved surveys, practice tests or other experiments), participant details (number of participants, age range), approach to digital skills (how conceptualised, if measured by performance tests or self-report, if the measures are validated), and whether skills are an outcome, moderator or predictor. Each study was also summarised in relation to aims, methodology and findings. For more details about the coding framework see Appendix 4.

4.4.10 Coding reliability

Similarly to the previous stages of the review, steps were taken to ensure the robustness and reliability of the reviewing process. The coding framework was tested by each member of the team using the same five studies, selected for their diversity. This was felt to be the minimum, and indeed this number of test cases raised a variety of issues. It was decided not to do more because of time constraints as other parts of the ySKILLS project awaited the report. The experiences of coding were discussed and used to make changes to both the technical process and the content of the framework. The alterations were related to streamlining the process (e.g. identifying a selection of types of method used or validation options) and expanding information recorded for each study (e.g. adding free-text sections that capture the specific approach of each study). Further guidance on how to apply the framework was also established. After the final coding process 10% of the 110 coded studies were coded again by second coders, and a qualitative comparison was made to understand the basis for coding decisions, where appropriate returning to check details in the original study text. There were no substantial differences as regards the results reported below.[11]

[11] The type of minor differences in coding related to whether an analysis counted as a structural analysis or not, or whether to count a study as a survey or secondary analysis given that it was not clear if the authors had taken part in the original project.

5. Systematic evidence review: Results

The analyses in the following sections have been guided by a number of considerations. In each section there is a summary of research, noting age ranges and detailing what has been studied (even if not found to be statistically significant), the direction of significant results, any contradictory findings across studies and whether these can be explained (e.g. by the nature of the sample or how digital skills were measured). We also note whether and why the results appear predictable or surprising. At the end of each section there is some indication of the research gaps that it is important to fill in through future research, hypotheses that could be tested with further analysis of the results, and hypotheses that future research in ySKILLS or beyond can test.

5.1 Organisation of the sections

The first section examines how digital skills have been **conceptualised** across the studies.

We then examine how youth digital skills have been **measured**.

This is followed by a summary of the **scope and methods of research** on youth digital skills.

Next, recognising that some research conducts **performance tests**, by contrast with the bulk of the studies that are survey-based, we examine the findings of the studies using performance tests.

Studies are then examined for evidence regarding the antecedents of digital skills. **These are classified into:**

- Personal attributes of the child (ascribed, attained and those specifically relating to digital skills)
- The social context of the child (socioeconomic status [SES], parental factors, educational factors, other factors)
- The ICT environment of the child
- The online activities of the child
- Country-level factors.

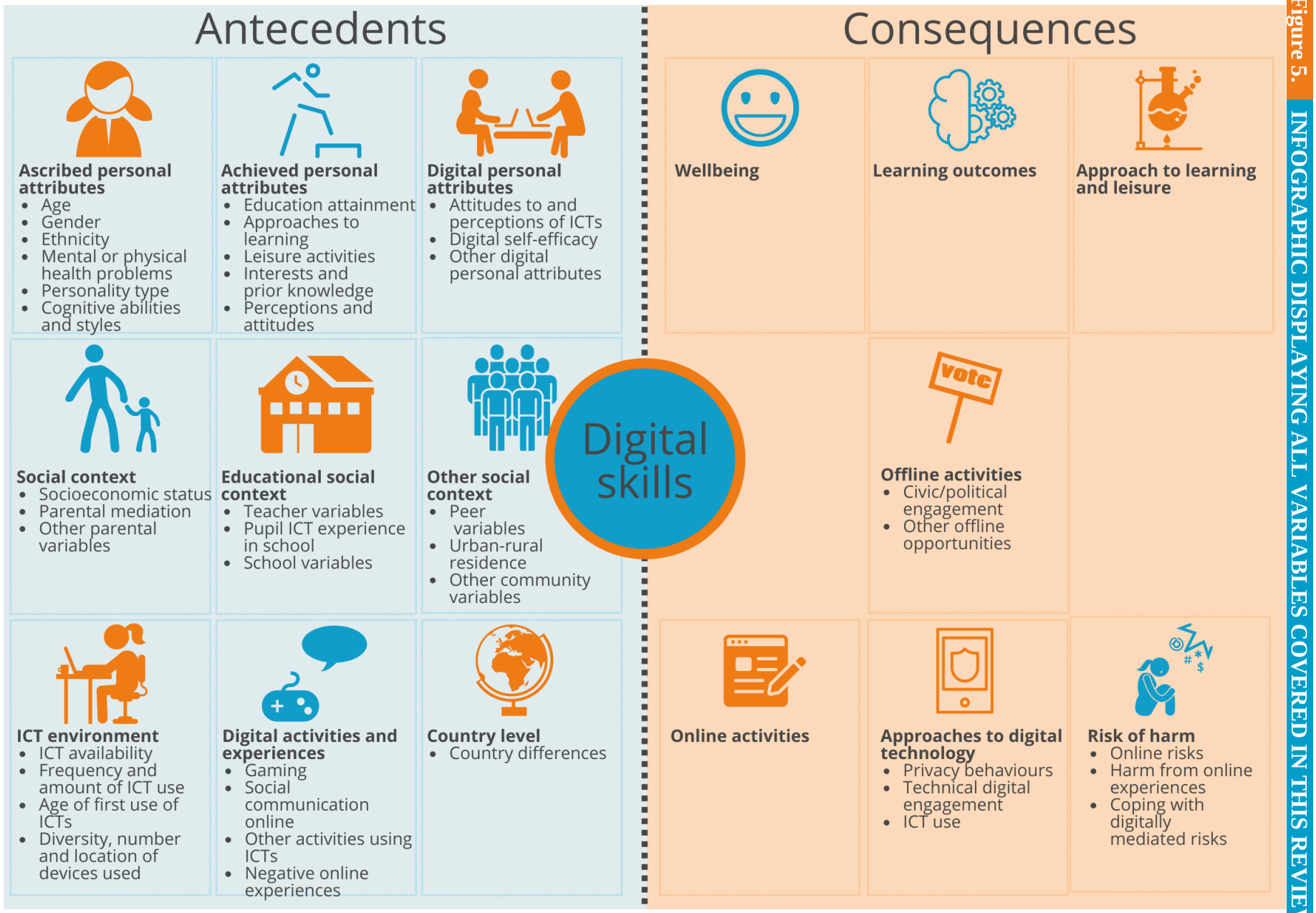
Studies are then examined for evidence regarding the consequences of digital skills. **These are classified into:**

- Wellbeing
- Learning outcomes
- Approaches to learning and leisure
- Offline activities (offline civic/political engagement, offline opportunities)
- Approaches to digital technologies (privacy behaviours, technical digital engagement)
- Online activities
- Risk of harm.

For an overview of the antecedents and consequences in this review, see Figure 5.

Finally, we examine studies that attempt to model the relation between the antecedents and consequences of youth digital skills.

Figure 5. INFOGRAPHIC DISPLAYING ALL VARIABLES COVERED IN THIS REVIEW



5.2 Conceptualising youth digital skills

Before turning to the details of the results concerning antecedents and consequences, this section and Section 6.3 first reflect on the nature of the digital skills that have been considered in the studies assembled in this review based on a detailed examination of how those skills were conceptualised and operationalised.

It is striking how diverse the definitions of digital skills used throughout the research literature are. In part, this is because we cast the net widely, seeking research on the combination of multiple synonyms for "digital" and "skills", as explained earlier. But we did this not only to be inclusive of different approaches and disciplines but also because the research, educator and policy communities have not settled on an agreed definition. In this section, we reflect on the conceptions and measurements included in the studies reviewed.

The challenge of defining digital skills arises for two distinct reasons:

- What is meant by digital? Is the focus on the particular knowledge concerning how to interact with technology, such as programming, or manipulating databases? Or is the emphasis on the more general skills needed to operate in a digital world, which today could encompass communication, information seeking, and a host of other activities now mediated by the use of digital technology and, possibly, which are not especially specific to technology? For example, is information seeking a digital skill, now that it is largely conducted online, or is it not much changed from the days when it involved going to a library?
- What is meant by skills? In principle, we refer to skills as a form of practical knowledge – the ability to do something that requires some expertise or know-how. But in practice, it is difficult to discern what people know without observing them demonstrate their knowledge (although this means we cannot recognise those who have the skill but do not use it). The only alternative is finding a way for people to report on their knowledge without social desirability bias.

It might have been expected that our present focus on children and young people would add further complexities to the definition. But in practice, the studies reviewed did not discuss whether youth digital skills are different from those of adults, and a fair number of studies sampled age ranges that included both children and adults with no particular attention to the issues that might arise. Implicitly, then, the literature on youth digital skills studies general digital skills but in relation to a youth sample, rather than conceptualising digital skills that are in some way specific to young people.

Regarding the meaning of "digital", we concur that both broad and narrow definitions are of value, depending on the purpose of the study and the domain or task for which skills are needed. As the review finds, it is likely that what makes skills effective is the degree of match between the dimensions of skills that young people possess and the benefit anticipated. For example, to use the internet effectively in everyday life, a wide range of digital skills is likely to be required. But if the task is to find and evaluate information, then specifically information literacy is what is needed.

Regarding the meaning of skills, we are less eclectic in our approach. First, skills typically encompass a range of knowledge levels, from novice to expert. While this is not always captured in the reviewed studies, this range is often implicit in the use of scalar measurement ("On a scale from 1 to 10, can you…").

Second, the difference between claimed and observed skills matters conceptually (as well as in terms of measurement accuracy). Some argue, or assume, that digital skills ("I know how to do x or y") and digital activities or internet use ("I do x or y") are identical (in other words, that competence can be reduced to performance). However, it is both possible to do something badly (use without skill) and

to have the skill but never use it (skill without use). Hence, in our review, we exclude from consideration studies that only measure internet use as a proxy for digital skills.

We pay particular attention to the distinctions made (although rarely discussed in the studies reviewed) between "I can do x or y" or "I am confident in doing x or y" or "I am good at x or y". The latter two, which involve a judgement about how well the person can do something, are usually considered measures of self-efficacy rather than skills, and are particularly subject to social desirability biases. Social desirability biases mean that more privileged people tend to claim more skills in answering questions phrased in this way (boys or men more than girls or women, educated people more than less educated people, etc.). A more robust conception of skills, we argue, either asks people to report on having specific abilities ("I know how to do x or y") or administers a performance test so that everyone in the sample is asked to demonstrate the skill.

In addition, van Deursen, Helsper and Eynon (2016) argue that self-report measures are enhanced by a focus on truth claims. They recommend presenting the respondent with a skill claim (e.g. "I know how to download a photo I found online") and evaluate its truth ("this is very true of me", or "this is not very true for me", etc.). To further reduce the pressure on respondents to over-claim their knowledge, they also advocate provision of a further option "I do not understand what this means" and a framing comment that the respondent should answer, bearing in mind that if asked to demonstrate the skill they claim, then and there, they could do so.

5.3 Measuring digital skills

In the reviewed studies, we found illustrations of diverse approaches to digital skills, including self-efficacy[12] (self-confidence in one's ability to achieve different goals), particular knowledge claims[13] ("I can do x"), demonstrating skills by action taken[14] and performance tests to check whether children have particular skills to achieve a goal.

The most common measure was self-efficacy, although this included some variation in approach. Usually by using a Likert scale, children can be asked to evaluate specific yet diverse instrumental competences, such as their ability to open an attachment,[15] use software to find and get rid of viruses[16] or design computer games.[17] Some questions are still focused on particular activities but also require the child to evaluate their social skills ("Can you write a polite email?"[18]) or judgement ("Can you judge if the information on a website is true or false?"[19]). Yet other questions are far more general ("I feel comfortable using digital devices that I am less familiar with"[20]).

About a third (37/110) of the reviewed studies included a performance test, often with the purpose of improving measurement reliability. These also adopted diverse formats, including requiring the child to achieve a specific goal in a simulation test,[21] create something online[22] or demonstrate knowledge

[12] For example: "I am good at…", "I am comfortable with…", "I find it easy to…"
[13] For example: "I am able to install new programs on my computer without any help" (study 13).
[14] For example: "Sometimes I use an online account with a different name, so that other people believe I am a different person" (study 24). Study 17 conceptualises digital skills as performative media practices, and so asks whether children do various activities online, such as update a profile.
[15] Study 5.
[16] Study 6.
[17] Study 105: "How confident are you in your ability to design computer games?"
[18] Study 5.
[19] Study 5.
[20] Studies 7 and 51 (PISA study). Other examples from those studies are: "If my friends and relatives want to buy new digital devices or applications, I can give them advice", "I feel comfortable using my digital devices at home", "When I come across problems with digital devices, I think I can solve them" and "If my friends and relatives have a problem with digital devices, I can help them".
[21] For example, studies 2 and 10.
[22] For example, "Participants were directed to an online travel guide and were asked to plan a trip to a European city they had never visited by navigating the site. They were asked to include a map, a daily schedule, and information about each tourist attraction" (study 77).

by answering factual multiple choice questions.[23] Again, these tests could cover basic through to more advanced skills, and some studies tried to measure and differentiate these levels.[24]

Operationalising skill levels is difficult, and not all agree on what counts as basic and what does not.[25] The nature and level of skills can also become confused, as illustrated by what are often called "functional" skills: they resemble basic skills in the sense of knowing something practical or factual rather than having to make an evaluation or interpretation, but they can be advanced in the sense that a beginner could not achieve this goal.[26] Some skills are demanding in both senses – advanced beyond what can be expected of a beginner and with an element of evaluation.[27]

Complicating matters further, some studies examine not "functional" but "critical" skills. These are often advanced in nature, but also draw on critical interpretation that is more akin to media literacy[28] than to enacting a series of learned operations to achieve a goal or gaining the next level of sophistication after more basic skills have been mastered.[29]

5.3.1 Domains of digital skills

In terms of the domains of digital skills, most studies included a number of items (questions or tests), and this varied considerably.[30] In some studies, the particular domains of digital skills were of interest, but at other times they were not, a range of diverse questions being simply combined to create a digital skill scale or score.[31] Conceptually, the creation of a single scale from a range of separate measures implies an underlying or integrated notion of digital skill that transcends the particular questions asked. In some studies, statistical techniques such as factor analysis were used to check the validity of combining measures across domains, but this was not always done. The skill domains most commonly measured included:

- Informational skills (sometimes called "search and process skills"[32]), such as skills relating to searching for information,[33] the ability to manipulate[34] or use information;[35] some referred to the evaluation of information.[36]

[23] For example, from study 5: Is an "IP address"…:
a) Code for distinct identification of a computer in a network?
b) Code for distinct identification of the memory device on the hard drive?
c) Code for the distinct identification of an information provider on the internet?
d) Code for distinct identification of an email address on the mail server?
I don't know.
[24] Study 6. In study 38 children's skills were rated "below basic", "basic", "average" and "excellent" depending on how they coped with the task.
[25] For example: "Play a movie on a computer" (study 5), "Upload text, images or video to an online profile" (study 6) and "Change filter preferences" (study 9).
[26] For example: "Change the settings on a computer to improve the way it operates" (study 6).
[27] For example: "Compare different apps with similar functions in order to choose the one that is most reliable" (study 9).
[28] For example: "Compare different websites to decide if information is true" (study 10). However, some studies refer to critical skills but do not use the term in this sense, e.g. in study 9, critical skills include "Bookmark a website".
[29] For example: "Delete the record of which sites you have visited" (study 12) implies the child already knows the skill of navigating to sites.
[30] Study 20: 3 items; study 7: 5 items; study 8: 12 items; study 1: 18 items; study 3: 27 items; study 2: 56 items; study 14: 78 items.
[31] The exception is study 11, which only asked one question: "What is your level of ICT literacy?"
[32] Study 27: "Communication skills" and "production skills" are also headings cited in this study.
[33] For example: "Improve a false search query in order to find the right information" (study 1).
[34] For example: "The ability to classify and reorganise (information)" (study 42).
[35] For example: "Use ICTs to convey the correct information to the right people" (study 84).
[36] For example: Judging online news or websites, whether an item is an advert. But also: "I am able to judge the degree to which information is practical or satisfies the needs of the task" (study 46).

- Social interaction skills (sometimes called "communication skills") – usually these imply more than whether someone can manage to send a message,[37] to capture an element of social skills or awareness of the conventions of social communication.[38]
- Content creation skills (sometimes called "production skills") – nowadays these can include various activities on social media[39] but also more general design and editing skills.[40]
- Programming or coding skills.[41]
- Lastly, some studies focus on very specific "skills" such as ethical behaviour online (e.g. "I treat others online as I would like to be treated by them"[42]), digital safety skills (e.g. "Block messages from someone you don't want to hear from"[43]) or critically evaluate the credibility of online health-related resources.[44]

It should be noted that distinguishing skill domains can be far from straightforward, especially when measures depend on interpretation[45] or fall into more than one category or none.[46]

5.3.2 Conclusion

The reviewed studies encompass considerable diversity in their approach, both to digital domains, and to the conceptualisation of skills, competence or self-efficacy. The use of statistical techniques to abstract what is common across domains, or to distinguish functional from critical skills, or novice from advanced skills, all add to the complexity of this field of research.

The "digital" of digital skills is conceptualised in the research literature either broadly, including a wide range of digital skill domains, or narrowly, often focusing on either programming skills or information literacy. This has consequences for the number of items typically measured in survey-based studies of youth digital skills. We have suggested that there can be no "correct" way of defining the meaning of "digital" in this context as it depends on the research question and purpose.

The literature is also bifurcated by those choosing self-report measures (which enables the inclusion of digital skills measures in surveys encompassing other variables) and those preferring performance tests to address possible measurement biases. Specifically, the "skills" of digital skills is variously operationalised as "I know how to do x or y" or "I am good at doing x or y". The decision about how to operationalise skills is rarely discussed explicitly, but we have suggested that more factual questions ("I know how to…") are preferable to self-evaluative questions ("I am good at…") because they introduce less measurement bias and because they help distinguish digital skills from digital self-efficacy.

[37] For example: "Send private messages" (study 17).
[38] For example: "Send a polite email", "Use email to ask a clear question that is completely understandable for the receiver" (both from study 5), "Participating in a discussion online" and "Making new friends on the internet" (both study 28).
[39] For example: "Create a blog" and "Make a website" (both study 18).
[40] For example: "Uses computer design software", "Uses images from the web" and "Download/edit digital content" (all from study 17).
[41] For example, study 15, where students were presented with the type of questions found in a computer science programming textbook.
[42] Studies 24 and 27.
[43] Studies 9 and 53.
[44] Study 38. The questions were: (1) "Who is the author of the web page?"; (2) "Is she or he an expert in the health effects of energy drinks? Why do you think so?"; and (3) "Is the information presented on the web page credible? Why do you think so?"
[45] For example: "Use the information of different websites to make a new product" – this could be "informational", "content creation" or both.
[46] For example, "build a website" implies functional in terms of knowing where to click and content creation in terms of applying the social conventions of what a (good) website should include or indeed innovating by stretching those conventions.

We also note that:

- Some studies infer skills by simply asking "Do you do x or y?", but we excluded these from the review as failing to measure skills directly.
- Several studies attempt to distinguish critical from functional digital skills, but we conclude that this is generally unsuccessful, the distinction being unclear both conceptually and in terms of measurement.
- Traditionally, skills are conceived and measured in relation to extent of expertise (from novice to advanced). Although such terms are occasionally used in the literature, no clear definition emerges. However, since many survey studies use a Likert scale (rather than a binary yes/no measure), it can be said that the degree of skill is measured in the literature.

All these considerations have informed our interpretation and comparison of the findings included in the reviewed studies, and in assessing which skills, or which measures of skills, are affected by which antecedents or lead to which consequences. They should all be taken into account by researchers seeking to design a new project, for example to make sure different types of skills are covered, or in assessing the kinds of future research needed.

We conclude that the International Telecommunication Union (ITU) definition of digital skills stated at the outset of this review is fit for purpose, similar to many other definitions and better than some.

5.4 The scope and methods of research on youth digital skills

In addition to coding information about the results of various studies, other background data about the study (e.g. country, age of children participating) as well as data about the methods used were also coded. These are reported in this section and in Section 6.5, specifically looking at performance tests.

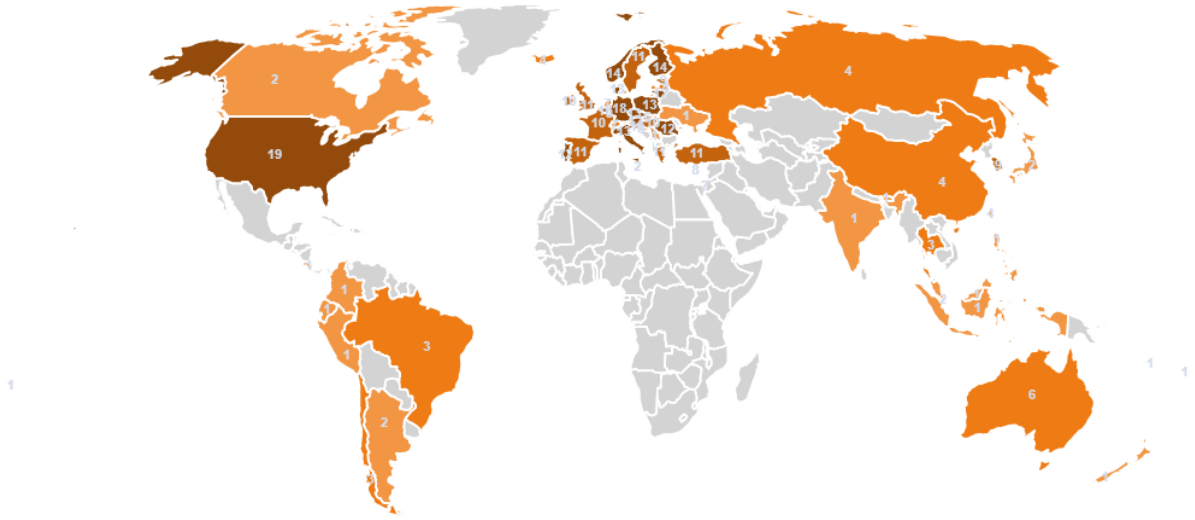
5.4.1 Research subjects

Country

The studies provide evidence from 64 countries, but with some notable gaps.

The most frequently studied countries are the USA (n=19) and Germany (n=18), followed by other European countries, with 10–15 studies each (see Figure 6 and Figure 7). In contrast, there are some large regional gaps: no studies covered any part of Africa, Central Asia or Central America, and only a small number of studies covered South America and Asia.

Figure 6. NUMBER OF STUDIES USING DATA FROM EACH COUNTRY[47]



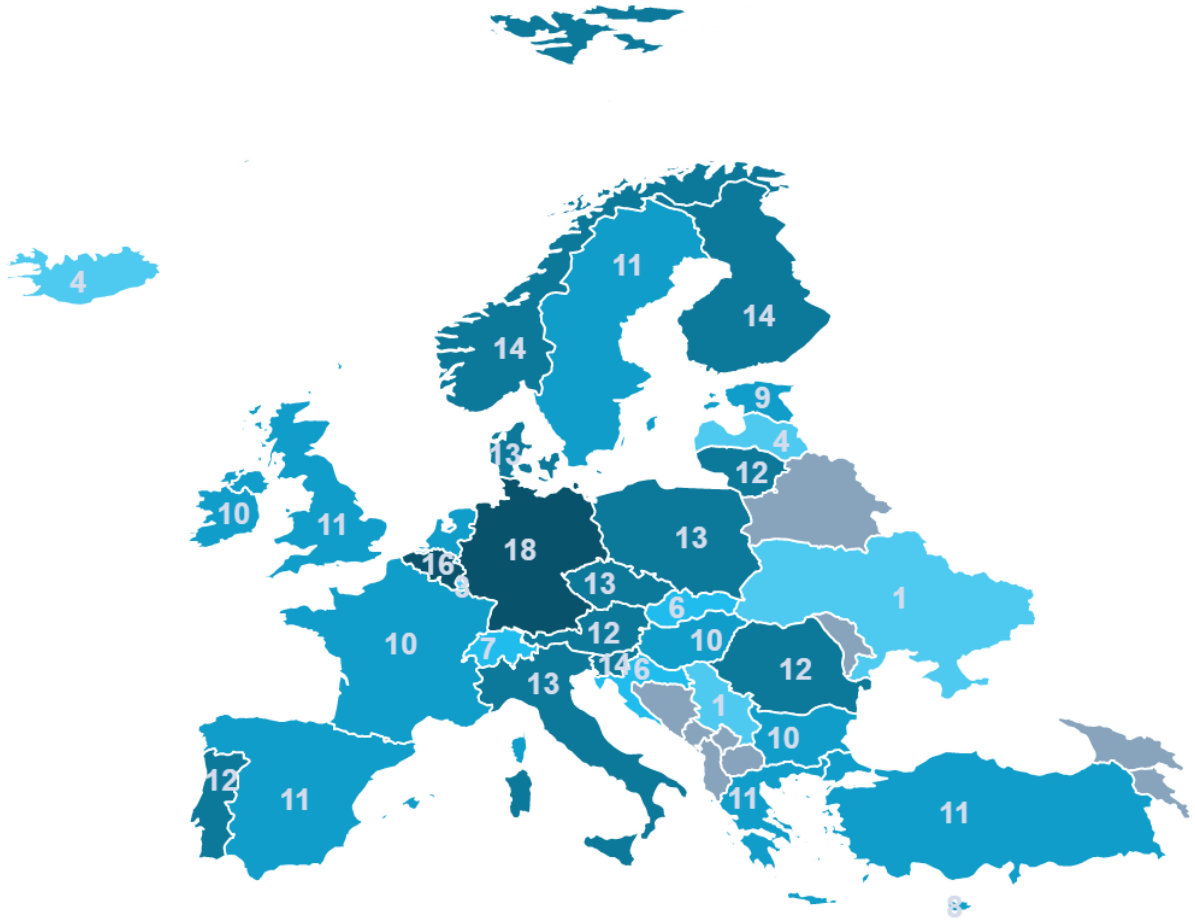
Part of the variation in geographic coverage can be explained by data availability. There were three large, cross-country datasets commonly used in the literature, most of which are weighted towards European and OECD countries. They are:

- Programme for International Student Assessment (PISA) – 8 studies.[48]
- EU Kids Online (EUKO)[49] – 7 studies.
- International Computer and Information Literacy Study (ICILS)[50] – 3 studies.

There was also geographic variation in methods. Most notably, studies based on experiments or interventions (as opposed to surveys or secondary data analysis) were much more common in the USA. While just one in six of all studies came from the USA, half of the experiments and interventions were American.

[47] Note: This map shows the countries covered from 108 studies, excluding two meta-analyses; 19 studies use data from multiple countries.
[48] The 2015 study covered Australia, Austria, Belgium, Canada, Chile, Colombia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, UK, USA.
[49] The 2009–11 study covered Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Turkey, UK.
[50] The 2013 study covered Australia, Argentina, Canada, Chile, Croatia, Czech Republic, Denmark, Germany, Hong Kong, Republic of Korea, Lithuania, Netherlands, Norway, Poland, Russia, Slovakia, Slovenia, Switzerland, Thailand, Turkey.

Figure 7. NUMBER OF STUDIES USING DATA FROM EACH EUROPEAN COUNTRY



Age

The inclusion criteria for this systematic review were that studies must include data for children aged between 12 and 17.[51] Overall, there was good coverage across this age range, although with slightly more studies focusing on the upper end of the range (see Figure 8). In addition, many studies included children outside of this target age range. Around half of the studies collected data from a broad range of ages (with a 5-year age range or higher). Those focusing on a narrower age range typically selected participants based on their school grade.

Figure 8. AGES OF RESEARCH SUBJECTS

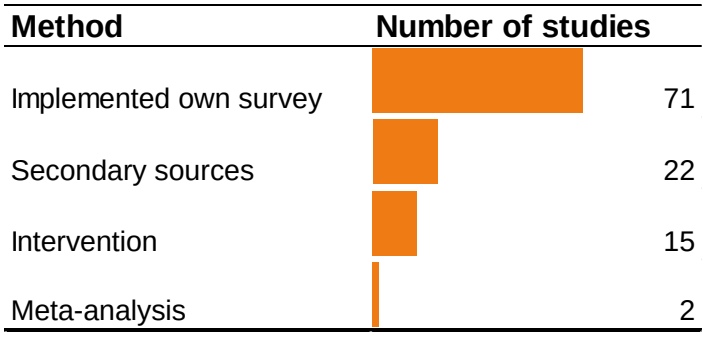
Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
Share of studies	3%	4%	4%	17%	25%	41%	52%	58%	65%	69%	63%	49%	38%	18%	7%

[51] Some studies provided only school grades; these were converted into age bands for reporting purposes.

5.4.2 *Research methods*

In most of the studies covered in this systematic review, the researchers had designed and administered their own survey – this was the primary method for 71 out of the 110 studies (see Figure 9). The second most common method was analysis of secondary data sources – including large cross-country datasets (PISA, EUKO, ICILS), as well as data from other sources (e.g. Eurostat or other national surveys).[52] Fifteen studies were experiments or interventions, many of which provided training intended to enhance children's digital skills. There were also two meta-analyses, which synthesised findings on gender gaps in ICT literacy (study 91) and the cognitive effects of learning computer programming (study 86).

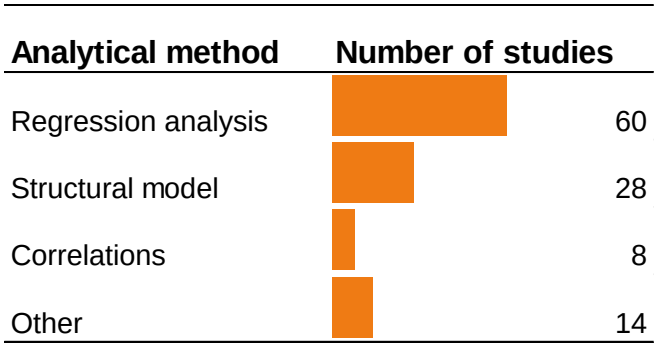
Figure 9. COUNT OF STUDIES BY PRIMARY METHOD



Primary analytical method

The predominant analytical method in analysing the antecedents and consequences of digital skills was regression analysis (see Figure 10). In addition, around one-quarter of studies used structural models, in which they proposed theoretical models for how digital skills are related to other variables and tested those models against their data. A small number of studies reported correlations, without additional analysis of the structure of the relationship, and 14 studies used other methods, the most common being factor analysis.

Figure 10. COUNT OF STUDIES BY PRIMARY ANALYTICAL METHOD[53]



[52] Note: The count of studies where the authors had administered a survey includes cases where the authors had written multiple papers reporting on a single survey.
[53] Note: Some studies use multiple methods, but this figure shows the predominant method in each paper.

Rigour in approach to measuring digital skills

Given that most studies designed and administered their own survey, it is worth considering some indicators of rigour in the authors' approaches to measuring digital skills. Overall, the majority of studies draw on established approaches, and report statistics to confirm the internal validity of their findings. Despite this, the large number of different ways of conceptualising digital skills in the literature (see Section 0) means it is challenging to compare findings across studies.

In designing measures and collecting data, just under half of the studies we reviewed stated that their measures of digital skills were based on conceptual frameworks or measures that had been used in previous research. However, because of the variety in contexts in which the studies were taking place – and in the focus of the research – authors often substantially adapted measures for their own use. Around 30% of studies used well-known instruments (e.g. PISA, EUKO, ICILS), or had adapted measures from those instruments. And around 10% of studies cited conversations or collaboration with experts (e.g. schoolteachers) in developing their measures and survey instruments.

After collecting data, almost half of the studies reported measures of internal consistency, the most common measure being Cronbach's alpha.

Around 20% of studies cited other indicators of rigour, ranging from practical measures like conducting pilot studies and cognitive testing, to more data-driven approaches, such as confirmatory factor analysis or cluster analysis.

Just under 10% of studies cited no indicators of rigour in developing or evaluating their measures of digital skills. These studies mainly measure digital skills with simple questions around children's self-efficacy; while they do not directly cite other studies, their measures are similar to those used in the literature.

Table 2. INDICATORS OF RIGOUR

Indicator of rigour	Number of all studies	Number of studies administering own survey
Use or adapt measures from other studies	51 (46%)	33 (46%)
Cronbach's alpha	48 (44%)	35 (49%)
Use well-known measures	31 (28%)	11 (15%)
Other indicators of rigour	21 (19%)	18 (25%)
Conversations with experts	11 (10%)	10 (14%)
No indication of rigour	9 (8%)	6 (8%)
Total	**110**	**71**

5.5 Results from performance tests on youth digital skills

5.5.1 Performance tests by country

Performance tests involve some form of task-based assessment.[54] This varied from achieving a goal in a simulation test to demonstrating knowledge by answering factual questions. From the 64 countries in N_3, 34 had one or more studies with performance tests of digital skills.

- Table 3 shows the countries with the most studies using performance tests are the USA and then Germany and Norway. But that does not mean that performance tests are only found in studies from wealthier Western countries. Many upper-income European countries have studies using tests, although some do not (e.g. Ireland, UK). There are also studies involving tests conducted in some Asian countries (e.g. China, India, Bhutan), South America

[54] Outlined in study 34.

(Argentina, Chile) and other countries (Russia, Turkey, Ukraine). Use of performance tests is not, therefore, limited to research conducted in high-income countries.

- Nor is it the case that that having more studies overall simply leads to countries having more performance tests. There are many countries (including many European ones) that have quite a number of studies but few or none with tests. In contrast, outside Europe, China has just four studies but three of them involved tests. That said, since over half of all tests (41/68) are found in European countries, this may reflect the fact that there is a high proportion of European studies overall.

Table 3. PERFORMANCE TESTS BY COUNTRY, ORDERED BY NUMBER OF TESTS[55]

Country	No. of all studies by country	No. of all performance tests by country[56]
USA	19	8
Germany	18	**5**
Norway	14	**5**
China	4	3
Finland	14	3
Slovenia	14	3
Switzerland	7	3
Austria	12	2
Belgium	16	2
Croatia	6	2
Czech Republic	13	2
Denmark	13	2
Hong Kong	7	2
Korea	8	2
Lithuania	12	2
Netherlands	12	2
Poland	13	2
Russia	4	2
Argentina	2	1
Australia	6	1
Bhutan	1	1
Canada	2	1
Chile	3	1
France	10	1
India	1	1
Israel	2	1
Italy	13	1
Liechtenstein	3	1
Romania	12	1
Slovakia	6	1
Sweden	11	1
Thailand	3	1
Turkey	11	1
Ukraine	1	1
Brazil	3	0

[55] The shading has been added so that it is easy to see that China, Finland, Slovenia and Switzerland are joint third in the list, ordered alphabetically.

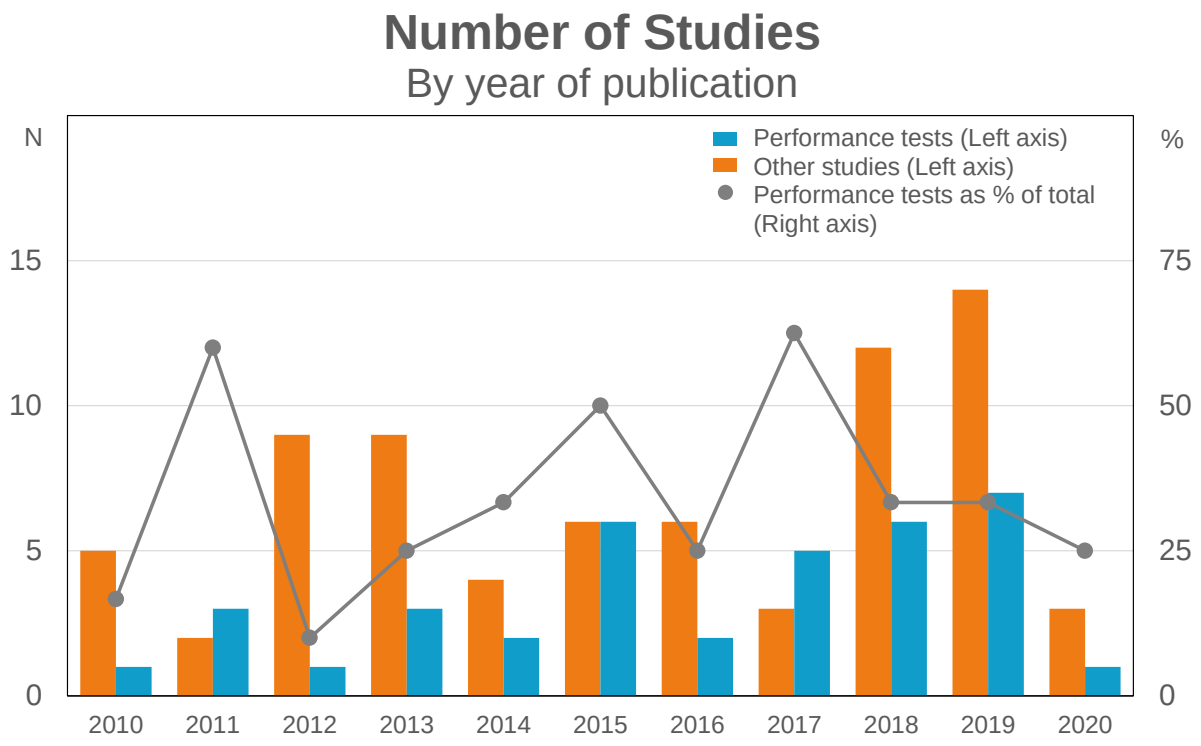
[56] Some of the publications with performance tests were from multi-country studies. In Table 3 each of the countries participating in such multi-country studies is accredited with that test. This means that if added together there are more tests listed than the number of publications in the review that had performance texts. The same logic applies to the column for the total number of studies: the total is over 400, much bigger than N for number of publications, because of how multi-country studies are counted.

Bulgaria	10	0
Colombia	1	0
Costa Rica	1	0
Cyprus	8	0
Ecuador	1	0
Estonia	9	0
Fiji	1	0
Greece	11	0
Hungary	10	0
Iceland	4	0
Indonesia	1	0
Ireland	10	0
Japan	2	0
Latvia	4	0
Luxembourg	3	0
Malta	2	0
Malaysia	1	0
New Zealand	1	0
Peru	1	0
Philippines	1	0
Portugal	12	0
Samoa	1	0
Serbia	1	0
Singapore	2	0
Spain	11	0
Taiwan	4	0
Tonga	1	0
UK	11	0
Vanuatu	1	0

5.5.2 Performance tests by year

Setting aside 2020, since our sample included only the first two months of that year, there are more performance tests in the second half of the decade (26) compared to the first half (10), but that partly reflects the fact that there were more studies in the period 2015–19. Looking at the percentage of studies that includes a test, there is no discernible trend over time.

Figure 11. PERFORMANCE TESTS BY YEAR



5.5.3 Performance tests in studies of outcomes, predictors or moderators

All the performance tests (37) were used in studies that examined the antecedents of digital skills, but four of those studies also examined consequences. To put it another way, the percentage of studies of the antecedents of digital skills that involved tests was much higher (42%) than the percentage of studies of the consequences of digital skills (8%).

Table 4. DIGITAL SKILLS AS OUTCOME, PREDICTOR OR MODERATOR

	No. of studies in N_3	No. of studies with performance test	% of studies with performance test
Digital skills as outcome (i.e., studies of antecedents of digital skills)	88	37	42
Digital skills as predictor (i.e., studies of consequences of digital skills)	53	4	8
Digital skills as mediator or moderator	11	0	0

5.5.4 Conclusions

- Overall, 37 out of 110 studies included a performance test.
- There is no obvious trend by country or region, or over time, that explains when or why performance tests are included in the research design of a study of youth digital skills.
- All uses of performance tests are in studies of the antecedents of digital skills, with very few deployed in studies that also include the consequences of digital skills. This may reflect the fact that studies of antecedents are often framed by education, as a discipline, or conducted

within school settings, where uses of testing are more common. Insofar as performance tests offer a more robust account of youth digital skills than self-report survey measures, we suggest that the body of available research on the antecedents of digital skills tends to be robust. Future research on the consequences of digital skills should also consider incorporating performance tests.[57]

5.6 Antecedents of youth digital skills

For a summary of the findings discussed in this section, see Table 5.

[57] However, as noted in Section 6.3 on measurement, for studies that rely on self-report measures (as in survey methodologies), some approaches to measurement are preferable to others.

Table 5. ANTECEDENTS TO DIGITAL SKILLS

		Number of studies	No effect	Positive effect	Negative effect	Our assessment of the evidence
Personal attributes						
Ascribed personal attributes	Age	26				Overall positive
	Gender	40				Mixed
	Ethnicity	7				Mixed
	Mental or physical health problems	4				Overall negative
	Personality type	3				Mixed
	Cognitive abilities and styles	8				Overall positive
Achieved personal attributes	Educational attainment	6				Overall positive
	Approaches to learning	5				Overall positive
	Leisure activities	2				Overall positive
	Interests and prior knowledge	3				Mixed
	Perceptions and attitudes	5				Overall positive
Digital personal attributes	Attitudes to and perceptions of ICT	12				Overall positive
	Digital self-efficacy	10				Inconclusive
	Other digital personal attributes	3				Mixed
Social context						
Social context	Socioeconomic status	21				Overall positive
	Parental mediation	14				Mixed
	Other parental variables	8				Overall positive
Educational social context	Teacher variables	4				Mixed
	Pupil ICT experience in school	16				Mixed
	School variables	9				Mixed
Other social context	Peer variables	5				Overall positive
	Urban-rural residence	4				Overall positive
	Other community variables	1				Inconclusive
ICT environment						
	ICT availability	15				Overall positive
	Frequency and amount of ICT use	14				Mixed
	Age of first use of ICTs	7				Overall positive
	Devices	3				Inconclusive
Digital activities and experiences						
	Gaming	3				Inconclusive
	Social communication online	5				Mixed
	Other activities using ICTs	4				Mixed
	Negative online experiences	2				Mixed
Country level						
	Country differences	2				Inconclusive

5.6.1 Personal attributes

This section examines factors relating to the characteristics of the child. It employs the common distinction between personal attributes that are achieved by some action of the child as opposed to those that are ascribed, such as their age. In addition, there is a section on digital personal attributes since studies have pointed to the importance of, for example, orientation to the digital world or evaluations of digital experiences.

Ascribed personal attributes

Some ascribed attributes of the child are commonly considered to be antecedents of digital skills. The six considered here are age, gender, ethnicity, personality type, mental or physical health problems, and cognitive abilities and styles. Singly or in combination, these were examined in 80 of the 110 studies. One caveat is that although often seen as ascribed, some of these attributes may themselves have been influenced by other factors: for example, one may be born with health problems but those problems can be also caused or exacerbated by social context. Being from an minority ethnic group and having health problems often leads to disadvantage in other aspects of life, so it is pertinent to ask whether this affects the development of digital skills. Meanwhile, personality assessments can be linked to learning styles or other factors including, possibly, digital skills. In the case of cognitive abilities, this is really a question of whether offline skills carry over into digital ones.

Age

There is strong evidence that children's digital skills improve with age. Twenty-six studies consider the relationship between children's age and their digital skills. Of these, 22 studies (85%) find a statistically significant relationship. Most (19 studies) find that digital skills improve with age. These studies cover a broad range of both upper-income and upper-middle-income countries, and many different types of digital skills, ranging from everyday functional abilities, to online safety, to coping with online harm, to information literacy.

A small number of studies find the opposite – that older children have lower levels of digital skills. Taking a closer look at these studies, it becomes clear that these findings are the result of specific sampling frames, and of younger children scoring higher on some, but not all, dimensions of digital skills:

- For three studies, the negative relationship can be explained by the study's sampling approach. Studies 17 and 48 survey children in a single school grade, meaning that the older children were a very select sample; they were repeating a grade or had otherwise fallen behind at school, and are therefore unlikely to be representative of all children of their age. Study 27 surveys teenagers and adults, and finds that younger respondents perform better in comparison with adults (the average age for respondents was 43).
- For two other studies, the negative finding can be explained by the type of digital skills measures used. Younger children had different approaches to evaluating the credibility of information online (study 60)[58] and in coping with online risks (study 98),[59] so they scored higher on those dimensions of digital skills but not others. The latter study in particular illustrates that while we often assume skills can be conceptualised on a linear scale (of low to

[58] Study 60 finds that while older children scored lower than younger children on concern about the credibility of information they find online, they believed they were better at evaluating which sources are and are not trustworthy, which may explain their lower levels of concern.

[59] In studying children's coping skills in response to online risk, study 98 finds that younger children scored higher on "communicative coping" (i.e., they were more likely to talk to friends or parents about unpleasant situations), while older children respond to risks in different ways.

high), this is not always the case. Older children sometimes make different choices from younger children (in this case, in deciding how to react to a problem), but that does not necessarily reflect a higher or lower level of skill.

- For one study (108), the negative finding is simply a correlation between explanatory variables; the correlation was not discussed and was not the focus of the paper.

There were three studies where no significant relationship was found. All were among children within a fairly narrow age range, suggesting that an age difference of one or two years may make less difference. Two were studies of children in their final years of schooling (studies 66 and 91), perhaps indicating that the correlation between age and digital skills may be weaker at older ages.[60]

Table 6.	STUDIES COVERING THE RELATIONSHIP BETWEEN AGE AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Summary of skill definition**	**Significant**	**Direction**
3	2015	Belgium, (Flanders)	10 to 13[61]	Test	Functional and information literacy	No	
9	2016	Romania	9 to 16	Self-report	Functional, safety information literacy and smartphone skills	Yes	Positive
12	2018	Brazil	9 to 17	Self-report	Functional, safety information literacy and smartphone skills	Yes	Positive
17	2013	Brazil	12 to 18	Self-report	Functional and creative skills	Yes	Negative
21	2012	Romania, Bulgaria	9 to 16	Self-report	Functional and safety skills	Yes	Positive
27	2013	United Kingdom	over 14	Self-report	Functional, safety, information literacy, and self-efficacy	Yes	Negative
32	2019	Finland	15 to 22	Test & self-report	Functional, safety, creative and programming skills	Yes	Positive
33	2018	Finland	13 to 15	Test	Functional, safety, information literacy and programming skills	Yes	Positive
38	2019	South Korea	10 to 15	Self-report	Functional, information literacy and programming	Yes	Positive
40	2013	South Korea	12-16	Test	Functional and information literacy	Yes	Positive
48	2010	China	14 to 17	Test	Functional, information literacy, and ethical use	Yes	Negative
50	2010	UK	10 to 17	Self-report	Functional, safety, and self-efficacy	Yes	Positive
51	2013	25 EU countries	9 to 16	Self-report	Safety skills	Yes	Positive
57	2010	Spain	11 to 18	Self-report	Functional skills	Yes	Positive

[60] A third study finds a non-significant relationship among younger children (study 3), which may be attributable to the inclusion of age in a model with many covariates, some of which are likely to be correlated with age (e.g. analytic intelligence).
[61] This was a study of 6th graders, so while their age varied a little, the children were in the same school year.

58	2015	USA	11 to 18	Test & self-report	Information literacy	Yes	Positive
59	2015	USA	11 to 18	Self-report	Information literacy	Yes	Positive
60	2012	USA	11 to 18	Self-report	Information literacy	Yes	Positive and negative[62]
66	2019	Sweden	16 to 19	Test & self-report	Information literacy and self-efficacy	No	
67	2015	USA	12 to 17	Self-report	Functional and creative skills	Yes	Positive
73	2019	Italy, Portugal	9 to 17	Self-report	Information literacy	N/A[63]	Positive
91	2019	Turkey	13 to 17	Self-report	Functional skills	No	
98	2015	Belgium, (Flanders)	10 to 16	Self-report	Coping with negative online experiences	Yes	Positive and negative
99	2010	Belgium, (Flanders)	15 to 19	Self-report	Functional, technical and creative skills	Yes	Positive
105	2018	Taiwan	12 to 14	Self-report	Functional skills	Yes	Positive
106	2014	Taiwan	9 to 12	Self-report	Functional skills	Yes	Positive
108	2018	China	11 to 19	Self-report	General ICT self-efficacy	Yes	Negative

Gender

It is often stated that boys have – or claim – greater digital skills than girls. The cultural stereotype is that boys are "geeky" or "techie" or more interested in computers and technology. The increasing importance of digital technologies for work means that policy-makers are concerned about girls' seemingly poorer performance. Focusing on adults, the ITU recently conducted a thorough review of the "gender gap" in digital access, skills and employment, recognising that skills gaps in childhood can contribute to significant inequalities later in relation to the labour market (Sey & Hafkin, 2019). Meanwhile, a range of organisations and educational initiatives has sprung up to promote girls' pathways into technology-related work.

But does the evidence confirm the gender gap in youth digital skills? Around one-third of the studies (40/110) examined the relation between gender and digital skills. Since few studies sampled only girls or only boys, it is perhaps surprising that the proportion is not higher. Of the 40 studies, 12 found girls had more digital skills than boys, while 14 found that boys had more skills, and 11 found no difference (3 reported mixed or complex results).

In sum, fewer than half of the studies report that boys have higher digital skills than girls, although this is the most common finding. However, it would be fairer to conclude that the results are mixed, with a quarter of studies finding girls to have higher skills, and even more finding no difference.

Is this observed gender difference reliable? In relation to gender especially, the potential influence of social desirability on self-report measures has long raised concerns, leading researchers to call for use

[62] These studies reported multiple measures of digital skills, and the relationship to age depends on the measure.

[63] This study reports differences in averages across age groups without a formal test for statistical significance.

of performance tests to produce reliable results. The present review lends modest support to this claim:

- 15 studies included a performance test to measure digital skills. The results were fairly balanced, or even tipped in favour of girls: 7 found girls to have more skills than boys; 4 found that boys had more skills; 4 found no significant difference.
- 25 studies used only a self-report measure. Here the results marginally favoured boys, as 10 found boys had more skills; 5 found girls to have more skills; 7 found no difference; and 3 reported more complex results.

In short, the picture is mixed when we consider the performance tests only, but while tests are slightly more likely to report girls' skills to be higher, the reverse is found for survey-based studies.

Do the findings depend on the digital skill measure used? There is no discernible pattern by gender in terms of the areas of skill measured (e.g. functional, informational, social). However, eight of the studies use a self-report measure not of knowledge or ability but of confidence (or self-efficacy, shown with an asterisk in Table 7): these all show boys to have higher skills than girls. For example, in study 86, boys scored themselves significantly higher than girls on half of the measures of digital self-efficacy. Again, for study 108, boys particularly score higher in the area of self-perceived software skills. This raises serious concerns regarding the possibility of self-report biases in the measures used in this field, for these have been shown to be greater for expressions of confidence than of competence (van Deursen & Helsper, 2018).

If we remove these eight studies, the self-report studies show the following results: girls have higher skills (five studies), boys have higher skills (two studies), no difference (seven studies), and mixed findings (three studies). This suggests that that, overall, there is no consistent gender difference in digital skills, and certainly not one that favours boys.

Some of the more detailed findings suggest that gender differences depend on the type of skills:

- Study 2 finds that "girls are particularly better at delivering digital information in a socially acceptable way, delivering digital information where the content is understandable for the receiver, delivering information using a non-structured format, reacting on a forum, assessing and judging the relevance of information, and sending emails to more known persons" (p.22).
- Study 13 finds that the relation between "the computer self-concept" (or efficacy) and basic computer skills is mediated by an interest in computers for boys but not for girls (p.10).
- Study 32 finds that boys did better on programming tasks than did girls.
- Study 45 complicates the question of whether boys or girls are more digitally skilled by using confirmatory factor analysis to show that the relationships among the dimensions of digital skills differ by gender. In other words, there is no single phenomenon, digital skills, of which one may have more or less. The study showed that boys and girls understand the constructs measured in a similar way, but they differ in their integration of types of digital skills; hence "teachers should attempt to understand how this difference is generated and adopt fundamentally different strategies to assess and promote ICT literacy for students of different genders" (p.85).

Are study findings the same across countries? Of the nine studies that found girls to have more digital skills than boys, four were conducted in Flanders (Belgium) and two in the USA; the others were from Europe. There is no clear pattern for positive, negative or null results by country. Since six of the seven studies conducted in upper-middle-income countries found no gender differences in digital skills, it certainly cannot be that wealthier countries have fewer gender inequalities.

Study 89 is a meta-analysis of the findings from performance tests reported in 23 empirical studies of gender and ICT literacy. This shows, among other things that, notwithstanding considerable variation across studies:

- Gender differences (favouring girls) are larger in primary than secondary school; however, they are small overall.
- Gender differences are found to be smaller when performance tests are used, compared with self-report surveys.
- "Considering that the extant literature reports considerable variation of gender effects across domains (Voyer & Voyer, 2014), we suspect that the existence of gender differences may be domain-specific or specific to certain assessment domains" (p.214).
- "Recent research has shown that, within the ICT literacy framework, boys and girls tend to score differently in different competence areas. For instance, girls were identified to outperform boys on scales related to using learning-related software and tools (e.g. word processing, spreadsheets, presentation software, image processing, and measures related to communication, social networking, and security issues). While boys performed significantly better than girls on scales that required more technical knowledge (e.g. basic operations, information networks, programming, and database operations" (p.215).

Table 7.	STUDIES COVERING THE RELATIONSHIP BETWEEN GENDER AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
2	2015	Belgium (Flanders)	11–12	Test	Yes	Positive
3	2015	Belgium (Flanders)	10–13	Test	Yes	Positive
9	2016	Romania	9–16	Self-report	Yes	Negative
12	2018	Brazil	9–17	Self-report	No	
13	2015	Germany	14–17	Test and self-report	Yes	Negative
16	2018	Turkey	14–20	Self-report*	Yes	Negative
17	2013	Brazil	12–18	Self-report	No	
18	2020	Australia	13–16	Self-report	Yes	Positive
21	2012	Romania, Bulgaria	9–16	Self-report	No	
22	2018	USA	12	Test	Yes	Positive
24	2011	Italy	15–20	Test	Yes	Negative
26	2017	Norway	14–15	Test	Yes	Positive
27	2013	UK	Over 14	Self-report*	Yes	Negative
28	2013	USA	13	Test and self-report	No	
32	2019	Finland	15–22	Test and self-report	Yes	Negative
33	2018	Finland	13–15	Test	Yes	Negative
39	2014	Republic of Korea	10–12	Self-report*	Yes	Negative
44	2011	Hong Kong	16–18	Test	No	
45	2015	Hong Kong	9–16	Self-report	Yes	Complex
48	2010	China	14–17	Test	No	
50	2010	UK	10–17	Self-report	No	
51	2013	25 EU countries	9–16	Self-report	No	
57	2010	Spain	11–18	Self-report	Yes	Mixed
60	2013	USA	11–18	Self-report	Yes	Positive
66	2019	Sweden	16–19	Test and self-report	No	
67	2015	USA	12–17	Self-report	Yes	Mixed
73	2019	Italy, Portugal	9–17	Self-report*	Yes	Negative
76	2017	21 EU countries	14	Test	Yes	Positive
77	2018	Fiji, Samoa, Tonga, Vanuatu	17–19	Self-report	No	
78	2013	USA (Florida)	11–13	Test	Yes	Positive
85	2019	Switzerland	14	Self-report*	Yes	Negative
86	2019	Germany	14–18	Self-report*	Yes	Negative
89	2019	N/A – meta-analysis	All school age	Test	Yes	Positive
91	2019	Turkey	13–17	Self-report	No	
94	2012	Germany	10–15	Self-report*	Yes	Negative
97	2011	Belgium (Flanders)	13, 15, 18	Self-report	Yes	Positive
98	2015	Belgium (Flanders)	10–16	Self-report	Yes	Positive
99	2010	Belgium (Flanders)	15–19	Self-report	Yes	Negative
103	2012	USA	11–13	Self-report	Yes	Positive
108	2018	China	11–19	Self-report*	Yes	Negative

Note: A positive direction means girls have higher digital skills than boys.

Ethnicity

Seven studies, mostly from higher-income countries but one from an upper-middle-income country, investigated the role of ethnicity. Some of the researchers framed their interest in the digital divide literature (studies 67, 78), and hence ethnicity was noted as a potential sociodemographic influence on digital skills, or else previous national studies that had noted the influence of immigrant status were cited to justify its inclusion (study 25). Sometimes it seems that ethnicity is just a standard item to check along with many others (studies 17, 60, 66).

Ethnicity was most commonly measured in terms of not being white, although the Brazilian study used brown as the reference group. An experimental study specifically compared white, black, Latino and Native American children with disabilities. But two studies defined ethnicity in term of being an immigrant and measured whether or not the native language was spoken at home – meaning the immigrant could be white.

- Three studies using a mixture of self-reports and performance tests of skills did indeed find that white/non-immigrant children were more successful. Two (studies 17, 25) found this in surveys measuring digital skills in general. In the other (study 78) white children were more successful in all five skills that were tested: related to technology operations and concepts, constructing and demonstrating knowledge, communication and collaboration, independent learning, and digital citizenship.
- In one study (66) there were no differences in terms of the skills of assessing whether online information was news or adverts, except that the white children could do this better in relation to one online newspaper.
- However, three studies, admittedly based on self-reports rather than tests, found that it was actually minority ethnic children who sometimes possessed more digital skills. One study (59) showed that they expressed greater concern about the credibility of online information. In the second study (67), minority ethnic children had more of some digital skills when using a mobile phone: social entertainment-based skills related to using a mobile phone for instant messaging, games, and social network access. But there were no differences in relation to other content creation skills (using/installing applications, recording video, and sending/receiving video). In the third study (104), involving a technology training intervention, Native American and Latino teenagers with disabilities improved their skills compared to white and African American teenagers.

Table 8. STUDIES COVERING THE RELATIONSHIP BETWEEN ETHNICITY AND DIGITAL SKILLS

Ref	Year	Country	Age range	Skill measure	Measure	Sig.	Direction
17	2013	Brazil	12–18	Self-report	White	Yes[64]	Positive
25	2015	Norway	14–15	Test and self-report	Language	Yes[65]	Positive
60	2013	USA	11–18	Self-report	White	Yes[66]	Negative
66	2019	Sweden	16–19	Test and self-report	Language	Mostly No[67]	
67	2015	USA	12–17	Self-report	White	Yes[68]	Negative
78	2013	USA	11–13	Test	White	Yes[69]	Positive
104	2018	USA	14–18	Self-report	White	Yes[70]	Negative

[64] Brown was the reference group compared to white, yellow and black. Being white was associated with more digital skills.
[65] "Language integration in the home." If children spoke Norwegian at home, this correlated with higher digital skills.
[66] White vs. minorities. Concern about the credibility of online information.
[67] Not speaking Swedish at home. Skills in assessing whether online information was news or adverts.
[68] White vs. non-white. Social entertainment and content creation skills.
[69] White vs. non-white. Skills relating to technology operations and concepts, constructing and demonstrating knowledge, communication and collaboration, independent learning, and digital citizenship
[70] Comparing white, black, Latino and Native American students with disabilities with regard to their perception of competency in relation to different computer programs.

Mental or physical health problems

Four studies, all from higher-income countries, looked at diverse mental and physical health problems, covering general physical heath, psychopathological symptoms and learning disabilities. All of the studies used self-report measures of skills.

The diversity of research interest in this field is illustrated by looking at the background to the studies reviewed here in a little more detail. Study 27 is sociological, looking at social exclusion, where alongside economic, cultural and social factors, "personal resources" can be important – and one example was health problems. Study 104 draws on the psychological literature on how psychopathological factors can contribute to internet addiction, and here, digital literacy was considered a possible mediating factor. Studies 105 and 106, from the same lead author, focus on the learning difficulties literature, with a wider digital divide framework. The earlier of the two studies considered the implications for digital access and competency; the later one focused on digital skills but tried to locate learning difficulties within a more complex model of interacting factors.[71]

- Study 27 found that general health was not significantly related to most skills but related marginally to creative skills, as internet users without a health problem or disability indicated having a higher level of creative skills than those with a health problem.
- Study 101 found that psychopathological symptoms correlated with a decrease in online self-regulation (conceptualised in this study as a dimension of internet literacy), where self-regulation is the mediator between these mental problems and internet addiction. The fact that that there were more adults than children in this research may have influenced the results (ages 14–29).
- The two learning disability studies (105, 106) found that children with learning disabilities rated themselves worse on a variety of measures of digital literacy compared to children without learning disabilities.

Table 9.	STUDIES COVERING THE RELATIONSHIP BETWEEN MENTAL OR PHYSICAL HEALTH PROBLEMS AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Problems**	**Sig.**	**Direction**
27	2013	UK	Over 14	Self-report	Physical health	Mostly no[72]	
101	2015	Germany	14–29	Self-report	Mental problems	Yes[73]	Negative
105	2018	Taiwan	12–14	Self-report	Learning disability	Yes[74]	Negative
106	2014	Taiwan	9–12	Self-report	Learning disability	Yes[75]	Negative

Personality type

Three studies, all from higher-income countries, examined whether personality traits had an influence on digital skills, although there was a great variation in what personality traits were considered. For example, study 14 notes how the personality tests used by employers and in career guidance have been shown to predict a range of other attributes, including problem-solving. Hence, this study explores whether an existing test can also be used to predict digital skills. Study 55 comes from the identity formation literature, where personality types are conceptualised as identity statuses, based on different approaches by which young people evaluate and commit to future life paths. And study 99,

[71] For example, learning difficulties did not affect attitudes to computers, covered elsewhere in this report.
[72] Poor physical health was calculated by asking participants: "Do you have a health problem or disability which prevents you from doing everyday tasks at home, work or school or elsewhere?"
[73] Psychopathological symptoms (depression, social anxiety).
[74] Learning disability and digital literacy.
[75] Learning disability and various digital skills.

ultimately interested in coping with the results of online risky activities, looks at how a range of sociological and psychological factors influence digital literacy, the latter including personality traits like self-image and risk perception. Clearly, these studies come from very different traditions and since they measure very different types of personality type, the results can only be considered individually.

- The first study (14), using performance tests to measure skills, found that those with personality traits characterised as innovative, curious, complex, conceptual, intellectual and independent abstract-sequential learners did better in two tests in the USA, the 8th Grade Technology Literacy test and 21st Century test. There was a weak positive correlation between those with personality traits characterised as sensible, judicious, traditional, organised, thorough, achievement-oriented, authoritative, concrete-sequential learners and the 21st Century test. There were some correlations between these other personality traits and particular digital skills.
- The second study (55) found that self-report digital skills were negatively associated with a "ruminative exploration" personality and positively with the other types of personality trait.
- The third study (99) found the level of self-report digital literacy shows a positive correlation with children's positive self-image/high self-confidence.

Table 10.	STUDIES COVERING THE RELATIONSHIP BETWEEN PERSONALITY TYPE AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
14	2016	USA	13–16	Test	Yes	Positive
55	2018	Finland	17–18	Self-report	Yes[76]	Positive and negative
99	2010	Belgium (Flanders)	15–19	Self-report	Yes[77]	Positive

Cognitive abilities and styles

Eight studies, all from higher-income countries, looked at the influence of cognitive abilities and styles on digital skills. All of them, using a mixture of tests and self-report digital skills, showed significant correlations.

Some researchers did not give a justification for their decision to look at particular cognitive processes (studies 1 and 3, from the same main author, looked at analytical intelligence and study 22 looked at reading) – in each case this was just one factor the researchers decided to test among others. Study 37 cited previous claims about the influence of reading on digital skills, but claimed that it was novel to test it, while study 53 did try to follow up previous research that had linked reading literacy to social networking site (SNS) use. Studies 58, 59 and 60, all from the same lead researcher, framed the main focus of the research within the literature on credibility of online material, but made a link with a different tradition looking at cognitive disposition or "thinking styles" (really, approaches to problem-solving).

- Two studies (1, 3), one with self-report and one with tested digital skills, found that higher analytical intelligence correlated with having more digital skills.

[76] Personality types (here called "identity formation") consisted of: commitment making ("I have decided on the direction I'm going to follow in my life"); identification with commitment ("My future plans give me self-confidence"); exploration in breadth ("I think actively about different directions I might take in my life"); exploration in depth ("I think about the future plans I already made"); and ruminative exploration ("I worry about what I want to do with my future").
[77] Self-image/self-confidence.

- Three studies (22, 37, 53), again, using a mixture of self-report and tested digital skills, found that reading comprehension and fluency, or reading skills generally, were predictors of the ability to evaluate online sources.
- One of the latter studies (53) also showed that working memory and vocabulary correlated with the ability to evaluate online sources.
- The three studies associated with the same lead researcher (58, 59, 60) examined children's thinking styles, using a mixture of tested and self-report skills. The main focus was on "need for cognition". In one of these studies (58), "need for cognition" correlated with greater use of analytic strategies to evaluate the credibility of online material and being less credulous of (likely to believe) online information. "Flexible thinking" and "faith in intuition" were other cognitive abilities that also predicted the use of these analytical strategies to evaluate credibility. However, that same "faith in intuition" as well as "trust in others" correlated with greater credulity. In the second study (59), need for cognition correlated with how much online material is believable and how likely children are to believe it, which could be seen as relating to discerning skills. In the third study (60), "need for cognition" correlated with children's optimism in their ability to evaluate the credibility of online information when the children compared themselves to typical internet users and to their parents.

Table 11.	STUDIES COVERING THE RELATIONSHIP BETWEEN COGNITIVE ABILITIES AND STYLES AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Abilities**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	11–12	Self-report	Analytical intelligence[78]	Yes	Positive
3	2015	Belgium (Flanders)	13	Test	Analytical intelligence	Yes	Positive
22	2018	USA	12	Test	Reading skills	Yes[79]	Positive
37	2018	Finland	12–13	Test and self-report	Reading comprehension and fluency	Yes[80]	Positive
53	2019	France	13–17	Test	Reading fluency, vocabulary and working memory	Yes[81]	Positive
58	2015	USA	11–18	Test and self-report	Need for cognition	Yes[82]	Positive and negative
59	2015	USA	11–18	Self-report	Need for cognition	Yes[83]	Positive
60	2012	USA	11–18	Self-report	Need for cognition	Yes[84]	Positive

[78] Non-verbal ability to deal with novelty and to solve problems.
[79] Reading skills correlated with evaluating the credibility of online information.
[80] Reading comprehension and reading fluency correlated with the skill of evaluating online sources.
[81] Reading fluency, vocabulary and working memory (i.e., based on a task requiring students to remember numbers and letters) correlated with evaluating online sources.
[82] "Need for cognition" covers the degree to which people engage in and enjoy thinking deeply about problems or information and, thus, are willing to exert effort on information acquisition, reasoning and problem-solving. The scale includes, "I like to do things that make me think hard", "I like to spend a lot of time and energy thinking about something" and "I like to do things where I don't have to think at all" (reverse coded). A flexible thinking scale includes "Even after I've made up my mind about something, I am always willing to consider a different opinion", "I often change what I believe when I find new information or evidence" and "I feel that thinking about other points of view is a waste of time" (reverse coded). Faith in intuition includes "I can usually feel when something is right or wrong even if I can't explain how I know", "I trust my initial or first feelings about things" and "When it comes to trusting, I can usually rely on my gut feelings". "Trust in others" was measured by "In general, would you say that most people can be trusted or not?" The dependent variables were the strategies used to evaluate the credibility of online material and the extent to which children believed online material (credulity).
[83] Need for cognition correlated with credibility of information.
[84] Need for cognition correlated with comparative optimism in their ability to evaluate the credibility of online information.

Conclusions

Age

We may intuitively expect that children's digital skills improve with age, and this expectation is supported by the data.

- In general, older children score more highly on various measures of digital skills than younger children. This finding is consistent across different countries, and across different ways of conceptualising and measuring digital skills.
- A small number of studies find a negative relationship between digital skills and age, but these findings can be explained by other features of the study design, and do not appear to reflect a general pattern.
- There is tentative evidence that the skills–age gradient flattens with age, with studies focusing on older children less likely to find a significant relationship between digital skills and age.

Gender

While the balance of findings across all studies is tipped in favour of boys having more digital skills than girls, this does not produce resounding evidence of a clear gender gap. This is because:

- Performance tests (more objective than surveys) are equivocal regarding gender differences, whereas self-report surveys more often produce evidence that boys have higher digital skills than girls.
- Studies that use a confidence rather than ability or knowledge measure are particularly likely to show boys to have more skills than girls, and may indicate that these studies are contaminated by social desirability. Alternatively, studies that measure confidence should treat the findings as indicating self-efficacy but not digital skills.
- The pattern of studies suggests that girls and boys may do better at different skills, perhaps reflecting gendered cultural expectations, although also girls' and boys' interests.
- A confirmatory factor analysis suggests that girls and boys understand digital skills similarly but combine the different types of digital skills in different ways.
- A meta-analysis suggests that girls have better digital skills than boys, particularly in primary school.

In short, much depends on the measures used, in terms of the dimensions of skills measured, how the questions are asked and whether the children are tested. Overall, we conclude that girls and boys do not consistently differ in their overall levels of digital skills. However, boys appear more confident of their digital skills, and both boys and girls can excel on particular skills.

The difference in findings between performance tests and self-report measures is likely to be a problem where social desirability effects apply, such as in relation to gender. However, arguably, the finding that boys tend to claim more digital skills than girls, even though performance tests don't substantiate this, should not lead us simply to dismiss self-report findings as biased, or boys as bragging. It surely reflects a gendered culture that boys do claim more skills than girls, and such claims may, in and of themselves, have consequences, for instance as regards boys' greater confidence or readiness to learn or in the culture of the classroom, including in how these can downgrade girls' opportunities to learn with and about technology.

Other ascribed personal attributes

- In contrast to any assumptions about ethnicity and disadvantage, the picture in relation to digital skills was mixed. Three studies did find white/non-immigrant advantage in relation to a number of skills, but when looking at very specific skills, another study found few ethnic differences and two pieces of research actually found that minority ethnic children had more skills. This still leaves open the question of why minority ethnic children should be more skilled in these particular areas – for example, in the case of the credibility of online information, do other life experiences make minority ethnic groups more critical in this respect?
- Of the few studies of mental and physical health, most found a correlation between health problems (specifically psychopathological symptoms and learning difficulties) and fewer digital skills. However, care should be taken when putting all of these under the heading of health because they reflect very diverse aspects of health studied from different frameworks.
- Several studies found that various personality traits were associated with greater digital skills. However, while it may be interesting to discover that personality type plays a role in the formation of digital skills, the actual personalities measured are so varied that it is difficult to say much more from these cumulative studies based on very different approaches from different traditions.
- There is a fair amount of research on a variety of cognitive abilities, most of which can point to some association with digital skills. The two abilities where more studies find a positive link to digital skills – analytical intelligence and need for cognition – are both related to problem-solving.

Recommendations for future research

Age

- The finding that digital skills in general improve with age is unsurprising. Although these studies covered a wide range of skills, future research could focus on how this relationship might vary depending on the nature and measure of the digital skills being evaluated.
- A useful next step could be to analyse the age at which children are most receptive to learning different types of digital skills; this could help inform curriculum development.
- There is little discussion in the literature on the mechanisms for how skills improve with age. Future research could consider evidence for and against specific channels – is it that the development of general cognitive and social skills helps children to improve their digital skills, or is it years of experience using ICT, or something else?

Gender

- A consensus is needed regarding the dimensions of digital skills so that these can be consistently examined for potential gender differences.
- Further exploration is needed of the finding that girls have better digital skills in primary school, but by secondary school the difference is smaller or absent. Is this because girls begin to fall behind with age, or boys begin to catch up, compared with their level of skill at primary school age?

- Insofar as girls and boys differ in their competence regarding particular dimensions of digital skills, research should explore whether this results from cultural (or parental or school) expectations and norms, and how such norms shape children's preferences and interests.

Other ascribed personal attributes

- Given the importance of ethnicity in other areas of life, more studies of this field would be welcome, to verify whether it creates disadvantages, or whether there are reasons why ethnicity correlates with certain specific digital skills.
- This whole area of mental and physical health deserves more attention given the growing interest in wellbeing and the fact that there are not many studies of health and digital skills. It would be useful to investigate more broadly which health issues had more and less of an influence on (which) digital skills. And in future research it would be worth making a distinction between health problems with which a child is born, which would clearly be antecedent to skills, and those that developed later, where the social context may itself influence both health and digital skills (like housing or social pressures that may affect both skills and mental health).
- If there were more studies of personality types, it may become easier to look across these studies to ascertain what elements in the different typologies of personalities are found in the studies showing a correlation with digital skills.

The cognitive abilities studies focused on these abilities being an antecedent to digital skills. But as children increasingly grow up with ICT from an early age because of easier to use interfaces (e.g. the touchscreens of tablets), that model may have to change if children are developing their digital skills and other cognitive skills at the same time.

Achieved personal attributes

To what extent (if at all) do children's personal experiences, activities and the orientations they develop – achieved attributes – influence their acquisition of digital skills? This section will review the literature exploring how children's educational attainment, approach to learning, leisure activities, personal interests, past experiences, as well as perceptions and attitudes can have a bearing on their digital skills. We conceptualised these areas in terms of children's personal attributes and achieved characteristics. In total, 17 studies were reviewed across these domains.

Educational attainment

Six studies conducted with participants aged 11–19 mostly in countries with upper and upper-middle incomes and using test and self-report methodologies measured children's educational attainment as a predictor of digital skills:

- Attainment was measured in terms of various measures of school grade (i.e., level of achievement in school subjects).
- In all cases, children scoring higher grades either reported or were shown to have higher levels of digital skills.

Table 12.	STUDIES COVERING THE RELATIONSHIP BETWEEN EDUCATIONAL ATTAINMENT AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
25	2015	Norway	14–15	Test and self-report	Yes[85]	Positive
39	2014	Republic of Korea	12–13 12–16	Test	Yes[86]	Positive
44	2011	Hong Kong	16–18	Test	Yes[87]	Positive
58	2015	USA	11–18	Test and self-report	Yes[88]	Positive
91	2019	Turkey	13–17	Self-report	Yes[89]	Positive
108	2018	China	11–19	Self-report	Yes[90]	Positive

Approaches to learning

Five studies conducted in upper-income countries with children aged 11–18 and relying on both self-report methodologies and tests looked at the relationship between children's approach to learning and digital skills. Approaches to learning were measured with respect to children's learning style, motivation, mastery orientation (i.e., the desire to learn as much as possible in school) and satisfaction with classes involving ICT use.

- All of the above-mentioned factors showed significant relationship with children's ICT self-efficacy and actual digital skills.
- Learning style was significant only when children would plan and monitor their learning process (studies 1, 3, 44), which are abilities requiring metacognition associated with digital skills.
- In study 1, "amotivation", a condition experienced by children with no sense of purpose for learning, was in turn significantly but negatively associated with digital skills, offering support for the notion that a general motivation to learn something new may also have positive impacts on children's confidence with and ability of use of digital technology. This was further supported by analyses showing that students' mastery orientation positively predicts digital competence.
- Unsurprisingly, children who reported higher levels of satisfaction with classes using ICT also reported higher levels of ICT literacy scores (study 39).

[85] Grades in Norwegian language, social sciences, science and maths.
[86] Achievement level: "Average percentage of student with normal or excellent level for three subjects including Korean language, mathematics and English in 2011 National Assessment of Educational Achievement" (p.33).
[87] "Band": Academic level of ability. A student's band was evaluated of his/her performance in three subjects (Chinese, English and maths) in Primary 5 (Grade 5) and Primary 6 (Grade 6).
[88] Academic performance was measured by participants' response to the question, "What kinds of grades do you usually get in school?" Academic performance positively predicted young people's use of more analytical strategies for evaluating the credibility of information online, but did not predict either credulity toward online information or belief in the hoax sites.
[89] For 10th, 11th and 12th grade students, educational attainment was measured based on their previous years' average success scores, for 9th grade students, on their TEOG scores of ability (Entrance to High School Exam).
[90] Grade Point Average (GPA).

Table 13.	STUDIES COVERING THE RELATIONSHIP BETWEEN APPROACHES TO LEARNING AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	11–12	Self-report	Yes[91]	Positive Negative
3	2015	Belgium (Flanders)	13	Test	Yes[92]	Positive
25	2015	Norway	14–15	Test and self-report	Yes[93]	Positive
39	2014	Republic of Korea	12–13 15–16	Test	Yes[94]	Positive
44	2011	Hong Kong	16–18	Test	Yes[95]	Positive

Leisure activities

We understand leisure activities as non-school-related activities that children engage in for pleasure, entertainment or personal satisfaction. Two studies conducted in Brazil and Serbia with children aged 11–18 and using self-report methodologies investigated their relationship with digital skills:

- The Brazilian study (17) covered a broad range of various indoor and outdoor leisure activities while the Serbian study (35) focused on reading professional magazines.
- Both studies show these activities were positive predictors of children's digital skills.

Table 13.	STUDIES COVERING THE RELATIONSHIP BETWEEN LEISURE ACTIVITIES AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
17	2013	Brazil	12–18	Self-report	Yes[96]	Positive
35	2016	Serbia	11–17	Self-report	Yes[97]	Positive

Interests and prior knowledge

Three studies, one comparing Singapore and Finland, one conducted in Sweden, and the third in the USA, using self-report and test measures with youth aged 12–19, focused on the relationship between children's personal interests and prior knowledge and digital skills.

- The first study (49) considered whether children's interest in science predicted perceived ICT competence; the second (66) examined how political party sympathies might predict digital skills in searching, evaluating and verifying social and political information online; and the

[91] Learning style: The "Control" style (studying by planning, monitoring and regulating their learning process) was correlated to digital skills but "Memorization" (repeating the material to be learned) and "Elaboration" (learning by connecting the learning subject to related areas of thinking or by finding alternative solutions) had no effect. Learning motivation: "Amotivation" (pupils have no sense of purpose or no expectation of reward of learning) had a negative association with digital skills.
[92] Learning style: As above, the "Control" style was correlated to digital skills but "Memorization" and "Elaboration" were not significantly related to pupils' ICT competences. Learning motivation: "Introjected regulation" (students' learning is driven by negative feelings of shame and guilt, or positive feelings of pride towards others) was the only factor correlated to digital skills.
[93] A "Mastery orientation" with items like "I want to learn as much as possible at school" was correlated to digital skills.
[94] The variable here is "satisfaction level of students in classes using ICT", operationalised as "Average value of four items (interests, fun, understanding of class contents and satisfaction of learning effect)".
[95] Sequential learners (who tend to perceive reality through their physical senses and think in an orderly, logical and sequentially manner) have greater digital skills than random learners (who have a strong sense of feeling and emotion and tend to think in a non-linear and emotional manner) in computer-related courses.
[96] Leisure activities were: going to the beach, going to bars and restaurants, going to the cinema, going to sports events or participating in sports activities, going to museums, going to theatres, reading newspapers, watching various programmes on TV, listening to music, using a mobile phone, using the internet, going to religious activities and reading the bible.
[97] Leisure activities in this study concerned reading professional magazines.

third (22) investigated whether prior knowledge about a topic would affect the ability to evaluate online science information.

- Interest in science positively and significantly predicted perceived ICT competence; no significant relationship was found between political party sympathies and digital skills. Knowing about a topic significantly predicted the ability to critically appraise scientific information, even though the effect was small.

Table 14.	STUDIES COVERING THE RELATIONSHIP BETWEEN INTERESTS AND PRIOR KNOWLEDGE AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
49	2019	Singapore, Finland	15	Self-report	Yes[98]	Positive
66	2019	Sweden	16–19	Test and self-report	No[99]	
22	2018	USA	12	Test	Yes[100]	Positive

Perceptions and attitudes

Five studies, all conducted in upper-income countries with children aged 11–19 and using self-report and test measures, investigated the relationship between a diverse range of children's perceptions and attitudes and their digital skills.

- One study of how much people feel in control of their lives (27) found no correlation with digital skills.
- Two studies found significant and positive relationships between children's perceptions and attitudes and their digital skills. In the first study (37), children's beliefs and prior knowledge about a commercialized item positively related to their ability to critically evaluate that item. In the second (66), if the credibility of news online was important to them, the children were more able to evaluate that news when tested.
- One study (30) found that pre-existing knowledge about a topic was, in turn, negatively related to digital skills, as believing to know an answer to a question was shown to be related to bias in online searching and evaluation of the source, thus hindering a critical appraisal of online information.
- There were mixed results for the effect of comparative optimism (59) in terms of how this affected children's concern about the credibility of online information depending on whether they compared themselves to their parents or other internet users.

[98] Interest in science.
[99] Interest is conceptualised here in terms of political party sympathies.
[100] Prior knowledge of science domains.

Table 15.	STUDIES COVERING THE RELATIONSHIP BETWEEN PERCEPTIONS AND ATTITUDES AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
27	2013	UK	Over 14	Self-report	No[101]	
30	2015	USA	11–14	Test and self-report	Yes[102]	Negative
37	2018	Finland	12–13	Test and self-report	Yes[103]	Positive
59	2015	USA	11–18	No data	Yes[104]	Positive Negative
66	2019	Sweden	16–19	Test and self-report	Yes[105]	Positive

Conclusions

- All six studies of education attainment found that the higher the academic achievement the children had in terms of grades, the greater were their digital skills.
- All five studies of approaches to learning – covering learning styles and learning motivation – found positive correlations between certain styles and motivations and the acquisition of digital skills. Conversely, and unsurprisingly, a lack of motivation was negatively correlated with digital skills.
- The two studies looking at leisure activities found that the breadth of activities, and specifically reading, found a positive correlation with digital skills. This information is relevant, as it may suggest that non-educational or non-school-related activities can promote informal learning of digital skills. For example, children who are more curious and inclined to exploration by going to the cinema, using the internet, reading books and the like, may engage in a process of recreational learning that may also promote learning digital skills.
- The two studies looking at children's interests had different results. An interest in science correlated with greater digital skills but having a political interest did not. Nevertheless, as with leisure studies, this supports the principle that aspects of children's lives outside of formal learning can potentially enhance digital skills.
- The findings from the five studies of perceptions and attitudes were mixed, which probably reflects that fact that we need to ask what these attitudes concern. One study found that whether children felt in control of their lives had no effect on skills. But two studies, and another with mixed positive and negative effects, suggested that certain perceptions and attitudes could have a bearing on particular digital skills.

Recommendations for future research

- Many of the areas covered in this section could themselves reflect other factors – for example, other studies have shown that SES affects education attainment. The same could

[101] "Internal Locus of Control" was the average agreement with "Becoming a success in life is a matter of hard work, luck has little or nothing to do with it", "What happens to me is my own doing", "Getting a good job depends mainly on being in the right place at the right time" and "Sometimes I feel that I don't have enough control over the direction my life is taking" (coding reversed).
[102] Positive testing (e.g. children believing they know an answer) related to bias in online searching and evaluation of the source.
[103]The variable here was students' prior stance (i.e., their opinions about selling energy drinks to children under 15 – negative, positive, no opinion). In the evaluation task, students with a negative stance scored highest, students with no opinion second highest, and students with a positive stance lowest.
[104] There were negative relationships between comparative optimism and (1) perceived believability of online information (when they compared themselves to internet users), and (2) concern about the credibility of online information (when they compared themselves to their parents). There was a positive relationship between comparative optimism and (1) concern about the credibility of online information (when they compared themselves to internet users) and (2) their tendency to evaluate online information analytically (also when they compared themselves to internet users).
[105] Children for whom credible news was important were more successful in evaluating news items online. Those who thought that their ability to check facts was good and who generally thought information on the internet was reliable were less likely to give the correct answers when evaluating news items.

be true of (many of) the other attributes covered here. Hence, there needs to be more research to ascertain how much these attributes have a bearing on digital skills in their own right and how much they reflect other influences.

- As is true of many factors, we can never be sure of the direction of causality (and hence, there is a general note about this in Section 7.4). For example, are digital skills an influence on the school grades that are achieved?
- Although it may seem unsurprising that better grades in traditional school subjects relate to better digital skills, more research could explore why this is the case. For example, do children with higher grades have better cognitive abilities, or do they make more effort, or are they pushed more to achieve higher grades, and which of these factors, or some combination of them, also has a bearing on their digital skills?
- A similar question can be asked of certain learning styles and motivations to learn – why do some correlate with the greater digital skills, and why do others not appear to enhance these skills? For example, why does the learning style "Elaboration" (learning by connecting the learning subject to related areas of thinking or by finding alternative solutions) not support greater digital skills?
- Some antecedents of skills may be skills in their own right: for example, children's method of evaluating an online source, framed as an antecedent of children believing in that source, involves knowing what kind of clues to look for (e.g. documented references, etc.). This is a skill per se, suggesting the multi-layered nature of digital skills. Future research may take a step back to investigate what independent variables predict children's ability to evaluate online content and believe them or not accordingly.
- Given that there were only two studies of leisure, this area deserves more attention since it illustrates how children may be learning digital skills informally, outside of school. What leisure activities are more important for digital skills and what is the mechanism, relating to leisure, by which those skills are acquired? For example, do those children who do more activities meet more peers in the course of doing so, and learn from them? Or, as technology has become more portable, do they use ICT more in the course of leisure and in that way develop skills? Or do the children who do more activities, or engage in certain activities, have a certain disposition that has a bearing on their digital skills?
- While the finding that interests can sometimes correlate with greater digital skills is important, it is less clear why some interests should be associated with those skills but others are not. More research on a broader range of interests and whether nowadays they tend to involve engaging with the digital world (e.g. researching family histories, looking up astronomical information) may help to clarify this.
- Similar questions to those raised above apply to perceptions and attitudes – while it is important to know that in principle they may have a bearing on the acquisition of digital skills, there is a question of which perceptions and attitudes have this outcome and why.

Digital personal attributes

Finally, we distinguish digital personal attributes. These look at how children's engagement with ICT and the online world may be antecedents to the development of digital skills. The studies reviewed (n=23) covered (1) attitudes to and perceptions of ICT; (2) digital self-efficacy; and (3) a few other, miscellaneous, aspects of children's digital lives.

Attitudes to and perceptions of ICT

There were 12 studies covering attitudes, perceptions and beliefs that came mainly from upper-income countries, with one study from an upper-middle-income country. While some of the studies reviewed here offer no justification for looking at attitudes, as one factor influencing digital literacy among many (studies 1, 3, same lead researcher), or mentioned that motivation or interest had been cited in previous research (studies 105, 109), it was more common to find attitudes discussed in relation to some broader theoretical framework. For example, several studies focused on (13, 28) or referred to (80) how interest in ICT has been discussed in relation to gender and digital literacy, and/or located their studies within a digital divide framework (28, 97, 105). Some come from an educational background interested in how digital skills are taught in schools (and how they could be taught better – study 85) or refer to a literature on learning models and the stages through which expertise develops (study 268).

Several studies referred to a literature on motivation (80, 87), or specifically, to writings on "interest" as an enduring disposition (13) or a dimension of cultural capital (97). One referred to "beliefs about the usefulness of technology" derived from a technology acceptance model and social cognitive theory (85). Some researchers went on to note that despite claims about the importance of these various attitudes, there is little empirical evidence relating this to digital competence (80, 85) or else the lack of evidence may reflect the fact that the motivations being discussed are too general (87[106]). Some studies asked very specific questions about perceptions reflecting their goals: study 44 looked at how children's understanding of the nature of computing affected they ability to program, while study 99 asked about children's perceptions of the internet as a safe place in order to understand their experience of online risks.

- The most common element that half the studies considered (6/12) was having an interest in computers, ICT or technology. Other studies considered more specific attitudes such as career aspirations and children's perceptions of the effects or usefulness of ICT.
- In line with expectations, nearly all the studies of general attitudes or interest (7/8) found correlations between positive attitudes to ICT and greater digital skills. Perhaps understandably, in one study (80), the perception that technology was tedious or difficult to use correlated negatively with digital skills.
- In two studies involving the same lead researcher (1, 3), the perception of the usefulness of computers was itself measured as a component of the scale for ICT attitudes, alongside interest and confidence in using computers (discussed in more detail in the next section below). Because these elements are combined, it is unclear which parts (e.g. interest vs. perception of usefulness vs. confidence) are most influential in these results.
- However, the other observation about this particular pair of studies is that when children self-report (1), there was a correlation with digital skills, but in the test (3), there was not. Given the studies were identical in other respects, this is one case suggesting that there may be different results from self-reporting and testing, where children are overconfident in describing their own digital abilities.
- Children's perceptions of the usefulness of ICT in learning had a positive correlation with self-report digital skills, as did mental models of computing (i.e., how children understood computing). But the perception of the internet as being a safe environment had no correlation with self-report skills.

[106] Which is why this particular research aims to develop a more refined motivational scale.

- Study 87 found that instrumental motives (information seeking, learning) had a positive association with digital skills, but other motivations (covering entertainment, social interaction online[107]) had a negative one.

Table 16.	STUDIES COVERING THE RELATIONSHIP BETWEEN ATTITUDES TO AND PERCEPTIONS OF ICT AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Attitudes measure**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	11–12	Self-report	Interest, perceptions and self-efficacy	Yes[108]	Positive
3	2015	Belgium (Flanders)	13	Test	Interest, perceptions and self-efficacy	No[109]	
13	2015	Germany	14–17	Test and self-report	Interest	Yes[110]	Positive
28	2013	USA	13	Test and self-report	Attitudes	Yes[111]	Positive
44	2011	Hong Kong	16–18	Test	Mental models of computing	Yes[112]	Positive
80	2019	Slovenia	11–14	Test and self-report	Career aspirations, perceptions	Yes[113]	Positive and negative
85	2019	Switzerland	14	Self-report	Beliefs	Yes[114]	Positive
87	2018	Germany	13–17	Test	Motives for using a computer	Yes[115]	Positive and negative
97	2011	Belgium (Flanders)	13, 15, 18	Self-report	Interest	Yes[116]	Positive
99	2010	Belgium (Flanders)	15–19	Self-report	Perceptions	No[117]	
105	2018	Taiwan	12–14	Self-report	Motivation and self-efficacy/confidence	Yes[118]	Positive
109	2019	China	13–17	Test	Interest	Yes[119]	Positive

[107] This is in contrast to the findings of the section on the use of social media/SNS for social communication where actual use for social communication, as opposed to motive, had a positive correlation with digital skills.
[108] ICT attitudes: Measured by questions about computer interest and confidence, and the perceived usefulness of computers.
[109] ICT attitudes: Measured by questions about computer interest and confidence, and the perceived usefulness of computers.
[110] Computer interest.
[111] Attitudes to computers.
[112] Mental models of computing: How children understood computing.
[113] ICT attitudes covered whether the children aspired to have a career in the field of technology, their interest in technology, their assessment of the tediousness of using technology, whether they think boys are more capable than girls, awareness of the effects of technology on society and perceptions of the difficulty of using technology.
[114] Children's beliefs about the usefulness of ICT in learning.
[115]Information seeking and learning and work were assigned to the instrumental motive, entertainment and escapism were assigned to the hedonic motive, and social exchange and self-presentation were assigned to the social interaction motive. There was a positive association between ICT literacy and instrumental motives and a negative one with the hedonic and social interaction motive.
[116] Computer attitude was measured by "I am very interested in working with computers", "I like to know a lot about computers", "I like to talk about computers with other people" and "I feel at ease when I use a computer".
[117] Perception of the internet as a safe environment.
[118] ICT attitude was measured by questions about motivation and confidence.
[119] Interest in ICT.

Digital self-efficacy

Ten studies investigated whether children's self-efficacy, their confidence in their own skills, affected their actual level of digital skill (although see the note above that confidence was also an element of attitude in two further studies not included in this section). Most did this by comparing self-efficacy with results from performance tests. A number of the studies reviewed simply included self-efficacy as one factor among others to be checked (e.g. 1, 3, 59, 21, 105), or else noted previous research relating self-efficacy to actual digital skills (109). One study reviewing the digital literacy literature wanted to check this precisely because of the potential discrepancy between the two. As with attitudes to, specifically am interest in, ICT, sometimes the focus on self-efficacy related to studies of gender differences (13, 28). The majority of studies were in upper-income countries, but three upper-middle income countries were covered.

- For the most part, children's confidence in their abilities was indeed reflected in their actual skills: nearly three-quarters (7/10) reported a positive correlation, both in relation to tested skills and self-report skills, where separate questions were asked about general confidence.
- However, two studies, both using a mix of tested and self-report skills, found no, or mostly no, correlations with digital skills.

Table 17. STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SELF-EFFICACY AND DIGITAL SKILLS

Ref	Year	Country	Age range	Skill measure	Sig.	Direction
1	2014	Belgium (Flanders)	11–12	Self-report	Yes[120]	Positive
3	2015	Belgium (Flanders)	13	Test and self-report	Yes[121]	Positive
13	2015	Germany	14–17	Test and self-report	Yes[122]	Positive
21	2012	Romania, Bulgaria	9–16	Self-report	Yes[123]	Positive
28	2013	USA	13	Test and self-report	Yes[124]	Positive
59	2015	USA	11–18	Self-report	Yes[125]	Positive
66	2019	Sweden	16–19	Test and self-report	Mostly no[126]	
74	2018	Israel	13	Test and self-report	No	
105	2018	Taiwan	12–14	Self-report	Yes[127]	Positive
109	2019	China	13–17	Test and self-report	Yes	Positive

Other digital personal attributes

Finally, there were three studies of other digital personal attributes, one in an upper-income country and two in upper-middle-income countries.

- Information literacy, which focuses on skills related specifically to information, predicted self-report digital literacy more generally.

[120] As noted earlier, ICT attitudes was measured by questions about computer interest and confidence, and the perceived usefulness of computers. The question about general "confidence" was separate from the specific questions that measured self-efficacy.
[121] Self-efficacy we also tested as a separate element as well as being part of computer attitudes.
[122] The researchers focus on "self-concept" as a more general self-evaluation of digital skills, preferring to refer to self-efficacy as evaluation of one's ability to do specific tasks.
[123] Digital skills were measured by one set of questions ("Can you do x?"); digital efficacy was measured by another set of questions ("How true is this of you?").
[124] Six digital skills all positively correlated with self-efficacy.
[125] This measured children's optimism about their digital skills when they compared themselves to typical internet users, as well as to their parents.
[126] Several digital skills were checked (e.g. finding information, fact checking, rating reliability).
[127] As noted earlier, ICT attitudes was measured by questions about motivation and general confidence in using computers, the latter looking similar to digital self-efficacy, although it was separate from the questions measuring digital self-efficacy.

- Another set of skills – smartphone skills – was also associated with more general self-reported digital skills.
- However, ICT-related social engagement, which referred to talking about ICT with friends, did not correlate with digital skills, either self-reported or tested.

Table 18.		STUDIES COVERING THE RELATIONSHIP BETWEEN OTHER DIGITAL PERSONAL ATTRIBUTES AND DIGITAL SKILLS				
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
Information literacy						
91	2019	Turkey	13–17	Self-report	Yes[128]	Positive
Smartphone skills						
9	2016	Romania	9–16	Self-report	Yes[129]	Positive
ICT-related social engagement						
13	2015	Germany	14–17	Test and self-report	No[130]	

Conclusions

- Nearly all the studies examining positive ICT attitudes found that these correlated with higher digital skills.
- Some perceptions (beliefs about the usefulness of ICT in learning and the mental model of computing) also produced positive correlations, although for other studies the findings are difficult to evaluate because perceptions are combined with other elements.
- The motivations behind (particular kinds of) computer use could also have a bearing on digital skills in positive and negative ways.
- Four-fifths of studies examining the relation between children's self-efficacy and their digital skills, mostly measured by performance tests, found a positive correlation. On the one hand, this provides some support for surveys that use children's assessment of their skills where it would be difficult (or much more expensive) to actually test those skills. On the other hand, the fact that two studies did not find this link gives rise to some reservations.

Some more specific skills (information literacy, smartphone skills) also predicted wider digital skills.

Recommendations for future research

- Although it is perhaps unsurprising that positive ICT attitudes are correlated with higher digital skills, only one study (97) asked how much those attitudes are themselves influenced by SES, such that attitudes are a mediating variable. More research into this relationship would help to disentangle whether it is positive attitudes that cause children to improve their skills, or whether it is other factors in children's environments that affect both attitudes and skills.
- Although self-efficacy, that feeling of confidence in digital abilities, may in itself contribute to the development of skills, it may be influenced by a variety of other factors, as shown in the path analysis in study 21. More studies that take these other factors into account would be welcome to evaluate the link between self-efficacy and skills.

[128] Information literacy means "an individual's ability of understanding their own information requirements, evaluating information quality, accessing, exploring and utilizing information efficiently".
[129] Smartphone skills in relation to internet skills
[130] ICT-related social engagement: "I like to talk to my friends about the current progress on computers".

- Most studies on these topics come from upper-income countries. However, it is not clear whether their findings can translate to other contexts, especially considering that attitudes and self-efficacy may be affected by culture. More research on these questions in a broader set of countries would be welcome.

5.6.2 Social context

Socioeconomic status

Families with children are usually early and enthusiastic adopters of the latest ICT, as documented by statistics on the diffusion of digital media among households. Nonetheless, early research on children's internet use demonstrated that variations in the domestic media environment exist based on various factors that characterise the family as a cultural unit, including parents' income and education. In this section, we will review the studies that examine the household's socioeconomic status (SES).

One in five studies (21/110) in our dataset examine SES as an antecedent of children's digital skills. Thirteen studies have been conducted in one or more European countries, six studies in the USA, two in Brazil, one in China and one in Ecuador, meaning that studies from upper- and upper-middle-income countries were covered.

- Of the 21 studies, 13 found a statistically significant relation between SES and digital skills. For the most part (12 studies) the relationship is positive, meaning that higher SES is associated with more digital skills. In one study, conversely, the relationship between SES and skills is negative. Moreover, 8 studies found no relationship between the household's SES and children's digital skills.

The resulting picture is mixed, and neither the methods of the study, nor the ways SES have been operationalised, nor the type of digital skills measured can fully explain variations across the studies. However, a few patterns can be observed, and some surprising findings emerge:

- SES was mostly operationalised as the highest educational level of the child's mother, or of both parents. Other measures included the household's income or the occupation of the main income earner. Three studies employed alternative proxies for SES – namely, the child's eligibility for free or reduced-price lunch or the number of books available at home as a measure of cultural capital. Generally speaking, SES measured by parents' education is statistically significant and positively associated with digital skills, while studies using income as the measure of SES generate mixed results. Interestingly, studies that adopt both education and income find a positive association between education and digital skills, but do not find any impact of income (see study 27, for example).
- Some studies that examine the association of SES with specific types of skills show that parents' education positively correlates with operational skills, but not with informational skills. This may sound counterintuitive and deserves further research.
- Some studies find only an indirect influence of SES on digital skills, mediated by access: children from different socioeconomic backgrounds but with similar access conditions do not differ in digital skills. This finding suggests that access is the determining factor and that parents' socioeconomic background is no longer a key mediator of children's digital skills.

Table 19.	STUDIES COVERING THE RELATIONSHIP BETWEEN SOCIOECONOMIC STATUS AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**SES measure**	**Sig.**	**Direction**
2	2015	Belgium (Flanders)	10 to 13	Test	Mother's education	Yes[131]	Positive
3	2015	Belgium (Flanders)	13	Test	Mother's education	Yes[132]	Positive
9	2016	Romania	9 to 16	Self-report	Parents' education	Yes[133]	Positive
12	2018	Brazil	9 to 17	Self-report	Parents' education	Yes[134]	Positive
17	2013	Brazil	12 to 18	Self-report	Parents' education	No[135]	
21	2012	Romania, Bulgaria	9 to 16	Self-report	Highest education in household	No[136]	
22	2018	USA	12	Test	Free or reduced-price lunch	No[137]	
24	2011	Italy	15 to 20	Test	Parents' education	Yes[138]	Positive
25	2015	Norway	14 to 15	Test & self-report	Number of books at home	Yes[139]	Positive
27	2013	UK	over 14	Self-report	Income and occupation of chief income earner	No[140]	
28	2013	USA	13	Test & self-report	School-level SES	No[141]	
50	2010	UK	10 to 17	Self-report	Household SES	Yes[142]	Positive
54	2011	Romania	7 to 19	Test & self-report	Household's income	No[143]	
58	2015	USA	11 to 18	Test & self-report	Household's income	Yes[144]	Negative
60[145]	2012	USA	11 to 18	Self-report	Household's income	Yes[146]	Positive

[131] The higher educational attainment of the mother is associated with more advanced technical, informational and communication skills.
[132] Children of higher educated mothers have greater information-processing and communication skills.
[133] Parents' highest education predicts smartphone skills.
[134] Parents' educational level.
[135] Mother's and father's education are not associated with children's digital skills.
[136] SES has an indirect influence on skills, but a direct influence on parental support, number of devices and the child's online experience (years online).
[137] Free or reduced-price lunch (FRPL) as a proxy measure of SES.
[138] The educational background of children (measured through both mother's and father's highest level of education) is influential on operational skills and theoretical skills. It has no effect on information navigation skills.
[139] Cultural capital (measured using Bourdieu & Thompson's measure of cultural capital asking about the number of books at home) is used as a proxy for SES. Student's cultural capital is a positive predictor of digital skills.
[140] The standard ACORN classification unit based on income and occupation of the chief income earner was found to be not statistically significant. Conversely, education was positively associated to all indicators of digital skills and self-efficacy.
[141] SES was only included in the last model to further test the gender significance for "ethics, safety and acceptable use". It was not significant.
[142] SES has an indirect effect on digital skills acquisition, mediated by access.
[143] Income was not statistically significant.
[144] Income was significantly but negatively related to information evaluation skills. SES did not influence young people's credulity about fake news.
[145] Study 58 and 60 draw on the same survey data, but present different analysis.
[146] Income was positively related to credibility beliefs: children from higher SES are more likely to believe that online information is reliable.

67	2015	USA	12 to 17	Self-report	Parents' income and education	No[147]	
78	2013	USA (Florida)	11 to 13	Test	Free or reduced-price lunch	Yes[148]	Positive
96	2017	Ecuador	16 to 18	Self-report	Parents' income and education	Yes[149]	Positive
97	2011	Belgium (Flanders)	13,15,18	Self-report	Parents' occupation	Yes[150]	Positive
99	2010	Belgium (Flanders)	15 to 19	Self-report	Parents' SES	No[151]	
108	2018	China	11 to 19	Self-report	Parents' education	Yes[152]	Positive

Parental mediation and digital skills

As Livingstone (2007) explains, media use in the domestic environment is defined both materially – the range and number of digital media available to children – and symbolically – whether children's access is unrestricted or regulated, whether technologies are praised for their educational, social, entertainment value or, conversely, feared as a threat to children's wellbeing, etc. Therefore, parental mediation practices – in which parents' attitudes towards technologies are materialised, taking the form of explicit norms or more informal conventions – are considered a key factor, for these practices shape children's access to and experience of the internet, including their digital skills

Fourteen studies examine the influence of parental mediation on children's acquisition of digital skills. These studies, covering the whole age range 7–19, have been mainly conducted across Europe (10/14), covering both upper- and upper-medium-income countries.

- Six studies find a positive correlation between parental mediation and children's digital skills; three find a negative association; and five report no significant relationship between parental mediation practices and digital skills. The findings are only apparently contrasting. In fact, the association between digital skills is positive when focusing on enabling parental mediation strategies. Parents' active support of children's internet use – in the forms of co-use, talk, etc. – positively predicts higher levels of digital skills. Conversely, studies that consider only restrictive mediation – rules aimed at limiting the time spent online or prohibiting certain online activities – show a negative correlation between restrictions and digital skills.
- Still, 5 out of 14 studies – also including a study based on performance test – did not find any statistically significant association between parents' active support of internet use and digital skills. Moreover, one performance test study (3) considered both active mediation and parental restrictions, without finding any significant relation. Among these studies, some also consider peer support, which is found to be positively associated with digital skills. As a further explanation, we might look at the age of the child, since parental mediation is usually higher and more influential when children are younger. However, two of these five studies cover the pre-adolescence age range, while the remaining three also include adolescents up to the age of 19.

[147] Parents' income and parents' education.
[148] SES – measured by eligibility for free/reduced price lunch – is positively related both to all 5 dimensions of skills and to each individual skill dimension.
[149] Level of education and family income influence digital skills both directly, and indirectly (mediated by access).
[150] Parents' occupation has a (small) influence on digital skills.
[151] Parents' SES.
[152] High mother's education and high father's education both correlated with more skills.

- Some studies also show how parental support is influenced by other factors, including parents' education, age and own ICT use, thus making other parent-related variables important.

Table 20.	STUDIES COVERING THE RELATIONSHIP BETWEEN PARENTAL MEDIATION AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Parental mediation**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	10–14	Self-report	Enabling	No[153]	
3	2015	Belgium (Flanders)	10–13	Test	Enabling	No[154]	
12	2018	Brazil	9–17	Self-report	Enabling	Yes[155]	Positive
19	2012	UK	12, 14, 17–19	Self-report	Enabling	No[156]	
21	2012	Romania, Bulgaria	9–16	Self-report	Enabling	Yes[157]	Positive
29	2012	Taiwan	15–18	Self-report	Enabling	Yes[158]	Positive
51	2013	25 EU countries, (EU Kids Online)	9–16	Self-report	Restrictive	Yes[159]	Negative
54	2011	Romania	7–19	Test and self-report	Restrictive	Yes[160]	Negative
60	2013	USA	11–18	Self-report	Enabling	Yes[161]	Positive
69	2013	25 EU countries, (EU Kids Online)	11–16	Self-report	Enabling	Yes[162]	Positive
79	2018	Spain	12–18	Self-report	Restrictive	Yes[163]	Negative
82	2019	Portugal	12–17+	Self-report	Enabling	Yes[164]	Positive
99	2010	Belgium (Flanders)	15–19	Self-report	Enabling and restrictive	No[165]	
109	2019	China	13–17	Test	Enabling	No[166]	

[153] Active ICT support from parents (co-use of ICT).
[154] Parents' active ICT support and ICT rules.
[155] Co-use and active mediation are positively associated with digital skills, while restrictive mediation is negatively associated.
[156] Parental support regarding internet use is measured through three items: co-use, recommendations of online content, and help.
[157] Parental support has a positive influence on children's digital skills.
[158] Perceived family support is positively associated with both basic and advanced digital self-efficacy (which, in turn, shapes use).
[159] Restrictive parental mediation is correlated with less digital skills (measured through three items: knowing how to change privacy settings on SNSs, blocking messages from unwanted people, and finding information on how to use the internet safely).
[160] Rules limiting computer use lead to lower computer skills.
[161] Discussing internet use with parents is associated with greater concern for the credibility of online information, as well as with thinking about credibility more frequently.
[162] Parental mediation predicts digital skills: children of restrictive parents are less skilled than children of parents who engage in active parental mediation.
[163] Restrictive parental mediation negatively predicts digital skills. Active parental mediation has no relationship with digital skills.
[164] Parental support positively predicts computer literacy, internet literacy and information literacy.
[165] Parental mediation – operationalised as counselling intervention (showing how to find interesting websites, teaching how to use the internet, pointing out existing online risks) and controlling intervention (limiting the length of time, checking the websites visited, and actively supervising children while they are using the computer) – has no significant relationship with digital skills.
[166] Enabling mediation does not influence digital skills.

Other parental variables and digital skills

Eight studies from upper- and upper-middle-income countries analysed other parent variables as antecedents of digital skills measured both through self-report measures of skills (5/8) and performance tests (4/8).

- Seven studies find a positive association between other variables related to parents and digital skills, including parents' attitudes towards ICT (three studies), parents' use of the internet and other ICTs (two studies), parenting style (one study), language integration at home (one study), and availability of books at home (one study). The age of parents (study 21) has no direct influence on children's digital skills, but shapes the extent of parental support.

Table 21.		STUDIES COVERING THE RELATIONSHIP BETWEEN OTHER PARENTS' VARIABLES AND DIGITAL SKILLS					
Ref	**Year**	**Age range**	**Country**	**Skill measure**	**Parents-related measures**	**Sig.**	**Direction**
1	2014	10–14	Belgium (Flanders)	Self-report	Attitudes towards ICT	Yes[167]	Positive
3	2015	10–13	Belgium (Flanders)	Test	Parents' attitudes towards ICT	Yes[168]	Positive
17	2013	12–18	Brazil	Self-report	Number of books at home	Yes[169]	Positive
21	2012	9–16	Romania, Bulgaria	Self-report	Age of parents	No[170]	
25	2015	14–15	Norway	Test and self-report	Language integration at home	Yes[171]	Positive
42	2016	10–12	Greece	Self-report	Parenting style	Yes[172]	Positive
107	2020	9–15	China	Test	Parents' internet use	Yes[173]	Positive
109	2019	13–17	China	Test	Parents' attitudes and use of ICT	Yes[174]	Positive

[167] Parents' belief that learning to use ICT is useful for their child and will result in educational, social and economic opportunities.
[168] Parents' attitudes towards ICT, measured as their belief in the usefulness of digital skills (as in study 1).
[169] Availability of books at home (contrary to study 25, where the number of books is used as a proxy for SES; here the same measure suggests parents' education).
[170] Age of parents has an indirect influence on skills and a direct influence on parental support.
[171] Language integration at home.
[172] Democratic and indulgent parenting styles are associated with higher levels of internet skills compared to authoritarian parenting styles.
[173] "Active internet user" parents is correlated with all dimensions of information literacy except ethics and law (for which there is no significant association).
[174] Parents' interest in and usage of ICT predicts children's digital skills, while parents' self-efficacy does not.

Educational social context

The 28 studies concerning the educational social context refer to a plethora of variables ranging from teachers' attributes about and familiarity with ICT, to students' experience in school, as well as systemic school variables such as policies, technological supplies, curriculum and general orientation towards ICT.

A number of studies examined education-related variables among others when looking at factors relating to digital literacy, although this often involved trying to evaluate the influence of education compared to other factors, such as the home/parents or peers (studies 1, 3, 19, 83, 109). In some cases, part of the aim seems to be to test whether influential factors found in other countries apply to the one being studied (Brazil, study 17; South Korea, study 39; China, study 109). Sometimes the focus is specifically on education, hoping to inform educational policy (study 17). Lastly, education is also one area with a number of interventions aimed at improving digital skills; hence a number of studies were evaluating these experiments (20, 64, 68, 104).

This section covers (1) various qualities associated with the teacher (4 studies); (2) student's ICT experience in schools (15 studies), the latter for the most part covering their experiences in that location; and (3) factors related to the school (9 studies). Students' ICT experience was created as a separate category in part because it was unclear whether, for example, the amount of time children spend using machines should be attributed to the teacher or the school.

Teacher variables

Educators have promoted both the development of teacher skills and attitudes and provision of equipment as being important for the development of digital skills, so here is a chance to check their assumptions.

Four studies, three from upper-income countries and one from a middle-income country, looked at various aspects of teachers' influence on children's digital skills. These were teacher satisfaction with available ICT equipment, competence in using ICT, attitudes to ICT, professional development with ICT, and teacher support for or collaborative use with children.

- Two separate studies from the same researcher (1, 3), one using self-report and the other tested digital skills, found no significant correlations with a variety of teacher attributes (teachers' ICT competence, attitudes to ICT and ICT professional development).
- One study (82), based on children's self-reported digital skills, found a positive association with teacher support for children's ICT use.
- One study (109) using performance tests of digital skills had mixed results: while teachers' ICT self-efficacy and collaborative ICT usage predict a child's information literacy, teachers' positive attitudes to ICT were actually associated with children having less information literacy.

Table 22.		STUDIES COVERING THE RELATIONSHIP BETWEEN TEACHER VARIABLES AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Teacher variables**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	11–12	Self-report	Various	No[175]	
3	2015	Belgium (Flanders)	13	Test	Various	No[176]	
82	2019	Portugal	12–17+	Self-report	Teacher support	Yes[177]	Positive
109	2019	China	13–17	Test	Self-efficacy, collaborative use, positive attitudes	Yes[178]	Positive and negative

Student ICT experience in school

Fifteen studies, eleven from upper-income countries, two from upper-middle-income countries and two from lower-middle-income countries, looked at how children's experiences at school might affect their digital skills.

- Just over half (8/15) covered whether, sometimes, how many or how much ICT was used by children at school, in one case focusing specifically on computer use.
- Of these eight, five studies (four using self-reports of digital skills, one using tests) found a positive correlation with children's digital skills.
- However, three studies (5, 66, 109 – two involving tests, one self-report digital skills) found no association with students' use of ICT at school.
- Other variables included use of ICT as information tools (positive correlation using tested digital skills), the completion of a computer course (study 40 – positive correlation using tested digital skills), the language of instruction (study 44 – positive correlation using tested skills) and whether schools provided training in the critical evaluation of sources of information (study 66 – no correlation using a mixture of tests and self-reports of digital skills).
- Four studies involved interventions, usually in the form of a course taught for a term. Two studies (64, 68) found a positive influence on digital skills, while the other two (20, 104) found no influence. The differences might reflect what was actually being taught on these courses.

[175] Teacher satisfaction with available ICT equipment, teacher competence in ICT, teachers' attitude (perceived usefulness of ICT), and teacher's professional development with ICT.
[176] Teacher satisfaction with available ICT equipment, teacher competence in ICT, teachers' attitude (perceived usefulness of ICT), and teacher's professional development with ICT.
[177] Teacher support was conceptualised as encouraging students to use the internet as a pedagogical tool to achieve better school performance.
[178] Teacher variables were teacher's ICT attitudes, ICT usage for teaching and learning, and collaborative usage of technology.

Table 23.	STUDIES COVERNG THE RELATIONSHIP BETWEEN PUPIL ICT EXPERIENCES IN SCHOOL AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Experience**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	11–12	Self-report	Lessons using computers	No[179]	
3	2015	Belgium (Flanders)	13	Test	Amount of ICT use	Yes[180]	Positive
5	2012	Austria	13–16	Test	Using a computer	No[181]	
17	2013	Brazil	12–18	Self-report	Using ICT	Yes[182]	Positive
19	2012	UK	12, 14, 17–19	Self-report	Evaluating ICT use	Yes[183]	Positive
20	2014	USA	11–13	Test	School training	No[184]	
39	2014	South Korea	12–13, 15–16	Test	Computer course	Yes[185]	Positive
44	2011	Hong Kong	16–18	Test	Language	Yes[186]	Positive
52	2017	USA	15–18	Test and self-report	School training	Yes[187]	Positive
64	2019	Ukraine	12–15	Test	School training	Yes[188]	Positive
66	2019	Sweden	16–19	Test and self-report	School training	No[189]	
68	2018	Indonesia	15–18	Self-report	School training	Yes[190]	Positive
75	2015	Australia	14–15	Self-report	Using ICT	Yes[191]	Positive
85	2019	Switzerland	14	Self-report	Using ICT	Yes[192]	Positive
104	2018	USA	14–18	Self-report	School training	No[193]	
109	2019	China	13–17	Test	Using ICT	No[194]	

School variables

School variables included the number of computers per student, the type of school (public vs. private; general education or vocational training), and the orientation of the school towards ICT (whether they had a policy or vision, whether they had an ICT coordinator or supported teachers' use of ICT).

Nine studies, conducted between high-income and some upper-middle-income countries with participants aged 11–24 and using self-report and test measures, investigated the relationship between school variables and digital skills.

- Two studies (1, 3) found no relationship between digital skills and various forms of ICT support from the school and one study (39) found that school size, location, achievement level

[179] Number of lessons in which the computer is used, and specific types of ICT use in the class.
[180] Amount of ICT used in the classroom, and ICT use as an information tool.
[181] Using the computer at school.
[182] Using ICT in school.
[183] School support items were: "the technology in your school, college, or university is very good", "you have lots of opportunity to use technology during lessons or lectures" and "you have lots of opportunity to use technology outside lessons or lectures".
[184] School training in media coverage of violence.
[185] The independent variable was completion of a computer course.
[186] Language used in teaching: Chinese or English.
[187] Provision of a 12-unit ICT literacy curriculum that was provided online, but with teachers supporting delivery through class activities.
[188] Students who enrolled in this "health-saving ICT use" intervention did significantly better on a test about healthy use of ICT.
[189] School training in the critical evaluation of sources of information.
[190] School training in blended learning
[191] Using various different ICTs in school.
[192] Using ICT in school, and whether open teaching models supported by digital technology were used.
[193] School training following the TechNow curriculum.
[194] Using ICT in school.

of the school and number of computers per teacher were not correlated to digital skills, although the number of computers per student had a positive correlation.

- Five studies examining various school types showed a variety of differences between levels of digital skills. The last study (99), however, did not provide the direction of effect but only reported a significant difference was present between school types.
- One study (70) found that formal education (as opposed to informal education) had no association with digital skills, although the problem is that this study actually included more adults than children (ages 15–24); their presence in the sample may have influenced the result.

Table 24.	STUDIES COVERING THE RELATIONSHIP BETWEEN SCHOOL VARIABLES AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**School variables**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	11–12	Self-report	ICT support	No[195]	
3	2015	Belgium (Flanders)	13	Test	ICT support	No[196]	
32	2019	Finland	15–22	Test and self-report	Type of school	Yes[197]	Positive
33	2018	Finland	13–15	Test	Type of school	Yes[198]	Positive
39	2014	Republic of Korea	12–13, 15–16	Test	Various	Yes[199]	Positive
57	2010	Spain	11–18	Self-report	Type of school	Yes[200]	Positive
70	2018	EU[201]	15–24	Self-report	Formal education	No[202]	
91	2019	Turkey	13–17	Self-report	Type of school	Yes[203]	N/A
99	2010	Belgium	15–19	Self-report	Type of school	Yes[204]	Positive

[195] ICT support (the technical and educational support that teachers receive in order to use technology in the classroom), having an ICT coordinator, vision and policy on ICT, and ratio of computers to pupils in the school all had no significant correlation with children's self-reported digital skills.
[196] ICT support (the technical and educational support that teachers receive in order to use technology in the classroom), having an ICT coordinator, vision and policy on ICT, and ratio of computers to pupils in the school all had no significant correlation with children's tested digital skills.
[197] General upper secondary school or vocational upper secondary school. Being a student in a general upper secondary school had a positive association with both medium- and content-related skills, while there was no significant relationship between the form of education and programming skills.
[198] Comprehensive, upper secondary general and upper secondary vocational schools. In the case of basic digital skills, all educational levels differed significantly from one another, with the comprehensive school students being the weakest and the general upper secondary school students performing the best. For advanced technical skills, the basic education students performed significantly weaker than the upper secondary level students did, and in professional ICT skills, students from the vocational institutions significantly outperformed other education level students.
[199] School size, location, achievement level of the school and number of computers per teacher were not correlated to digital skills, but number of computers per student had a positive correlation.
[200] Children attending private schools had more digital skills than children attending public ones.
[201] Data were obtained from Eurostat from the section about "youth" (yth) contained in the database "Population and social conditions".
[202] Formal education was not significantly correlated to digital skills (although informal education, such as training courses in adult education and self-learning, was correlated with digital skills).
[203] Type of school: Students of technical and vocational high school had a significant difference from other high school students except from sports high schools in terms of ICT literacy.
[204] General secondary education, technical secondary education and vocational secondary education. Teenagers in vocational training show a significantly lower digital literacy level than their peers from general education and technical education.

Other social context variables

Peer variables

Five studies investigated the role of peer variables in children's acquisition of digital skills, and all found a positive relationship. They were conducted in the USA, UK, Romania and Bulgaria, Taiwan and Serbia with children aged 9–19; four of them used self-report measures and one test.

- Peer variables were conceptualised in terms of informal teaching and learning of ICT skills between friends.
- Findings suggest that children who co-use technology with their friends and communicate with friends about technology use have a higher chance of improving their digital skills.
- Results of an intervention (15) based on a dyadic computer instructional setting show that when children from the dyad are friends, they benefit more from the opportunity to learn digital skills resulting from the activity compared to partners who are not friends.
- These findings suggest that interacting with and learning from peers and using technology together can support children's ability to use technology.

Table 25.	STUDIES COVERING THE RELATIONSHIP BETWEEN PEER VARIABLES AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
15	2014	USA	10–14	Test	Yes [205]	Positive
19	2012	UK	12–14, 17–19	Self-report	Yes [206]	Positive
21	2012	Romania, Bulgaria	9–16	Self-report	Yes [207]	Positive
29	2012	Taiwan	15–18	Self-report	Yes [208]	Positive
35	2016	Serbia	11–17	Self-report	Yes [209]	Positive

Urban–rural residence

Four studies tested the relationship between digital skills and children's urban–rural residence and school location. These studies were conducted in countries from the Global North and South with children aged 11–19, using test and self-report measures.

- While two of the studies (39, 108) found that children coming from urban areas or larger cities reported or had higher levels of digital skills compared to those coming from and attending school in rural areas and smaller cities, one (67) found no evidence of this and

[205] Students worked in pairs with their peers to learn computing skills. Those students who worked with friends benefited more from this collaboration than those working with peers who were not their friends, and showed more skills at the end of the intervention.
[206] The study investigates the role of friends, as members of a network of support, in influencing young people's online information-seeking behaviour, showing that youth with friends engaged in technology are more likely to engage in online information seeking.
[207] The study measured peers support by asking the participant child "Have your friends ever done any of these things? (a) Helped you when something is difficult to do or find on the internet? (b) Suggested ways to use the internet safely? (c) Explained why some websites are good or bad? (d) Suggested ways to behave towards other people online? (e) Helped you in the past when something has bothered you on the internet?" (p.98).
[208] Perceived peer support was measured through items such as "When my friends and I get together we enjoy doing things on the computer" (p.170).
[209] The study conceptualises communication with friends as a variable, fostering informal learning of digital skills.

in another (40), children from small and medium-sized cities scored highest, with ones from rural areas second and one from major cities third.

- These differences may be due to a different implementation of the curriculum in schools located in major cities, but may also depend on differences in SES associated with urban–rural residence.

Table 26.		STUDIES COVERING THE RELATIONSHIP BETWEEN URBAN-RURAL RESIDENCE AND DIGITAL SKILLS				
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
39	2014	Republic of Korea	10–12	Test	Yes[210]	Positive
40	2013	Republic of Korea	12–16	Test	Yes[211]	Mixed
67	2015	USA	12–17	Self-report	No[212]	
108	2018	China	11–19	Self-report	Yes[213]	Positive

Other community variables

A community project based on a computer literacy intervention study was conducted in India and Bhutan to study the learning outcomes of playground learning station with children aged 6–14 with the aim of improving children's computer literacy.

- The computer literacy program proved successful as both the experimental groups reported higher digital literacy scores after the intervention.
- Children in India progressed more; this may be due to the fact that they were longer exposed to the programme.
- The study supports the role of unstructured learning of ICT promoted by community projects.

Table 27.		STUDIES COVERING THE RELATIONSHIP BETWEEN OTHER COMMUNITY VARIABLES AND DIGITAL SKILLS				
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
61	2017	India, Bhutan	6–14	Test	Yes[214]	Positive

Conclusions

Socioeconomic status

- While overall, analysis of the relationship between household's SES and digital skills shows that the influence of the SES narrows down once children achieve similar access conditions, we should not underestimate the importance of income and education in shaping children's

[210] Children from schools located in major cities had more skills than those from small or medium-sized cities.
[211] Children from schools located in small and medium-size cities had the highest digital skill scores, followed by rural, then major cities.
[212] A dichotomous variable of urban vs. non-urban residence was used to explore the influence of social environment on children's digital skills.
[213] The study looked at the relationship between the geographic area where children live (urban vs. rural) and problematic internet use.
[214] Children's digital skills were conceptualised as the ability of children to recognise and associate some of the commonly used computer icons with their functionality.

digital skills in developing countries or under new conditions (e.g. distant learning during the COVID-19 lockdown).

Parenting variables

- As regards parental mediation, most of the studies confirm that enabling mediation positively predicts digital skills, whereas restrictive parental mediation negatively influences skills. Children whose online activities are limited by parents' restrictions develop less digital skills than children who receive encouragement, support and help from their parents. This holds especially for younger children, as parental mediation is shown to decrease as children grow up.
- Even studies that did not find any association between parental mediation and digital skills, however, show evidence of the importance of the domestic context – for example in the form of parents' own use of the internet and their attitudes towards digital technologies (e.g. see studies 1 and 3).

Educational variables

- Educational factors are often seen as antecedents to digital skills, although they may themselves be influenced by other factors – for example, SES may influence the choice of school and hence students' experiences there.
- The picture as regards various qualities of the teachers is mixed. While the positive associations (relating to teacher support of children) may be welcomed, the studies with no correlation or a negative correlation will be somewhat disappointing for those hoping that the teachers' role can be beneficial for the development of children's digital skills
- On balance, there seems to be a positive association between ICT availability in school and digital skills, although once again the very fact that in several studies no correlation was found might be disappointing for some educationalists promoting ICT use in schools.
- Single studies found that some other factors such as use of ICT as information tools, the completion of a computer course and the language of instruction had positive correlations with digital skills.
- Interventions involving teaching components on the curriculum had mixed results: two increased digital skills and two had no effect.
- Findings from the studies of school characteristics are also mixed. The strongest findings are that school type correlates with digital skills, be that in terms of private or vocational schools being associated with more skills. Of course, causality is an issue: do these schools lead to more skills or do the type of children likely to develop such skills go to particular schools?
- There is some evidence that the ratio of computers to students is correlated with children having digital skills.
- All other school characteristics, such as the orientation to ICT or location and size, do not appear to be significant. This will be disappointing for educators who try to persuade schools to do more to support ICT use.

Other social context variables

- There is strong evidence that peer-to-peer teaching and co-use of ICT with peers is associated with higher levels of digital skills, although the direction of causation is not clear.
- There is mixed evidence as to whether children living and going to school in urban areas have higher levels of digital skills than children in rural areas or small towns.
- Digital literacy interventions seem to prove effective even in low-income contexts where there might be a paucity of digital-related opportunities for youth to develop digital skills.

Recommendations for future research

Socioeconomic status

- Future research should further investigate the differential influence of household's SES on different types of skills.

Parenting variables

- Since five studies found no significant association between parental mediation and children's digital skills, more research is needed to understand under which conditions parental mediation ceases to be influential. For example, future research might explore whether this occurs when children receive ICT support at school or from their peers.

Educational variables

- Given the discussions in educational circles about how poor teacher attitudes to and competence in using ICT can be a barrier to children gaining competence, the whole area of teacher influence deserves more attention.
- In the light of those discussions, it is important to explore why some school variables, such as having coordinators, policies and supporting teachers, were actually not influential in increasing children's acquisition of digital skills. It may be the case that even well-intended policies may fail to reach their goal.
- Although it is probable that school type makes a difference, future studies could check causality by surveying the orientations and skills of children at the moment when they first go to these different types of secondary school.
- How much influence are teacher variables, students' experience in schools and school characteristics really mediating variables given that parents' choices and efforts can influence the school attended – specifically, how much is this another case where digital skills are influenced indirectly by SES (a factor not explored in these particular studies)?

Other social context variables

- Experimental research testing interventions that encourage peer-to-peer teaching of digital skills would help to confirm whether it is peer interaction that leads to improved digital skills, or vice versa. This type of research would be useful to understand whether and how peer interaction can be leveraged to improve children's digital skills.
- The geographical context children come from seems to be significant in influencing children's digital skills, and should be further investigated. In particular, in order to understand why children in rural areas have lower levels of digital skills, research that analyses other factors

– such as SES – that affect both children's living area and their digital skills would be helpful to understand how childhood digital skills may reinforce (digital) inequalities.

- Projects effective in promoting children's digital skills may pave the way towards new and more advanced interventions aimed at fostering the acquisition of skills by disadvantaged children, and as such should be implemented to bridge the gap between youth from different socioeconomic areas.

5.6.3 ICT environment

Does the ICT available to children affect the development of their digital skills? The expectation of a positive relationship – better ICT, more chance to develop and exercise digital skills – underlies research, policy and practice designed both to ameliorate the digital divide and to update the school curriculum for the 21st century.

We do not ask here why some children have more ICT available to them, although this is likely to be associated with household (and country) income, among other factors (parental education, urban/rural location, etc.) that stratify children's circumstances and result in digital inequalities.

The reviewed studies all positioned variables measuring ICT environment as potential antecedents for digital skills. They operationalised children's "ICT environment" by examining (1) measures of ICT availability (15 studies); (2) the child's frequency or amount of ICT use (14 studies); (3) their age of first use of ICTs (7 studies); and (4) the number or type of devices used by the child (3 studies). Some studies used several measures and so are included in several groupings of findings. We note that some measures, such as whether a child has a computer or internet access at home, are time-limited: as ICTs diffuse through the world, it will become ever more taken for granted that children do have such access, although it is likely that other measures will reveal persistent inequalities.

ICT availability

Fifteen studies, covering the full age range 12–17 and conducted mainly in high-income and a few upper-middle-income countries, examined the relation between ICT availability (mostly at home) and children's digital skills. Most asked whether the child had access to a computer or the internet at home, although some studies distinguished personal from shared access, among other variables. Study 67 asked whether access to the internet via the mobile phone was possible.

- Ten of the studies reported a positive correlation between ICT availability at home and the child's level of digital skills. The other five found no significant relationship. There is no obvious way to distinguish those that did or did not find a positive relationship. We conclude, based on the majority of the studies, that the more ICT is available to a child at home, the higher their digital skills.
- Not all of these studies measure or control for SES, although clearly it could be that the observed correlation between ICT availability and digital skills is due to SES as an underlying cause of both. In studies that include a measure of SES (usually level of parental education), it appears that both SES and ICT availability are independently and positively associated with digital skills (as well as SES predicting ICT availability).

Table 28.		STUDIES COVERING THE RELATIONSHIP BETWEEN ICT AVAILABILITY AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**ICT available**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	10–14	Self-report	PC and internet	No[215]	
3	2015	Belgium (Flanders)	10–13	Test	Internet	No[216]	
9	2016	Romania	9–16	Self-report	Smartphone	Yes[217]	Positive
12	2018	Brazil	11–17	Self-report	Internet	Yes[218]	Positive
17	2013	Brazil	12–18	Self-report	Media	Yes[219]	Positive
19	2012	UK	12, 14, 17–19	Self-report	Internet	No[220]	
48	2010	China	14–17	Test	PC or internet	No[221]	
50	2010	UK	12–17	Self-report	Internet	Yes[222]	Positive
51	2013	EUKO 25	9–16	Self-report	Internet	Yes[223]	Positive
54	2011	Romania	7–19	Test and self-report	PC	Yes[224]	Positive
67	2015	USA	12–17	Self-report	Smartphone	Yes[225]	Positive
75	2015	Australia	14–15	Self-report	PC	Yes[226]	Positive
96	2017	Ecuador	16–18	Self-report	PC and internet	Yes[227]	Positive
97	2011	Belgium (Flanders)	13, 15, 18	Self-report	PC	Yes[228]	Positive
105	2018	Taiwan	12–14	Self-report	PC	No[229]	

Frequency and amount of ICT use

Fourteen studies, covering the full age range of 12–17 across multiple high- and upper-middle-income countries around the world, examined the frequency and amount of a child's ICT use for its relation to digital skills. The most common measures used were frequency of computer or internet use and the amount of time spent on a computer or online, although one study (9) focused specifically on frequency of mobile use of smartphones to access the internet and another (67) looked at texts sent on a mobile.

- Although most studies (9/14) reported a positive relationship, five found no relationship. Among those that found no relationship, three used a performance test to measure digital skills.

[215] Availability of private/shared computer and internet access at home.
[216] Availability covers having no internet access at home, having internet access only through a computer that is shared by all family members, having internet access only through a private computer, and having internet access through both a private and shared computer.
[217] Owns or has a smartphone for private use (predicts smartphone skills).
[218] Internet access at home.
[219] "Availability of media" – this probably means electronics at home, not just computers or the internet.
[220] Internet access at home.
[221] Having a computer or internet access at home.
[222] Internet access at home.
[223] Two measures: (1) internet access at home; and (2) location of internet use: in the children's own bedroom, at home but not in their own bedroom, elsewhere only.
[224] Receiving a voucher to buy a home computer increased both scores on the computer test, and self-reported computer fluency.
[225] Smartphone internet access predicted both content creation-based and social entertainment-based skills.
[226] Use of computer outside of school; one option is "at home".
[227] Physical access is measured by a scale based on number of computers in the household, internet access from home and access to the internet on a mobile phone.
[228] Personal ownership of a computer.
[229] Family ownership of a computer. Positive (p=0.05) for use of Office software.

- If it is considered that performance measures are less susceptible to self-report bias, this pattern of results casts doubt on survey findings that rely on children's self-report digital skills.

Table 29.	STUDIES COVERING THE RELATIONSHIP BETWEEN FREQUENCY AND AMOUNT OF ICT USE AND DIGITAL SKILLS						
Ref.	**Year**	**Country**	**Age range**	**Skill measure**	**ICT used**	**Sig.**	**Direction**
1	2014	Belgium (Flanders)	10–14	Self-report	Smartphone internet access	Yes[230]	Positive
9	2016	Romania	10–13	Self-report	PC	Yes[231]	Positive
17	2013	Brazil	12–18	Self-report	PC	Yes[232]	Positive
18	2020	Australia	13–16	Self-report	PC	No[233]	
28	2013	USA	13	Test and self-report	Technology	No[234]	
48	2010	China	14–17	Test	PC or internet	No[235]	
51	2013	EUKO 25	9–16	Self-report	Internet	Yes[236]	Positive
57	2010	Spain	11–18	Self-report	Internet	Yes[237]	Positive
67	2015	USA	12–17	Self-report	Texts on mobile phone	Yes[238]	Positive
81	2010	Sweden	13	Self-report	PC	Yes[239]	Positive
83	2017	Norway	14–16	Test and self-report	Internet	No[240]	
85	2019	Switzerland	14	Self-report	ICT	Yes[241]	Positive
97	2011	Belgium (Flanders)	13, 15, 18	Self-report	PC	Yes[242]	Positive
109	2019	China	13–17	Test	ICT	No[243]	

Age of first use of ICT

Seven studies across continents (mainly high-income countries) asked children either how old they were when they first used ICT or for how many years they had been using ICT:

- All these studies were based on self-reported digital skills and all reported a positive association with age of first use.
- However, one study (31) had a word of caution about the uneven effect of years of use: "Subsequently it was shown that, in many countries, there is no significant difference between students who started using a computer between seven and nine years of age and the students who first used a computer at the age of ten or later. These results suggest that rather than a linear relationship, this is a situation in which the pre-school period (i.e. until seven years of age) is a 'critical' period and that the children's experience with digital technologies acquired

[230] Hours per week spent on a computer at home.
[231] Using a smartphone to access the internet daily when mobile (as opposed to non-daily) correlates with greater smartphone digital skills.
[232] Frequency of computer use at home.
[233] Average engagement with technology over the week.
[234] Frequency of computer use.
[235] Frequency of use of a computer or internet at home.
[236] Frequency and minutes per day spent online.
[237] Time spent online outside school.
[238] Number of daily texts on a mobile phone predicts both content creation-based and social entertainment-based skills.
[239] Frequency of computer use predicts computer knowledge.
[240] Frequency of internet use.
[241] The variable was "ICT use at home"; there is no further description.
[242] A scale based on frequency of computer use in the classroom, for schoolwork and for leisure.
[243] In-school and out-of-school ICT usage.

in this particular period have a more important effect on the subsequent development of their ICT competence and autonomy than experience acquired later" (p.11).

Table 30.	STUDIES COVERING THE RELATIONSHIP BETWEEN AGE OF FIRST USE OF ICT AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**ICT used**	**Sig.**	**Direction**
9	2016	Romania	9–16	Self-report	Mobile phone	Yes[244]	Positive
17	2013	Brazil	12–18	Self-report	PC	Yes[245]	Positive
21	2012	Romania, Bulgaria	9–16	Self-report	Internet	Yes[246]	Positive
31	2019	21 European countries	15	Self-report	PC	Yes[247]	Positive
50	2010	UK	12–17	Self-report	Internet	Yes[248]	Positive
60	2012	USA	11–18	Self-report	Internet	Yes[249]	Positive
67	2015	USA	12–17	Self-report	Mobile phone	Yes[250]	Positive

Diversity, number and location of devices used

Three studies examined the diversity, number and location of devices used by children aged 9–17, across Europe and the Philippines:

- All three studies found a positive relationship. Although this is a small number of studies, this suggests that the more and varied digital devices available to a child in more locations within the home, the better their digital skills.

Table 31.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIVERSITY, NUMBER AND LOCATION OF DEVICES USED AND DIGITAL SKILLS						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**ICT variable**	**Sig.**	**Direction**
11	2019	Philippines	11–25	Self-report	Diversity	Yes[251]	Positive
21	2012	Romania, Bulgaria	9–16	Self-report	Number	Yes[252]	Positive
51	2013	EUKO 25	9–16	Self-report	Location	Yes[253]	Positive

Conclusions

- Although studies operationalise children's ICT availability in different ways, we conclude that those with more or earlier or broader access to ICT have better digital skills.
- However, the evidence is more equivocal regarding the frequency of use. While it is unclear whether more frequent use results in better skills, other research shows frequency of use is associated with online opportunities (and, thereby, with online risks).

[244] Years of mobile phone use predicts smartphone skills.
[245] Years of using a computer.
[246] Number of years online.
[247] Age when first used a computer.
[248] Years online.
[249] Years online.
[250] Age of initial mobile phone adoption predicted content creation-based skills.
[251] "Diversity of connectivity" means the number of options used from personal mobile broadband, mobile data, free data, shared Wi-Fi, Wi-Fi from a private establishment, Wi-Fi from the government, and DSL.
[252] Number of devices used to access the internet.
[253] Location with the home of internet use.

- There are two reasons to question the demonstrated link between ICT availability and digital skills. First, the finding holds for most studies based on self-reported digital skills but not for those based on performance testing. Second, an obvious third cause has not been examined, namely, the possible role of SES. Although it seems plausible that children with access to more digital devices come from higher SES homes, most of these studies did not control for SES.

Recommendations for future research

- It is surprising, given the well-established relation between SES and the household ICT environment, that some studies do not measure or adequately control for SES when examining the relation between ICT environment and digital skills. We urge that future research on the antecedents of digital skills carefully attends to the possible role of SES.
- Research appears not to have considered the possibility that the aspects of a child's ICT environment, such as frequency of use or which ICTs are available, could be an outcome of their digital skills. It is a hypothesis worth testing in the future that children with better digital skills would seek out or otherwise gain access to a better ICT environment.
- The finding, for frequency and amount of ICT use, that self-report and performance tests produce different results merits further exploration. It is difficult to find an explanation for why performance measures of skills would be particularly relevant to the frequency and amount of ICT use only, unless, perhaps, it is hypothesised that children who claim they go online more are also the children who report their digital skills to be higher. Controlling for social desirability in survey-based studies is surely called for.
- As regards years of use, it is worth investigating further whether first access at certain "critical" ages is important in shaping digital skills.

5.6.4 Digital activities and experiences

Do the particular digital activities in which children participate, offline and online, help to develop their digital skills? Researchers have for some years speculated about whether activities such as gaming improve computer skills. The opposite view has also been expressed, with concerns that the large amount of time that many children spend on entertainment activities using ICTs, especially gaming and interacting on SNSs or via social media more generally, could displace time spent on learning skills. Hence, one question is whether these activities have a side effect of improving digital skills more generally,[254] or are they a distraction from developing those digital skills,[255] taking time away from more "worthwhile" activities like learning these skills?

On the other hand, we might anticipate that online activities involving an element of learning or studying might lead to more digital skills. One last question concerns how children may or may not learn from their experiences, how negative experiences online in the past relates to current digital skills. Hence, the digital activities covered in the research literature and reviewed here (n=12) were (1) gaming (offline as well as online); (2) the use of ICT (including SNSs and other social media) for social communication; (3) a small group of other learning and studying ICTs activities; and (4) previous negative online experiences.

[254] Study 5 notes the potential parallel in that leisure activities such as keeping diaries or reading novels are associated with better language skills.
[255] Noted in study 4. The fact that it is not clear which hypothesis is correct is shown by the researcher in study 4 expecting social communication to be associated with higher digital skills, whereas the team in study 5 were surprised when this occurred.

Gaming

Three studies[256] looked at whether gaming affected digital literacy, two from upper-income countries and one from an upper-middle-income country.

- Two studies found positive correlations, when each was looking at different aspects of gaming.
- In the first study, time spent playing games correlated with digital skills (from a performance test) and this was true for both practical and theoretical knowledge. Specifically playing fantasy games was associated with more theoretical knowledge.
- In a second study, time spent playing games and self-identifying as a "gamer" both predicted more self-report digital skills.
- However, the third study, also involving a performance test, found no link between a range of gaming characteristics and complex problem-solving skills.
- Overall, the picture is mixed.

Table 32.	STUDIES COVERING THE RELATIONSHIP BETWEEN GAMING AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
5	2012	Austria	13–16	Test	Yes[257]	Positive
8	2019	USA	10–14	Self-report	Yes[258]	Positive
16	2018	Turkey	14–20	Test	No[259]	

Social communication online

Five studies considered whether various types of social use of the internet were associated with digital skills. Two studies looked at the use of ICT for social communication, two covered social media use, and the last focused on the use of SNSs. Most studies were in upper-income countries, although one multi-country study included upper-middle-income countries and most studies involved performance tests of digital skills.

- Four (4/5) studies found a positive correlation, while one, the SNS study, found a negative association. Although studies focused on slightly different age ranges, together they cover the full range considered in this review.
- One question concerns which digital skills are associated with social behaviour online. In one case (study 4) we are not told this information. Study 105 found a correlation with very functional skills, as did study 5, where the correlation was with practical knowledge, but not theoretical knowledge (skills), whereas study 53 found a negative association with children's judgemental skills when assessing the reliability of sources. It might be tempting to speculate that social use enhances more basic, practical skills but is to the detriment of higher level ones, but in study 93, the children who used social media more were also more skilled at making judgements about the credibility of sources. Overall, the picture is not conclusive.

[256] A third study (105) had a category "use for leisure", but this combined gaming and listening to music. There was a significant correlation with digital skills.
[257] Time spent playing games, and playing fantasy games.
[258] Time spent playing games, and gamer identity.
[259] Time spent gaming, gaming frequency, gaming experience, perceived gaming skills, playing alone vs. playing with a team, and game genre had no correlation with complex problem-solving skills.

Table 33.		STUDIES COVERING THE RELATIONSHIP BETWEEN SOCIAL COMMUNICATION ONLINE AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Use**	**Sig.**	**Direction**
4	2016	Multiple countries[260]	16–19	Test	ICT for social communication	Yes[261]	Positive[262]
5	2012	Austria	13–16	Test	Social media	Yes	Positive[263]
53	2019	France	13–17	Test	SNSs	Yes	Negative[264]
93	2018	Germany, Austria, Switzerland, Liechtenstein	14–19	Test and self-report	Social media	Yes[265]	Positive
105	2018	Taiwan	11–14	Self-report	ICT for social communication	Yes[266]	Positive

Other activities using ICT

Four studies – three from upper-income countries, one from an upper-middle-income country – looked at whether learning and studying digital activities predicted greater digital skills.

- Programming at home (study 5) and using the internet to acquire digital skills (study 35) were associated with increased digital competence, although one study (105) found that using ICT for learning had no significant correlation.
- Counterintuitive findings from one study (39) were that time spent on the internet for purposes other than study was positively associated with digital skills and time spent on the internet for study was actually negatively associated with those skills. The researchers noted that this was an unexpected result, and while they offered no explanation, they did add some caveats: in the case of use for purposes other than study the only difference was between a basic skills score and average skills score, and in the case of use for study the effect was significant but not large.

[260] Argentina, Australia, Canada, Chile, Croatia, Czech Republic, Denmark, Germany, Hong Kong, Lithuania, Netherlands, Norway, Poland, Russia, Slovakia, Slovenia, South Korea, Switzerland, Thailand, Turkey.
[261] Use of ICT for social communication: posting comments to online profiles or blogs, uploading images or videos to an [online profile] or [online community] (e.g. Facebook or YouTube), using voice chat (e.g. Skype) to chat with friends or family online, and communicating with others using messaging or social networks (e.g. instant messaging or status updates).
[262] Use of ICT for social communication was significant in 16 out of 21 countries.
[263] Social media use was related to practical skills but not theoretical knowledge.
[264] SNS frequency of use negatively predicted both participants' ability to select the most reliable source from two conflicting sources on the same topic and their ability to cite source features when justifying their choice.
[265] Use of social media is associated with social media literacy, an instrument developed by the researchers to measure specifically skills related to social media use (e.g. where children have to think about credibility of different sources, including social media).
[266] ICT use for social interaction was associated with higher digital skills of a functional nature (word processing, presentation software skills).

Table 34.		STUDIES COVERING THE RELATIONSHIP BETWEEN OTHER ACTIVITIES USING ICT AND DIGITAL SKILLS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Activity**	**Sig.**	**Direction**
5	2012	Austria	13–16	Test	Programming at home	Yes	Positive
35	2016	Serbia	14–18	Self-report	Using the internet to acquire digital skills	Yes	Positive
39	2014	South Korea	12–13, 15–16	Test	Time online for non-study and for study	Yes[267]	Positive and Negative
105	2018	Taiwan	12–14	Self-report	ICT for learning	No	

Negative online experiences

Two studies from the USA from the same lead researcher looked at how children's own negative experiences in relation to information encountered online, or those they had heard about, affected certain digital skills.

- In one study (58), using tested and self-report skills, children who had had a bad experience with false information in the past were more likely to use analytic credibility evaluation strategies[268] and were less likely to believe online information.
- In a second study (60), a bad experience with the credibility of online sources or hearing about such experiences from others increased self-reported concern about and how often children think about credibility.

Table 35.		STUDIES COVERING THE RELATIONSHIP BETWEEN NEGATIVE ONLINE EXPERIENCES AND DIGITAL SKILLS				
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
58	2015	USA	11–18	Test and self-report	Yes[269]	Negative
60	2012	USA	11–18	Self-report	Yes[270]	Positive

Conclusions

- Two studies found that different aspects of gaming were correlated with greater digital skills, but one did not. More studies would be welcome to corroborate these findings as well as to explore the direction of causality: although it is less obvious why being digitally more skilled should lead to more game-playing, it is possible that both gaming and digital skills are jointly caused by a third factor. However, if there is some evidence that gaming has a positive effect and no evidence that it actually has a negative effect on skills this should be seen as a challenge to the view that games are a mere distraction from more serious and constructive digital activities.

[267] Log usage time for purposes other than study and log usage time for study.
[268] Analytic credibility evaluation strategies: "When you decide what information to believe on the internet, do you: (a) Give careful thought to the information? (b) Look at several things to figure out whether you should believe it or not? (c) Double-check your information to be sure you have the right facts? (d) Gather as much information as you can to help you decide? Or (e) Make decisions in a careful, well thought-out way?"
[269] "Whether they or anyone they knew had a bad experience because of false information found on the internet in the past, as well as whether they had ever heard a news report about someone who had a bad experience because of false information found on the Internet."
[270] Same as study 15.

- A clear majority of studies found that social communication online was associated with greater digital skills, although one out of the five found a negative correlation. If we consider the direction of causality, maybe digital competence does enable more easy use of social media, that is, maybe digital skills is an antecedent and not a consequence. However, like gaming, if it is the case that use of online social communication enhances digital skills, this may be seen as a challenge to some parents' views that social media use is a waste of time.
- Another question concerns the nature of the actual skills being learned through using social media – certainly that use seems to be associated with more functional digital skills, but the picture is inconclusive as regards skills involving evaluations.
- Apart from one study with counter-intuitive findings, on balance, the research showing children engaging in other digital activities related to learning (such as programming or using the internet for learning) finds a correlation with them having more digital skills.
- From the studies available it seems that bad experiences in relation to information online can have both positive and negative effects on skill development.

Recommendations for future research

- Taken together, the gaming and social communication studies suggest that simply spending time interacting in these digital worlds may increase (at least some) digital skills. Experimental research to disentangle the direction of causality would help to confirm whether this is the case. If the relationship holds up under a more careful causal analysis, one question is whether this applies to any other activities in the digital world, for example, following up a hobby or political engagement. Or does the activity require more interactivity to develop skills: would merely watching YouTube videos be less likely to develop skills, but would developing search strategies to find those videos develop broader skills?
- More research into the mechanisms explaining these relationships, and how they may vary with the specific measure of digital skills, would be welcome. For instance, when children use social media, how does this develop at least functional skills needed to interact on social networks? But in addition, how might spending time on social media inspire children to explore other ways of using ICT and the internet, and to develop other, unrelated skills, perhaps involving more evaluative skills?
- These digital activities could themselves be influenced by other personal attributes of the child and their social context – the digital activities may not necessarily be independently causing changes in digital skills.
- Only one study (8) analysed these interrelations – more research into how personal and contextual factors can influence the relationship between digital activities and skills would improve our understanding in this area.
- Only two studies consider the effects of negative online experience on digital skills, and they focus on a very specific type of experience and skill relating to the credibility of information. In future, research could explore how other types of negative online experiences, such as frustration with the workings or design of some part of the internet or experiencing unwanted peer communications, might affect children's motivation to develop further certain digital skills.

5.6.5 Country level

Country differences

Beyond the immediate social context in which children live, do macro variables have a bearing on their digital skills? The few studies reviewed here (n=2) covered national comparisons of skills by country and whether the social network platforms available in countries had a bearing on digital skills. They report results from upper- and upper-middle-income countries.

- The first study (49) involved a comparison of Singapore and Finland. It found that children in Singapore had more digital skills than children in Finland, although there was no discussion of why this difference might exist.
- The second study (51) provides information about basic country differences in reported skills and differences in skill by the social network platform most often used in different countries without further statistical analysis in terms of formal tests of significance.

Table 36.		STUDIES COVERING THE RELATIONSHIP BETWEEN COUNTRY AND DIGITAL SKILLS				
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
49	2019	Singapore, Finland	15	Self-report	Yes	Positive
51	2013	25 EU Kids Online countries	9–16	Self-report	N/A	

Conclusions

- From the few studies that considered national differences, there is some evidence of country differences in digital skills.

Recommendations for future research

- It is striking that there are so few comparisons at the national level, and studies have only looked at where digital skills differences exist at all, and, more specifically, whether the national online social network platform available was associated with variations in digital skills. Other questions may be whether cross-country differences in national adoption rates of ICT or the internet, availability of ICT-related jobs, parenting styles, or youth culture have some influence on digital skills in general – and more specifically, on the types of digital skills that children develop.

5.7 Consequences of youth digital skills

For a summary of the findings discussed in this section, see Table 38.

Table 37. CONSEQUENCES OF DIGITAL SKILLS

		Number of studies	No effect	Positive effect	Negative effect	Our assessment of the evidence
Wellbeing						
		6				Inconclusive
Learning outcomes						
		9				Inconclusive
Approach to learning and leisure						
		7				Overall positive
Offline activities						
	Civic/political engagement	3				Mixed
	Other offline opportunities	1				Inconclusive
Online activities						
		16				Overall positive
Approaches to digital technology						
	Privacy behaviours	3				Mixed
	Technical digital engagement	1				Inconclusive
	ICT use	2				Overall positive
Risk of harm						
	Online risks	14				Overall positive
	Harm from online experiences	4				Mixed
	Coping with digitally mediated risks	2				Overall positive

5.7.1 Wellbeing

It is vital to understand the long-term effects of digital skills on child outcomes. But can research identify when digital technologies are beneficial and when they are harmful to children? In a society highly mediated by the internet, it is crucial to understand what growing up in a digital world means for children now and in their future. One area of investigation that can offer such insights is children's wellbeing. Going beyond happiness, quality of life and positive psychological functioning, wellbeing incorporates how well children feel and function at both personal and social levels and how well they handle change (Dodge et al., 2012).

The relationship between digital technologies and wellbeing is complex, encompassing the possibility of both positive and negative effects on children's mental and physical health, life satisfaction or happiness. In spite of the substantial efforts over the past decades to establish whether digital technology hampers or fosters wellbeing, many questions remain, especially when it comes to the conditions that minimise the negative effects and maximise the benefits (Dienlin, 2020). So, can digital skills be the factor that tips the scales in a positive direction? It is intuitive to assume that children who have better digital skills would be in a better position to minimise the risks and optimise the benefits from internet use, thus enjoying better outcomes in the long term. But is this the case?

Our systematic review identified only six studies that address the relationship between digital skills and children's wellbeing, suggesting that this is an area that greatly lacks sufficient development. Not only are there few studies, but they also examine different aspects of wellbeing: life satisfaction, mental health, peer victimisation, cognitive wellbeing (complex problem-solving), and physical

health and body image. These different aspects and, in consequence, different measures used, make comparisons challenging. Note also that the studies are based on surveys (n=2) or interventions (n=4), but they all use self-report measures of digital skills.

Of the six studies, only two found that digital skills improve wellbeing in various ways. One of these studies (56) is an intervention and the other (23) is a survey:

- Study 56 found a positive relationship between digital skills (measured as scepticism towards the unrealistic representations in social media and critical thinking about appearance-focused social media) and body image. Better skills contributed to a more positive body image, measured in relation to general feelings about appearance, weight satisfaction, evaluations attributed to others about one's body and appearance and the influence of body weight or shape on self-evaluation.
- A lack of certain digital skills ("ethical media use", such as being respectful to others and social rules) are associated with experiences of being a victim of traditional bullying and cyberbullying, according to study 23.

In the remaining four studies, the effect on wellbeing is either negative or there is no effect:

- Using online coping behaviour (online emotional support seeking, information seeking and self-distraction) can have a negative effect on mental health by increasing experiences of loneliness, worry and jealousy (study 18, intervention).
- Study 55 found no effect of digital skills on life satisfaction, but this was marginally addressed by the study, which looked at the relationship between skills and online identity, using life satisfaction as a control variable. Study 16 found no significant relationship between cognitive wellbeing (complex problem-solving)[271] and skills (measured as gaming). Study 20 found no effect on children's aggressive behaviour (pushing and shoving other students, threatening to hit or hurt someone).

Table 38.		STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND WELLBEING					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Wellbeing measure**	**Sig.**	**Direction**
Surveys							
23	2019	Italy	14–18	Self-report	Off/online bullying victimisation and perpetration	Yes	Negative
55	2018	Finland	17–18	Self-report	Life satisfaction	No	
Interventions							
16	2018	Turkey	14–20	Self-report	Cognitive wellbeing (complex problem-solving)	No[272]	
18	2020	Australia	13–16	Self-report	Mental health – loneliness, worry and jealousy	Yes	Negative
20	2012	USA	11–13	Self-report	Mental health – aggressive behaviour	No	
56	2017	Australia	11–14	Self-report	Body image	Yes	Positive

[271] Measured via the PISA Creative Problem-Solving Test.
[272] Perceived gaming skills.

Conclusions

The reviewed wellbeing studies identified more gaps than answers about the contribution of digital skills to children's wellbeing.

- There is some indication that digital skills can have positive effects on wellbeing, for example on body image or experiences of peer victimisation.
- Still, the research evidence is very limited – there are very few studies that explore the relationship between wellbeing and digital skills. The existing studies are constrained by their narrow and specific measurement of both skills and wellbeing. The bigger picture of how skills might affect wellbeing is still to be established, and a model of the relationship between the two is currently lacking.
- The findings represent children from upper-middle-income countries only, leaving important gaps in our knowledge on how children fare in less affluent environments.
- Some studies mix children with young adults (aged 18 or over); hence we have no understanding about the relationship between child development, wellbeing and skills.

Recommendations for future research

- Future research needs to address these gaps by creating a comprehensive measurement of digital skills and wellbeing and a model of the possible relationship between the different dimensions of both. We need to understand not only the different dimensions of wellbeing and skills, but also to have a granular knowledge of the different levels (from low to high) of wellbeing and skills.
- Knowledge from other areas of children's internet use about protective factors and vulnerabilities can be applied and tested – for example, whether skills make a difference in relation to the ways online and offline violence and victimisation affect children's wellbeing, and how skills mediate the possible protective effects of social factors and online support.
- Longitudinal high-quality research will have a better explanatory power in terms of causality: does poor wellbeing trigger risky online engagement with harmful outcomes, or is harm from internet use the cause of decrease in wellbeing, and how is that relationship mediated by skills? Does having better skills lead to better wellbeing, or is better wellbeing a pre-condition of being able to acquire better digital skills?

5.7.2 Learning outcomes

One primary rationale for educating children to improve their digital skills is that this will enhance their learning outcomes. On the grounds that digital skills today are akin to reading, writing and arithmetic – the so-called fourth "R" of basic literacy – schools in many countries have sought to include the teaching of certain digital skills in the curriculum. Similarly, parents increasingly regard digital skills as beneficial for their child's schoolwork as well as for informal learning outcomes.

Although the policy and practical investment to support children's learning outcomes is considerable, making it surely expedient to support the development of digital skills if this is likely to benefit children's learning, we found only seven studies in the overall sample which directly addressed the possible relation between digital skills and learning outcomes. This suggests that the evidence base to promote digital skills for learning outcomes is lacking. The studies were conducted in diverse countries, most of them focused on children of secondary school age, and they addressed a variety of

learning outcomes, as shown in Table 40. This means that, for any particular outcome – for instance, reading ability – we found only one or two studies.

- Most studies reported a positive relationship between digital skills and children's learning outcomes. This is broadly encouraging for the many educational initiatives that seek to motivate students, and facilitate personalised learning, by deploying educational technology in the classroom.
- The exceptions were one study that found no effect of greater digital skills on reading ability (84) and one that obtained mixed results (in fact, mostly negative, suggesting that greater digital skills could undermine children's mathematical ability; study 110). This latter explains that much depends on the skills being learned, and that it is when these are both time-consuming and unrelated to the material to be learned (in this case, programming skills that have no transferable benefit for mathematics) that the negative effect is observed.
- The dimensions of digital skill investigated in the studies differed, generally being matched to the particular learning outcome of interest. For instance, study 19 found that children's ability to seek information online predicted their seeking of online information for homework (although not for more everyday life purposes).
- Relatedly, study 96 found that higher information analysis and evaluation skills benefited children's academic performance (and that these information skills, in turn, are supported by operational information skills). In other words, this study traces a learning pathway, often proposed in the research literature but less often tested, from access through operational skills to information skills and thence to creativity and improved academic grades.
- We should note that some findings are primarily correlational, despite being framed here (and by their authors) as learning outcomes. For example, study 77 finds an association between ICT competence and mobile learning readiness, suggesting that gaining proficiency in using technology prepares a child better to learn to use that technology although it is possible to reverse the direction of causality underpinning this suggestion).

Study 84 is a meta-analysis of 105 studies conducted to answer the question, does learning computer programming improve children's cognitive skills (defined broadly)? As the authors summarise, "results suggested that students who learned computer programming outperformed those who did not in programming skills and other cognitive skills, such as creative thinking, mathematical skills, metacognition, and reasoning" (p.764). Greater computer programming skills was not found to benefit reading or literacy, doubtless because, as the authors suggest, there is little relation between them.

Table 39.		STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND LEARNING OUTCOMES					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Learning outcome**	**Sig.**	**Direction**
16	2018	Turkey	14–20	Self-report	Complex problem-solving skills	No[273]	
					Academic performance	No[274]	
19	2012	UK	12, 14, 17–19	Self-report	Technical/digital abilities	Yes[275]	Positive
46	2012	Hong Kong	9–19	Self-report	Academic performance	Yes	Positive
72	2012	USA	12–18	Self-report	Awareness of media influence on teen's sexual decision-making	Yes[276]	Positive
77	2018	Fiji, Samoa, Tonga, Vanuatu	17–19	Self-report	Technical/digital abilities	Yes[277]	Positive
82	2019	Portugal	12–17+	Self-report	Academic performance	Yes	Positive
84	2019	Multiple (not listed)	All	Multiple/ meta-	Creative thinking, spatial skills, reasoning, metacognition	Yes[278]	Positive
					Reading ability/literacy	No	n/a
					Mathematical ability	Yes	Positive
96	2017	Ecuador	16–18	Self-report	Academic performance	Yes[279]	Positive
					Technical/digital abilities	Yes	Positive[280]
110	2010	Turkey	15	Self-report	Mathematical ability	Yes	Mixed/ negative

Conclusions

- Greater digital skills are linked to better learning outcomes for children.
- However, the evidence base is fairly small, and the diversity of measures used (for both digital skills and learning outcomes) means that we cannot draw strong conclusions.
- It seems likely that the benefits for learning outcomes are greater when there is a cognitive link (or underlying mechanism) between the dimensions of digital skill and the specific learning outcome under investigation.

[273] The cognitive processes in complex problem-solving skills are goal setting, establishing connections and hypothesis testing (p. 0.40).
[274] Grade Point Average (GPA).
[275] The paper includes two measures for online information seeking: (1) for everyday life (ELIS) and (2) for homework. Perceived online information-seeking ability predicts online information seeking for homework (b=0.12) but is not significant for the uptake of ELIS.
[276] The study found that students receiving the media literacy training were more able to understand the influence that media have on a teen's sexual decision-making and were more able than the control group to recognise that sexual depictions in the media are inaccurate.
[277] Mobile learning readiness is a composite of 11 questions that include both "I know how" questions about learning "using your mobile device" and others about attitudes, e.g. "I'm looking forward to engaging in mobile learning".
[278] Creative thinking, reasoning, metacognition and spatial skills were all significantly improved by programming interventions.
[279] The high degree of analysis and evaluation (A&E) skills of the information found on the internet is associated with creative use of the internet for academic use. There is an indirect effect of skills on academic use.
[280] The high level of operational internet skills (OIS) is associated with the skills of analysis and evaluation (A&E) of the information found on the internet.

Recommendations for future research

- The most obvious question for future research is to explore, and explain, which dimensions of digital skill can contribute to which learning outcomes.
- Since most studies reviewed in this section are correlational, we now greatly need longitudinal studies or interventions to explore the hypothesis that improving children's digital skills (in general, or specific dimensions) results in learning outcomes (again, whether a general effect on academic grades or a more specific effect).
- Most of the research in this section concerns secondary school students. Since children now use technology at an ever-younger age, and primary schools increasingly incorporate educational technology, future research should examine the possible learning benefits for them.

5.7.3 Approach to learning and leisure

In addition to research on the possibility of direct effects on children's learning outcomes, the review also identified seven studies concerned with the consequences of digital skills for children's approach to learning and leisure defined broadly. Conducted in a range of countries, and concentrated on children aged 9–18, all but one (103) report significant and positive effects, but of diverse kinds.

- For example, study 7 analysed PISA data collected from 15-year-olds across 42 countries to see whether greater ICT competence is linked to greater enjoyment of science, interest in broad science topics, science self-efficacy, and epistemological beliefs about science, which the findings confirmed.
- Greater computer efficacy predicted children's interest in computers (study 13) and interest in ICT-related careers (study 86).
- Study 21 reports on the result of an intervention study finding that increased levels of digital skills may promote a change in children's beliefs about media violence.
- Another intervention (study 103) aimed at promoting a relationship between digital skills and attitudes towards STEM (science, technology, engineering and maths) did not produce any significant effect between the treatment and control group.

Table 40.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND APPROACHES TO LEARNING AND LEISURE						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Effect**	**Sig.**	**Direction**
7	2019	Multiple[281]	15	Self-report	Science interest and beliefs	Yes[282]	Positive
13	2015	Germany	14–17	Test and self-report	Interest in computers	Yes[283]	Positive
20	2014	USA	11–13	Self-report	Beliefs about media violence	Yes[284]	Positive
60	2013	USA	11–18	Self-report	Beliefs about and approach to information literacy	Yes[285]	Positive
86	2019	Germany	14–18	Self-report	ICT-related careers	Yes	Positive
88	2012	South Korea	9–12	Self-report	Attitudes to online advertising	Yes[286]	Positive
103	2012	USA	11–13	Self-report	Attitudes towards STEM	No	

Conclusions

- Greater digital skills are linked to diverse consequences related to learning and leisure.
- However, the evidence base is small and lacks a systematic approach to inquiry: it is hard to discern the overall rationale for this body of work, although each study has its own rationale.

Recommendations for future research

- Taken together, these studies raise an open question: what consequences for children's attitudes, beliefs and interests should be explored, as their digital skills grow?
- Also, since digital skills are unevenly distributed within and across populations, what consequences might this have, and what research priorities should be set?

5.7.4 Offline activities

How can digital skills help children and young people not only make better use of ICT, but also participate in society more fully? This question has been a recurrent underlying theme in research on children and digital technologies. Digital divide research developed the argument that digital

[281] Australia, Austria, Belgium, Brazil, Bulgaria, Chile, Taiwan, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Peru Poland, Portugal, Russia, Singapore, Slovakia, New Zealand, Slovenia, Spain, Switzerland, Thailand, UK.
[282] The study investigated the relationships between perceived competence and autonomy in ICT use with disposition towards science in terms of enjoying science, interest in scientific topics, science self-efficacy and epistemological beliefs about science.
[283] Computer interest was treated as a mediator by which to investigate the link between computer self-concept and basic computer skills.
[284] A violence prevention media literacy curriculum called "Beyond Blame" was assessed using a quasi-experimental design that tested students before and after the curriculum was implemented.
[285] The skill refers to the evaluation method (types of sources and arguments children use to evaluate online information) that can affect children's concern about the credibility of information online and whether they believe that information. If children evaluate the information analytically (carefully considering the information, double-checking facts, gathering a lot of information and considering all views), they are more likely to be concerned about the credibility of information on the internet and less likely to believe it. If they evaluate heuristically (rely on gut feeling), they are less likely to be concerned about credibility and more likely to believe in online sources and in the overall reliability of the internet.
[286] Children's attitudes towards online advertising was measured by four five-point semantic differential scales (good–bad, beneficial–harmful, useful–not useful and informative–uninformative).

engagement translates into tangible offline outcomes. The online–offline relationship, it has been argued, provides a more comprehensive explanation of the ways in which digital and social inequalities become entrenched.

Accordingly, both the policy agenda and the academic debate have been informed by the hope that internet use could actually compensate for social inequalities and promote children's inclusion. The former espoused a vague notion of digital citizenship[287] encompassing safe and responsible use of ICT as a prerequisite for forming future responsible citizens. The latter discussed the consequences of social, political and economic change for young people's (declining) political participation, and theorised the emergence of expressive networked forms of digital engagement (Bennett, 2008; Loader, Vromen & Xenos, 2014, 2016), and a new ideal type of citizen called the networked young citizen (Bennett, 2008; Loader et al., 2014, 2016). From this perspective, the question becomes how digital participation can be conducive to offline political and civic participation, rather than simply replacing it.

Three studies explored the relationship between digital skills and offline civic/political participation, and one study examined how digital skills influence other offline activities.

Digital skills and offline civic/political engagement

Three studies, covering the age range 10–18, conducted in South Korea and the USA, examined the relation between children's digital skills and their engagement in offline civic and political activities:

- Digital skills are operationalised as multi-dimensional, consisting of (1) operational skills (basic technical skills required to use the internet); (2) mobile skills (basic technical skills applied to smartphones); (3) informational skills (critical skills related to the ability to locate and evaluate relevant information); (4) communicative skills; and (5) content creation skills.
- Civic and political participation was operationalised as (1) interest in political and/or social issues; (2) offline civic activities such as volunteering, donations and involvement in charitable organisations; (3) offline political activities such as rallies, boycotts and signature-seeking campaigns; and (4) political socialisation. Measures of offline participation therefore include both conventional and non-conventional citizenship practices, the latter believed to be more suitable for networked young citizens.
- The key finding is that the influence of digital skills on offline participation is differentiated and depends on the type of skills examined. All studies are in agreement in showing that operational skills have no effect on civic or political participation (the relation is not significant, and in study 41 the direction is even negative). Informational skills are the strongest predictors of interest in political and social issues and of engagement in offline civic and political participation. However, study 62 finds that the relationship between informational skills and offline engagement is mediated by the child's prior interest in political or social news. Communicative and content creation skills are equally found to be positively associated with offline civic and political engagement. However, if we focus on mobile phones and smartphones, social entertainment-based skills are shown to have no significant relationship with indicators of civic and political engagement.

[287] For an overview of the trajectory of the concept of digital citizenship in youth and media research and practice, see Cortesi et al. (2020).

Table 41.		STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND OFFLINE CIVIC/POLITICAL ENGAGEMENT					
Ref	**Year**	**Age range**	**Country**	**Skill measure**	**Type of skills**	**Sig.**	**Direction**
41	2016	16–17	South Korea	Self-report	Informational	Yes[288]	Positive
62	2020	13–18	South Korea	Self-report	Informational, communicative and creative skills	Yes[289]	Positive
67	2015	12–17	USA	Self-report	Operational and creative skills	Yes[290]	Positive

Digital skills and other offline opportunities

Only one study in our sample examined the relationship between digital skills and other kinds of offline opportunities. More specifically, study 102 investigated what predicts women's persistence in computer science or other technology-related university degrees.

- The findings show that skills in the area of game design and inventing applications are not significant (study 20), while programming skills positively predict the likelihood that young women would choose a degree in computer science or other technology-related degrees (study 102).

Table 42.		STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND OTHER KINDS OF ONLINE OPPORTUNITIES					
Ref	**Year**	**Age range**	**Country**	**Skill measure**	**Type of skills**	**Sig.**	**Direction**
102	2020	14–18	USA	Self-report	Programming skills	Yes[291]	Positive

Conclusions

- It is surprising, given the well-established literature associating the internet and digital media with emerging citizenship practices especially favoured by young people, that only a few studies examine the relationship between skills and offline civic and political engagement.
- All the studies find that some digital skills are associated with these different forms of offline engagement but others are not; hence it is important to specify which digital skills are being considered.

Recommendations for future research

- Given the broad interest in the offline opportunities related to internet use – especially in terms of civic and political participation – more research is needed on this topic.

[288] Information literacy skills predicted interest in both social and political issues. Internet skills literacy was not significant, and the direction of the coefficient was negative.
[289] Interest in social issues, volunteering and donations are predicted by informational, communicative and creative skills. Operational skills did not predict any engagement.
[290] Instrumental use and content creation skills predicted engagement in community volunteering, participation in a charity cause and political socialisation. Social entertainment-based skills had no influence.
[291] Programming skills are significant, while game design and apps design skills are not.

- The finding that prior interest in political and social issues mediates the effect of skills merits further exploration. Controlling for political socialisation and interest in politics in surveys is surely called for.
- Some other tangible outcomes of internet use (Helsper et al., 2015) could be tested for children and young people, including forming new friendship ties or improving pre-existing relationships with friends, and getting non-academic certificates related to one's interests and hobbies, etc.

5.7.5 Online activities

The breadth and range of digital activities has been considered an important measure of digital and, potentially, social inclusion, as the uptake of online opportunities has been found to have positive tangible outcomes at various levels – learning and education, participation, self-expression, sociality, job opportunities, etc. It may be surprising, then, that only 14 studies in our dataset (14/110) deal with digital engagement as an outcome of digital skills.

Online opportunities have been operationalised in the following ways: critical engagement; creative engagement; civic and political participation; academic collaboration; other online opportunities, including communication, and use of the internet for schoolwork; and number of activities taken up. Some studies cover different kinds of digital engagement simultaneously, while other focus only on one set of online opportunities. Below, research is grouped thematically, so that studies that cover multiple online opportunities may figure more than once.

Digital skills and digital engagement

Five studies[292] are included in this group, covering the full age range from 9–18, and countries from upper and upper-middle incomes.

- Digital skills were measured as self-reported skills in the areas of operational, information navigation, critical, communication and safety skills.
- Digital engagement was operationalised as the breadth of online activities undertaken by children, including activities that involve information, communication, participation or entertainment.
- All studies converged in finding a positive correlation between acquisition of digital skills and breadth of digital engagement.
- One exception was offered by study 83, which combined performance test and a measure of self-efficacy, and defined digital engagement as "high ICT use". Notwithstanding different measures of skills and digital engagement, the correlation remained positive.

[292] Study 27 addresses digital engagement but examines the differential effect of distinct types of skills on different kinds of engagement, so it is discussed next.

Table 43.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND DIGITAL ENGAGEMENT					
Ref	**Year**	**Age range**	**Country**	**Skill measure**	**Sig.**	**Direction**
12	2018	9–17	Brazil	Self-report	Yes[293]	Positive
21	2012	9–16	Romania, Bulgaria	Self-report	Yes[294]	Positive
50	2010	10–17	UK	Self-report	Yes[295]	Positive
79	2018	12–18	Spain	Self-report	Yes[296]	Positive
83	2017	14–16	Norway	Test and self-report	Yes[297]	Positive

Digital skills and specific types of digital engagement

Nine studies analysed the relationship between digital skills and specific types of digital engagement, one of which (27) simultaneously examined the consequences of digital skills on critical, social and creative engagement. All found a positive association between digital skills and engagement in certain online activities.

- Two studies from upper-income countries examined the relationship between digital skills and critical engagement. The first (study 27) examined engagement in a wide set of critical activities (checking facts, looking up definitions, health information, news, local event information, travel information, school or work information, topics of personal interest, distance learning), while study 63 involved just looking for health information alone. Both studies found a positive correlation between digital skills and critical engagement, but when study 27 discriminated among different kinds of self-reported digital skills, technical skills mattered more for critical engagement.
- In contrast to the emphasis on online opportunities as a means to re-engage disaffected young people that characterises many public and policies discourses, only two studies (34, 62) examined the relationship between digital skills and engagement in civic or political online activities, both from upper-income countries. That engagement covered activities such as sharing political content, participating in online discussions around social or political issues, participating in an online campaign or signing and promoting a petition. Content creation, critical and social skills were more influential. However, the effect of digital skills appeared to be moderated by other factors, namely, an interest in political news (study 62).
- One multi-country study (mostly upper income but some upper-middle income – study 6) and one UK study (upper income – study 27) examined the relationship between digital skills and communication. The key finding of the studies concerned with engagement in online communication as a consequence of digital skills was that skills positively predicted the use of the internet for social interactions. More specifically, when the effect of different digital skills was examined separately, social communication was associated with social skills. Also noteworthy in study 27 is the fact that critical skills were negatively correlated with social engagement.
- Three studies (10, 27, 96) from upper- and middle-income countries examined the role of digital skills in explaining variations in creative engagement. All found a positive correlation between digital skills and creative engagement, although the findings related to the specific effect of distinct types of skills were mixed. Study 27 found that social and creative skills

[293] Number of online activities taken up by the child.
[294] Number of online activities taken up by the child.
[295] Number of online activities taken up by the child.
[296] An 11-item aggregate, mostly relating to frequency of communication, entertainment and multimedia use.
[297] High ICT use.

predicted creative engagement while the association with critical skills was negative. Study 96, by contrast, found that informational skills, which are usually considered to be critical skills, were the most influential factor predicting children's engagement with content creation online. Beyond measurement issues, one explanation may be that the first study focused on both teenagers and adults, while the second only examined adolescents.

- Finally, two studies from upper-income countries (36, 82) investigated the online opportunities for learning, measured not in terms of learning outcomes, but in terms of using the internet for academic collaboration and/or schoolwork. Both studies found that the more skilled children were, the more likely they were to exploit social communication tools for academic collaboration, or to use the internet for school-related searches.

Table 44.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND SPECIFIC TYPES OF DIGITAL ENGAGEMENT						
Ref	**Year**	**Age range**	**Country**	**Skill measure**	**Digital engagement**	**Sig.**	**Direction**
2	2020	13–18	South Korea	Self-report	Civic	Yes[298]	Positive
3	2013	12–19	Israel	Self-report	Critical	Yes[299]	Positive
6	2017	15	Multi-country[300]	Self-report	Online communication	Yes[301]	Positive
10	2016	11–16	Romania	Self-report	Creative	Yes[302]	Positive
27	2013	Over 14	UK	Self-report	Online communication	Yes[303]	Positive
27	2013	Over 14	UK	Self-report	Critical	Yes[304]	Positive
27	2013	Over 14	UK	Self-report	Creative	Yes[305]	Positive
34	2019	11–17	USA	Self-report	Civic	Yes[306]	Positive
36	2014	14–17	USA	Self-report	Academic collaboration/ schoolwork	Yes[307]	Positive
82	2019	12–17+	Portugal	Self-report	Academic collaboration/ schoolwork	Yes[308]	Positive
96	2017	16–18	Ecuador	Self-report	Creative	Yes[309]	Positive

[298] Social issues (covering original postings or replies about social issues, re-tweets or hyperlinks about social issues, and joining online petitions) are positively associated with three components of digital skills (information usage, communication, and content creation). Technical skills showed no significant relationships with online (and offline) civic engagement.
[299] Digital skills are positively correlated with searching for health information online. But skills are not the main barrier. Other reasons such as preferences for in-person consultation, privacy and English proficiency were more important barriers.
[300] Argentina, Australia, Canada, Chile, Hong Kong, Croatia, Czech Republic, Denmark, Germany, Lithuania, Netherlands, Norway, Poland, South Korea, Russia, Slovakia, Slovenia, Switzerland, Thailand, Turkey.
[301] Both basic and advanced ICT self-efficacy predicted use of ICT for social communication.
[302] More skilled children are more likely to reach the most advanced/creative level of the ladder of opportunity. When interaction terms are held constant, however, the influence of digital skills disappears.
[303] Social engagement is positively predicted by social skills, and negatively associated with critical skills.
[304] Critical engagement is predicted by technical skills and digital self-efficacy.
[305] Social skills and creative skills are positively related to creative engagement; critical skills, instead, negatively predict creative engagement.
[306] Learning how to create and share digital media is positively correlated with online participatory politics (which covers recirculating online political content, creating and circulating original political content, commenting online about political content, and posting status updates or sending electronic messages about "a political campaign, candidate, or issue") and with targeted online political pressure (including trying to influence institutions either by signing a petition or having communicated electronically with a governmental, corporate or community institution in an effort to influence them).
[307] Information navigation skills predict Facebook class-related academic collaboration.
[308] Digital skills are positively correlated with the use of the internet for schoolwork.
[309] A high degree of informational skills is associated with creative uses of the internet. There is an indirect effect of operational skills on creative engagement.

Conclusions

- Although sometimes only a limited number of studies cover these fields, they find a correlation between digital skills and digital engagement, critical engagement and civic engagement.
- The same is true of the relationship between digital skills and online communication, creative engagement and academic collaboration and schoolwork.
- Only some of the studies examine specific digital skills and particular outcomes within these broad headings.

Recommendations for future research

- It is surprising – given the shift in both policy debates towards a focus on fostering online opportunities as a way to balance internet risks, and in the digital inclusion debate towards tangible outcomes of internet use – that only 14 out of 110 studies examine the relationship between digital skills and digital engagement. More research on this topic generally is needed.
- More specifically, research is needed that examines the differential effect of distinct skills types on different sets of online opportunities. In fact, while all studies show a positive correlation between digital skills and digital engagement, when looking at the distinct influence of diverse skills results are currently mixed or contrasting. For example, as we have seen above, creative engagement is predicted in one study by social and creative skills, and by informational skills in another study. However, a more thorough understanding of the relationship between specific skills and different ways to engage with digital media is crucial if we want to fill in a gap in current research and know more about the third-level digital divide among children and young people – that is, about how variations in digital skills lead to inequalities in the online and offline outcomes of internet use.

5.7.6 Approach to digital technology

Privacy behaviours

Three studies investigated the role of digital skills in influencing children's privacy behaviours. These studies were conducted in countries from the Global North and South with people aged 9–25 and using self-report measures.

- Overall, findings suggest a significant and positive relationship, with more skilled children being better equipped to engage in privacy protecting behaviour online. The exception is that one study (88) finds that those with higher self-perceived skills were also more likely to disclose personal information to online marketers.
- It may be the case that those children who report having high skills but are more willing to disclose personal information to online marketers may erroneously feel confident enough with their understanding of the internet. They may believe they are still in control of their information once shared online. Problems with self-reported measures of digital skills may contribute to this relationship, with these children potentially over-reporting their level of skills.

Table 45.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND PRIVACY BEHAVIOUR					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
11	2013	Philippine	11–25	Self-report	Yes[310]	Positive
51	2013	25 EU countries	9–16	Self-report	Yes[311]	Positive
88	2012	South Korea	9–12	Self-report	Yes[312]	Positive

Technical digital engagement

One study conducted in the UK with children and adults aged over 14 (mean age = 43) and using self-report measures investigated the relationship between digital skills and technical digital engagement:

- The concept refers to activities such as blocking spam, changing filters, fact checking, looking for information online, etc.
- People with higher levels of digital skills are more likely to engage in technical digital engagement activities. There is an overlap between type of skills and type of engagement (e.g. technical skills predict technical engagement; critical skills predict critical engagement).

Table 46.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND TECHNICAL DIGITAL ENGAGEMENT					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
27	2013	UK	Over 14	Self-report	Yes[313]	Positive

ICT use and media consumption

One study (29) conducted in Taiwan with children aged 15–18 using self-report measures investigated the relationship between digital skills and ICT use, while an intervention study conducted in the USA (20) evaluated the role played by the intervention in reducing children's media consumption.

- Findings from the Taiwan study (29) show that digital skills significantly and positively predict computer use.
- The intervention study (20) in the USA found no significant effects on the time spent with media daily by the children taking part in the media literacy programme.

Table 47.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND ICT USE					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
29	2012	Taiwan	15–18	Self-report	Yes[314]	Positive
20	2014	USA	11–13	Self-report	No[315]	

[310] Online privacy behaviour is conceptualised as the ability to change passwords, delete browser history, private browsing, log out after use, and check privacy options.
[311] The study looks for the relationship between knowing how to change privacy settings on SNSs and actually using them.
[312] Privacy behaviour was conceptualised as children's willingness to provide online advertisers with personal information.
[313] The term "digital engagement" is used to refer to the ways people use and participate in different internet activities, concerning creative, social, critical and technical types of engagement.
[314] ICT use was measured in terms of hours per week spent using the computer and the internet.
[315] Time spent with media in terms of hours during an average school day/night, including watching TV, playing video games, using the internet, listening to music, and reading newspapers/magazines.

Conclusions

- Children with higher levels of digital skills are also generally better able to protect their privacy online. However, there is some evidence that some children may be over-confident in those abilities.
- Unsurprisingly, children with higher levels of skills have more technical digital engagement – that is, blocking spam, changing filters, fact checking and looking for information online.
- There is a positive association between digital skills and computer use, suggesting there may be a self-reinforcing relationship, where use of computers improves digital skills and digital skills increases computer use.
- The fact that reducing the number of different types of media consumed daily was among the goals of an intervention needs to be understood in cultural and situational terms, bearing in mind that this may reflect negative assumptions about children's use of digital media.

Recommendations for future research

- The evidence suggests that children with higher levels of digital skills are better able to protect their privacy online. However, these findings come from studies with self-report measures of skills. Research on these topics using performance tests as measures of digital skills would help to confirm this relationship.
- Research into which types of digital skills are most strongly associated with privacy protection behaviours would be helpful in designing interventions or curricula that empowers children to manage online risks.

5.7.7 Risk of harm

Relevant to anxieties about children's online safety and protectionist approaches, risk of harm is a widely debated aspect of children's internet use. Risk refers to children's potential exposure to a range of online hazards related to content (exposure to unwelcome or inappropriate content), contact (risky communication and behaviour) and conduct (risky behaviour by the child and their peer group) (Livingstone & Haddon, 2009; Livingstone et al, 2011). Even though risks stem from the conditions of the online and offline environment, the presence of such risks does not imply that harm will follow, or that all children will be equally affected (Livingstone, 2013). Therefore, it is important to distinguish between risks and harm and to acknowledge that children might perceive risks differently from how adults expect them to.

As not all children are similarly affected by the risks they encounter, understanding the role of digital skills is particularly important. It is intuitive to expect that children with better digital skills encounter fewer online risks, but does the evidence support this? More importantly, do digital skills help children to reduce the experiences of harm and thus act as a protective factor? Are some skills more important than others for minimising risk?

A total of 14 studies address risk of harm as a possible consequence of digital skills. These studies focus on a wide range of risks – 7 studies focus on multiple dimensions of risks (composite, see Table 49), 6 studies focus on conduct (such as cyberbullying or excessive internet use), and one study focuses only on content (materials related to pornography, drugs, racism and suicide). The findings do not seem to differ based on the type of risks studied. All the studies use self-reported skills measures. Geographically the 14 studies cover Europe (EU25, Belgium, Germany, Italy, Spain, UK), Asia (China, Hong Kong, Japan, Malaysia) and part of Latin America (Brazil).

The main points of agreement include:

- All but one study (12) found a significant (mostly positive) relationship between skills and online risk.
- Of the 14 studies, 11 found that better skills actually mean more exposure to online risk or exposure to a greater range of online risks. Only two studies found a negative relationship (23, 101). While these findings might be counterintuitive, they are in line with previous research (Global Kids Online, 2019; Smahel et al., 2020), showing that children who have better skills tend to be the ones who spend more time online and hence, encounter more risks. This is supported by study 12, which found that the relationship between risks and skills is mediated by online opportunities, and study 50, which found that opportunities precede risks – children are online and engage in a variety of activities before they encounter risks. Similarly, study 79 found that the relationship between skills and risks is weaker than between skills and opportunities. These suggest that more skills mean more online opportunities and more risks then follow.

Table 48.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND RISK OF HARM						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Type of risk**	**Sig.**	**Direction**
12	2018	Brazil	9–17	Self-report	Composite	#N/A	Indirect effect via opportunities
23	2019	Italy	14–18	Self-report	Conduct	Yes	Negative
43	2011	Japan	6–18	Self-report	Conduct	Yes	Positive
46	2012	Hong Kong	9–19	Self-report	Conduct	Yes	Positive
47	2012	Hong Kong	9–19	Self-report	Composite	Yes	Positive
50	2010	UK	10–17	Self-report	Composite	Yes	Positive
65	2016	25 EU countries (EU Kids Online)	14–16	Self-report	Conduct	Yes	Positive
79	2018	Spain	12–18	Self-report	Composite	Yes	Positive
90	2013	25 EU countries (EU Kids Online)	11–16	Self-report	Composite	Yes	Positive
92	2013	25 EU countries (EU Kids Online)	9–16	Self-report	Composite	Yes	Positive
95	2018	Malaysia	9–16	Self-report	Composite	Yes	Positive
99	2010	Belgium (Flanders)	15–19	Self-report	Content	Yes	Positive
101	2015	Germany	14–29	Self-report	Conduct	Yes	Negative
108	2018	China	11–19	Self-report	Conduct	Yes	Positive

Looking beyond these points of consensus that more skills mean more risk, there are important details that demonstrate that the relationship between skills and risk is more complex and nuanced:

- Two studies found that skills reduce risks. Study 23 shows that ethical media use[316] reduces both online aggressive behaviour and experiences of victimisation of such behaviour, while study 101 found that ability to manage online behaviour reduces excessive internet use. This might suggest that risk can be reduced when children possess the specific skills relevant to

[316] A set of 18 behaviours in computer-mediated peer communication, such as "I treat others online as I would like to be treated by them" and "Sometimes I use an online account with a different name, so that other people believe I am a different person" (reverse coded).

the risks they encounter. The broad and general measurement of skills and/or risks might miss that.

- More advanced skills related to critical thinking, information evaluation and awareness of the social context in which information is produced do not increase the likelihood of risk exposure (studies 46, 47).[317] The combination of skills also makes a difference to risk exposure – study 47 also found that children who are skilled in publishing information[318] but lack critical literacy skills are more likely to experience risk.
- It matters if children are aware of the risks and if they feel that they might encounter them – study 95 found that the perceived severity of online risks reduces children's exposure risk, while higher skills increase it. So, advanced skills need to be paired with risk awareness.
- A range of factors related to personal attributes and social context (such as age, gender, family background, parental mediation, SES, digital development of the social environment at the country level) affect children's exposure to risk, but their effects seem to vary depending on the types of risks (studies 12, 50, 65, 92). For example, study 43 found that risks increase with skills only for secondary school students, but not for elementary and high school students.[319] This suggests that there might be other factors, such as peer culture or critical awareness, that might operate in a different way for children by age and could mediate the relationship between skills and risk.

Conclusions

- At a first glance, it might appear that more digital skills lead to more risk, but a more detailed examination of the findings suggests a much more nuanced relationship between the two.
- The research covers a substantial range of different risks with many studies using composite measures and exploring multiple dimensions of risk. While the findings do not seem to differ significantly by type of risk studied, differences may be masked by reporting about online risks and digital skills as unified categories. Some skills, such as those related to critical thinking, digital media awareness or risk perception, do not increase risks, and in some cases reduce it. It might be argued that such skills require a more advanced understanding of the digital environment.
- It is possible that children would need a full set of skills to reduce their chances of experiencing online risk and to have skills that are specific to the online risks that they encounter.
- Other factors such as age, gender, peer culture and social factors also make a difference to how children handle and initiate online risks. It is important to consider the role of such mediating factors in order to understand the relationship between skills and risks.
- Yet, better skills most often means more risk as children who are online more tend to have a larger share of both the online risks and the benefits from internet use.

[317] Study 47 uses the term "social structural literacy" for understanding how information is socially situated and produced and "tool literacy" to refer to the ability to locate information in multiple sources, decide the type of resources needed to yield useful information for a particular need, browse online databases to locate pertinent information, and recognise different access methods of information resources.
[318] "Publishing literacy" reflects the ability to format and publish research and ideas in textual and multimedia formats.
[319] Studies 12 and 92 also found that risk increases with age.

Recommendations for future research

- We need a more nuanced understanding of both skills and risks and how specific skills relate to specific risks, rather than conceptualising these in general or broad terms. So, further research needs to establish how specific skills affect specific risks.
- How do different types of skills lead to different levels of risk exposure, and to what extent do some skills (such as critical literacy) reduce risks or "flatten" the risk curve?
- Are certain types of skill combinations reducing or increasing risk?
- How do personal attributes and social context affect the relationship between skills and risk? For example, what is the role of peer culture, risk awareness and vulnerabilities?
- It is likely that there are moderation effects between digital skills and online risks and we need more research to establish these effects.

Harm from online experiences

A total of four studies explore the relationship between skills and harm – all were surveys. The surveys all measure harm by self-reported experiences of being upset or bothered by something online (90, 92, 98, 100). All studies are based in Europe, and three use EU Kids Online data.

Two studies found a negative relationship between skills and harm (90, 100), one study found a positive relationship (92), and one study (198) was inconclusive (they did not measure sufficiently the direct relationship between skills and harm). Hence, the data on the relationship between skills and harm is limited. Still there are some points of agreement.

Table 49.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND HARM FROM ONLINE EXPERIENCES						
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Type of harm**	**Sig.**	**Direction**
90	2013	25 EU countries (EU Kids Online)	11–16	Self-report	Something online made them feel uncomfortable, upset, or that they shouldn't have seen it	Yes	Negative
92	2013	25 EU countries (EU Kids Online)	9–16	Self-report	Something online made them feel uncomfortable, upset, or that they shouldn't have seen it	Yes	Positive[320]
100	2013	25 EU countries (EU Kids Online)	9–16	Self-report	Something online made them feel uncomfortable, upset, or that they shouldn't have seen it	Yes	Negative
198	2015	Belgium (Flanders)	10–16	Self-report	Feeling bothered	N/A	N/A

First, better skills do not predict more harm (even though these children tend to face more risks), and in some cases, better skills can reduce harm:

- Children who experience harm from online risks have lower skills than children who face these risks but do not report harm (study 90).

[320] This relationship loses significance when you control for risk exposure.

- Study 92 found that being bothered or upset by something online is higher for children with higher digital skills but this relationship loses significance when you control for risk exposure.
- How digital literacy affects children's experiences of harm varies by the type of risk. According to study 100, children with lower digital skills experience more harm only in relation to sexual images, but not cyberbullying or sexting. Similarly, study 90 found that children with lower skills experience harm from seeing and receiving sexual messages but not from meeting online contacts.

Second, the research suggests that experiences of harm vary based on additional factors, such as coping strategies and personal characteristics, which are intertwined with the effects of skills:

- Digital skills impact on how children cope with risky situations. Children with better skills tend to engage in more proactive strategies that are more likely to solve the problem (study 100). For example, more digitally literate children are more likely to delete messages and block senders when experiencing cyberbullying or unwelcome sexting (study 100). Hence, better skills result in better resilience (understood as being able to deal with negative online experiences and show problem-solving coping that can reduce future harm; see Vandoninck et al., 2013).
- Factors such as age, gender, SES, self-efficacy and psychological difficulties affect how strongly children experience harm (study 100). These intersect with different types of risks children encounter, according to study 100. Girls feel more upset than boys when they experience cyberbullying and sexting; younger children (aged 11–12) are more upset by sexual images and sexting; children from lower socioeconomic backgrounds are more upset by sexual images and cyberbullying; children with low self-efficacy are more upset by cyberbullying and sexting; and children with more psychological difficulties are more upset by all risks than children with fewer difficulties (study 100). This is important because personal characteristics also make a difference to the coping strategies children choose (studies 98, 100).
- The strategies children select vary by age and gender, but in many cases also depend on the type of risk experienced online. Study 98 found that girls and younger children (aged 10–12) are more likely to talk about unpleasant situations online[321] than boys and older children (aged 13–16). Younger children are also more indifferent – they are more likely not to care about what happened, to hope that the problem goes away by itself, or to ignore the incident. Girls use more proactive strategies than boys (change privacy settings, block the person, delete images or messages) when dealing with shocking images, strangers, sexting, online bullying, sexual images and privacy misuse. The study, however, does not assess how effective these strategies are in preventing harm.

Conclusions

- Children with better skills experience more risks, but this does not seem to lead to more harm. In some cases, better skills reduce harm.
- The relationship between skills and harm differs based on the type of risk and on the personal characteristics of the child.
- Digital skills affect the coping strategies children choose and how active they are in handling harmful experiences. There are important gaps related to the effectiveness of different coping

[321] Refers to online bullying, seeing sexual or shocking images, contact with strangers, sexting, or privacy misuse.

strategies and how that affects harm. Further gaps related to our limited understanding of how skills might contribute to building resilience over time.

Recommendations for future research

- There is very little evidence on how different skills result in different strategies of coping with harm. Do a broad range of skills produce better protection from harm, or do advanced skills have more positive effects? What is the best combination of skills that reduces harm most efficiently?
- How does the relationship between different skills and different risks affect children's experiences of harm? What types of skills do children need to face particular types of risks so that they experience minimum harm?
- Can skills have a preventative effect on harm and does that lead to resilience over time?
- Do children who use active strategies have better outcomes in the long run?

Coping with digitally mediated risks

Two studies investigated coping with digitally mediated risks as a consequence of digital skills. One study (94) was conducted in Germany and the other (100) across 25 EU countries with children aged 9–16 – both relied on self-report measures.

- The studies on coping with online risks focused on seeing sexual content, being a target of bullying, sexting and experiencing online victimisation.
- Ways to cope with these risks included more or less proactive strategies, such as talking to somebody, hoping the problem would go away, stopping using the internet, deleting the message, blocking the sender and reporting the problem to an internet provider.
- Findings show that children with higher levels of other types of digital skills cope better with online risks.
- These findings support the notion that more skilled children are able to cope better when facing potential risks online, preventing risks from translating into harm.

Table 50.	STUDIES COVERING THE RELATIONSHIP BETWEEN DIGITAL SKILLS AND COPING WITH DIGITALLY MEDIATED RISKS					
Ref	**Year**	**Country**	**Age range**	**Skill measure**	**Sig.**	**Direction**
94	2012	Germany	10–15	Self-report	Yes[322]	Positive
100	2013	25 EU countries	9–16	Self-report	Yes[323]	Positive

Conclusions

- Children with higher levels of digital skills were better able to cope with online risks, suggesting that digital skills can help to mediate between online risks and online harm.

[322] This study investigates the role of internet literacy on coping with online victimisation.
[323] The study looks at the relationship between digital skills and harmful situations online, such as sexual risks.

Recommendations for future research

- The evidence suggests that children with higher levels of digital skills are better able to cope with online risks. However, these findings come from studies with self-report measures of skills. Research on these topics using performance tests as measures of digital skills would help to confirm this relationship.
- Research into which types of digital skills are most strongly associated with coping behaviour would be helpful in designing interventions or curricula that empower children to manage online risks.

5.8 Modelling the relationship between antecedents and consequences

How do the many factors discussed in this review relate not only to digital skills but also to each other? Can we combine the different findings to suggest a multi-factor model that explores their interrelations? In this section, we examine the 12 studies identified by the systematic review that hypothesise and test specific pathways that lead from the possible antecedents of digital skills at the individual, social and country level to the possible online and offline consequences of digital skills for children. The studies, covering the full age range 9–17, were mainly conducted across Europe, with some in Latin America, Asia and the Pacific region.

Each of the 12 studies proposes a model that positions digital skills as an outcome (of hypothesised antecedents – 12 out of 12 studies), a predictor (of hypothesised consequences – 11 out of 12 studies) and/or a mediator (8 of 12 studies) in a more complex model. Looking at the antecedents and consequences measured (Table 52), we can make several observations:

- Four studies (11, 56, 79, 82) include just one antecedent of digital skills in the model and one or two consequences of skills. In other words, they present fairly simple models linking antecedents and consequences. For example, study 11 examines, first, how access to a better ICT environment is associated with a child having greater digital skills and then, how those with greater digital skills are better at managing technology (specifically, adopting privacy protective behaviours). The other three studies examine social context antecedents for their influence on digital skills, and then trace the consequences in relation to wellbeing (56), risks and opportunities (79) and opportunities including learning (82). A fifth study (55) only considers antecedents of digital skills.
- Four studies (19, 27, 96, 99) examine the relationship between different categories of predictors and digital skills, as well as the effect of digital skills on one or two consequences. The various authors have selected different combinations of antecedents and consequences with no discernible trend in terms of study focus.
- Three studies (12, 21, 50) consider all three categories of antecedents and also include one or two consequences in the model. This relatively greater attention to antecedents than consequences reflects an observation made throughout this review, namely, that researchers appear more interested in how to improve children's digital skills than to investigate the benefits these may bring. This inverts the popular understanding that children gain digital skills "naturally" through use, or via education, but that society really needs to be sure they bring benefits before investing further in educational technology provision.

Table 51.		STUDIES MODELLING THE RELATIONSHIP BETWEEN ANTECEDENTS AND CONSEQUENCES				
Ref	**Year**	**Age range**	**Country**	**Skill measure**	**Type of antecedents**	**Type of consequences**
11	2019	11–25	Philippines	Self-report	ICT environment (diversity of connectivity)	Managing technology (privacy protective behaviours)
12	2018	9–17	Brazil	Self-report	Personal attributes (age, gender) Social context (parental education) ICT environment (availability at home)	Risk of harm Online opportunities
19	2012	12, 14, 17–19	UK	Self-report	Social context (parental mediation; peer support) ICT environment (availability at home)	Learning outcomes
21	2012	9–16	Romania, Bulgaria	Self-report	Personal attributes (age, gender) Social context (parental education, parental mediation, parent age) ICT environment (age of first use, number/type of devices used to go online and number of locations where internet access is available)	Online opportunities
27	2013	14+	UK	Self-report	Personal attributes (age, gender) Social context (SES)	Managing technology Online opportunities
50	2010	10–17	UK	Self-report	Personal attributes (age, gender) Social context (parental education) ICT environment (availability at home and age of first internet use)	Risk of harm Online opportunities
55	2018	17–18	Finland	Self-report	Personal attributes (motivations and commitment to identity formation)	
56	2017	11–14	Australia	Self-report	Social context (media education)	Wellbeing
79	2018	12–18	Spain	Self-report	Social context (parental mediation)	Risk of harm Online opportunities
82	2019	12–17+	Portugal	Self-report	Social context (parent/teacher support)	Learning outcomes Online opportunities
96	2017	16–18	Ecuador	Self-report	Social context (SES) ICT environment (availability at home)	Learning outcomes Online opportunities
99	2010	15–19	Belgium (Flanders)	Self-report	Personal attributes (age, gender, personality) Social context (parental mediation, SES)	Risk of harm

5.8.1 Skills as an outcome, a predictor and a mediator

The eight studies that position digital skills not only as an outcome (of antecedent factors) and a predictor (of consequences) but also as a mediator unsurprisingly base their analysis on more complex statistical models. All employ different techniques of path analysis, to test the dependencies between antecedents, consequences and mediators. Through their focus on the potential mediators of the relationships between antecedents and consequences, they can address the following research question: where do digital skills fit in explaining the pathway from children's life circumstances to their outcomes?

They include the three studies discussed earlier (12, 21, 50) that consider ascribed personal characteristics, social context and quality of internet access as antecedents of digital skills, and possible beneficial outcomes of internet use (online opportunities and/or learning outcomes). Meanwhile, studies 12, 50 and 79 are distinctive in their integration of the digital inclusion literature and the risks and opportunities literature.

What do these studies conclude? Crucially, they show that more simple statistical analyses fail to adequately explain the variation in children's experiences of the internet. We can summarise the main findings related to the role of digital skills as follows:

- Studies that examine the role of digital skills in relation to both positive and negative consequences (12, 50, 79) show that digital skills only predict risks indirectly, via opportunities. In other words, each finds that (1) antecedents of digital skills (sociodemographic factors and ICT environment variables) and (2) digital skills predict breadth of digital engagement, and that (3) online opportunities, in turn, are positively correlated with exposure to online risks. Digital skills are also found to mediate between active parental mediation and online opportunities (study 12): in other words, active parental mediation has only an indirect effect on digital skills via its effect on facilitating online opportunities.
- The most important finding for the digital inclusion debate relates to the mediating role of digital skills. Complex models (e.g. study 27) show not only a linear path between social context/personal attributes and digital skills, and between digital skills and online/offline consequences; they also show the influence of structural and social inequalities (e.g. the individual's gender and education) in determining engagement changes when digital skills are taken into account. More precisely, some relationships lost significance or strength when digital skills were included in the model. Only the relationships between SES and digital engagement, and age and digital engagement remain unchanged (see especially study 27). This suggests that, if other ways can be found to improve children's digital skills, they can benefit from the opportunities even though structurally they remain disadvantaged (in other words, that the digital divide can be overcome, even if social divisions are harder to change). It also suggests that there is a direct effect of inequality on outcomes that is unmediated by digital skills.
- Studies that measure the differential influence of distinct skills on online opportunities (27, 96) suggest the importance of looking at the specific mediating role played by each type of digital skill. For example, study 96, which operationalises digital skills as a progression from basic operational skills to more advanced skills, shows that the role of operational skills on creative and academic use is both direct and indirect (mediated by advanced digital skills). Study 27 reveals variations in how digital skills mediate the impact of sociodemographic factors on different sets of online opportunities, depending on both the type of digital skills and the type of opportunities examined.

Table 52.		STUDIES MODELLING THE RELATIONSHIP BETWEEN ANTECEDENTS AND CONSEQUENCES, INCLUDING THE DIRECT AND INDIRECT EFFECTS OF DIGITAL SKILLS					
R	Year	Antecedents	Sig.	Direction	Consequences	Sig.	Direction
12	2018	Personal attributes Social context ICT environment	Yes[324]	Positive	Online opportunities Risk of harm	Yes[325]	Positive
19	2012	Social context ICT environment	Yes[326]	Positive	Learning outcomes	Yes[327]	Positive
21	2012	Personal attributes Social context ICT environment	Yes[328]	Positive	Online opportunities	Yes[329]	Positive
27	2013	Personal attributes Social context	Yes[330]	Negative	Managing technology Online opportunities	Yes[331]	Positive
50	2010	Personal attributes Social context ICT environment	Yes[332]	Positive	Online opportunities Risk of harm	Yes[333]	Positive
79	2018	Social context	Yes[334]	Negative	Online opportunities Risk of harm	Yes[335]	Positive
82	2019	Social context	Yes[336]	Positive	Learning outcomes Online opportunities	Yes[337]	Positive
96	2017	Social context ICT environment	Yes[338]	Positive	Learning outcomes Online opportunities	Yes[339]	Positive

[324] Age, gender (non-significant), SES (parents' educational attainment), parental mediation (co-use and active mediation are positively associated with digital skills, while restrictive mediation is negatively associated), and ICT availability at home.
[325] Online opportunities (number of online activities undertaken by the child) and exposure to online risks. There is no direct effect of digital skills on risk, but there is an indirect effect via opportunities.
[326] The study measures both parental mediation and peer mediation, but only support from peers predicts digital skills. ICT availability at home is not associated with digital skills.
[327] Informational skills are positively associated with online information seeking for schoolwork, but not with information seeking for everyday life.
[328] Age of first use, number and type of devices used and number of locations predict digital skills. The age of the child has an indirect influence on skills, and a direct influence on parental support, peer support, internet experience, self-efficacy, and number of devices used to go online. Gender has an indirect influence on skills, and a direct influence on internet experience and number of places where the internet is used. Parental education has an indirect influence on skills, and a direct influence on parental support, number of devices and child's online experience (years online). Parents' age has an indirect influence on skills, and a direct influence on parental support.
[329] Number of activities undertaken by the child.
[330] Gender and age are negatively associated with digital skills (women and older respondents are less confident – but note that the sample is 14+); vulnerabilities and SES are not significant.
[331] Technical skills are positively related to critical engagement. Social skills are positively associated with social engagement and creative engagement. Critical skills are negatively related to creative and social engagement. Creative skills are positively related to creative engagement. Technical digital engagement is positively associated with digital skills.
[332] Age, gender (non-significant), SES, ICT availability at home, and age of first internet use.
[333] Breadth of digital engagement (number of online activities undertaken by the child). The relationship between digital skills and risks is indirect, mediated by opportunities.
[334] Restrictive parental mediation associated with lower digital skills; no significant relationship with active parental mediation.
[335] There is no direct effect of digital skills on risk, but there is an indirect effect via opportunities.
[336] Support from parents and teachers.
[337] School performance and using the internet to study.
[338] Family income and parental education; ICT availability at home.
[339] School performance; information seeking; creative engagement.

5.8.2 Skills as an outcome and a predictor

The two studies in this group (56, 99) examine the factors that explain variations in the acquisition of digital skills among youth, and then the effect of digital skills – and antecedents in study 99 – on the outcome under investigation. Whether and how digital skills mediate the relationship between antecedents and consequences – by changing its strength or rendering it insignificant – is not analysed.

Table 53.	STUDIES MODELLING THE RELATIONSHIP OF BOTH ANTECEDENTS AND CONSEQUENCES TO DIGITAL SKILLS						
Re	Year	Antecedents	Sig.	Direction	Consequences	Sig.	Direction
56	2017	Social context	Yes[340]	Positive	Wellbeing	Yes[341]	Positive
99	2010	Personal attributes Social context	Yes[342]	Positive	Risk of harm	Yes[343]	Positive

5.8.3 Skills as an outcome and a mediator

Study 11 is distinctive insofar as it conceptualises digital skills (here operationalised as information literacy) as an outcome of diversity of connectivity and a positive mediator between diversity of connectivity and online privacy behaviour – namely, explaining the different practices through which urban poor youth in Manila try to protect their privacy online. The study shows that children who benefit from more diverse connectivity options develop more skills and are also better at protecting their privacy online.

Table 54.	STUDIES MODELLING DIGITAL SKILLS AS AN OUTCOME AND A MEDIATOR						
R	Year	Antecedents	Sig.	Direction	Consequences	Sig.	Direction
11	2019	ICT environment	Yes[344]	Positive	Managing technology	Yes[345]	Positive

5.8.4 Skills as an outcome

Finally, study 55 can be considered as an antecedent-only, or antecedent-mainly, study, as it examines the relationship between ascribed characteristics and other personal attributes (namely, motivations and commitment to identity development) and digital skills, and interest-driven internet activities and excessive ICT use. The (positive) effect of digital skills on identity development and, therefore, wellbeing, is hypothesised but not tested in the study.

[340] Media literacy education intervention.
[341] Body image and eating disorders.
[342] Age, personality type (self-image and self-confidence) and type of school are positively associated with digital skills. Gender is negatively associated (boys score higher than girls), while perception of the internet as a safe environment, SES and parental mediation are not significant.
[343] Online risks.
[344] Diversity of connectivity.
[345] Online privacy behaviour.

Table 55.	STUDIES MODELLING DIGITAL SKILLS AS AN OUTCOME						
Ref	Year	Antecedents	Sig.	Direction	Consequences	Sig.	Direction
55	2018	Personal attributes	Yes[346]	Positive			

5.8.5 Conclusions

- It is surprising that only 12 studies in our systematic review aimed to model the relationship between antecedents, digital skills and consequences at the individual, social and country level, given that these studies – especially those examining digital skills as both an outcome, a predictor and a mediator – contribute to shed light on critical questions and knowledge gaps.
- One of the main contributions of the studies reviewed in this section is to explain that the relation between digital skills and exposure to risks is only indirect.
- Also remarkable is the finding that active parental mediation predicts children's engagement in online opportunities, thus influencing children's acquisition of digital skills only indirectly.
- The most important conclusion for the digital divide debate, and for policy-makers more generally, is that digital skills can, at least partially, mediate between pre-existing social inequalities and the beneficial outcomes of digital engagement. In other words, this finding suggests that, while social and structural inequalities still matter and determine variations in the outcomes of children's internet use, digital skills can reduce or compensate for part of such disadvantage.
- Finally, a major achievement of these studies, and simultaneously a recommendation for future research, is the acknowledgment that specific kinds of skills predict digital engagement, or mediate the effect of other antecedents on digital engagements, in distinctive ways. So it is worth examining the pathways from antecedents to consequences for different sets of digital skills, and explaining how such distinctive sets of skills relate to each other.

5.8.6 Hypotheses and recommendations for future research

The studies that model the relationship between skills as an outcome, a predictor and/or a mediator identify a number of research gaps or hypotheses that future research could address:

- One limitation of the 12 studies discussed in this section is the cross-sectional nature of the data. This means that, although the statistical path analyses are used to test hypothesised causal relationships, they cannot rule out the opposite hypothesis – for example: is it digital skills that lead to digital engagement, or vice versa? No wonder that these studies call for future longitudinal data so as to be able to identify relations of causality.
- Another limitation is their reliance on self-report measures of digital skills. These are subject to social desirability biases, and may reflect self-efficacy more than actual achievement. Therefore, the authors commonly call for more studies based on performance tests and observations.
- Studies that did not examine the role of digital skills as a mediating variable identify this a shortcoming of their research and call for multivariate analysis to gain a deeper understanding into mediating relationships between the various factors involved (see study 99, for example).

[346] Controlling for age, gender and SES, motivations and commitment to identity formation are positively associated with the acquisition of digital skills, except for ruminative exploration.

- As explained above, one strength of study 27 is that it operationalised different kinds of skills when exploring the relationship between social inclusion, digital engagement and digital inclusion. Its findings suggest that variations in digital engagement account for differential levels of digital skills, and that training in different sets of digital skills may compensate for social exclusion. As the authors of study 27 conclude: "To make model testing more manageable, future research could focus on testing specific paths comparing groups on sociodemographic characteristic or specific types of engagement and the mediating effect of specific types of different skills within these group comparisons or for these specific types of engagement" (Helsper & Eynon, 2013, p.710).
- Based on the strong association observed between risks and opportunities, some studies (12, 50) call for a better classification of online risks, to take into account the normative assumptions underpinning the labelling of certain risky opportunities as "risks", given that their meaning can vary between children and adults, and also among children. Therefore, these studies call for more subtle theorisations of online risks.
- Relatedly, more research is needed that examines the tangible outcomes of digital skills and digital engagement, including both beneficial outcomes (children's wellbeing) and negative outcomes (harm). The measure of harm, it is argued, remains especially elusive.
- One study (19), which examined informational digital skills and the use of the internet for information, recommends that future research should examine what children do with the information they find online in more detail. Study 19 also calls for further explorations between motivations and attitudes towards learning and use of the internet for information.
- Researchers from non-Western countries discuss the relevance played by ICT environment variables on both digital skills acquisition and online opportunities: therefore, while digital skills are found to mediate inequalities in connectivity, measuring the quality of internet access remains important.
- Finally, the models that examine parental mediation (which, in brief, suggest that restrictive mediation leads to lower skills, while active mediation sometimes positively predicts skills) call for the need to include other parent-related variables (e.g. the family's cultural capital and parenting style) to explain variations in digital skills and online opportunities.

6. General conclusions and recommendations

6.1 Skills

- There is considerable diversity in the conceptualisation of digital skills, competence and self-efficacy. Skills are sometimes considered broadly, including a wide range of digital skill domains, and sometimes narrowly, focusing on particular elements. While there can be no "correct" way of defining the meaning of "digital" in this context, when it comes to the decision about how to operationalise skills, more factual questions ("I know how to…") are preferable to self-evaluative questions ("I am good at…") because they introduce less measurement bias and help distinguish digital skills from digital self-efficacy.
- Self-report and performance tests produce different results for areas such as gender and frequency and amount of ICT use but not for other areas. This merits further exploration. Perhaps some areas are more "sensitive" in replicating social desirability bias and cultural norms than others. In addition, all uses of performance tests are in studies of the antecedents of digital skills, with very few deployed in studies of the consequences of digital skills.

6.2 Antecedents

- Children's skills improve with age – older children have better skills than younger children. This finding is consistent across different countries, and across different ways of conceptualising and measuring digital skills. There is tentative evidence that the skills–age gradient flattens with age; hence children acquire more skills when they are younger and the process slows down as they grow up. A useful next step could be to analyse the age at which children are most receptive to learning different types of digital skills and the mechanisms by which skills improve with age.
- The balance of findings across all studies is tipped in favour of boys having more digital skills than girls, especially when studies use self-report surveys with confidence rather than ability or knowledge measures. Performance tests, on the other hand (more objective than surveys), are equivocal regarding gender differences. The pattern of studies suggests that girls and boys may do better at different skills, perhaps reflecting gendered cultural expectations, although also girls' and boys' interests.
- Personal characteristics matter for digital skills, but it is important to look at specific skills, rather than digital skills generally. For example, girls and boys differ in their competence regarding particular dimensions of digital skills, as do children from different ethnic backgrounds. Hence, research should explore whether this results from cultural (or parental or school) expectations and norms, and also from (for example, ethnic) experiences.
- It would also be important to learn more about the dynamics of skills inequalities within age groups and how these change over time and intersect with other personal characteristics. Are children who have fewer skills when they are younger able to "catch up" with their peers later? Girls also seem to have better digital skills than boys when they are younger (primary school age), but these differences disappear with age. Is this because girls begin to fall behind with age, or boys begin to catch up, compared with their level of skill at primary school age?
- A wide range of personal attributes such as a lack of health problems, certain cognitive styles (related to approaches to problem-solving), higher educational attainment, an interest in science, an active approach to learning and recreational reading are associated with better digital skills. The evidence on attitudes to learning is more mixed, but some studies suggest that certain perceptions and attitudes can have a bearing on particular digital skills. The

evidence is more convincing in relation to attitudes to digital technologies in particular, which predict better digital skills. Children's self-efficacy – their confidence in their own skills – is also positively associated with better digital skills.

- The influence of a household's SES on digital skills narrows down once children achieve similar levels of digital access. Yet, factors such as parents' own use of the internet and their attitudes towards digital technologies, which, in turn, may be related to socioeconomic or educational background, continue to influence children's digital skills. In addition, children whose online activities are limited by parents' restrictions (which tends to happen when parents themselves have lower skills) develop less digital skills than children who receive encouragement, support and help from their parents. Such inequalities are important in shaping children's digital skills, particularly under conditions of limited input from other educational sources (e.g. distant learning during the COVID-19 lockdown).
- The ICT context in the domestic sphere certainly appears to make a difference. The general availability of ICT in the home, frequency and amount of children's use, the earlier age of first use of ICT and having more and varied digital devices available to a child in more locations within the home all correlate with better digital skills.
- The influence of the education context is mixed. While there are some positive associations relating to the support given by teachers to children, some studies found no correlation or a negative correlation between teacher attributes (e.g. competence) and children's digital skills. On balance, there seems to be a positive association between ICT availability in their schools and children's digital skills. But apart from this and school type (e.g. private school), other school characteristics do not appear to be influential.
- As regards other social context factors, there is strong evidence that peer-to-peer teaching and co-use of ICT with peers is associated with higher levels of digital skills, as is going to school in urban areas.
- On balance, gaming was correlated with greater digital skills, as was social communication online (e.g. social media). If these do enhance digital skills, this may be seen as a challenge to some views that both are a waste of time. Other digital activities related to learning are less surprisingly associated with more digital skills, while bad experiences in relation to information online can have both positive and negative effects on skill development.
- Lastly, while there are hardly any studies measuring country influences, there is some evidence that this makes a difference to digital skills.

6.3 Consequences

- There is some indication that digital skills can have positive effects on wellbeing, but the research evidence remains limited, with narrow and specific measures of both skills and wellbeing. Future research needs to explore more comprehensive measures of digital skills and wellbeing and the relationship between the different dimensions of both.
- Greater digital skills are linked both to diverse consequences related to learning and leisure and better learning outcomes for children, although in both cases the evidence base is small and would benefit from a more systematic approach. It would appear that learning benefits are more likely when there is a cognitive link between the nature of the digital skill and the specific learning outcome.
- All the (surprisingly few) studies find that some kinds of digital skills are associated with different forms of offline engagement but others are not – hence, once again, it is important

to specify which digital skills are being considered. There is also a correlation between digital skills and breadth of online activities, including online digital, critical and civic engagement. The same is true of the relationship between certain kinds of (but not all) digital skills and online communication, creative engagement and academic collaboration and schoolwork.

- Children with higher levels of digital skills were better able to cope with online risks, protect their privacy online and generally they are more digitally active (e.g. seeking information, changing privacy settings).
- At a first glance, it might appear that more digital skills lead to more risk, but this is because children who are online more simply tend to have a larger share of both the online risks and the benefits from internet use. That said, some skills, such as those related to critical thinking, digital media awareness or risk perception, do not increase risks and in some cases reduce it. Hence, we need a more nuanced understanding of how specific skills relate to specific risks, rather than conceptualising these in general or broad terms. In addition, although children with better skills experience more risks, this does not actually seem to lead to more harm. In fact, in some cases, better skills reduce harm.

6.4 Methodology

- While the systematic evidence review identified some geographic diversity in the studies, still more studies of digital skills come from the Global North or middle- and upper-income countries. The evidence on how these findings can translate to other contexts remains scarce.
- Many studies focus on whether there is a statistically significant correlation between digital skills and particular antecedents and consequences without looking at the interrelationship of a range of variables. For example, various personal attributes and aspects of the digital environment could themselves be influenced by the SES of household, and so be considered to be mediating variables. Similarly, digital skills can mediate the effect of personal attributes and SES of the household on both positive and negative outcomes of internet use. Only about 10% of studies developed models of multiple variables and more approaches using such statistical path analyses would be welcome.
- One final limitation of the majority of studies discussed is the cross-sectional nature of the data. Even the studies using statistical path analyses to test hypothesised causal relationships cannot rule out the opposite hypothesis – for example: is it digital skills that lead to digital engagement, or vice versa? No wonder that many studies call for future longitudinal data so as to be able to identify relations of causality.

6.5 Recommendations for future research

- Following up on the methodological issues just outlined, a few more recommendations for future research can be drawn from our systematic evidence review, including the opportunity to employ measures of digital skills based on factual questions rather than self-evaluative questions.
- In terms of skills conceptualisation and measurement, more studies investigating both the antecedents and consequences of digital skills through a combination of survey and performance tests are needed in order to isolate the effect of social desirability bias in children's self-assessment of their own skills.
- Moreover, there is evidence that the influence of individual and social characteristics varies across different kinds of skills. Therefore, future research should adopt and measure different dimensions of digital skills, and variations within their antecedents and consequences.

- The systematic evidence review also highlighted some notable gaps in the knowledge base: namely, future research should investigate further the relationship between (different sets of) digital skills and harm and wellbeing.

6.6 Recommendations for policy-makers

- The systematic review has confirmed that digital skills are only indirectly related to exposure to online risks. Rather, specific kinds of digital skills (critical thinking, digital media awareness or risk perception) not only protect children from harm, but also reduce their likelihood to encounter risky situations online. Strengthening children's digital skills should therefore remain a priority on the policy, research and public agenda, to ensure that children's engagement with the internet results in wellbeing at various levels.
- The evidence reviewed in this report suggests that children acquire more skills when they are younger, but skills improve with age. If further studies identify at which age children are more receptive to learning different types of digital skills, and when the differences between girls and boys emerge, policy-makers could design age-appropriate programmes that also contribute to address gender inequalities.
- Positive attitudes towards technologies, and self-confidence predict better digital skills. This finding, together with the conclusion that both gaming and online communication are associated with higher level of digital skills, should encourage the design of both informal and formal educational programmes that promote digital skills through playful activities and reinforcing children's self-confidence.
- While the influence of a household's SES on digital skills narrows down once children achieve similar levels of digital access, the availability of ICT at home, parents' own use of the internet and digital media, and parental mediation still shape children's level of digital skills. Therefore, raising parents' awareness that a positive attitude towards ICT in the domestic environment contribute to higher digital skills and more abilities to cope with online risks is still needed.
- Peer-to-peer education should be fostered, since co-use of ICT with peers and learning from peers are associated with higher levels of digital skills.
- Particular attention, moreover, should be paid to rural areas, where children may benefit from fewer opportunities to get involved in peer education or other forms of digital skills training.

7. Limitations of the review

- Systematic reviews are based on filtering and analysing a pool of studies returned from specific search parameters. But the pool of studies may not include all relevant existing research in that some studies may not have appeared in the databases used. In addition, some studies were filtered out for practical reasons – for example, because the paper was not written in English, or because the full paper was not accessible.
- The coding procedure involved multiple stages where several coders worked on a portion of the database following common rules. Regular meeting were scheduled to clarify and adjust these rules as needed, sharing doubts and tips on how to go to code the database, and inter-coder reliability was checked. However, systematic reviews should be understood in relation to their situational and contextual nature. While the methodology followed clear and rigorous procedures, in principle no epistemic effort can be conceived as being fully objective where an element of judgement is involved.

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Appendix 1: Developing the search strategy process

The main task at this stage was developing the strategy for the search words in a way that would help identify the relevant literature. The most experimentation was around the technology skill search words. First, a series of terms related to the particular technologies of interest were chosen (e.g. computer, social media). Then, based on general knowledge of the literature, words were chosen that, while not synonyms of "skill", might capture related material (e.g. competency, literacy). All combinations of these terms were included in the full search protocol (although not all are in common use).

A period of experimentation followed involving Web of Science searches for these words in abstracts, titles and keywords, and then reading abstracts of the material found. The aims were to decide if these words did indeed lead to results of interest to the project but, equally significant, how much they led to results that were irrelevant, that might be termed "noise".[347] This is important because it is very time-consuming at a later stage (screening) to read thousands of abstracts, so it is vital to develop search strategies to reduce that noise and hence the volume of material to be checked. This strategy still produces unavoidable noise,[348] although attempts have been made to minimise this.

Some databases allow searches of the whole text, but this actually increases the chance of finding irrelevant material.[349] Hence, it was decided to only search by title, keywords and abstract – if an article was relevant, the search terms were likely to be in those places.

In general, this experimentation process was also useful for other reasons. By the time of screening stage (i.e., reading the abstracts assembled from the search in order to choose what is relevant), if the causes of some of the noise were already known, it made the screening decisions easier.[350] Second, this examination of some abstracts already allows a preliminary overview of the type of material that the whole search process might capture. This was important in early discussions with ySKILLS members working on other work packages. Third, it enabled initial reflection on the details of the screening criteria and screening process. For example, it was already clear at this experimentation stage that there might be grey areas where we would have to make a decision about relevancy. Whether an item is relevant will depend on what counts as "wellbeing", so the decision about what to include in this core concept affecting the whole project needs to be considered. And there are sources that might be interesting for some reason (e.g. they conceptually discuss skills, they describe a skills acquisition process, they use a particular scale for measuring skills) but they fall outside our selection criteria (e.g. the study is of an age group younger than 12 years old).

[347] For example, searching for the word "digital" as a separate term produces an enormous amount of noise including digital resource, digital divide, digital society, digital media, digital object, digitised environments, digital format, digital experience, digital devices, digital communication, and digital artefacts. The same was true for searching for "skill" on its own, which produced 5,500 results, including communications skills, visualisation skills, social skills, behavioural skills, parent skills, sensory motor skills, language skills, listening skills, creativity skills, relationship skills, and mathematics skill. Hence, the best strategy to overcome this problem was to search phrases like "digital skill*".

[348] The most striking example is the "e-" suffix, as in "e-skills", because the searches do not recognise the hyphen or indeed any other punctuation or special characters. Hence a search for "e-skills" finds "the skills", "i.e., skills" and "(e) skills" because in each case there is an "e" and a space before the word skills. However, it was important to retain the "e-" option because articles do refer to words like "e-skills". While the use of the operator NOT was an option (e.g. do not accept results "i.e., skills") in a search that already had long strings or words and instructions, this potentially introduces further complications. Therefore, it was decided to simply exclude those irrelevant results at screening stage.

[349] For example, one of search phrases may be present, but be mentioned just in passing (as in "future research might look at…") rather than being a central element of that publication.

[350] The search process itself highlights the search terms that it found in the title, keyword or abstract, so it is clear why it identified those sources as relevant.

Child terms

Terms relating to children had been identified in previous reviews by the research team (Livingstone et al. 2017, 2019); Stoilova et al., 2019, although "school student" was added in consultation with the ySKILLS project.

(child* OR youth OR teen* OR adolescen* OR minors OR kid* OR girl* OR boy* OR pupil* OR "school student")

Note that the truncation sign * means the search looks for any term starting with the stem. Hence, child* will identify both child and children, girl* will identify both girl and girls. The parentheses mean the search identifies terms that occur together, so "school student" will identify school student but not student (on its own). The Boolean operator OR means the search identifies sources that contain one or more of the terms in the list.

In discussions, "secondary school" and "high school" were examples of terms that were considered but that led to too much noise. The term "school student" produced more relevant sources.

Methods terms

Since the aim was to identify evidence relating to the antecedents and consequences of children's digital skills, a set of methods terms were chosen to identify these. The methods terms include those designed to identify sources reporting on primary or secondary analysis of evidence (empirical, study, finding, etc.) and those specifically designed to identify quantitative research (quantitative, test, scale, etc.).

(survey* OR questionnaire OR meta-analys* OR quantitative OR empirical OR performance OR test* OR study OR studies OR finding* OR result* OR exam OR "measur*" OR scale OR instrument OR cohort OR sample OR validate)

"Case study", "focus group" and "observation" were all omitted because they were associated with qualitative approaches, while "interview" and "method" produced too much noise. "Measur*", "scale", "instrument", "cohort" and "sample" were added after discussion and testing these words.

Digital skill terms

As noted above, the decision was taken to search for digital+skill terms in combination. The digital terms were: digital, mobile, internet, social media, cyber-, technology, computer, information, coding, programming, gaming, ICT and the prefix "e-". The skill terms were: competency, resilience, literacy, coping, efficacy and confidence.

("digital skill*" OR "mobile* skill*" OR "internet skill*" OR "online skill*" OR "social media skill*" OR "cyber* skill*" OR "app skill*" OR "technolog* skill*" OR "comput* skill*" OR "information skill*" OR "coding skill*" OR "programming skill*" OR "gaming skill*" OR "ICT skill*" OR "e-skill*")*

("digital competen*" OR "mobile* competen*" OR "internet competen*" OR "online competen*" OR "social media competen*" OR "cyber* competen*" OR "app competen*" OR "technolog* competen*" OR "comput* competen*" OR "information competen*" OR "coding competen*" OR "programming competen*" OR "gaming competen*" OR "ICT competen*" OR "e-competen*")*

("digital resilien*" OR "mobile* resilien*" OR "internet resilien*" OR "online resilien*" OR "social media resilien*" OR "cyber* resilien*" OR "app resilien*" OR "technolog* resilien*" OR "comput* resilien*" OR "information resilien*" OR "coding resilien*" OR "programming resilien*" OR "gaming resilien*" OR "ICT resilien*" OR "e-resilien*")*

("digital literac*" OR "mobile* literac*" OR "internet literac*" OR "online literac*" OR "social media literac*" OR "cyber* literac*" OR "app literac*" OR "technolog* literac*" OR "comput* literac*" OR "information literac*" OR "coding literac*" OR "programming literac*" OR "gaming literac*" OR "ICT literac*" OR "e-literac*")*

("digital literate" OR "mobile* literate" OR "internet literate" OR "online literate" OR "social media literate" OR "cyber* literate" OR "app literate" OR "technolog* literate" OR "comput* literate" OR "information literate" OR "coding literate" OR "programming literate" OR "gaming literate" OR "ICT literate" OR "e-literate")*

("digital coping" OR "mobile* coping" OR "internet coping" OR "online coping" OR "social media coping" OR "cyber* coping" OR "app coping" OR "technolog* coping" OR "comput* coping" OR "information coping" OR "coding coping" OR "programming coping" OR "gaming coping" OR "ICT coping" OR "e-coping")*

("digital efficacy" OR "mobile* efficacy" OR "internet efficacy" OR "online efficacy" OR "social media efficacy" OR "cyber* efficacy" OR "app efficacy" OR "technolog* efficacy" OR "comput* efficacy" OR "information efficacy" OR "coding efficacy" OR "programming efficacy" OR "gaming efficacy" OR "ICT efficacy" OR "e-efficacy")*

Combining digital words with "learn" produced too much noise, but "confidence" was added at this stage.

The final search string took the form: child terms AND methods terms AND digital skill terms. The sources thereby identified must include all three of these types of term (e.g. child+study+"digital skill" or girl+finding+"coding literate").[351]

[351] There had to be small adaptations for different databases. The chief one was that some of databases would not recognise "social media skill", because they allowed phrases with two words, but not with three words. However, the databases accepted a search for this phrase (and related ones like social media competen*) which did not require the use of the parentheses "" when these sources we in a separate search.

(child OR youth OR teen* OR adolescen* OR minors OR kid* OR girl* OR boy* OR pupil* OR "school student") AND (survey* OR questionnaire OR meta-analys* OR quantitative OR empirical OR performance OR test* OR study OR studies OR finding* OR result* OR exam OR "measur*" OR scale OR instrument OR cohort OR sample OR validate) AND ("digital* skill*" OR "mobile* skill*" OR "internet skill*" OR "online skill*" OR "social media skill*" OR "cyber* skill*" OR "app skill*" OR "technolog* skill*" OR "comput* skill*" OR "information skill*" OR "coding skill*" OR "programming skill*" OR "gaming skill*" OR "ICT skill*" OR "e-skill*") OR ("digital* competen*" OR "mobile* competen*" OR "internet competen*" OR "online competen*" OR "social media competen*" OR "cyber* competen*" OR "app competen*" OR "technolog* competen*" OR "comput* competen*" OR "information competen*" OR "coding competen*" OR "programming competen*" OR "gaming competen*" OR "ICT competen*" OR "e-competen*") OR ("digital* resilien*" OR "mobile* resilien*" OR "internet resilien*" OR "online resilien*" OR "social media resilien*" OR "cyber* resilien*" OR "app resilien*" OR "technolog* resilien*" OR "comput* resilien*" OR "information resilien*" OR "coding resilien*" OR "programming resilien*" OR "gaming resilien*" OR "ICT resilien*" OR "e-resilien*") OR ("digital* literac*" OR "mobile* literac*" OR "internet literac*" OR "online literac*" OR "social media literac*" OR "cyber* literac*" OR "app literac*" OR "technolog* literac*" OR "comput* literac*" OR "information literac*" OR "coding literac*" OR "programming literac*" OR "gaming literac*" OR "ICT literac*" OR "e-literac*") OR ("digital* literate" OR "mobile* literate" OR "internet literate" OR "online literate" OR "social media literate" OR "cyber* literate" OR "app literate" OR "technolog* literate" OR "comput* literate" OR "information literate" OR "coding literate" OR "programming literate" OR "gaming literate" OR "ICT literate" OR "e-literate") OR ("digital* coping" OR "mobile* coping" OR "internet coping" OR "online coping" OR "social media coping" OR "cyber* coping" OR "app coping" OR "technolog* coping" OR "comput* coping" OR "information coping" OR "coding coping" OR "programming coping" OR "gaming coping" OR "ICT coping" OR "e-coping") OR ("digital* efficacy" OR "mobile* efficacy" OR "internet efficacy" OR "online efficacy" OR "social media efficacy" OR "cyber* efficacy" OR "app efficacy" OR "technolog* efficacy" OR "comput* efficacy" OR "information efficacy" OR "coding efficacy" OR "programming efficacy" OR "gaming efficacy" OR "ICT efficacy" OR "e-efficacy") OR ("digital* confidence" OR "mobile* confidence" OR "internet confidence" OR "online confidence" OR "social media confidence" OR "cyber* confidence" OR "app confidence" OR "technolog* confidence" OR "comput* confidence" OR "information confidence" OR "coding confidence" OR "programming confidence" OR "gaming confidence" OR "ICT confidence" OR "e-confidence")*

The search covered "Topic" (in Web Of Science); "Title, Abstract and Keyword" (Scopus, SocINDEX, Communication & Mass Media Complete, ERIC, Embase); "Title, Abstract, Key Concept" (PsychINFO); "Anywhere" (IBSS).

It also covered "All without editorial material" (Web of Science); "Conference papers, Journal articles, books, reviews, short surveys" (Scopus); "All document types" (PsychINFO, SocINDEX, Communication & Mass Media Complete, ERIC, Embase, IBSS).

Appendix 2: Rapid mapping of the evidence – identifying gaps

We carried out a rapid mapping review of the evidence: a preparatory overview of the existing evidence by year, country, language, discipline, and type of publication. This helped identify gaps in the existing research (Aim 1) and to define the inclusion criteria for the systematic evidence review.

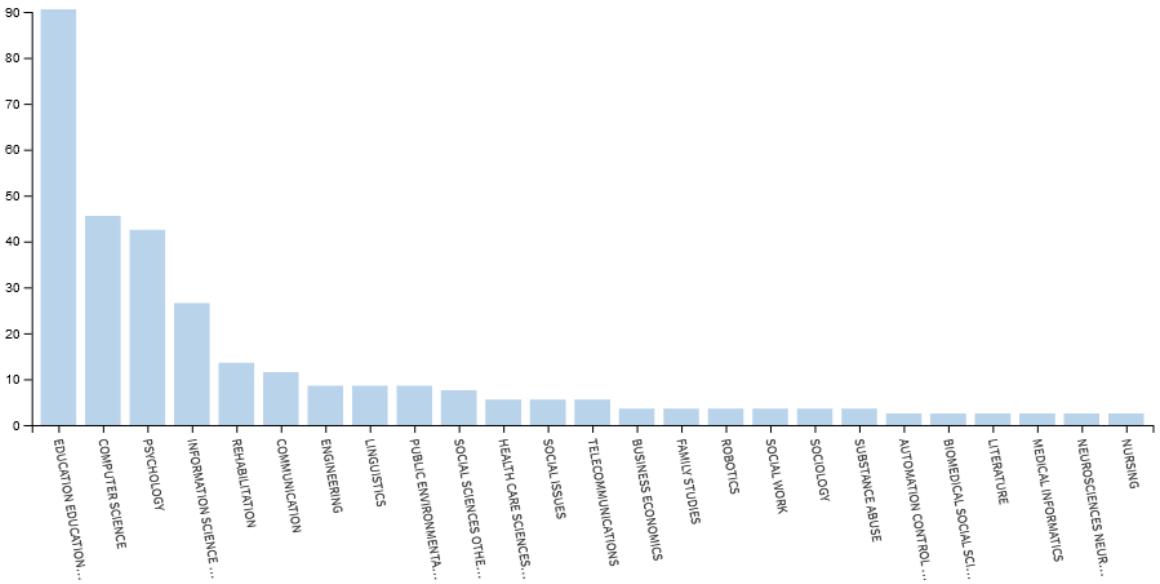
The following analysis compares sources identified for 2000–09 (n=207) and 2010–20 (n=1,401), based on a search of Web of Science.

Research disciplines and publication outlets

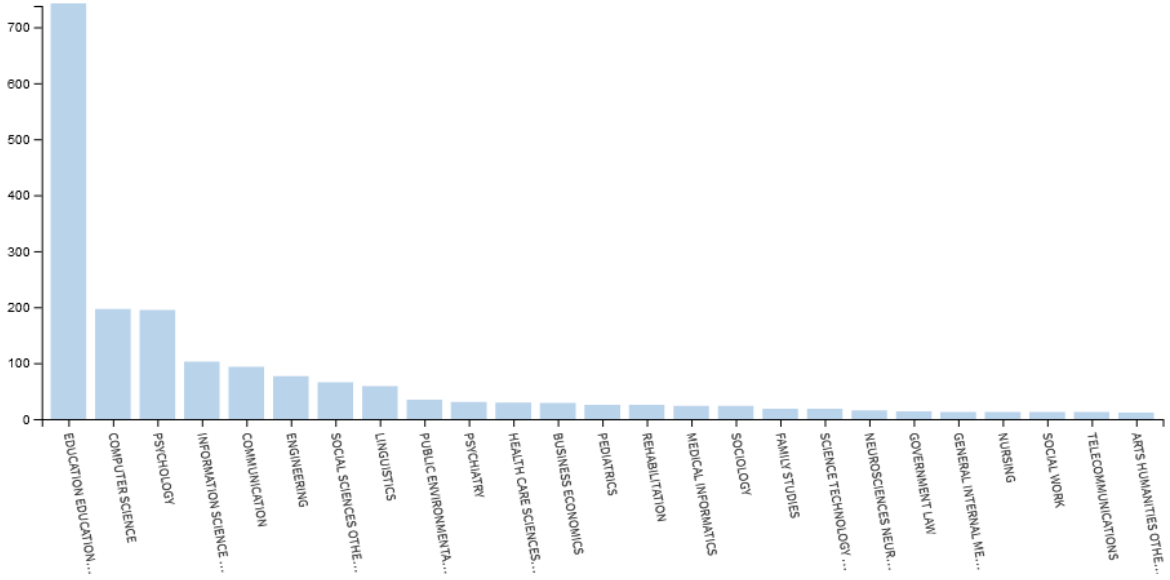
In both decades, by far the main source of publications was the discipline of education followed by computer science and psychology on a similar level, and then information science (see Figure 12). Turning to the type of document, the same order applies in both decades, with publications being first and foremost journal articles, followed by conference proceedings and papers a clear second (see Figure 13).

Figure 12: Research area of publications

2009–20



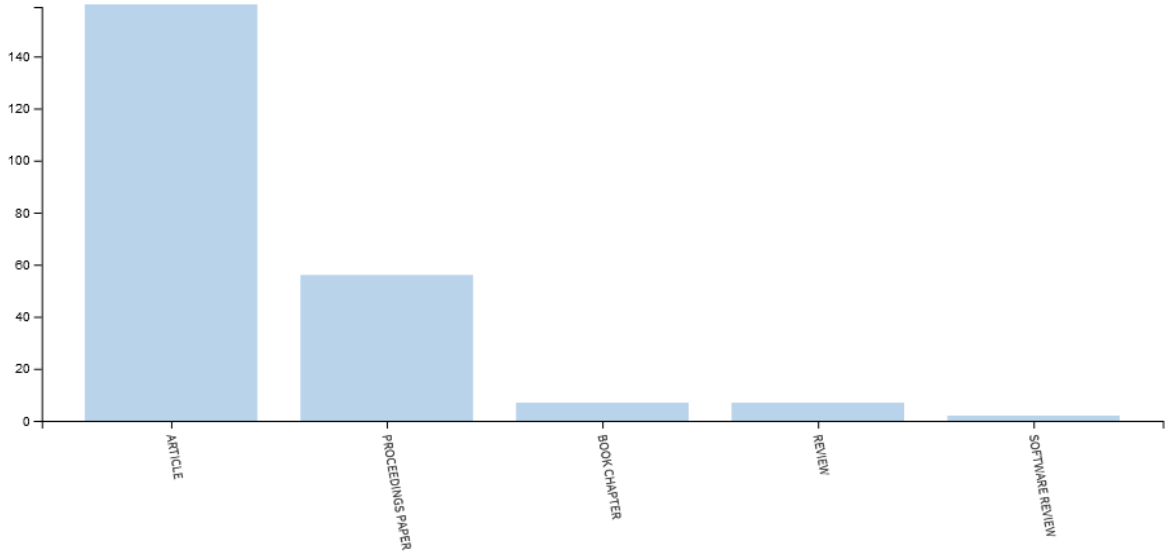
2010–20



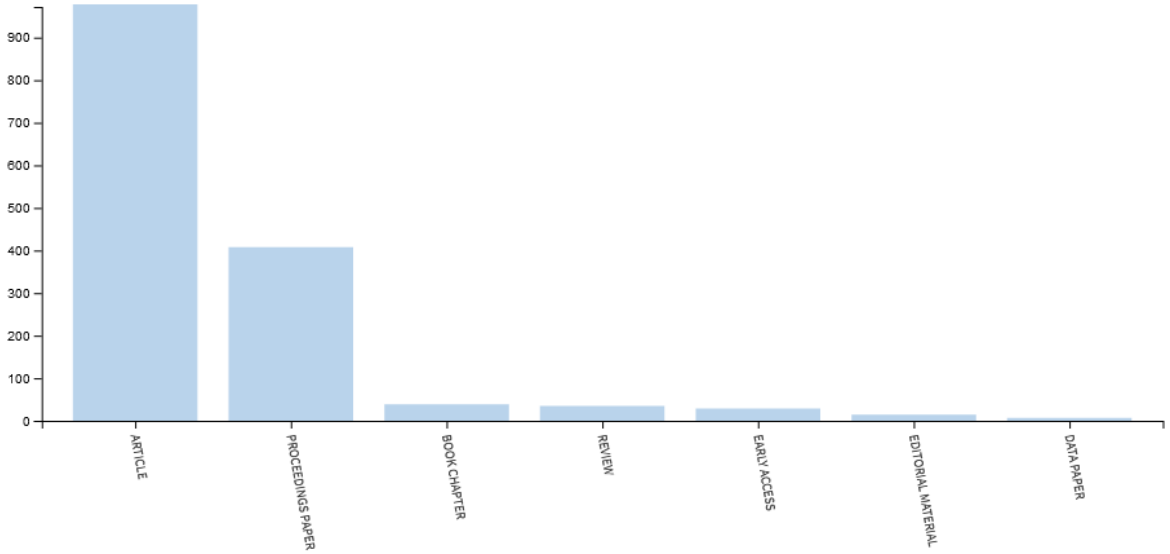
In Figure 12, the general pattern is the same for both decades, with studies from the field of education and educational research dominating, followed by computer science and psychology on a similar level, and then information science. Fewer studies come from sources such as engineering, linguistics, business economics and sociology. Education is the more dominant source of publications in the second decade, 35% of publications coming from education in the first decade, rising to 43% in the second. By comparison, in 2000–09 computer science accounts for 22% and psychology 20%, followed by information science at 12%. In 2010–20, although they increase in numbers, the proportion of studies from these disciplines drops in percentages, as computer science and psychology each account for 14%, followed by information science at 7%.

Figure 13: Type of publication

2009–10



2010–20



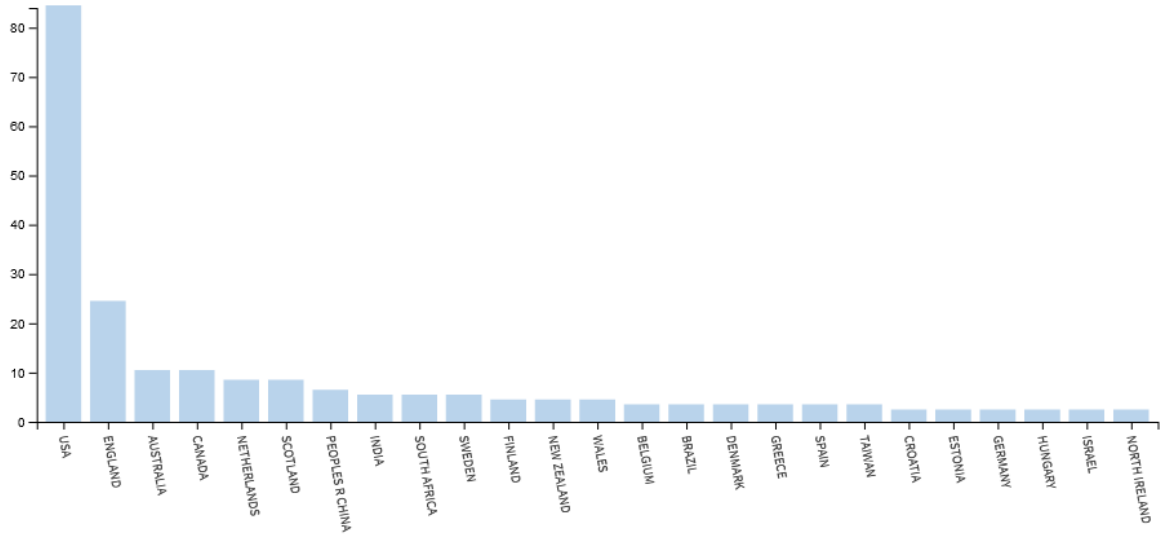
In Figure 13, showing types of document, the same order applies in both decades. Publications are first and foremost journal articles, followed by conference proceedings and papers a clear second, with relatively few other types of document such as book chapters and reviews. The dominance of articles becomes slightly less, accounting for 76% of studies in first decade and 69% in second. The proportion of conference papers is fairly constant (26% and 28% respectively), as is book chapters and reviews, both 3% in the first decade, both 2% in the second one.

Research published by country

Figure 14 shows that by far the predominant origin of publications is the USA, but there is a decline in the percentage of studies from that source, from 41% in the first decade to 26% in the second. The change in the proportion of publications coming from Spain is striking, moving from 1% in the first decade, to clear second place after the USA in the subsequent decade, with 12% of publications. Apart from this change, the order of next few countries remains the same: England (12% in the first decade, 7% in the second) and then Australia and Canada (both 5% in the first decade, both 4% in the second). Smaller proportions of studies come from various European countries and other countries such as China, South Africa and Brazil, where multiple factors may influence the order. There is no basis to conclude that DESI (the degree of national digitisation) influences the number of publications from different countries.

Figure 14: Country of origin of publication

2000–09



2010–20

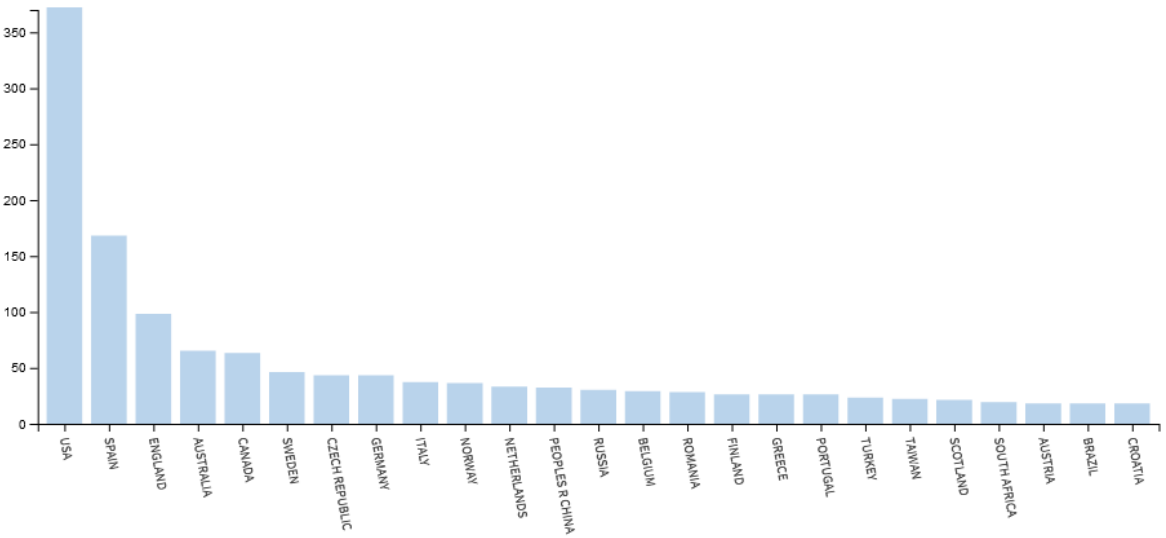
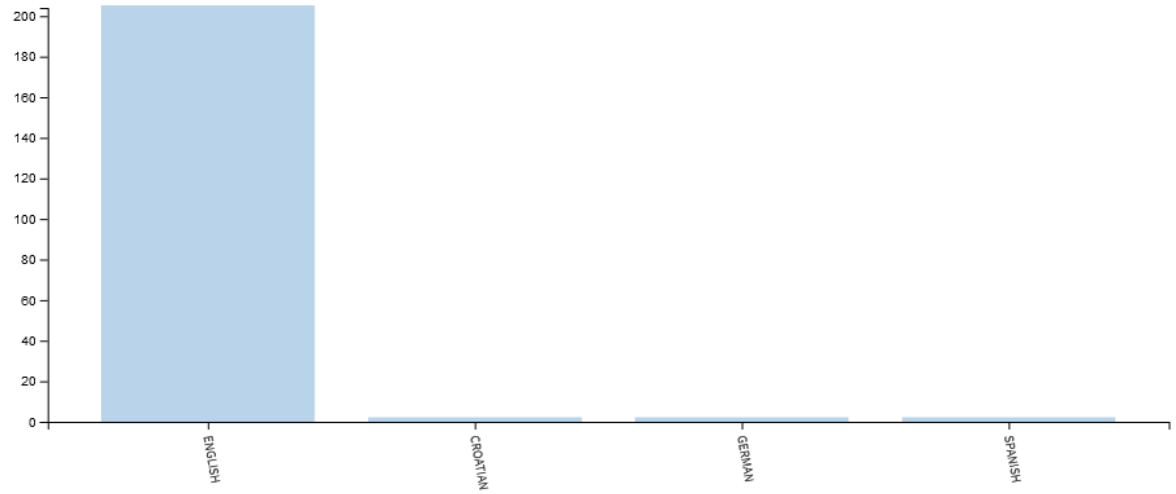


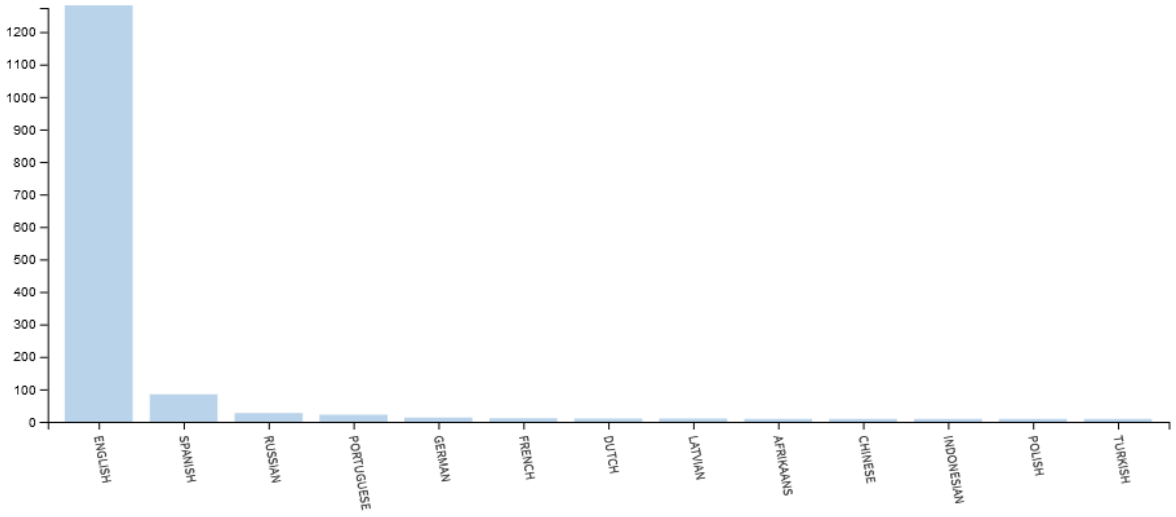
Figure 15 shows that although more publications may now come from diverse countries, most of these are written in English. In 2000–09, 98% were in English, with the remainder in Croatian, German and Spanish. In 2010–20 English is still the main language, accounting for 91% of publications, the small but noticeable change being that 5% are now in Spanish and there are more languages accounting for the remainder (European ones, but also Russian, Chinese, Indonesian and Turkish, for example).

Figure 15: Language of publication

2000–09



2010–20



Appendix 3: Inclusion criteria for screening and Weight of Evidence

This table explains the difference between the eligibility criteria and the Weight of Evidence (WoE) framework and how the studies were scored from "poor" to "good". The list of considerations that help guide whether a study was rated 1, 2 or 3 was identified via consultation with other experts in the ySKILLS project.

	Inclusion criteria	
Eligibility	**Scores and reporting**	**Criteria for inclusion**
Eligibility step 1: Title/ Abstract/ keywords only	Four criteria, cascading principle Yes/No score for each, four 'yes' to remain	**Criterion 1:** Yes: has data on children and digital skills – primary research or secondary data analysis or meta reviews **Criterion 2:** Yes: has quantitative data on children – surveys or experiments **Criterion 3:** Yes: sample includes children aged 12–17 **Criterion 4:** Yes: robust and suitable method – ethical research, understandable and transparent research process and findings, large-enough sample (rule of thumb), if smaller sample needs to have robust analysis or be a randomised experiment
Eligibility step 2: Full text	As above, based on full text	As above
Weight of Evidence	**Scores and reporting**	**Criteria** **Use these criteria as a guide – these should be used to reach a balanced overall judgement**
WoE A	**Score 1–3 for generic quality and execution of study**	**1: Poor** Convenience sampling, no effort to limit selection bias Might have a small sample <500 No controls for confounding effects (and not a randomised experiment) No clear hypotheses No clear links between methods and findings An experiment/intervention/evaluation that is not randomised, and not well designed Mixes children and adults in reporting results
		2: Fair Convenience sampling with a large sample >1,000, or random/stratified sampling with smaller samples 500–1,000 Reports descriptive statistics and correlations from surveys with relevant controls Clear hypotheses An experiment/intervention/evaluation that is not randomised, but is otherwise fairly well designed (e.g. quasi-experimental methods such as difference-in-differences) Reports data on children separately
		3: Good Cross-sectional surveys with randomised representative sampling or longitudinal designs Large sample 1,000 and over Stats are used to convincingly test causal hypotheses Includes performance tests Robust experiment/intervention/evaluation with RCT, control group or quasi-experimental design (pre and post) Reports data on children separately or by different age groups of children
WoE B	**Score 1–3 for digital skills**	**1: Poor** No clear definition or measure of digital skills Uses online activities as a proxy for skills Measures skills on a particular platform (e.g. Facebook) in a way that can't be applied to the internet as a whole
		2: Fair Clear definition and measure of digital skills but one-dimensional (e.g. only technical competence, or only social media skills) If internet use is as a proxy for skills, it is clearly related to a broad range of different technical, communicative, information and content creation critical skills Uses confidence or self-efficacy measures for skills (e.g. how good are you at using the internet?) No theoretical or statistical model of skills
		3: Good

		Complex definition of digital skills allowing multiple dimensions (e.g. information, social, technical) Robust measures of the different dimensions of digital skills Measures digital skill competence, not confidence ("I know how to…") Includes a model of skills explain how the different dimensions fit together Includes least the descriptive characteristics of the skills measures (means and standard deviations). Might discuss skills in a model of learning, child outcomes Might have some offline elements of skills (e.g. critical thinking) Might report on reliability and validity of scales
WoE C	**Score 1–3 for antecedents and consequences**	**1: Poor** No or very limited discussion of antecedents and/or consequences (e.g. only gender or only age) Antecedents and/or consequences are not clearly defined There is no theoretical or statistical model to explain antecedents and/or consequences
		2: Fair Includes a fairly in-depth discussion of antecedents and/or consequences No theoretical or statistical model to explain antecedents and/or consequences
		3: Good Includes a substantial and in-depth discussion of antecedents and/or consequences Has some (even simple) theoretical or statistical model to explain antecedents and/or consequences (pathways) Reports how these measures influence or are influenced by digital skills
WoE D	**Score 1–3: Average of scores for A, B and C**	Studies scoring 2 or above were retained for analysis on the basis that a score of 1 on WoE A, B or C did not merit further analysis unless compensated by a score of 3 on another WoE criterion. Studies scoring below 2 on WoE C were also excluded on the grounds that they could not be coded for antecedents or consequences

Appendix 4: Original coding framework

This is a Word version of the information originally collected on an Excel sheet. On the Excel sheet there were many cells in which notes could be added – these are not shown in the table below. At a later stage the various "others" noted below were allocated to different categories, or were combined to produce new categories (e.g. the antecedent "perceptions and attitudes"), some categories were renamed ("managing technologies" became "approach to digital technologies") and re-ordered to produce the final report.

Authors	Year	Title		
WoE[352] A score	WoE B score	WoE C score	WoE overall score	
Country/countries				
Method:[353] Survey, Experiment, Other				
Analytical method: Correlations, Regression analysis, Structural model, Other				
Number of participants				
Age (or school grade if age n/a)				
Summary: Aims, Methods, Findings				
Digital skills				
How are digital skills conceptualised?				
What type of measure?[354] Performance test, Self-report, Other				
What is the claim for rigour of the digital skills measure? Well-known measure (e.g. PISA, EUKO), References another paper, Within paper – Cronbach's alpha, Within paper – other, Expert advice				
Are digital skills… An outcome, A predictor, A mediator or moderator				
Antecedents				
Personal attributes	Has it been measured?	Statistically significant?	Positive or negative[355]	Significance threshold[356]
Age				
Gender				
Ethnicity[357]				
Personality type				
Vulnerabilities[358]				
Approach to learning[359]				
Interests[360]				
Attitudes to computers/internet				
Digital self-efficacy (i.e., confidence in one's skills)[361]				
Cognitive abilities[362]				
Education (e.g. grades)				
Leisure activities[363]				
Past experiences[364]				
Other				

[352] WoE score from the pre-coding stage.
[353] Coders could indicate which methods were applicable.
[354] Coders could indicate which measures were applicable.
[355] For example, it is a positive direction of influence if higher age is correlates with more digital skills. Sometimes what counted as positive had to be defined (e.g. female = positive).
[356] P value (e.g. p=0.001).
[357] Including migrant background.
[358] For example, SEND – special educational needs and disabilities, mental health problems.
[359] For example, motivation, learning style.
[360] For example, in science, news.
[361] This has been an antecedent (i.e., whether this confidence actually leads to improved digital skills).
[362] For example, cognitive style, analytical intelligence, reading ability.
[363] For example, time spent reading.
[364] For example, exposure to media violence, traditional victimisation.

Social context	Has it been measured?	Statistically significant?	Positive or negative	Significance threshold
SES[365]				
Household composition[366]				
Parental mediation[367]				
Other parental variables[368]				
Peer variables[369]				
Urban–rural residence				
Other community variables[370]				
Teacher variables[371]				
Students' experience in the school[372]				
School variables[373]				
Other				
ICT environment	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
ICT availability at home[374]				
Frequency of use of ICT				
Age of first use of ICT				
Number and type of devices used				
Other				
Online activities	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Gaming[375]				
Use of social media/SNS				
Other activities using ICT[376]				
Negative online experiences[377]				
Other				
System-level	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Country/cultural environment[378]				
Country ICT/internet adoption level				
Media systems				
Other				
Other antecedent	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Consequences				
Wellbeing	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Life satisfaction				
Mental health				
Other				

[365] Including proxies like parent's education, income and free lunches.
[366] For example, single-parent household.
[367] Including active support.
[368] For example, parental attitudes to ICT/internet, ICT competence, children's general relationship with parents, whether parents informally teach children about ICT.
[369] For example, informal teaching of ICT skills, friend's supporting activity.
[370] For example, after- or outside school clubs for teaching ICT.
[371] For example, ICT competence, attitudes to ICT, teaching methods, amount of teacher support.
[372] A separate category because sometimes this could be at the class/teacher level and sometimes it could be at the school level, e.g. what ICTs are used for in class, number of lessons when children use computers, having a personalised learning curriculum, enrolment in technology-related classes.
[373] For example, policy, ICT support, technological literacy component in the curriculum.
[374] For example, no internet vs. shared internet; having access to a computer.
[375] If there are several studies on a topic like gaming, does it deserve its own category?
[376] For example, learning, community participation, civic participation, creative participation, social relationship, entertainment, personal (health, support), commercial, communication.
[377] For example, cyber-victimisation, problematic internet use.
[378] For example, Coronavirus rates, Hofstede's cultural categories.

Offline actions	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Civic engagement[379]				
Other actions[380]				
Other				
Learning outcomes	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Reading ability/literacy				
Maths ability				
Other cognitive abilities[381]				
Other attributes[382]				
Technical/digital abilities[383]				
School performance/grades[384]				
Other				
Risk of harm	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Online risks[385]				
Harmful online experiences[386]				
Other				
Managing technology	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Coping with digitally mediated risks or other experiences[387]				
Privacy-related[388]				
Technical digital engagement[389]				
Other				
Online opportunities	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Civic engagement[390]				
Creative engagement[391]				
Other changes in internet engagement[392]				
Other				
Changes in other people[393]	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold
Other consequence	Has it been measured?	Statistically significant?	Positive or negative?	Significance threshold

[379] For example, volunteering, donations, involvement in charitable organisations, political activities, signature-seeking campaigns, boycotts, rallies.
[380] For example, willingness to disclose personal information generally, persistence in following a career choice.
[381] For example, spatial skills, reasoning skills, creative thinking, metacognition, concentration.
[382] For example, aggressive behaviour.
[383] For example, coding, information seeking.
[384] For example, academic success, performance in PISA tests.
[385] For example, cyberbullying, being cyberbullied, excessive use/addiction, safety on SNSs.
[386] For example, stress from online victimisation, being bothered by things on the internet.
[387] For example, how much they cope, strategies they use, more self-regulation.
[388] For example, management of online privacy, willingness to disclose personal information online.
[389] For example, blocking spam, changing filters, more careful searching.
[390] For example, posting messages to persuade others, sharing others' posts and joining online campaigns, signing online petitions.
[391] For example, creating a blog, posting created material.
[392] For example, more social communication, more media access and use, gaming, greater breadth of use, non-adoption of the internet.
[393] Parents (e.g. parental behaviour), extended family (e.g. skills of grandparents, siblings), peers, teachers, etc.

Appendix 5: List of studies in N_3

Table A.1	List of all studies in N_3							
	Reference	Type	Skills measure	N[394]	Country	Age	A/C/M[395]	Method[396]
1	Aesaert, K. & van Braak, J. (2014). Exploring factors related to primary school pupils' ICT self-efficacy: A multilevel approach. Computers in Human Behavior, 41, 327–41.	Survey	Self-report	2,421	Belgium (Flanders)	10–14	A	C R
2	Aesaert, K. & van Braak, J. (2015). Gender and socioeconomic related differences in performance based ICT competences. Computers & Education, 84, 8–25.	Survey	Test	378	Belgium (Flanders)	11–12	A	C
3	Aesaert, K., van Nijlen, D., Vanderlinde, R., Tondeur, J., Devlieger, I., & van Braak, J. (2015). The contribution of pupil, classroom and school level characteristics to primary school pupils' ICT competences: A performance-based approach. Computers & Education, 87, 55–69.	Survey	Test	378	Belgium (Flanders)	10–13	A	R
4	Alkan, M. & Meinck, S. (2016). The relationship between students' use of ICT for social communication and their computer and information literacy. Large-scale Assessments in Education, 4(1), 15.	Survey	Test	60,000	Australia, Chile, Croatia, Czech Republic, Germany, South Korea, Lithuania, Norway, Poland, Russia, Slovakia, Slovenia, Thailand, Turkey, Canada, Denmark, Hong Kong,	13	A	R

[394] Sample size.
[395] Antecedent, consequence or mediator/moderator.
[396] C = correlations, R = regressions, S = structural, O = other.

					Netherlands, Switzerland, Argentina			
5	Appel, M. (2012). Are heavy users of computer games and social media more computer literate? Computers & Education, 59(4), 1339–49.	Survey	Test	200	Austria	16–19	A	C R
6	Areepattamannil, S. & Khine, M. S. (2017). Early adolescents' use of information and communication technologies (ICTs) for social communication in 20 countries: Examining the roles of ICT-related behavioral and motivational characteristics. Computers in Human Behavior, 73, 263–72.	Survey	Self-report	56,209	Argentina, Australia, Canada, Chile, Hong Kong, Croatia, Czech Republic, Denmark, Germany, Lithuania, Netherlands, Norway, Poland, South Korea, Russia, Slovakia, Slovenia, Switzerland, Thailand, Turkey. International Computer and Information Literacy Study (ICILS) database	13–16	C	R

7	Areepattamannil, S. & Santos, I. M. (2019). Adolescent students' perceived information and communication technology (ICT) competence and autonomy: Examining links to dispositions toward science in 42 countries. Computers in Human Behavior, 98, 50–8.	Survey	Self-report	258,192	Australia, Austria, Belgium, Brazil, Bulgaria, Chile, Taiwan, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Peru Poland, Portugal, Russia, Singapore, Slovakia, New Zealand, Slovenia, Spain, Switzerland, Thailand, UK	15	C	S
8	Ashlock, M., Stojnic, M., & Tufekci, Z. (2019). Gender and videogames in the path to computing careers. Conference Papers – American Sociological Association. Washington, DC: American Sociological Association.	Survey	Self-report	5,235	USA	11–13	A	C R
9	Balea, B. (2016). The role of smartphones in increasing digital and social inequalities among Romanian children. Journal of Comparative Research in Anthropology and Sociology, 7(02), 1–20.	Survey	Self-report	522	Romania	9 –16	A	R

10	Balea, B. (2016). Digital natives or not? How do Romanian adolescents cross the boundaries of internet common use? Studia Universitatis Babes-Bolyai Sociologia, 61(1), 59–76.	Survey	Self-report	595	Romania	11–16	C	R
11	Bernadas, J. M. A. C. & Soriano, C. R. (2019). Online privacy behavior among youth in the Global South. Journal of Information, Communication and Ethics in Society, 17(1), 17–30.	Survey	Self-report	300	Philippines	11–25	A C M	R S
12	Cabello-Hutt, T., Cabello, P., & Claro, M. (2018). Online opportunities and risks for children and adolescents: The role of digital skills, age, gender and parental mediation in Brazil. New Media & Society, 20(7), 2411–31.	Survey	Self-report	1,694	Brazil	9–17	A C M	C S
13	Christoph, G., Goldhammer, F., Zylka, J., & Hartig, J. (2015). Adolescents' computer performance: The role of self-concept and motivational aspects. Computers & Education, 81, 1–12.	Survey	Test and self-report	445	Germany	14–17	A C	R
14	Colvin-Sterling, S. (2016). The correlation between temperament and technology preference and proficiency in middle school students. Journal of Information Technology Education: Research, 15, 1–18.	Survey	Test	194	USA	13–16	A	R
15	DeLay, D., Hartl, A. C., Laursen, B., Denner, J., Werner, L., Campe, S., & Ortiz, E. (2014). Learning from friends: Measuring influence in a dyadic computer instructional setting. International Journal of Research & Method in Education, 37(2), 190–205.	Survey and intervention	Test	160	USA (California)	10–14	A C	O
16	Dindar, M. (2018). An empirical study on gender, video game play, academic success and complex problem solving skills.	Survey and intervention	Self-report	479	Turkey	14–20	A C	C

	Computers & Education, 125, 39–52.							
17	Duarte, R., Cazelli, S., Migliora, R., & Coimbra, C. (2013). Computer skills and digital media uses among young students in Rio de Janeiro. Education Policy Analysis Archives/Archivos Analíticos de Políticas Educativas, 21, 1–29.	Survey	Self-report	3,705	Brazil	12–18	A	R
18	Duvenage, M., Correia, H., Uink, B., Barber, B. L., Donovan, C. L., & Modecki, K. L. (2020). Technology can sting when reality bites: Adolescents' frequent online coping is ineffective with momentary stress. Computers in Human Behavior, 102, 248–59.	Intervention	Self-report	156	Australia	13–16	A C	R
19	Eynon, R. & Malmberg, L. E. (2012). Understanding the online information-seeking behaviours of young people: the role of networks of support. Journal of Computer Assisted Learning, 28(6), 514–29.	Survey	Self-report	669	UK	12, 14, 17–19	A C	S O
20	Fingar, K. R. & Jolls, T. (2014). Evaluation of a school-based violence prevention media literacy curriculum. Injury Prevention, 20(3), 183–90.	Survey & intervention	Self-report	2,006	USA (California)	11–13	A C	R
21	Fizeşan, B. (2012). Digital engagement among Eastern European children. Studia Universitatis Babes-Bolyai-Sociologia, 57(1), 83–99.	Survey	Self-report	1,609	Romania, Bulgaria	9–16	A C	S
22	Forzani, E. (2018). How well can students evaluate online science information? Contributions of prior knowledge, gender, socioeconomic status, and offline reading ability. Reading Research Quarterly, 53(4), 385–90.	Survey and intervention	Test	1,434	US	12	A	C R O
23	Gini, G., Marino, C., Xie, J. Y., Pfetsch, J., & Pozzoli, T. (2019). Associations of traditional and peer cyber-victimization with adolescents' internet use: A latent profile analysis.	Survey	Self-report	1,377	Italy	14–18	C	R O

	Cyberpsychology: Journal of Psychosocial Research on Cyberspace, 13(4).							
24	Gui, M. & Argentin, G. (2011). Digital skills of internet natives: Different forms of digital literacy in a random sample of northern Italian high school students. New Media & Society, 13(6), 963–80.	Survey	Test	980	Italy	15–20	A	R
25	Hatlevik, O. E., Guðmundsdóttir, G. B., & Loi, M. (2015). Examining factors predicting students' digital competence. Journal of Information Technology Education: Research, 14(14), 123–37.	Survey	Test and self-report	852	Norway	14–15	A	S
26	Hatlevik, O. E., Scherer, R., & Christophersen, K. A. (2017). Moving beyond the study of gender differences: An analysis of measurement invariance and differential item functioning of an ICT literacy scale. Computers & Education, 113, 280–93.	Survey	Test	919	Norway	14–15	A	O
27	Helsper, E. J. & Eynon, R. (2013). Distinct skill pathways to digital engagement. European Journal of Communication, 28(6), 696–713.	Secondary	Self-report	2,057	UK	Over 14	A C M	S
28	Hohlfeld, T. N., Ritzhaupt, A. D., & Barron, A. E. (2013). Are gender differences in perceived and demonstrated technology literacy significant? It depends on the model. Educational Technology Research and Development, 61(4), 639–63.	Survey	Test and self-report	1,513	USA	13	A	C S
29	Hsiao, H. C., Tu, Y. L., & Chung, H. N. (2012). Perceived social supports, computer self-efficacy, and computer use among high school students. Turkish Online Journal of Educational Technology: TOJET, 11(2), 167–77.	Survey	Self-report	525	Taiwan	15–18	A C M	S

30	Jean, B. S., Subramaniam, M., Taylor, N. G., Follman, R., Kodama, C., & Casciotti, D. (2015). The influence of positive hypothesis testing on youths' online health-related information seeking. New Library World, 116(3/4), 136–54.	Intervention	Test and self-report	11	USA	11–14	A	O
31	Juhaňák, L., Zounek, J., Záleská, K., Bárta, O., & Vlčková, K. (2019). The relationship between the age at first computer use and students' perceived competence and autonomy in ICT usage: A mediation analysis. Computers & Education, 141, 103614.	Secondary	Self-report	123,983	21 European OECD countries	15	A	R S
32	Kaarakainen, M. T. (2019). ICT intentions and digital abilities of future labor market entrants in Finland. Nordic Journal of Working Life Studies, 9(2), 105–26.	Survey	Test and self-report	3,206	Finland	15–22	A C	C R
33	Kaarakainen, M. T., Kivinen, O., & Vainio, T. (2018). Performance-based testing for ICT skills assessing: A case study of students and teachers' ICT skills in Finnish schools. Universal Access in the Information Society, 17(2), 349–60.	Survey	Test	3,159	Finland	13–15	A	O
34	Kahne, J. & Bowyer, B. (2019). Can media literacy education increase digital engagement in politics? Learning, Media and Technology, 44(2), 211–24.	Survey	Self-report	498	USA	11–17	C	R
35	Karuovic, D., Glusac, D., Radosav, D., & Grahovac, D. (2016, May). Use of informal knowledge sources and net generation. In 2016 6th International Conference on Computers Communications and Control (ICCCC) (pp.55–63). IEEE.	Survey	Self-report	930	Serbia	14–18	A	C O
36	Khan, M. L., Wohn, D. Y., & Ellison, N. B. (2014). Actual friends matter: An internet skills perspective on teens' informal academic collaboration on Facebook.	Survey	Self-report	690	USA	14–17	C	R

	Computers & Education, 79, 138–47.							
37	Kiili, C., Leu, D. J., Marttunen, M., Hautala, J., & Leppänen, P. H. (2018). Exploring early adolescents' evaluation of academic and commercial online resources related to health. Reading and Writing, 31(3), 533–57.	Survey	Test and self-report	415	Finland	12–13	A	R
38	Kim, H. S., Ahn, S. H., & Kim, C. M. (2019). A new ICT literacy test for elementary and middle school students in Republic of Korea. The Asia-Pacific Education Researcher, 28(3), 203–12.	Survey	Self-report	15,000	Republic of Korea	10–15	A	O
39	Kim, H. S., Kil, H. J., & Shin, A. (2014). An analysis of variables affecting the ICT literacy level of Korean elementary school students. Computers & Education, 77, 29–38.	Survey	Test	11,767	Republic of Korea	10–12	A	R
40	Kim, J. & Lee, W. (2013). Meanings of criteria and norms: Analyses and comparisons of ICT literacy competencies of middle school students. Computers & Education, 64, 81–94.	Survey	Test	15,558	Republic of Korea	12–16	A	R
41	Kim, E. M. & Yang, S. (2016). Internet literacy and digital natives' civic engagement: Internet skill literacy or internet information literacy? Journal of Youth Studies, 19(4), 438–56.	Survey	Self-report	238	South Korea	16–17	C	R
42	Kokkinos, C. M., Antoniadou, N., Asdre, A., & Voulgaridou, K. (2016). Parenting and Internet behavior predictors of cyber-bullying and cyber-victimization among preadolescents. Deviant Behavior, 37(4), 439–55.	Survey	Self-report	220	Greece	10–12	A	C R
43	Kumazaki, A., Suzuki, K., Katsura, R., Sakamoto, A., & Kashibuchi, M. (2011). The effects of netiquette and ICT skills on school-bullying and cyber-bullying: The two-wave panel study of	Survey	Self-report	4,308	Japan	6–18	C	R

	Japanese elementary, secondary, and high school students. Procedia – Social and Behavioral Sciences, 29, 735–41.								
44	Lau, W. W. & Yuen, A. H. (2011). Modelling programming performance: Beyond the influence of learner characteristics. Computers & Education, 57(1), 1202–13.	Survey	Test	131	Hong Kong	16–18	A	S
45	Lau, W. W. & Yuen, A. H. (2015). Factorial invariance across gender of a perceived ICT literacy scale. Learning and Individual Differences, 41, 79–85.	Survey	Self-report	826	Hong Kong	9–16	A	O
46	Leung, L. & Lee, P. S. (2012). Impact of internet literacy, internet addiction symptoms, and internet activities on academic performance. Social Science Computer Review, 30(4), 403–18.	Survey	Self-report	718	Hong Kong	9–19	C	R
47	Leung, L. & Lee, P. S. (2012). The influences of information literacy, internet addiction and parenting styles on internet risks. New Media & Society, 14(1), 117–36.	Survey	Self-report	718	Hong Kong	9–19	C	C R
48	Li, Y. & Ranieri, M. (2010). Are 'digital natives' really digitally competent? A study on Chinese teenagers. British Journal of Educational Technology, 41(6), 1029–42.	Survey	Test	317	China	14–17	A	C
49	Lin, P. Y., Chai, C. S., & Jong, M. S. Y. (2019). A PISA-2015 comparative meta-analysis between Singapore and Finland: Relations of students' interest in science, perceived ICT competence, and environmental awareness and optimism. International Journal of Environmental Research and Public Health, 16(24), 5157.	Secondary	Self-report	11,997	Singapore, Finland	15	A C	C R

50	Livingstone, S. & Helsper, E. (2010). Balancing opportunities and risks in teenagers' use of the internet: The role of online skills and internet self-efficacy. New Media & Society, 12(2), 309–29.	Survey	Self-report	789	UK	10–17	A C M	C S
51	Livingstone, S., Ólafsson, K., & Staksrud, E. (2013). Risky social networking practices among "underage" users: Lessons for evidence-based policy. Journal of Computer-Mediated Communication, 18(3), 303–20.	Survey	Self-report	25,142	25 EU countries, (EU Kids Online)	9–16	A C	C
52	Lombardi, A., Izzo, M. V., Gelbar, N., Murray, A., Buck, A., Johnson, V., ... & Kowitt, J. (2017). Leveraging information technology literacy to enhance college and career readiness for secondary students with disabilities. Journal of Vocational Rehabilitation, 46(3), 389–97.	Intervention	Test and self-report	108	USA	15–18	A	R
53	Macedo-Rouet, M., Salmerón, L., Ros, C., Pérez, A., Stadtler, M., & Rouet, J. F. (2020). Are frequent users of social network sites good information evaluators? An investigation of adolescents' sourcing abilities (¿Son los usuarios frecuentes de las redes sociales evaluadores competentes? Un estudio de las habilidades de los adolescentes para identificar, evaluar y hacer uso de las fuentes). Journal for the Study of Education and Development, 43(1), 101–38.	Survey	Test	146	France	13–17	A	R
54	Malamud, O, & Pop-Eleches, C. (2011). Home computer use and the development of human capital. The Quarterly Journal of Economics, 126(2), 987–1027.	Survey and intervention	Test and self-report	3,354	Romania	7–19	A	R

55	Mannerström, R., Hietajärvi, L., Muotka, J., & Salmela-Aro, K. (2018). Identity profiles and digital engagement among Finnish high school students. Cyberpsychology, 12(1).	Survey	Self-report	932	Finland	17–18	A C	R S
56	McLean, S. A., Wertheim, E. H., Masters, J., & Paxton, S. J. (2017). A pilot evaluation of a social media literacy intervention to reduce risk factors for eating disorders. International Journal of Eating Disorders, 50(7), 847–51.	Intervention	Self-report	101	Australia	11–14	A C M	S
57	Meneses, J. & Mominó, J. M. (2010). Putting digital literacy in practice: How schools contribute to digital inclusion in the network society. The Information Society, 26(3), 197–208.	Survey	Self-report	6,602	Spain	11–18	A	R
58	Metzger, M. J., Flanagin, A. J., Markov, A., Grossman, R., & Bulger, M. (2015). Believing the unbelievable: understanding young people's information literacy beliefs and practices in the United States. Journal of Children and Media, 9(3), 325–48.	Survey	Test and self-report	2,747	USA	11–18	A	R
59	Metzger, M., Flanagin, A., & Nekmat, E. (2015). Comparative optimism in online credibility evaluation among parents and children. Journal of Broadcasting & Electronic Media, 59(3), 509–29.	Survey	Self-report	2,747	USA	11–18	A	R
60	Metzger, M. J., Flanagin, A. J., Medders, R., Pure, R., Markov, A., & Hartsell, E. (2013). The special case of youth and digital information credibility. In Online Credibility and Digital Ethos: Evaluating Computer-Mediated Communication (pp.148–68). IGI Global.	Survey	Self-report	2,747	USA	11–18	A C	R

61	Mitra, S. & Dangwal, R. (2017). Acquisition of computer literacy skills through self-organizing systems of learning among children in Bhutan and India. Prospects, 47(3), 275–92.	Intervention	Test	550	India, Bhutan	6–14	A	R
62	Moon, S. J. & Bai, S. Y. (2020). Components of digital literacy as predictors of youth civic engagement and the role of social media news attention: The case of Korea. Journal of Children and Media, 1–17.	Survey	Self-report	2,584	South Korea	13–18	C	R
63	Neumark, Y., Lopez-Quintero, C., Feldman, B. S., Hirsch Allen, A. J., & Shtarkshall, R. (2013). Online health information seeking among Jewish and Arab adolescents in Israel: Results from a national school survey. Journal of Health Communication, 18(9), 1097–115.	Survey	Self-report	7,028	Israel	12–19	C	R
64	Носенко, Ю. Г., & Сухих, А. С. (2019). The Method for Forming the Health-Saving Component of Basic School Students' Digital Competence. In Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume II: Workshops (No. 2393, pp.178–90). CEUR Workshop Proceedings.	Intervention	Test	280	Ukraine	12–15	A	R
65	Notten, N. & Nikken, P. (2016). Boys and girls taking risks online: A gendered perspective on social context and adolescents' risky online behavior. New Media & Society, 18(6), 966–88.	Survey	Self-report	8,554	25 EU countries, (EU Kids Online)	14–16	C	R
66	Nygren, T. & Guath, M. (2019). Swedish teenagers' difficulties and abilities to determine digital news credibility. Nordicom Review, 40(1), 23–42.	Survey	Test and self-report	483	Sweden	16–19	A	R

67	Park, Y. J. (2015). My whole world's in my palm! The second-level divide of teenagers' mobile use and skill. New Media & Society, 17(6), 977–95.	Secondary	Self-report	552	USA	12–17	AC	R
68	Patmanthara, S. & Hidayat, W. N. (2018, June). Improving vocational high school students' digital literacy skill through blended learning model. Journal of Physics: Conference Series (Vol. 1028, No. 1, p. 012076). IOP Publishing.	Intervention	Self-report	172	Indonesia	15–18	A	O
69	Paus-Hasebrink, I., Bauwens, J., Dürager, A. E., & Ponte, C. (2013). Exploring types of parent–child relationship and internet use across Europe. Journal of Children and Media, 7(1), 114–32.	Survey	Self-report	25,142	25 EU countries, (EU Kids Online)	11–16	A	O
70	Picatoste, J., Pérez-Ortiz, L., & Ruesga-Benito, S. M. (2018). A new educational pattern in response to new technologies and sustainable development. Enlightening ICT skills for youth employability in the European Union. Telematics and Informatics, 35(4), 1031–8.	Secondary	Self-report	–	EU countries, Eurostat data	15–24	A	S
71	Picatoste, J., Pérez-Ortiz, L., Ruesga-Benito, S. M., & Novo-Corti, I. (2018). Smart cities for wellbeing: Youth employment and their skills on computers. Journal of Science and Technology Policy Management.	Secondary	Self-report	–	Eurozone and other countries in the EU	15–24	C	S O
72	Pinkleton, B. E., Austin, E. W., Chen, Y. C. Y., & Cohen, M. (2012). The role of media literacy in shaping adolescents' understanding of and responses to sexual portrayals in mass media. Journal of Health Communication, 17(4), 460–76.	Intervention	Self-report	922	USA	12–18	C	O

73	Ponte, C. (2019). Challenging online situations reported by Italian and Portuguese children in 2018. Mediterranean Journal of Communication, 10(1), 1–14.	Survey	Self-report	1,001	Italy, Portugal	9–17	A	C
74	Porat, E., Blau, I., & Barak, A. (2018). Measuring digital literacies: Junior high-school students' perceived competencies versus actual performance. Computers & Education, 126, 23–36.	Survey	Test and self-report	280	Israel	13	A	C
75	Pullen, D. (2015). The influence of the home learning environment on middle school students' use of ICT at school. Australian Educational Computing, 30(1).	Survey	Self-report	120	Australia	14–15	A	S
76	Punter, R. A., Meelissen, M. R., & Glas, C. A. (2017). Gender differences in computer and information literacy: An exploration of the performances of girls and boys in ICILS 2013. European Educational Research Journal, 16(6), 762–80.	Secondary	Test	25,133	21 EU countries	14	A	C O
77	Reddy, E., Sharma, B., Reddy, P., & Dakuidreketi, M. (2017, December). Mobile Learning Readiness and ICT Competency: A Case Study of Senior Secondary School Students in the Pacific Islands. In 2017 4th Asia-Pacific World Congress on Computer Science and Engineering (APWC on CSE) (pp.137–43). IEEE.	Survey	Self-report	936	Fiji, Samoa, Tonga, Vanuatu	17–19	A C	R
78	Ritzhaupt, A. D., Liu, F., Dawson, K., & Barron, A. E. (2013). Differences in student information and communication technology literacy based on socio-economic status, ethnicity, and gender: Evidence of a digital divide in Florida schools. Journal of Research on Technology in Education, 45(4), 291–307.	Survey	Test	5,990	USA (Florida)	11–13	A	R

79	Rodríguez-de-Dios, I., van Oosten, J. M., & Igartua, J. J. (2018). A study of the relationship between parental mediation and adolescents' digital skills, online risks and online opportunities. Computers in Human Behavior, 82, 186–98.	Survey	Self-report	1,446	Spain	12–18	A C M	S
80	Rupnik, D. & Avsec, S. (2019). The relationship between student attitudes towards technology and technological literacy. World Transactions on Engineering and Technology Education, 17(1), 48–53.	Survey	Test and self-report	180	Slovenia	11–14	A	R
81	Samuelsson, U. (2010). ICT use among 13-year-old Swedish children. Learning, Media and Technology, 35(1), 15–30.	Survey	Self-report	256	Sweden	13	A	C
82	Santos, G., Ramos, E., Escola J., & Reis, M. (2019). ICT literacy and school performance. The Turkish Online Journal of Educational Technology, 18(2), 19–39.	Survey	Self-report	808	Turkey	12–17+	A C M	S
83	Scherer, R., Rohatgi, A., & Hatlevik, O. E. (2017). Students' profiles of ICT use: Identification, determinants, and relations to achievement in a computer and information literacy test. Computers in Human Behavior, 70, 486–99.	Survey	Test and self-report	2,426	Norway	14–16	A C	C
84	Scherer, R., Siddiq, F., & Sánchez Viveros, B. (2019). The cognitive benefits of learning computer programming: A meta-analysis of transfer effects. Journal of Educational Psychology, 111(5), 764.	Second ary	NA	–	Meta-analysis covering many countries – not listed	(Pre-K to grade 12)	C	R
85	Schmid, R. & Petko, D. (2019). Does the use of educational technology in personalized learning environments correlate with self-report digital skills and beliefs of secondary school students? Computers & Education, 136, 75–86.	Survey	Self-report	860	Switzerland	14	A	S

86	Schorr, A. (2019). Pipped at the post: Knowledge gaps and expected low parental IT competence ratings affect young women's awakening interest in professional careers in information science. Frontiers in Psychology, 10, 968.	Survey	Self-report	134	Germany	14–18	A C	R
87	Senkbeil, M. (2018). Development and validation of the ICT motivation scale for young adolescents. Results of the international school assessment study ICILS 2013 in Germany. Learning and Individual Differences, 67, 167–76.	Survey	Test	2,075	Germany	13–17	A	S
88	Shin, W., Huh, J., & Faber, R. J. (2012). Developmental antecedents to children's responses to online advertising. International Journal of Advertising, 31(4), 719–40.	Survey	Self-report	381	South Korea	9–12	C	S
89	Siddiq, F. & Scherer, R. (2019). Is there a gender gap? A meta-analysis of the gender differences in students' ICT literacy. Educational Research Review, 27, 205–17.	Secondary	Test	–	N/A – meta-analysis	(Primary and secondary school)	A	R
90	Sonck, N. & de Haan, J. (2013). How the internet skills of European 11-to 16-year-olds mediate between online risk and harm. Journal of Children and Media, 7(1), 79–95.	Survey	Self-report	19,406	25 EU countries, (EU Kids Online)	11–16	C M	R
91	Soysal, F., Büşra, A. Ç., & Coşkun, E. (2019). Intra and intergenerational digital divide through ICT literacy, information acquisition skills, and internet utilization purposes: An analysis of Gen Z. TEM Journal, 8(1), 264.	Survey	Self-report	477	Turkey	13–17	A	C
92	Staksrud, E., Ólafsson, K., & Livingstone, S. (2013). Does the use of social networking sites increase children's risk of harm? Computers in Human Behavior, 29(1), 40–50.	Survey	Self-report	25,142	25 EU countries, (EU Kids Online)	9–16	C M	

93	Stanoevska-Slabeva, K., Mueller, S., Lippe, S., Seufert, S., Hagel, S., Lischeid, T., ... & Vom Brocke, J. (2017). Modeling and Measuring Social Media Literacy of Digital Natives in the Example of the Lake Constance Region. ICIS Conference.	Survey	Test and self-report	434	Germany, Austria, Switzerland, Liechtenstein (Lake Constance region)	14–19	A	R
94	Staude-Müller, F., Hansen, B., & Voss, M. (2012). How stressful is online victimization? Effects of victim's personality and properties of the incident. European Journal of Developmental Psychology, 9(2), 260–74.	Survey	Self-report	9,760	Germany	10–15	A C M	R
95	Teimouri, M., Benrazavi, S. R., Griffiths, M. D., & Hassan, M. S. (2018). A model of online protection to reduce children's online risk exposure: Empirical evidence from Asia. Sexuality & Culture, 22(4), 1205–29.	Survey	Self-report	420	Malaysia	9–16	C	S
96	Tirado-Morueta, R., Mendoza-Zambrano, D. M., Aguaded-Gómez, J. I., & Marín-Gutiérrez, I. (2017). Empirical study of a sequence of access to internet use in Ecuador. Telematics and Informatics, 34(4), 171–83.	Survey	Self-report	3,754	Ecuador	16–18	A C	S
97	Tondeur, J., Sinnaeve, I., Van Houtte, M., & van Braak, J. (2011). ICT as cultural capital: The relationship between socioeconomic status and the computer-use profile of young people. New Media & Society, 13(1), 151–68.	Survey	Self-report	1,241	Belgium (Flanders)	13, 15, 18	A	C S
98	Vandoninck, S. & d'Haenens, L. (2015). Children's online coping strategies: Rethinking coping typologies in a risk-specific approach. Journal of Adolescence, 45, 225–36.	Survey	Self-report	2,046	Belgium (Flanders)	10–16	A C	O

99	Vandoninck, S., d'Haenens, L., & Donoso, V. (2010). Digital literacy of Flemish youth: How do they handle online content risks? Communications, 35(4), 397–416.	Survey	Self-report	815	Belgium (Flanders)	15–19	A C	S
100	Vandoninck, S., d'Haenens, L., & Roe, K. (2013). Online risks: Coping strategies of less resilient children and teenagers across Europe. Journal of Children and Media, 7(1), 60–78.	Survey	Self-report	25,000	25 EU countries (EU Kids Online)	9–16	C	R
101	Wegmann, E., Stodt, B., & Brand, M. (2015). Addictive use of social networking sites can be explained by the interaction of internet use expectancies, internet literacy, and psychopathological symptoms. Journal of Behavioral Addictions, 4(3), 155–62.	Survey	Self-report	334	Germany	14–29	A C M	S
102	Weston, T. J., Dubow, W. M., & Kaminsky, A. (2020). Predicting women's persistence in computer science- and technology-related majors from high school to college. ACM Transactions on Computing Education, September 2019. https://doi.org/10.1145/3343195	Survey	Self-report	494	USA	14–18	C	R
103	Whitman, L. E., Phelps, M. C., Reynolds, K. V., & Chaparro, B. S. (2012). Assessing technological literacy of middle school students. https://commons.erau.edu/publication/1199	Intervention	Self-report	800	USA	11–13	M	R
104	Williams-Diehm, K. L., Miller, C. R., Sinclair, T. E., & Wronowski, M. L. (2018). Technology-based employability curriculum and culturally diverse learners with disabilities. Journal of Special Education Technology, 33(3), 159–70.	Intervention	Self-report	254	USA	14–18	A	R

105	Wu, T. F., Chen, C. M., Lo, H. S., Yeh, Y. M., & Chen, M. C. (2018). Factors related to ICT competencies for students with learning disabilities. Journal of Educational Technology & Society, 21(4), 76–88.	Survey	Self-report	438	Taiwan	12–14	A	S
106	Wu, T. F., Chen, M. C., Yeh, Y. M., Wang, H. P., & Chang, S. C. H. (2014). Is digital divide an issue for students with learning disabilities? Computers in Human Behavior, 39, 112–17.	Survey	Self-report	234	Taiwan	9–12	A	C R
107	Wu, D., Yu, L., Yang, H. H., Zhu, S., & Tsai, C. C. (2020). Parents' profiles concerning ICT proficiency and their relation to adolescents' information literacy: A latent profile analysis approach. British Journal of Educational Technology.	Survey	Test	1,396	China	9–15	A	C R
108	Yu, L., Recker, M., Chen, S., Zhao, N., & Yang, Q. (2018). The moderating effect of geographic area on the relationship between age, gender, and information and communication technology literacy and problematic internet use. Cyberpsychology, Behavior, and Social Networking, 21(6), 367–73.	Survey	Self-report	2,160	China	11–19	A C	C R
109	Zhu, S., Yang, H. H., MacLeod, J., Yu, L., & Wu, D. (2019). Investigating teenage students' information literacy in china: a social cognitive theory perspective. The Asia-Pacific Education Researcher, 28(3), 251–63.	Survey	Test	2,127	China	13–17	A	R
110	Ziya, E., Dogan, N., & Kelecioglu, H. (2010). What is the predict level of which computer using skills measured in PISA for achievement in mathematics. Turkish Online Journal of Educational Technology: TOJET, 9(4), 185–91.	Survey	Self-report	4,942	Turkey	15	C	R