youth SKILLS

Theoretical Integration of ySKILLS: Towards a New Model of Digital Literacy

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Theoretical Integration of ySKILLS: Towards a New Model of Digital Literacy

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Table of contents

Acknowledgements **4**

Executive summary **5**

1 Introduction **7**

1.1 The ySKILLS project 7

1.2 This report 9

2 Conceptualisation of Digital Literacy **12**

3 Measuring Digital Skills and Digital Knowledge **16**

4 Antecedents of Digital Skills **19**

4.1 Individual Factors of Digital Skills Antecendents 21

4.2 Social factors of digital skills antecedents 25

5 Consequences of Digital Skills: Online Opportunities **29**

5.1 Digital engagement 30

5.2 Learning and leisure 32

6 Consequences of Digital Skills: Online Risks **33**

7 Consequences of Digital Skills: Wellbeing **36**

7.1 Psychological wellbeing 38

7.2 Social wellbeing 40

7.3 Physical wellbeing 41

7.4 Cognitive wellbeing 42

8 Towards a New Model of Digital Literacy **44**

8.1 Overview of the relations of the different dimensions of the digital skills 46

8.2 New ySKILLS model: Comparison to previous theoretical models 49

9 Conclusions **51**

10 References **54**

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Executive summary

This report integrates findings from various ySKILLS deliverables into a new model, unravelling their theoretical implications:

Conceptualisation of Digital Literacy

- Four domains of digital literacy: Technical & Operational, Information Navigation & Processing, Communication & Interaction, and Content Creation & Production.
- Digital literacy consists of both skills and knowledge.
- Digital literacy should be conceptualised not just as functional but also as critical.
- While self-efficacy, attitudes and using technologies in diverse and positive ways are all important in determining fruitful engagement with the internet, they do not allow for conclusions around which specific skills and knowledge are needed to be able to achieve wellbeing.
- The youth Digital Skills Indicator (yDSI) survey instrument includes answer scales validated in different languages that allow for minimal impact of common issues in survey research using self-report measures, such as social desirability or confirmation bias.

Antecedents of Digital Skills: Individual and Social Factors

- Age positively correlates with most digital skills, but not with specialised skills like programming or content creation.
- Gender differences exist, with girls excelling in communication and boys in technical skills. No gender gap in digital knowledge, though it may vary in non-Western cultures.
- Online activity relates positively to digital skills, especially communication skills. However, more online engagement does not guarantee skill improvement.
- Parental mediation: Restrictive mediation negatively affects skills, while enabling mediation weakly boosts them.
- Psychological family support, though generally not tied to literacy, enhances communication and interaction skills.
- Peer social support has modest effects on literacy, with social connections slightly improving communication and interaction skills.

Consequences of Digital Skills: Digital Engagement and Online Risks

- Engagement in digital activities links positively to most digital skills. Improved communication skills increase online activity and communication with friends, but higher programming skills reduce communication with friends.
- While digital literacy in general and engagement are interconnected, individual skill effects on engagement are rare.
- In general, enhancing digital literacy does not tend to increase online risks. However, there is an exception to this pattern: content creation skills are positively correlated with exposure to harmful content.

Consequences of Digital Skills: Wellbeing

- Weak or no relationship between digital literacy, technology use, and psychological wellbeing. Digital skills may moderate ICT use and wellbeing.
- Limited connections between digital literacy and social wellbeing. Better communication skills relate to higher friend support, but more ICT use can lead to increased loneliness.
- No within-subject effects of digital literacy on physical activities, but increased internet use may reduce physical activity.
- Information navigation skills are linked to better school performance, while content creation skills are associated with lower performance. Improved communication and interaction skills positively impact school performance.

Towards the New Model of Digital Literacy

- Building upon ySKILLS findings and literature review, we developed a new theoretical model, where digital literacy mediates between antecedents and consequences, with the broader concept of digital literacy at the core rather than digital skills.
- Digital literacy can also play the role of moderator between other concepts: individual/social factors and digital engagement; ICT access and online activities; digital engagement and wellbeing.

1 Introduction

1.1 The ySKILLS project

The ySKILLS (Youth Skills) project is funded by the European Union (EU's) Horizon 2020 programme. It involves 16 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 young people 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 https://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 **identify the actors and factors** that undermine or can promote **children's wellbeing** in the digital age. The relations between ICT use and wellbeing will be critically and empirically examined over time.

ySKILLS' research objectives

- To acquire extensive knowledge and better measurement of digital skills.
- 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.
- 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 heir risk factors (material, social, psychological).
- 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 a **conceptual model** (Figure 1) that is inspired by these theories:

- Bronfenbrenner's (1977, 2005) Ecological Systems Theory (EST) provides a framework for understanding the interaction between subject effects and social influences on development by situating the children within their wider environment (understood to operate at multiple levels and timescales (Tudge et al., 2009).
- The theory of sociocultural development of Vygotsky (1978), which stated that child development does not occur in isolation but that the social environment of the child is important because it impacts the ways in which the individual makes meaning.
- Digital skills have traditionally been the focus of theories of digital divide, gaining prominence within the concept of the second-level digital divide (Hargittai, 2002). With the shift to the third-level digital divide, the question becomes how differences in digital skills and digital engagement are associated with different beneficial or negative tangible outcomes of internet use (Helsper et al., 2021), or how digital skills can moderate the relationship between inequalities in social and personal characteristics and inequalities in the ability to maximise online opportunities for wellbeing.
- Co-construction Theory (Subrahmanyam, Smahel, & Greenfield, 2006), which states that both the online and offline lives of children are intertwined and that digital media helps adolescents to fulfil their developmental tasks.
- Jessor's (2014) Problem Behaviour Theory (PBT), which provides a framework for children's problem behaviours and specifies the risk and protective factors that affect their development. The theory recognises several domains where we can identify these factors, including personality, perceived environment, and actual behaviour.
- The EU Kids Online theoretical model, which positions digital skills as a mediator of children's online risks and opportunities, and recognises the individual and social antecedents of digital skills (Livingstone, Mascheroni, & Staksrud, 2018).
- The iMEW model (Smahel et al., 2022) which proposed to differentiate dimensions of wellbeing and also the short-term and long-term relationships in the model.

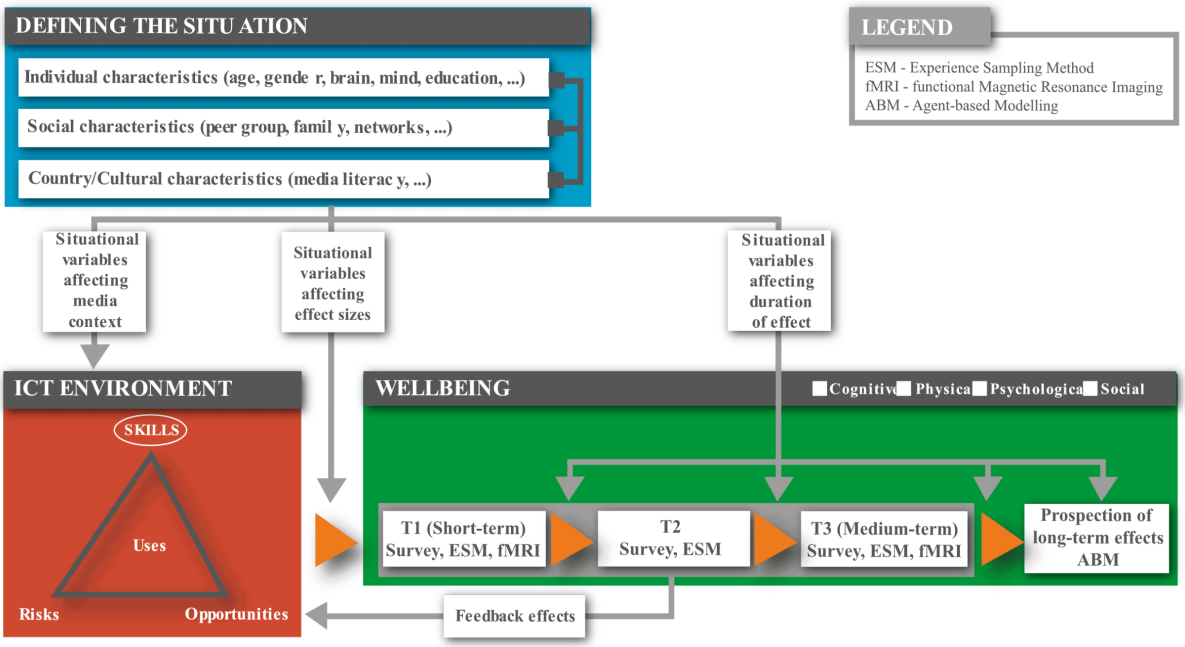


Figure 1: The ySKILLS conceptual model

Elements of the ySKILLS conceptual model:

Defining the situation: We distinguish between individual characteristics (e.g., age, gender, SES, life satisfaction, anxiety), social characteristics (e.g., peer group, family support, school), and the country/cultural environment (e.g., cultural values, media systems). These variables serve as predictors of the ICT environment, wellbeing, and the possible moderators of the relationship between the ICT environment and wellbeing.

The **ICT environment** is described as children's and adolescents' general patterns of ICT use (e.g., time and frequency, types of use, devices used). Part of the ICT uses are also online risks and opportunities. Digital skills are the core of the ySKILLS project and part of the ICT environment. As we know from previous research, digital skills are also related to possible online risks and opportunities (Smahel et al, 2020).

Wellbeing is the main outcome of the model. The ySKILLS project understands wellbeing as a measure to capture and assess, objectively and/or subjectively, the overall quality of children's lives (Diener, 2000) and the complexity of their lives and relationships. We differentiate the dimensions of the cognitive wellbeing (e.g., attention-related functions), physical wellbeing (e.g., sleeping, physical activity), psychological wellbeing (e.g., emotional state, life satisfaction, self-efficacy), and social wellbeing (e.g., peer support, family support, school). The white boxes inside the wellbeing section (i.e., T1 Survey, T2, Survey, ESM, T3 Survey, ESM, fMRI) indicate the methods used in the ySKILLS work packages.

1.2 This report

This report focuses on the development of a new model to integrate the results of all of the ySKILLS deliverables in order to identify their theoretical implications.

The field of children's digital lives is highly multidisciplinary and rapidly developing. Theory is a "way of explaining, of saying how things relate to each other, why they are the way that they are, and how they relate to other things" (Thomson, 2018). While social scientists must "learn how *to translate highly abstract problems into thoroughly practical scientific operations*" (Bourdieu & Wacquant, 1992, p. 221), the reverse also applies. In this report, we consider how to derive abstract understandings from a substantial body of practical scientific findings. The **purpose is to draw out more general conclusions** to add to the knowledge in the field and guide future research.

ySKILLS deliverables and reports for the project findings are listed in Table 1. In the report sections, we refer to deliverables by numbers (i.e., D2.1, D2.2, D5.2) so readers can find further information. In addition to drawing on key conceptual and theoretical insights, as noted above, the ySKILLS project and its deliverables are based on a variety of methods, such as a longitudinal survey, the experience sampling method, fMRI (i.e., Functional Magnetic Resonance Imaging), in-depth interviews, thematic analysis and focus group interviews. Therefore, Table 1 includes a brief description of the methodology used in the relevant deliverable.

This report is divided into the following main sections: the **introduction** describes the preliminary ySKILLS conceptual model, the logic of this report and the ySKILLS' conceptualisation of digital skills. The section **conceptualisation of digital literacy** introduces dimensions of digital literary and shows how the indicator for measuring digital skills (yDSI)

was developed and presents its theoretical contribution. As in previous reports (i.e., D2.1, D2.2, D5.2), we have different sections for the antecedents and the consequences of the digital skills. This helps to compare and integrate results across various ySKILLS reports. Each section includes a table that summarises the quantitative results of the ySKILLS deliverables, offers an interpretation, and provides several examples from qualitative research. The section on **antecedents of digital skills** describes personal attributes related to digital skills (e.g., gender, age, self-efficacy, internet availability, frequency and amount of ICT use) and the social context (e.g., socioeconomic status), and parental mediation (e.g., active and restrictive, family support, friend support). The section on the **consequences of digital skills** presents the following outcomes: online opportunities i.e., digital engagement, learning, leisure, online risks i.e., cyberhate, harmful content (which causes to children distress or harm), sexual content), and wellbeing (i.e., psychological, social, physical, cognitive wellbeing). The section titled **Towards a New Model of Digital Literacy** focuses on the development of the theoretical model, which is based on the ySKILLS results from the previous sections. In the next sections, we use the term **digital literacy** where we write about the new conceptualisation of digital literacy and about the new model of ySKILLS. We use the term **digital skills** in chapters where we integrate results of the previous reports which also used the term digital skills.

Table 1	Overview of ySKILLS deliverables (reports) and used methods
Reports	**Methods**
D2.1 Children's and young people's digital skills - a systematic evidence review (Haddon et al., 2020)	**Systematic evidence review:** A combination of database searches, application of inclusion criteria, and rigorous screening to identify and analyse relevant research articles on youth digital skills.
D2.2 Digital skills, risks and wellbeing among European children – a survey (Mascheroni et al., 2020)	**Secondary survey data analysis:** Examines the digital skills of 12- to 16-year-olds as outcomes, predictors and moderator, using nationally representative data from the EU Kids Online 2020 survey in 19 European countries.
D3.3 The youth Digital Skills Indicator (Helsper et al., 2020)	**Cognitive interviews and pilot surveys:** Pilot surveys were conducted with an age group (18-25 years old) to validate the statistical properties of the items and scales.
D4.5 Report on the effects of ICT use on attention-related cognitive functions measured with ESM and fMRI (Salmela-Aro et al., 2023)	**fMRI:** The fMRI data from ***N*=185** Finnish participants (aged 12-13) using a 3 Tesla MRI scanner were gathered. They MRI data were processed via techniques including motion and slice-time correction, normalisation to standard space, and noise correction. Participants also completed the ySKILLS questionnaire.
D5.1 Report on the influence of situational variables and personal networks on online resilience and digital skills (Boomgaarden et al., 2023)	**Survey:** The data was collected through a school survey, collected in school classes across different countries and schools. The dataset includes information on 123 networks (school classes) across 15 schools in Germany, Italy, and Portugal. The student'' age range was 12 to 20 years.
D5.2 Digital skills among children and youth: A report from a 3-wave longitudinal study in 6 European countries (Machackova et al., 2023)	**Longitudinal survey:** The study used a three-year longitudinal survey. It aimed for a purposive, non-probability sample of children aged 12 to 15 attending secondary schools. The sample size varied across waves and countries, with a total of ***N*=2660** participants across three waves.
D5.4 Situational and daily technology use and wellbeing among adolescents (Järvinen et al., 2023)	**Experience Sampling Method (ESM):** Data was gathered in two waves across Finland and Belgium, with additional data collected in Finland. Participants used a mobile app to answer questionnaires to capture their real-time experiences of digital device use and emotions. A total of 17671 responses provided by 456 Finnish and Belgian adolescent.
D5.5 Report on collected fMRI data related to effects of intensity of ICT use on brain activity associated with attention and with linguistic and mathematical processes (Alho et al., 2023)	**fMRI, survey and performance tests:** Finnish participants engaged in **fMRI tasks** related to maths and language, while Belgian participants completed the Flanker and n-back tasks to assess attention, inhibition, and working memory. Some Belgian participants also took ICT skills performance tests. In Finland, data was collected from ***N*=189** participants aged 12-14, in Belgium, ***N*=51** participants aged 12-13 were surveyed, with an additional ***N*=19** participants undergoing **performance tests**.
D6.1 Young people experiencing internet-related mental health difficulties (Livingstone et al., 2022)	**In-depth interviews:** With ***N*= 62** young people aged 12–22 (46 girls and 16 boys) who had experienced varying degrees of mental health difficulties from the UK and Norway.
D6.2 Young people's digital skills practices in non-formal learning contexts – Observations, interviews, co-design (Cino et al., 2022)	**Observation** of workshops in different socioeconomic neighbourhoods, plus **interviews** with workshop organisers and moderators to gain insights into teaching philosophies, technological imaginaries, and digital skills acquisition, and **co-design sessions** focusing on specific aspects (new tools, learning activities).
D6.3 Report on the role of critical information skills in recognising mis- and disinformation (Vissenberg et al., 2022)	**Online survey and news exposure (*N*=257):** Participants aged 12-15 in Belgium, the Czech Republic, and Finland took an online survey covering digital skills, news consumption, and trust. They later assessed the credibility of twelve news messages, half real and half fake, using specific criteria. **Focus groups** (***N*=244**) were conducted to delve deeper into findings from the first phase.
D4.3 The youth Digital Skills Performance Tests (van Laar et al., 2022)	**Real-life performance tests** were used to measure digital skills among young people. These tests covered three dimensions: information navigation and processing, communication and interaction, and content creation and production skills. The development process was guided by the youth Digital Skills Indicator (yDSI), considering both functional and critical aspects.
D6.4 Vulnerabilities and digital skills. Interactive report on the in-depth studies (Baptista et al., 2022)	Teen refugees ***N*=96** (aged 14-18) in Belgium, Greece, and the UK were **interviewed** using a shared topic guide, aiming for individual reflections on their digital lives and skills. **Creative workshops *N*=5** involving young refugees from various backgrounds were conducted across the three countries. Each workshop had 8-10 participants.

2 Conceptualisation of Digital Literacy

This report outlines the contribution of the ySKILLS project to conceptualising digital skills using a range of methods (see section 2 methodology) including: a systematic review of the literature (Haddon et al., 2020), the lessons learned during the development of the youth Digital Skills Indicator (yDSI) (D3.3) and its applications in longitudinal panel surveys (D5.2), the development of performance tests (van Laar et al., 2022), and the application among a subsample of young people that participated in the surveys (van Deursen et al., 2023). This work builds on previous work of scholars involved in the ySKILLS project and this section outlines the innovation approach in the ySKILLS theorisation. The result of this work is a move away from the use of skills to describe young people's abilities towards a multi-dimensional conceptualisation of digital literacy made up of skills and knowledge and which has functional and critical aspects.

Digital skills are widely seen as key to fruitful participation in digital societies and their futures. However, it is often unclear what exactly digital skills incorporate, or how they relate to other popular concepts, such as digital or media literacy. In traditional (print) literacy, there is a critique of understanding reading, writing and maths in the purely functional way. This limits skilled engagement to the abilities needed to operate devices, access services, and consume content. Critical literacy scholars argue that for full citizenship and constructive participation, people have to have critical knowledge and awareness of the societal, political, and economic processes that shape how media work (Bergsma, 2004; Freire & Macedo, 1987; Higgins, 1999; Yosso, 2002). Translated to digital societies this means that digital literacy is about much more than the ability to use a particular device such as a PC or tablet, ticking boxes on a form or changing settings in an app. Digital literacy should allow and even push people to go beyond just satisfying their immediate needs, only using platforms in the way intended by designers, or in modes seen as productive by 'authorities'(Forman, Nyatanga, & Rich, 2002; Luke, 2012; Roberts, 1998).

Following this, we argue that digital literacy should be conceptualised not just as functional but also as critical; as the abilities needed to engage with technology in ways that allow people to shape as well as use digital platforms and environments, building on knowledge about why ICTs do what they do and what the consequences of this for individuals and society might be.

Empirical work of ySKILLS confirms that both functional and critical components of digital literacy are essential in relation to studying wellbeing in increasingly digital societies (Cortesi et al., 2020). ySKILLS furthermore stresses the importance of not only recognizing the distinction between functional and critical literacy, but also that between different dimensions or types of literacy. Early work in applied computer science and STEM education fields led to an emphasis on technical skills related to operating devices and using software or, on the more advanced end of the spectrum, programming and coding. Increasingly, with the broader diffusion of the internet, information navigation also became part of the definition of digital skills (Bawden, 2001; Kolle, 2017; Saranto & Hovenga, 2004). These two elements are still important in academic research. With the rise of the interactive web2.0, these definitions have been expanded further (van Deursen & van Dijk, 2014). Meanwhile, especially drawing on the

five-decade-long history of research and practice on media literacy, the importance of skills to create messages and digital forms of expression should not be forgotten.

The ySKILLS conceptualisation is part of a move towards an integrated literacy framework that distinguishes not only technical skills and web or information navigation skills but also 'softer' skills such as social and content creation skills which have become increasingly important with the rise of social media (Helsper & van Deursen, 2018; Vuorikari et al., 2016).

The distinction between these different dimensions is important even in relation to online activities that do not seem intuitively based on these types of literacy. Take informal learning online; knowing how to network and how to decide who to trust, to understand what language is appropriate in asking for information are all important in relation to most of the learning that takes place online through, for example, social media, Q&A sections on websites or user generated news sites. In addition, knowing how to create content in the 'right' format and on the 'right' platforms to get feedback from others, and understanding what rights are applicable to online content are all relevant for engaged and productive learning online. The importance of skills and knowledge across various literacy domains is supported by both the performance tests and the longitudinal ySKILLS survey results.

Specifically, the ySKILLS conceptualisation distinguishes the following four dimensions of digital literacy (skills and knowledge) as essential to achieving wellbeing in digital societies:

- **Technical and operational**: The ability to manage and operate ICTs and the technical affordances of devices, platforms and apps, from 'button' knowledge to settings management to programming[1].
- **Information navigation and processing**: The ability to find, select and critically evaluate digital sources of information.
- **Communication and interaction**: The ability to use different digital media and technological features to interact with others and build networks as well as to critically evaluate the impact of interpersonal mediated communication and interactions on others.
- **Content creation and production**: The ability to create digital content to a high standard, understand how and why content is produced and published and how it generates impact.

To participate fully in digital societies, all four dimensions are indispensable. ySKILLS holds that all four skill dimensions encompass both functional skills (understanding technical functionalities and being able to use these) and critical knowledge (understanding how and why devices and content are produced in certain ways). Following the ySKILLS' novel conceptualisation of digital literacy, the framework was operationalised in empirical survey and performance test research. For the surveys, ySKILLS developed the yDSI (D3.3) that applies the distinction between *digital skills* and *digital knowledge*. Other distinctions applied are:

[1] While programming is conceptually categorised as a technical or operational skill in empirical work it behaved differently from some of the other indicators on this dimension and in some countries grouped more with content creation skills and knowledge. Therefore, empirically programming was measured separately while still conceptually being considered a (high level) technical skill.

1. between *self-efficacy* (i.e., the confidence people have in themselves as users) and *literacy* (i.e., what one is able to do or knows). While digital self-efficacy is important for informal learning about and broad engagement with ICTs, digital literacy is more important in terms of positive participation and wellbeing in society. Self-efficacy and confidence are often expressions of a person's general social position (e.g., gender, race) and associated status in society rather than whether someone can actually complete a digtal task (Haddon et al., 2020). However, while self-efficacy often increases when literacy improves, the reverse is not necessarily true. Higher levels of self-efficacy combined with lower levels of literacy might lead a young person not to notice instances when things go wrong or dismiss them due to blaming technological faults rather than their own lack of literacy (Broos & Roe, 2006). Such cases might lead to a higher exposure to harm, unless the young person's literacy levels improve.

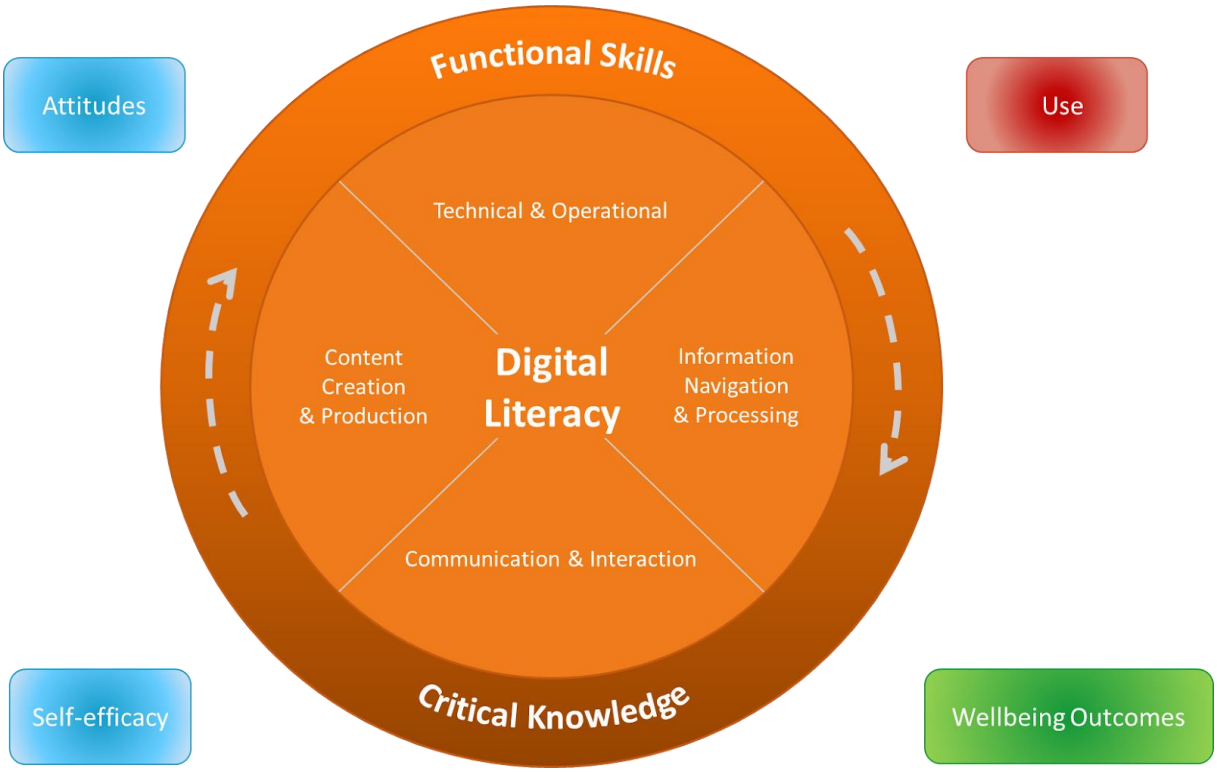
2. between *digital literacy* (and self-efficacy) and *attitudes* towards ICTs such as beliefs that technology use facilitates access to opportunities or that digitisation is detrimental for society or individual wellbeing. These attitudes are often wrongly included as indicators of a critical understanding of technologies and thus as an indicator of digital literacy. However, they more often represent societal discourses popularised by the media than actual knowledge about how the digital world works. The former can lead to uncritical or pressured adoption of technologies that might actually be harmful, and the latter, to a perceived lack of agency and helplessness leading to people disconnecting, not accumulating digital skills and knowledge and not building resilience.

3. between *digital literacy* and *online activities or frequent use* of ICTs. Young people may report engaging in a range of online activities which does not mean that they do these activities well. Similarly, being very active does not mean that this use enables high quality outcomes (Livingstone & Helsper, 2010). While spending more time online and doing a wider range of online activities are shown to correlate with digital literacy (Machackova et al., 2023), these are not identical and should be distinguished conceptually. Indeed, much of the fascination with a generation labelled,as 'digital natives' comes from wrongly equating frequent use of technology with skilled use of technology (Bennett, 2008; Hargittai, 2010; Selwyn, 2009; Smith, Skrbis, & Western, 2013). However, not (frequently) using ICTs for certain things does not mean a lack of literacy in deciding when it's helpful to use technologies. For example, the performance tests results revealed that the number of activities performed online by youth is to some extent a predictor for functional operational skills, but that these children are not more critical when undertaking more activities online. Because of its pivotal function in translating use into positive outcomes, ySKILLS focuses on conceptualising and measuring literacy alongside use.

4. between the *outcomes achieved* from engaging digitally and the *digital literacies* that enable these outcomes. Many definitions of digital literacy include the concept of digital problem solving and safety. But being able to solve a problem using digital tools or encountering harm in digital environments can depend on non-literacy related factors, such as low-quality *access*, a lack of *availability* of relevant services or content, *algorithmic bias* or *discrimination* by other users of the platforms. Even if problem solving is literacy related, it is important to understand which particular skills are needed to solve the problem.

While self-efficacy, attitudes and using technologies in diverse and positive ways are all important in determining fruitful engagement with the internet, they do not allow for conclusions around which specific literacies are needed to be able to achieve wellbeing in digital societies.

Figure 2 shows our theoretical conceptualisation of digital literacy consisting of knowledge and skills elements as well as functional and critical aspects, but as distinct from these concepts. The fundamental principle of the ySKILLS framework is that all four dimensions of literacy are necessary for positive engagement with digital technologies and that, therefore, they all need to be conceptualised in theoretical work and operationalised in empirical work.



Note. This model underpins the design of the youth Digital Skills Indicator (yDSI) and performance tests.

Figure 2: ySKILLS theoretical model of Digital Literacy (distinguishable from attitudes, self-efficacy, use and outcomes).

3 Measuring Digital Skills and Digital Knowledge

The measurement of digital skills can be broadly divided into indirect (self-report) and direct (observation) measurement. The youth Digital Skills Indicator (yDSI) developed for the ySKILLS surveys is an example of the first and entails a unique and extensively cross-nationally validated measurement tool with 31 items, distributed over digital skills and digital knowledge questions. The yDSI is an ideal instrument for *large-scale population* research based on reliable and externally validated measures (see Helsper et al., 2020). Performance testing is an example of direct measurements and is preferable in terms of validity. However, it is a time-consuming and labour-intensive method that depends on task completion levels. This makes it less ideal for conducting large-scale population research. In ySKILLS we developed and applied validated performance tests, presenting participants with tasks that represent an authentic situation in an open internet environment.

The ySKILLS performance tests allowed for task-related testing of theory-based measurements of digital literacy, something that has neither been fully exploited nor recognised as important before (Siddiq et al., 2016).

A big issue in existing measurements was that items and tasks were not theoretically grounded but app- or activity-specific. This made them too dependent on social and technological trends that drive adoption of (or diversion from) using certain devices or online platforms (van Deursen et al., 2016). These skills and knowledge related to specific apps or activities may not always be transferable to the next popular digital tools.

The ySKILLS digital literacy dimensions that underpin the yDSI and performance test measurements were designed to be broadly applicable, ensuring their relevance even in a changing digital landscape.

Our empirical work on the yDSI and performance tests further highlighted that functional and practical skills are not only conceptually different but also need different formulations than critical, knowledge-based items and that, to achieve this, conceptualising sub-categorisations was useful in operationalising further subtleties in the different skills dimensions. These sub-categorisations were an innovation especially for the communication and content related skills dimensions. In the design of the measurement instruments for the yDSI and performance tests the following sub-categorisations served to ensure that the selected items captured the breadth of digital skills associated with each dimension.

- **Technical and operational:** Operating (e.g., turning on, using accessories), connecting (e.g., linking to the cloud, printers), customising (e.g., programming, personalising settings).

- **Information navigation and processing**: Navigating (e.g., searching for and orienting to information), interpreting (e.g., understanding hyperlink structure and symbols, selecting information) evaluating (e.g., verifying the trustworthiness).
- **Communication and interaction**: Using features (e.g., matching media to context, managing contacts), protecting (e.g., privacy settings, sharing information of self and others, netiquette (e.g., understanding normative and non-discriminatory behaviour).
- **Content creation and production**: Using modalities (e.g., mixing different media, manipulating colour, sound), quality (e.g., reaching others, attracting attention), understanding ownership (e.g., persuasive intent, funding structures, copyrights).

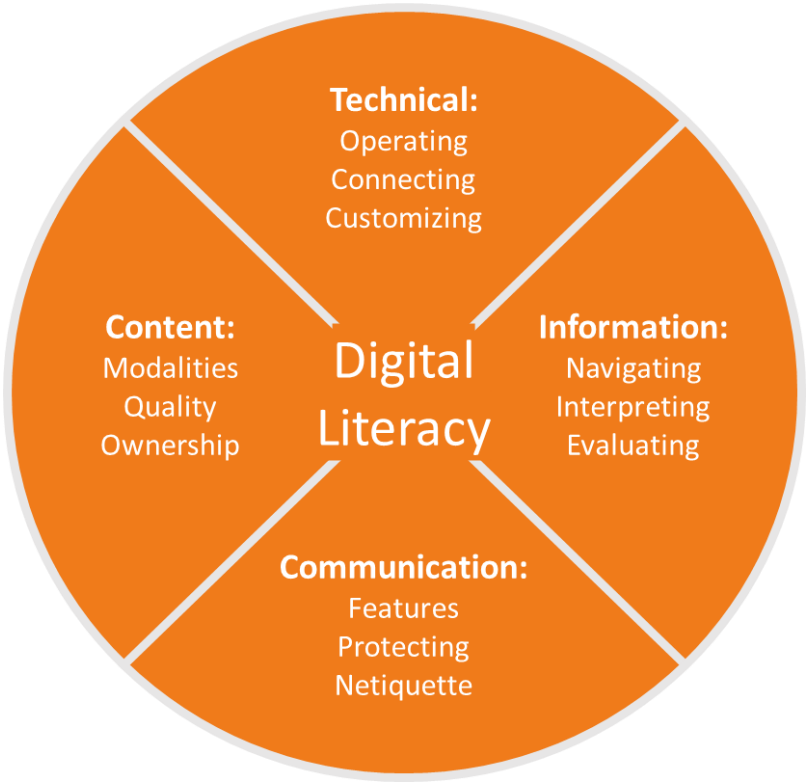


Figure 3: Experimental conceptualisation of the subcomponents of the 4 digital literacy dimensions.

The development of the ySKILLS performance test was largely informed by the yDSI framework (see Figure 2), and based on the theorised detailed skill dimensions (see Figure 3), authentic tasks were designed. The use of tasks reflecting authentic everyday situations has the advantage that children complete assignments that require them to apply their digital skills in a natural or realistic context. Despite these benefits, it proved hard to design the direct measures (performance tests) in ways that were equally valid for different countries and age groups. Unexpectedly, it was especially difficult to design critical information literacy tasks (rather than, as expected, the more newly theorised content creation or communication and interaction literacy tasks). It turns out that critical information literacy tasks in particular had to be designed in ways that were more tailored to national digital information and media environments. This complicated the design of a performance test that could be used for cross-cultural comparisons,

with tasks that measured young people's digital literacy equally in different nations (for more details, see van Deursen et al., 2023).

> Higher scores on the yDSI measures corresponded to better performance across the different countries, which suggest that the theoretical model with four dimensions and different aspects is transferable and robust for use in different political, economic and cultural contexts.

In addition to considerations about future relevance and cultural adaptability, there is also the challenge of bridging the gap in measuring various aspects of literacy. Although the theoretical framework of digital literacy clearly distinguishes between different domains and aspects, when it comes to creating practical measures that accurately capture these literacy skills (as opposed to self-confidence, usage patterns, or end results), it becomes more difficult to maintain these distinctions. The yDSI report gives an in-depth description of how these conceptual nuances and distinctions were captured and subsequently validated to be turned into a survey instrument that was both comprehensive but also practical in its length (Helsper et al., 2022). The development and application of the performance tests brought similar and other lessons learned, especially by bringing attention to country level comparisons and differences between youth (e.g., gender, age, and support from family and friends) in terms of the different ways in which they experienced difficulties completing tasks (van Deursen et al., 2023; van Laar et al., 2020). The results around information navigation and processing tasks demonstrate that children experience most difficulties in performing tasks focused on evaluating information (e.g., selecting the most reliable website, naming the intention of a post). The performance on communication and interaction tasks furthermore demonstrates that what is appropriate and courteous online behaviour is not self-evident.

Overall, the results raise doubts whether youth possess sufficient digital literacy levels, and what having or lacking skills and knowledge means for the achievement of outcomes in different cultural and learning environments. The performance tests show that much more work is needed to understand how the literacy varies in different contexts particularly when it comes to critical knowledge, but also when it comes to functional skills.

4 Antecedents of Digital Skills

In this section, we describe the antecedents of the digital skills that were analysed in the ySKILLS project. These antecedents were covered in the systematic review (D2.1), in the analyses of previous data (D2.2), and in the longitudinal study (D5.2). The overall picture is enriched by the qualitative interviews, focus groups, and the workshops of WP6. In this (and other) sections which discribe and integrate results of the previous reports, we use the term **digital skills** (not literacy) to be in line with terminology of previous reports.

Based on the results of the systematic review (D2.1), this section is divided into two parts:

a. **Personal factors**, which include gender, age, self-efficacy, internet availability, and the frequency and amount of ICT use; and
b. **Social factors**, which includes socioeconomic status, parental mediation (active and restrictive), family support, and friend support.

Explanation of tables integrating results of ySKILLS: The rows in the tables show individual variables (i.e., age, gender, harmful content, wellbeing) and columns show results from different studies (reports) of ySKILLS. Numbers of reports (DX.X) indicate deliverables, which are summarised in Table 1. The results from the D5.2 report are divided into the between-subject and within-subject results (see the next blue box). The acronyms are explained under each table.

Explanation of between-subject and within-subject results: in essence, the between-subject results (models) describe the correlational nature of the relationships we are examining. These findings are based on robust data collected over a three-year period. They allow us to determine whether there is a connection between digital skills and experiences related to online risk, activities or wellbeing. However, it is crucial to approach these results with caution because they do not establish causation. What we can confidently assert is whether these factors are related, either positively or negatively, but we must be mindful of the sequence of events. Within-subject results provide insights into how changes in an individual's digital skills affect their experiences. These results focus on the impact of digital skills on individual outcomes over time. They offer a stronger basis for making causal interpretations, suggesting that variations in digital skills within individuals directly influence changes in online risk, activities, or wellbeing.

See Table 2 for an overview of results within the quantitative studies of ySKILLS. The report 5.2 analysed models that disentangled two types of effect.

Table 2	Antecedents of Digital Skills			
Individual Factors	**D2.1 systematic review (*N* = number of studies)**	**D2.2 Analysis of existing data**	**WP5 longitudinal between-subject**	**WP5 longitudinal within-subject**
Age	Overall positive (*N*=26) 17 pos, 4 neg, 2 pos & neg, 3 not significant	-	Pos: -> Tech. S., Info. S., Comm. S., K. items No relationship: -> C. C. S., Prog. S.	-
Gender	Mixed (*N*=40) 14 pos, 13 neg, 2 mixed, 1 complex, 10 not significant	Pos: boys -> Dig Skills	Pos: boys -> Tech. S., Info. S., Prog. S. Pos: girls -> Comm. S. No relationship: -> C. C. S., K. items	-
Self-efficacy	Inconclusive (*N*=10) 8 pos, 2 not significant	Pos: self efficacy -> Dig skills	Pos: self efficacy -> Tech. S., Info. S., C. C. S., Comm. S., Prog. S., K. items	Pos: self efficacy -> Tech. S., Info. S., C. C. S., Comm. S. No relationship: self efficacy -> Prog. S., K. items
ICT availability	Overall positive (*N*=15) 10 pos, 5 not significant	-	No relationship: internet access -> all dimensions of skills	-
Frequency and amount of ICT use	Mixed (*N*=14) 9 pos, 5 not significant	Pos: Internet use -> Dig skills Pos: Online activities -> Dig skills	Pos: Daily act. -> all dimensions of skills Pos: Internet use -> Tech. S., C. C. S., Comm. S., K. items No relationship: Internet use -> Info. S., Prog. S.	Pos: Daily act. -> Info. S., Comm. S. No relationship: Daily act. -> Tech. S., K. items, C. C. S., Prog. S. Internet use -> N/A
Social Factors	**D2.1 systematic review (*N* = number of studies)**	**D2.2 Analysis of existing data**	**WP5 longitudinal between-subject**	**WP5 longitudinal within-subject**
Socioeconomic status	Overall positive (*N*=21) 12 pos, 1 neg, 8 not significant	No relationship -> Dig skills	Pos: -> Info. S. No relationship: -> Tech. S., Comm. S., K. items, C. C. S., Prog. S.	-
Parental mediation	Mixed (*N*=14) 6 pos, 3 neg, 5 not significant	Neg: restrictive -> Dig skills Pos: active -> Dig skills	Neg: restrictive -> Tech. S. No relationship: restrictive -> Info. S., Comm. S., K. items, C. C. S., Prog. S. Neg: enabling -> Tech. S. No relationship: enabling -> Info. S., Comm. S., K. items, C. C. S., Prog. S.	Neg: restrictive -> Tech. S. No relationship: restrictive -> Info. S., Comm. S., K. items, C. C. S., Prog. S. No relationship: enabling -> all dimensions of skills
Other parental variables	Overall positive (*N*=8) 7 pos, 1 not significant	-	Pos: Family support -> CommS. No relationship: Family support -> Info. S., Tech. S., K. items, C. C. S., Prog. S.	-
Peer variables	Overall positive (*N*=5) 5 pos	-	Pos: Friend support -> Tech. S., Comm. S. No relationship: Friend support -> Info. S., K. items, C. C. S., Prog. S.	No relationship: Friend support -> all dimensions of digital skills

Note. (pos) = positive relationship; (neg) = negative relationship; (tech. s.) = technical and operational skills; (info. s.) = information navigation and processing skills; (comm. s.) = communication and interaction skills; (c. c. s.) = content creation and production skills; (prog. s.) = programming skills; (k. items) = digital knowledge items.

4.1 Individual Factors of Digital Skills Antecendents

In this section, we focus on the antecedents that were part of the ySKILLS research: gender, age, self-efficacy, internet availability and frequency, and the amount of ICT use. The systematic review (D2.1) included several other personal attributes, such as personality type, cognitive abilities, teacher variables, ICT experience in school, devices, gaming, and others. These variables were included in previous research on this topic, but it was not possible to include all of them in the ySKILLS research.

Age: The systematic review confirms that children's digital skills improve with age. Out of 26 studies focused on this topic, 22 find a positive relation between age and digital skills. Most show that digital skills improve with age (19 studies). A small number of studies found the opposite relationship, that digital skills decrease with age (D2.1). However, it seems that these results are based on specific samples that focus only on some digital skills dimensions, such as the credibility of the online information (Metzger et al., 2013).

In the ySKILLS longitudinal research, we also show a positive relationship between age and the following digital skills dimensions: technical and operational information navigation and processing, communication, interaction, and knowledge items. However, we found no association for age with programming skills, content creation, and production skills (D5.2).

Because vulnerable young people with internet-related mental health difficulties (see for details the report D6.1) obtain digital skills by doing or through lived experience, it is no surprise that it is valid also for vulnerable adolescents that older adolescents have higher digital skills to manage their online presence and that they achieve beneficial outcomes in terms of psychological and social wellbeing.

Likewise, young refugees develop digital skills through a process of learning by doing (Baptista et al., 2022). Generally speaking, older adolescents among vulnerable groups have developed more digital skills, primarily as a result of the many opportunities they have had to access and use digital media in the past and present, and to learn from more experienced peers.

Research on digital skills practices in non-formal learning settings (D6.2) shows that, if not specifically targeted to an older age group, workshops are attended mostly by primary school children (7-11-year-olds), both because of the activities offered (e.g., basic programming with Scratch) and because the children's participation is encouraged by their parents.

In relation to previous research, the ySKILLS research confirmed the positive association between age and most dimensions of digital skills: digital skills are generally developed through a learning-by-doing process. However, there was no relation between age and programming skills, content creation, and production skills. It seems that more 'specialised' digital skills are not related to age: those children who learn programming and gain content-creation skills do so when they are young (i.e., by attending a programming workshop).

Gender: The systematic review identified 40 studies focused on the relationship between digital skills and gender. Twelve of the studies found that girls reported more digital skills than boys, 14 revealed that boys reported more digital skills than girls, and 11 found no difference (D2.1). Fifteen of the studies included performance tests. These results were also balanced: seven found girls had more digital skills than boys; four revealed boys had more skills; and four found no difference. The results of the systematic review are mixed. Furthermore, there is no clear pattern to explain the gender differences by the areas of measured digital skills (e.g., functional, informational, social).

In the ySKILLS analysis of the previous data (EU Kids Online), boys self-reported slightly better digital skills in all 17 countries. In the ySKILLS longitudinal research (D5.2), we found gender differences in the reporting about various digital skills dimensions: boys reported higher technical and operational skills, programming skills, and information navigation and processing skills; girls reported higher communication and interaction skills; and there was no difference in content creation, production skills, and in the knowledge items. These results indicate that boys and girls might have different levels of knowledge in various digital skills dimensions.

Results of the in-depth qualitative studies (WP6) allow a more contextualised exploration of the gender dimension. In fact, qualitative data show a more nuanced and less linear relationship between gender and digital skills. Our study on digital skills practices in non-formal learning environments (D6.2) has shown that, in countries where parents motivated their children to attend programming workshops (Belgium and Italy), gender imbalances could be observed among the participating children. Moderators in Italy also suggested that, if parents had to choose between female and male children, they would encourage boys to take up programming first. However, in the workshops specifically designed for marginalised (lower SES and migrant) children, only girls eventually showed up. In Denmark, such gender imbalances were dealt with by designing workshops aimed especially at girls.

We also observed interesting gender differences in our study of digital skills among young people with internet-related mental health difficulties (D6.1). This research showed that the online experiences of boys and girls with mental health difficulties may vary and that the digital skills they value can be different. For example, the girls we spoke to seemed more vulnerable to the social pressures of always looking perfect online and they struggled with hostile comments related to their body, appearance, and sexuality. The associated need to always be in control of their public image can be overwhelming and encourage these young women to develop specific skills (e.g., blocking others from sharing their TikTok videos, putting the phone on 'do not disturb', not tagging friends in a comment) in response to the specific ways in which technology use has upset them. Boys, on the other hand, seemed more vulnerable to cyber attacks related to their participation in online group activities, such as gaming. The extent to which such behaviours were normalised left little space for any positive display of male vulnerability, which made it harder for boys who were struggling with their mental health to acknowledge such experiences.

Refugee children's gendered experiences with technology vary and are often associated with the experience of being uprooted and resettled. Arab and Afghan boys who participated in the study were more likely to learn digital skills from other male peers. They showed higher levels of trust for those peers, especially when they lived together and when their skills in the language of their country of settlement were limited. Across ethnic groups, girls were more aware of the risks associated with sexual harassment, but, notably, both girls and boys expressed concerns about cyberbullying (Baptista et al., 2022).

The recent ySKILLS research indicates potential differences in the levels of knowledge across various digital skill dimensions between boys and girls. Girls tend to report higher communication skills, while boys appear to excel in technical and operational skills, as well as in information navigation, processing skills, and programming skills. Interestingly, there were no gender differences in knowledge items related to digital skills. It is important to note that these gender patterns may vary in non-Western cultures, suggesting that cultural factors could play a role in shaping these disparities. Further research is needed to explore these differences across different cultural contexts.

Self-efficacy: Different types of self-efficacy relate to different areas. The systematic review identified 10 studies that focused on the self-efficacy of digital skills knowledge (D2.1). Most studies compared the results of performance tests to the self-efficacy of digital skills and found positive associations. However, ySKILLS measured general psychological self-efficacy with items such as: "I can solve most problems if I try hard" and "If I am in trouble I can usually think of something to do".

In ySKILLS, we found moderate associations between the self-efficacy and self-evaluation of digital skills. In the analyses of previous data (D2.2), self-efficacy was positively related to digital skills in all 17 countries. In the longitudinal research on the between-subject level (D2.1), children with higher self-efficacy reported higher digital skills for all of the dimensions. Furthermore, on the within-subject level, the individual change in self-efficacy had a positive effect on the improvement of technical and operational skills, information navigation and processing skills, and communication and interaction skills. However, the change in self-efficacy had no effect on the knowledge items. This could indicate that higher self-efficacy has no effect on real knowledge in digital skills, but it does engender a a higher self-evaluation by the children.

For vulnerable youth, including young people with mental health difficulties and young refugees, the relationship between self-efficacy and digital skills is characterised by a virtuous cycle: as they learn more about the digital environment and how to manage it, they also learn more about themselves and become more self-confident (Baptista et al., 2022). Among young people with mental health difficulties, the process of developing digital skills generates a sense of self-efficacy because they find ways to manage their online lives and perceive themselves as becoming stronger.

High levels of precarity experienced by many young refugees (e.g., separation from parents; life-risk experiences through war and migration) means that their self-efficacy emerges out of necessity because they have to develop a range of skills at an early stage of their lives. Some young refugees explained that they had to take responsibility for learning the skills of autonomous living quickly and at a young age (e.g., by learning how to navigate digital and other resources in order to find passage to safety and to reach their European destinations) (Baptista et al., 2022).

Psychological self-efficacy emerges as a significant predictor of self-reported digital skills across all dimensions. As a result, we recommend the incorporation of such indicators in future research to assess digital skills through self-reports. This can be a valuable control variable to consider in related studies.

ICT availability: The systematic review identified 15 studies on ICT availability (mostly at home) and digital skills (D2.1). Ten of these studies found a positive association between ICT availability at home and digital skills; five studies did not find a significant relationship.

In the ySKILLS longitudinal research, we included a question about whether children were able to access the internet at home (D2.1). The results revealed that there is no relationship between internet access at home and digital skills. However, only 1.2% of children said that they had no internet access at home in the ySKILLS longitudinal research.

The qualitative data confirm the continued relevance of "autonomy of use" (=the possibility to access the internet from a variety of contexts and devices) and quality of access on the development of digital skills. In other words, to borrow the digital divide's terminology, first level digital divide reverbates on second-level digital divides (skills and usage) and, as a consequence, on third level digital divide (tangible outcomes). For example, in D6.2 we observed that lower SES children are more familiar with smartphones and tablets than with computers, and this affects their experience of programming workshops.

Similarly, the digital needs for young refugees cut across issues identified across all levels of the digital divide. To explain: on the first level, many young refugees found themselves experiencing emotional and embodied risks when lacking access to digital technologies (e.g., embodied risks presented when lacking phones to navigate dangerous journey; emotional risks presented when disconnected from loved ones); on the second level, skills and risks converged around excessive use (e.g., necessary connections for psychological support but too much exposure to harmful content); and on the third level, many use digital resources to compensate for lack of access to critical resources for their wellbeing and growth (e.g., learning languages outside interrupted formal education) but rarely learn how to develop advanced skills, such as programming (Baptista et al., 2022).

Digital access and ICT availability seem to be less relevant indicators of digital skills in highly developed countries because the majority of children have internet access at home. However, ICT availability is still crucial for minorities and vulnerable children, such as refugees and children with mental health problems.

Frequency and amount of ICT use: The systematic review revealed 14 studies focused on the frequency and amount of ICT usage in relation to digital skills (D2.1). These studies measured ICT usage, mostly by the frequency of computer, internet, or smartphone use, time spent online, and smartphone access to the internet. Nine of these studies found positive associations between the amount of ICT use and digital skills. Five found no relationship. However, three of these five studies used performance tests to measure the children's digital skills.

In the analysis of the previous data, we found a positive relationship between internet use (measured by hours online weekly) and digital skills in all 17 European countries (D2.1). In the ySKILLS longitudinal research, we revealed that, on the between-subject level, children who participate in more activities online have higher digital skills for all dimensions. The children who spend more time online have higher technical and operational skills, better content creation and production skills, and better knowledge items. Furthermore, we found that, on the within-

subject level, the individual increase in daily online activities had an effect on the increase in information navigation and processing skills, and communication and interaction skills. There was no within-subject effect on the other dimensions of digital skills.

While the quality of access and the breadth of digital engagement are positively associated with the development of digital skills, research with young people experiencing internet-related mental health difficulties also shows how the affordances of the digital environment fail to support children's acquisition of relevant digital skills that would help them cope with risks threatening their wellbeing, including encounters with extreme content, rabbit holes created by algorithmic filtering, etc. (D6.2).

The quantity of online activities is strongly connected to all dimensions of digital skills. However, it is important to note that an individual increase in the amount of online activities does not automatically result in an increase in all dimensions of digital skills. Specifically, the within-subject analysis revealed that information navigation, processing skills, and communication and interaction skills were affected differently by changes in online activity levels.

4.2 Social factors of digital skills antecedents

In the ySKILLS research, the social factors included socioeconomic status (SES), parental mediation (active and restrictive), family support, and friend support. However, the systematic review (D2.1) revealed more social context variables, such as variables related to teachers and the school, urban-rural residence, and other community variables. These variables were not included in the ySKILLS research.

Socioeconomic status: The systematic review indicated 21 studies about SES as an antecedent of digital skills (D2.1). Thirteen found a significant association between SES and digital skills: 12 found that higher SES was related to higher digital skills and one found that the relationship was the opposite (i.e., higher SES, lower skills). Eight of the 21 studies found no relationship.

In the analysis of existing data (D2.2), we found no association between SES and digital skills (measured as children's perceptions of their skills) in all 17 countries. Similarly, in the ySKILLS longitudinal research (D5.2), there was no relationship between SES and most dimensions of digital skills and no relationship for knowledge items in both the between-subject and within-subject levels. We found the only positive relation on the between subject-level: children with higher SES had better information navigation and processing skills.

Although programming workshops are free, and laptops are available for children who do not bring one from home, participants tend to belong to middle- or higher-SES families. Despite efforts to promote diversity and inclusion, participants in these workshops generally had a homogenous socioeconomic and cultural background: in fact, it is mainly middle- and upper-middle class parents who want their children to gain programming skills (in order to be competitive in the labour market or to become active internet users). What makes current programming workshops less attractive for lower SES and marginalised children is that these workshops rest on a narrow definition of digital skills that holds that individual achievement is future-oriented (and related to better school and professional performance). In fact, even when specifically designed and targeted at lower SES children, this group expresses disinterest in the

non-formal digital skill practices offered by these organisations, for they see them as disconnected from their lived experiences and interests and, therefore, boring.

The ySKILLS research uncovered that among young people in developed countries, there is generally no significant association between socioeconomic status (SES) and most dimensions of digital skills. However, we did identify some notable exceptions. Children from higher SES backgrounds tended to exhibit better information navigation and processing skills, and they were also more likely to participate in extracurricular programming workshops.

Parental mediation: The systematic review found 14 studies focused on parental mediation as an antecedent of digital skills (D2.1). Five of these studies found no association between active (enabling) parental mediation and digital skills. Nevertheless, six studies revealed a positive relation for enabling parental mediation to digital skills. Concerning restrictive parental mediation, three studies revealed a negative relationship: higher restrictive parental mediation was associated with lower digital skills. One study found no significant relationship between restrictive mediation and digital skills.

In the analysis of previous data, we found a weak but positive relationship between active parental mediation and digital skills in all 17 European countries (D2.2). The negative association between restrictive parental mediation and digital skills was stronger: children in families with higher restrictive mediation had lower digital skills. In the ySKILLS longitudinal research (D5.2), we found that, on the within-subject level, there was a negative effect for restrictive parental mediation on technical and operational skills. That means that the individual increase of parental restrictive mediation lowered children's technical and operational skills. On the other hand, there was no other significant within-subject effect for both the enabling and restrictive parental mediation on the other dimensions of digital skills. On the between-subject level, the longitudinal study revealed that in families with both higher restrictive and enabling parental mediation, children have lower technical and operational skills. It could be that if parents are actively helping their children, they prevent them from developing technical digital skills: the children know they can ask their parents for help, so they seek help instead of trying to solve the problem. However, there were no significant relationships with other dimensions of digital skills.

Evidence from the qualitative research of WP6 further problematises the role of parental mediation in children's and adolescents' development of digital skills. For instance, the report D6.2 showed that in Belgium and Italy parents actively encouraged their children to participate in programming workshops. The fact that these children were accompanied by their parents suggests parental interest in their children's digital education, and their adherence to the normative understanding of programming skills as a gateway to the labour market. While parents have a beneficial role in motivating children in their first approach to programming, their presence during workshops has been observed as an important barrier to children's autonomous learning.

In the case of refugee children and young people (Baptista et al., 2022), benefitting from parental support in the process of learning digital skills is, in many cases, limited. This is the case because many are either separated from family or because of their parents' own limited digital skills and struggles. Refugee children and young people benefit from peer support and,

in fact, many told us how they "learn together" because those with more advanced skills among their refugee peers support the learning-by-doing approach among the younger. Refugees could also benefit more from peers within their new school environments, but this is an area of uneven success. More needs to be done in educational environments so that students who have been in their school for a while can understand that newcomers might struggle with some skills but have other skills that they themselves could learn from.

Similarly, in relation to children with mental health difficulties, the role of parents was unclear at best. The interviews made little mention of the role of parents, or they were discussed in terms of generalised support rather than specific guidance in the development of digital skills. The parents' lack of understanding of some of the specialist uses of technology made by these adolescents, along with the adolescents' concern that their digital activities remain private, also meant that parents appeared to have little opportunity to support their children's digital engagement.

The ySKILLS research confirms the negative association between restrictive parental mediation and digital skills. Furthermore, the individual increase of restrictive mediation decreased children's technical and operational skills. Enabling parental mediation was weakly but positively related to digital skills.

Family support: The systematic review (D2.1) identified one study that found a positive relationship between positive family support and both basic and advanced digital self-efficacy (Hsiao et al., 2012). Seven studies uncovered a positive relationship between digital skills and various parental variables, such as parental internet use, parenting style, language interaction at home, and the availability of books at home.

In the longitudinal research (D5.2), we investigated family support as an antecedent of digital skills. We found no significant within-subject relationships, which means that the individual change in family support had no effect on digital skills. On the between-subject level, there was no significant relationship between family support and digital skills for the majority of digital skills dimensions. However, we found that, in families with higher family support, children reported higher communication and interaction skills. It might be that if the family has good social support, which is related to good family communication, children also have higher online communication skills.

Further insights come from research with young people experiencing internet-related mental health difficulties. Participants often saw themselves as individually tasked with the responsibility to learn digital skills and manage the digital world. They felt they could not count on their parents' support, either because they think their parents cannot understand their online experiences, or because they feel guilty and ashamed for engaging in risky behaviour while still being insufficiently skilled.

Psychological family support appears to exhibit little to no significant correlation with most dimensions of digital skills, suggesting a weak relationship in these areas. However, our research did uncover an interesting finding: children from families with higher levels of family support tended to report stronger communication and interaction skills.
This suggests the possibility that strong family support may have a positive influence on communication skills in general, although further investigation is needed to better understand this connection.

Friend support: The systematic review found five studies focused on the relationship between peer variables and digital skills. All five studies found positive associations between digital skills and peer variables, such as with informal teaching and the learning of ICT skills among friends and the co-usage of ICT with friends. The results suggest that peer communication and learning from friends can increase the ICT usage and digital skills of children.

In the longitudinal research, we found no within-subject effects for peer support on digital skills. However, we revealed that on a between-subject level, children with higher friend support had both higher communication and interaction skills and technical and operational skills (D5.2). The associations between friend support and other dimensions of digital skills were not significant.

Qualitative research sheds more light on the role of peers in the development of digital skills. With respect to programming skills (D6.2), even when activities were designed as individual tasks, the moderators of programming workshops verbally encouraged collaboration between participants. While the moderators were ready to step in to assist children who needed help, they usually encouraged children to ask their peers first. Indeed, we observed children occasionally looking at their neighbour's laptops and helping each other by pointing at their code and discussing the task. Moreover, there were instances in which children sat next to an older and more experienced child in order to be able to ask for guidance. The ability to work at their own pace and to express their own interests occasionally led to the emergence of "leaders" or "masters" whom other children turn to for advice, which, in turn, is an important catalysator to learning from peers. However, it was not uncommon to observe that collaboration among participants remained limited and children remained focused on their individual projects.

Research with young people with mental health difficulties points to the social and collaborative character of adolescents' digital encounters. Yet, some ambivalences emerge: While many people enthusiastically share their digital experiences with peers, providing insights, tips, and strategies in online communities to offer support and help with challenges, this behaviour can potentially exacerbate mental health issues.

The psychological peer social support has no effect on most dimensions of digital skills. There was an association in one dimension of digital skills: children who are better socially connected might have better communication and interaction skills. However, the qualitative research shows that, for vulnerable children, the help of peers can still be crucial. That means that the help of peers to vulnerable children should be focused in a specific area, such as in development of programming.

5 Consequences of Digital Skills: Online Opportunities

In this section, we describe various online opportunities as the potential outcomes of digital skills. We also incorporate civic and political engagement as offline opportunities associated with digital skills. Previous research on digital skills and online (and offline) opportunities was summarised in the systematic reviews (D2.1). It predominantly revealed positive relationships between digital skills and online opportunities. In the ySKILLS longitudinal research, we included online activities, such as digital content creation, online communication with friends, civic engagement, listening to music, watching videos, and learning new things. We analysed these activities as the potential consequences for the different dimensions of digital skills (D5.2). We also analysed previous data to identify digital skills as predictors of online information seeking and online communication activities (D2.2).

This section is divided into two chapters:

1. Digital engagement, which includes critical, social, civic, and creative engagement, such as online communication with friends and digital content creation.
2. Learning and leisure, which includes learning new things, listening to music/watching videos, and searching for health information online.

In Table 3, we summarise the ySKILLS results for online opportunities.

Table 3	**Consequences of Digital Skills: Online Opportunities**			
	D2.1 Assessment of the evidence (*N* = number of studies)	**D2.2 Analysis of existing data**	**WP5 Longitudinal between-subject**	**WP5 Longitudinal within-subject**
Digital engagement	Positive (*N* = 16)	Pos: Dig skills informational -> communication Pos: Dig skills social -> communication (weak)	Pos: C. C. S., Comm. S., Prog. S. -> digital content creation Pos: Info. S., C. C. S. -> daily online activities Pos: Tech. S., Comm. S., C. C. S. -> communication with friends Neg: Prog. S., Info. S. -> communication with friends Pos: C. C. S., K. items -> civic engagement	Pos: C. C. S. -> digital content creation Pos: Comm. S. -> daily online activities Pos: Comm. S., Tech. S. -> communication with friends Neg: Prog. S. -> communication with friends No relationship -> civic engagement
Learning and leisure	Overall positive (*N* = 7) Pos: ICT skills -> mobile learning readiness	Pos: Dig skills informational -> information-seeking Pos: Dig skills social -> information-seeking	Pos: C. C. S. -> searching for health info Pos: C. C. S., Tech. S., K. items -> music/watching videos Neg: Prog. S. -> music/watching videos Pos: Prog. S., Info. S., C. C. S., K. items -> learning new things	Pos: C. C. S. -> searching for health info No relationship -> listening to music/watching videos No relationship -> learning new things

Note. (pos) = positive relationship; (neg) = negative relationship; (tech. s.) = technical and operational skills; (info. s.) = information navigation and processing skills; (comm. s.) = communication and interaction skills; (c. c. s.) = content creation and production skills; (prog. s.) = programming skills; (k. items) = digital knowledge items.

5.1 Digital engagement

The systematic review identified 16 studies that focused on the relationship between digital skills and digital engagement (D2.1). All of these studies discovered positive associations between digital skills (and their dimensions) and various forms of digital engagement. These activities include online endeavours that involve information consumption, communication, participation, entertainment, creative pursuits, civic engagement, and academic collaboration. For instance, a multi-country study that investigated online communication as a consequence of digital skills found that higher digital skills positively predicted the greater usage of the internet for social interactions (Helsper & Eynon, 2013). Another study observed that children with enhanced digital skills employed the internet more frequently for academic collaboration (Khan, Wohn, Ellison, 2014; Santos et al., 2019). Earlier research (Kahne & Bowyer, 2019; Moon & Bai, 2020) confirmed the link between digital skills and civic engagement. This involvement includes actions like sharing political content, engaging in online dialogues on social or political topics, participating in online campaigns, and promoting petitions.

In a study by Helsper and Eynon (2013), the impact of digital skills on critical, social, and creative engagement was examined. Notably, social and creative skills predicted creative engagement, whereas the association with critical skills was negative. Conversely, a study found that informational skills, typically considered critical skills, were the most influential factor for predicting children‘s engagement in online content creation (Tirado-Morueta et al., 2017). The divergent outcomes of these studies could be attributed to their participant demographics.

In the ySKILLS longitudinal research (D5.2), we observed at the between-subject level that children with higher content creation skills engaged in a wider range of online activities on a daily basis, communicated more with friends online, and participated in more digital content creation. However, at the within-subject level, we identified only one effect: individual increases in content creation skills had a positive impact on digital content creation activity.

We discovered that children with higher communication skills, at the between-subject level, engaged more in digital content creation and had more online communication with friends. At the within-subject level, an individual increase in communication skills positively affected the amount of daily online activities and communication with friends. Technical skills also exhibited positive effects on communication with friends at both the between-subject and within-subject levels (D5.2). Similarly, the positive association between social digital skills and online communication was replicated in the analysis of data from 17 European countries (D2.2).

Interestingly, at the between-subject level in the longitudinal research, we observed that children with higher informational skills engaged in less online communication with friends (D5.2). This contradicts the results of the analysis of EU Kids Online data, where a positive relationship between informational skills and online communication activities was identified (D2.2). While the effect in the longitudinal research is weak, this contradiction is intriguing. It is possible that communication with friends holds different associations with digital skills compared to general communication activities. Further research is warranted to elucidate this contradiction.

Consistent with a previous study (Moon & Bai, 2020), the ySKILLS longitudinal research demonstrated positive associations between digital skills and online civic engagement (D5.2). At the between-subject level, children with higher content creation skills and those with higher

scores in knowledge items reported greater online civic engagement. Conversely, at the within-subject level, we found no effect for the digital skills dimensions on online civic engagement. This suggests that individual changes in digital skills do not impact changes in online civic engagement. It is conceivable that children with higher overall creativity may exhibit enhanced online creative skills and both increased political activism and greater participation in online civic engagement activities. Nevertheless, the direct impact of digital skills on children's online civic engagement appears unlikely. This hypothesis could be explored in future research.

The findings from the ySKILLS longitudinal research suggest a distinctive role for programming skills in online engagement (D5.2), particularly in online communication. We discovered both between-subject and within-subject negative effects for programming skills on communication with friends. Among individuals where programming skills increased, there was a decrease in online communication with friends, even after accounting for time spent online.

The study of programming skills in non-formal learning contexts (D6.2) complements the findings of ySKILLS longitudinal research (D5.2), showing how programming skills are used by young participants to pursue creativity and engage in digital content creation (i.e., developing video games and websites, creating fantastic stories).

Research with young people experiencing internet-related mental health difficulties (D6.1) also enriches the findings of ySKILLS longitudinal research by providing explanatory insights on the positive association between technical and operational skills and engagement in online communication: indeed, for vulnerable young people the value of technical and operational skills lies in the potential for managing online communication with friends or strangers, namely, in the ability to define differential levels of accessibility based on the degree of intimacy with different online contacts (D6.1). Likewise, information skills are valued in light of vulnerable young people's need to find trustworthy information online about their mental health difficulties, both from experts and peers. For this reason, as much as technical skills blend with communication skills, information skills overlap heavily with communication skills: those higher in technical and information skills feel safer in engaging in online communication. Although content creation skills were less discussed by this group of users, findings suggest they are valuable both for managing online self-presentation and communication and for engagement in advocacy campaigns.

Among young refugees, digital skills help to reach beneficial learning and social outcomes, towards a better inclusion in their destination countries: social media and YouTube are the primary, if not the only, sources of learning, of managing mental health and self-care, and legal information (Baptista et al., 2022).

New findings from the ySKILLS research indicate a positive correlation between digital engagement activities and most dimensions of digital skills. Additionally, when looking at individual skill improvement, we observed that enhanced communication skills positively impacted increased daily online activities and communication with friends.
However, in contrast, higher levels of programming skills were found to have a negative influence on communication with friends. This effect was evident not only at the group level but also within individuals.

5.2 Learning and leisure

The systematic review found seven studies that focused on the learning outcomes and one study that focused on digital skills and leisure (D2.1). Previous research revealed mostly positive relationships between digital skills and learning outcomes. For instance, one study showed that higher online information seeking is associated with higher online information seeking for homework (Eynon & Malmberg, 2012). Additionally, a study conducted by Reddy and colleagues (2017) found a correlation between ICT skills and mobile learning readiness.

The ySKILLS longitudinal research uncovered, at the between-subject level, that children with higher programming skills, information navigation, and processing skills, and higher knowledge items, reported more engagement in the learning of new things online (D5.2). However, interestingly, there was no effect at the within-subject level: changes in digital skills had no impact on learning new things online.

The longitudinal research also found that children with higher information navigation and processing skills reported a greater inclination to search for health-related information. Intriguingly, an individual-level within-subject effect was also observed: an increase in content creation and production skills had a positive impact on online health information seeking (D5.2). In the analyses of previous data (D2.2), we found positive associations among informational digital skills, social digital skills, and online information seeking in all 17 countries.

During the non-formal programming skills workshops studied in WP6, the children adopted a problem-solving mentality. In addition to programming-related skills, the children trained time management and planning competences as they had limited time to finish the project. By offering stimuli and leaving children working on their own, the moderators facilitated creativity and autonomous thinking.

Interviews with refugee teenagers (Baptista et al., 2022) highlighted the positive role of information and communication skills in facilitating the learning of a new language. In cases where children and adolescents had experienced a lack of formal education in their countries of origin or arrival, digital skills played a vital role in helping them compensate with poor literacy and numeracy skills. Young refugees also learned how to navigate their new environments by using apps (e.g.,GPS and online resources for navigating their new cities); importantly, digital skills help them manage belonging in transnational families, as they have to conduct much of their intimate relationships across distances and mostly through social media connections. In conclusion, for young refugees, digital technologies are embedded in learning how to manage all elements of life, from education to long-distance family relations.

The ySKILLS research has verified that the various dimensions of digital skills are closely connected to various types of digital engagement. However, it is important to note that the individual impact of digital skills on digital engagement within the same person is relatively uncommon. In other words, just because someone improves their digital skills does not necessarily guarantee they will automatically have more online opportunities or engagement.

6 Consequences of Digital Skills: Online Risks

In the systematic review (D2.1), we identified 14 studies that focused on the potential consequences of digital skills in relation to online risks. These studies pursued various objectives: seven examined multiple risk dimensions and six focused on behavioural risks, such as cyberbullying and online addiction. One study concentrated on content-related risks that involved exposure to materials like pornography, drugs, racism, and suicide (Vandoninck et al., 2010). The majority of these studies (11 out of 14) indicated that enhanced skills correlated with greater exposure to online risks or a wider array of online risks. This finding might be surprising, given that children with superior skills often spend more time online and consequently encounter a higher frequency of online risks (Smahel et al., 2020). A study carried out in Brazil (Cabello-Hutt, Cabello & Claro, 2018) showed that the association between digital skills and online risks is mediated by online opportunities. The scope of digital skills in this research included self-reported proficiency across operational, information-navigation, critical-thinking, communication, and safety domains.

Within the systematic review, only two studies uncovered a negative relationship between digital skills and online risks (Gini et al., 2019; Wegmann et al., 2015). However, the first study (Gini et al., 2019) demonstrated that ethical media use (such as being respectful to others and social rules) can mitigate online aggression and victimisation experiences. Additionally, the second study (Wegmann et al., 2015) found that adeptly managing online behaviour reduces excessive internet use. This implies that possessing skills associated with specific risks might lead to a reduction in those particular risks.

We recognise that adolescents face a variety of online risks (Smahel et al, 2014). However, in the ySKILLS study, due to space constraints in the survey, we focused on specific online risks in the longitudinal research (D5.2). These included cyberhate, exposure to harmful content, and exposure to sexual content. What sets our research apart and significantly contributes to existing literature is our differentiation between intentional and unintentional exposure[2] to these online risks. We also examined whether the four dimensions of digital skills could predict these types of exposure. The online risks resulting from digital skills were also included in the analyses of EU Kids Online data (D2.2), where we explored the role of digital skills as moderators between emotional problems and online risks. Online risks in relation to digital skills were also mentioned in several interviews and focus groups in the qualitative research of WP6 providing deeper insights into this relationship. Please refer to Table 4 for an overview of the ySKILLS results, which examined online risks as potential outcomes of the different digital skills dimensions.

[2] Intentional exposure to the relevant risk was measured by the following question: And how often have you seen something like this when you INTENDED to see it?. Unintentional exposure was measured by the question: And how often have you seen something like this when you DID NOT INTEND to see it?.

Table 4	Consequences of Digital Skills: Online Risks			
	D2.1 assessment of the evidence (*N* = number of studies)	**D2.2 Analysis of existing data**	**WP5 longitudinal between-subject**	**WP5 longitudinal within-subject**
	Overall positive (*N* = 14)			
Cyberhate	-	-	Pos: C. C. S., Prog. S. -> intended Pos: K. items -> unintended Neg: Info. S. -> unintended	No relationship -> intended No relationship -> unintended
Harmful content	-	Pos: digital skills -> harmful content Moderator: digital skills as moderator between emotional problems and harmful content	Pos: C. C. S., K. items -> intended Pos: K. items -> unintended	Pos: C. C. S. -> intended Pos: C. C. S. -> unintended
Sexual content	lower digital skills -> more harm in relation to sexual images lower digital skills -> more harm from seeing and receiving sexual messages	-	Pos: K. items -> intended Pos: K. items, C. C. S. -> unintended	No relationship -> intended No relationship -> unintended

Note. (pos) = positive relationship; (neg) = negative relationship; (tech. s.) = technical and operational skills; (info. s.) = information navigation and processing skills; (comm. s.) = communication and interaction skills; (c. c. s.) = content creation and production skills; (prog. s.) = programming skills; (k. items) = digital knowledge items.

In the longitudinal research of ySKILLS (D5.2), we revealed, on the within-subject level, that the increase in content creation skills increased the chances of both intended and unintended exposure to harmful content. On the between-subject level, children with higher content creation skills reported higher exposure to intended cyberhate content, higher exposure to intended harmful content, and higher exposure to unintended sexual content. As we will explore further, it appears that content creation skills represent a unique aspect of digital skills concerning online risks. Interestingly, we observed an impact specifically within individuals in relation to this dimension, and it did not manifest in the between-subject analysis.

We can also notice that the majority of the within-subject effects of the digital skills dimensions on online risks are insignificant. That means that it should be safe to increase the digital skills of children, with the exception of content creation skills. On the between-subject level, children with higher digital skills had higher unintended exposure to cyberhate, higher unintended exposure to harmful content, and higher unintended (and also intended) exposure to sexual content. We also find one negative effect on the between-subject level: children with higher information navigation and processing skills had lower exposure to unintended cyberhate content. It seems that this kind of digital skills might protect children from the unintended cyberhate content.

In **the analysis of the existing data** (EU Kids Online), we confirmed the positive relationship of digital skills and exposure to harmful content (D2.2). Interestingly, we tested the digital skills as a **moderator between emotional problems and exposure to harmful content**. The results

in all 17 countries were significant: when children who suffer from emotional problems have higher digital skills, they are more likely to be exposed to harmful online content.

Research with young people experiencing internet-related mental health difficulties (D6.1) shows, first, that sophisticated **digital skills often lead to riskier digital engagement**. And, second, although often very proficient in technical and operational, information navigation, communication, and content creation skills this particular group of users struggles to avoid content and contacts that are risky for their wellbeing. More specifically, what this group of users expose is the potentially pernicious interaction of digital affordances (the scalability of digital content, the mechanisms of recommendation systems, the algorithmic amplification of viral content, including harmful content), platform business models, (sub)cultural practices and norms, and the vulnerabilities of adolescents with mental health difficulties. Encounters with extreme content, algorithmically amplified triggers for vulnerability, deceptive online identities and social pressures to maintain their popularity on platforms are particularly dangerous for young people with mental health difficulties, requiring them to develop particular digital skills- i.e., recognizing an extreme space, unmasking deceptive identities, or, more positively, knowing how to game the algorithm to make one's feed positive or locate 'safe' spaces or trustworthy people.

Similarly, **refugee adolescents show how higher digital skills may come with higher risks**. Importantly, sometimes young refugees have little choice but to expose themselves to high risks (e.g., as so many of them depend on traffickers to reach safety when they escape war) (Baptista et al., 2022). That means that digital skills help young refugees gain access to life saving information, which can at the same time be life threatening. In some other cases, awareness of different technological affordances means that they skilfully make choices that are also risky. Risky choices include deliberately disconnecting from their phones when crossing into Europe so that authorities cannot use GPS technologies to track them. Also, sometimes, for young refugees, information navigation skills mean being exposed to harmful content (e.g., violent war content from their home countries) that revives trauma and perpetuates anxieties and insecurities.

The longitudinal research conducted by ySKILLS has provided valuable insights by revealing minimal effects of increased digital skills on individual risks at the within-subject level. This suggests that it is generally safe to enhance the digital skills of children. However, there are some notable exceptions, particularly in the case of content creation and production skills, where we observed an impact on both intended and unintended exposure to harmful content. Qualitative research further emphasises that possessing digital skills alone may not be sufficient. The nature of online platforms and specific life circumstances often make it challenging for young people to completely avoid exposure to online risks. In other words, digital skills alone may not provide complete protection in certain situations.

7 Consequences of Digital Skills: Wellbeing

The systematic review performed within ySKILLS (D2.1) identified only six studies that focused on the relationship between digital skills and wellbeing. The report assessed the evidence as "inconclusive" and recommended future research in this area. Therefore, the primary goals of the ySKILLS project were to further uncover the relationship between ICT usage, digital skills, and wellbeing, focusing on both the long-term and short-term relationships. Wellbeing indicators were included in the longitudinal research (see Report D5.2) and in the ESM research, with a focus on short-term relationships (see Report D5.4). In the longitudinal research, we included indicators for psychological, social, physical, and cognitive wellbeing, and we focused on the longitudinal impact of digital skills on wellbeing. In the ESM research, we included indicators for psychological and physical wellbeing, but we focused more on the short-term impact of ICT usage on wellbeing because digital skills do not change on a daily basis. In the qualitative research of WP6, the topic of wellbeing was present in several materials, in focus groups' discussions. In the research that utilised (f)MRI data, we further examined the dimensions of digital skills and children's abilities to learn and perform various tasks (D5.5).

Table 5 summarises the results of the systematic review, the longitudinal research, the ESM research, and the results of (f)MRI.

Table 5	Consequences of Digital Skills: Wellbeing					
	D2.1 Assessment of the evidence (*N* = 6 studies)	**WP5 Longitudinal between-subject**	**WP5 Longitudinal within-subject**	**D5.4 ESM analysis within-subject**	**D5.4 ESM analysis between-subject**	**D5.5 (f)MRI data**
Psychological WB	Neg: Information seeking and emotional support seeking -> mental health (loneliness, worry and jealousy) No relationship: Dig skills -> life satisfaction	Neg: Prog. S. -> life satisfaction Pos: Comm. S. -> life satisfaction Neg: Internet use -> life satisfaction	No relationship -> life satisfaction	Pos: ICT use → boredom, relaxation, loneliness Pos: Social media → boredom, relaxation, loneliness Pos: Browsing → boredom Pos: Videos, gaming → relaxation	Pos: ICT use → boredom, loneliness Neg: ICT use → relaxation Pos: Social media use → boredom, tiredness, loneliness Pos: Browsing → boredom, tiredness Pos: Music → boredom, tiredness, frustration, loneliness	-
Social WB	-	Pos: Comm. S. -> friend support No relationship: Internet use -> friend support	No relationship -> friend support	-	-	-
Physical WB	Pos: Critical digital skills -> positive body image	No relationship -> phys activities Neg: Internet use -> phys activities	No relationship -> phys activities	Pos: Phone in bed before sleep, Messaging → fall asleep easy Neg: Phone in bed before sleep, Music → sleep duration Neg: Messaging → bedtime (earlier) Neg: Social media → bedtime (later)	Pos: Messaging, Social media → bedtime (later) Neg: Social media, Browsing, Phone sleep → sleep duration Neg: Music → sleep quality Pos: Phone sleep → fall asleep easily; bedtime (later)	-
Cognitive WB	No relationship: cognitive WB & skills Pos: ICT literacy -> school perf Pos: Learning programming -> cognitive skills Pos: Internet literacy-> academic perf	Pos: Info. S., K. Items -> school perf Neg: C. C. S. -> school perf No relationship: Internet use -> school perf	Pos: Comm. S. -> school perf	-	-	No relationship Digital skills -> Performance (or brain activity) in arithmetic tasks. Neg: Info. S. and C.C.S -> Performance in attention-demanding linguistic tasks Neg: Info S. and C. C. S. -> Working memory capacity Pos: ySKILLS performance test -> Working memory capacity

Note. (pos) = positive relationship; (neg) = negative relationship; (tech. s.) = technical and operational skills; (info. s.) = information navigation and processing skills; (comm. s.) = communication and interaction skills; (c. c. s.) = content creation and production skills; (prog. s.) = programming skills; (k. items) = digital knowledge items.

7.1 Psychological wellbeing

In the systematic review, we identified only two studies that focused on the relationships of psychological wellbeing and digital skills. The first study found a negative association for information and emotional support seeking and mental health, which was specified as loneliness, worry, and jealousy (Duvenage et al., 2020). The second study found no relationship between digital skills and life satisfaction (McLean et al., 2017).

The longitudinal research in ySKILLS provides new insights to the understanding of this relationship (D5.2). First, we find **no within-subject effects** for the five digital skills dimensions on life satisfaction. However, the study revealed that, on **the between-subject level**, children with higher programming skills reported lower life satisfaction, and children with higher communication skills reported higher life satisfaction. Nevertheless, both effects were weak and it could be that the relationship is impacted by the third variable, such as the role of a moderator or a mediator. Future research and the analysis should look at these relationships in more detail and look separately at the different dimensions of digital skills. Our results indicate that different dimensions of digital skills might have the opposite effects on wellbeing, such as in the case of programming skills and communication skills.

We also found more insights into the relationship of digital skills and psychological wellbeing **in the qualitative research** of WP6 (D6.1). Such as, young people with internet-related mental health difficulties develop ad hoc digital skills to protect their psychological wellbeing, avoiding being exposed to extreme content and locating safe spaces and contacts where they can receive important social support. Migrant children develop identity-related skills, which are necessary for their socio-emotional development (i.e., to gain social validation, social control, and achieve self-awareness) and communication skills that help them keep in touch with their diasporic families and networks. For many young refugees, digital skills are vital for self-care and for the caring of others (Baptista et al., 2022). However, higher information navigation skills means for some being exposed to harmful content (information about war in their countries of origin), that upsets them (see reports D6.1 and D6.4). This insight from the qualitative studies is also indicating the possible role of other mediating variables, such as higher navigation skills effects higher exposure to harmful content which affects the possible lower wellbeing.

In the **ESM research** (report D5.4) we focused on the short-term impact of ICT usage on psychological and physical wellbeing. On a daily level, we found an association between ICT use, social media use, and watching videos with relaxation, but we also revealed the within-subject relationships of ICT use, social media use, and browsing with boredom. Indeed, it suggests that individuals who use ICT more intensively on certain days might experience increased relaxation during those periods, but on days with higher media usage, they may subsequently feel more bored or unstimulated. This dynamic highlights the complex relationship between ICT use, relaxation, and boredom, which can vary from one day to another. However, this specific research does not provide information about the causality: we do not know if higher ICT use on the daily level causes boredom and relaxation or vice versa. Future research should focus more on causal effects in these relationships.

At **the between-subject level**, the ESM research found a positive association between ICT use and boredom (D5.4). Interestingly, the results also show the negative association of ICT use with relaxation. That means that children who, in general, report higher ICT use reported lower relaxation: this is the opposite trend to the within-subject daily result. On the between-subject

level, social media use is also associated with boredom and tiredness; browsing with boredom and tiredness.

The **ESM research** provides findings on the daily level, showing mainly associations with the different digital media uses and the wellbeing indicators (D5.4). However, the role of digital skills in this relationship on a daily level is still unclear. Future research should test the digital skills as a moderator between ICT usage and wellbeing. For example, we can establish a hypothesis that children with higher digital skills are able to find better ways of online relaxation.

Research with **young people with internet-related mental health difficulties** shows how the relationship between the daily use of digital media and wellbeing is moderated by digital skills and the affordances of online platforms (D6.1). In fact, although young people report learning how to protect themselves from excessive use and the potential harms of the digital engagement by developing particular digital skills, taking control of their online use in daily life remains challenging due to the combination of social pressure to conform to problematic norms and the functioning of algorithmic selection and the curation of digital content.

Likewise, qualitative insights from research with refugee adolescents (Baptista et al., 2022) show complex, non-linear associations among digital media use, digital skills, and wellbeing. For young refugees, digital connections and temporary disconnections are fundamental to managing and sustaining identity under conditions of enormous uncertainty. Digital skills are always conditioned by the particular challenging circumstances of their daily lives, and they cannot compensate for the lack of security, the experiences of racism, and the high levels of exclusion. However, by providing access to the networks of support and information that help them understand their new country, digital skills can help young people manage these deteriorating conditions.

Our results indicate that there is either no significant relationship, or a very weak one, among digital skills, technology use, and psychological wellbeing. However, digital skills can play the role of moderator between ICT usage and wellbeing. This hypothesis should be further examined and validated in future research. In our study of children's daily ICT usage, we found only weak relationships between their ICT usage and their psychological wellbeing.

7.2 Social wellbeing

There is currently very limited knowledge about the relationships between digital skills and social wellbeing. The systematic review (D2.1) identified no studies in this area. If we consider loneliness, which is defined as lack of social relationships, under the umbrella of social wellbeing, there is one relevant study that found a negative association between information and emotional support-seeking behaviours and social wellbeing (Duvenage et al., 2020).

Within ySKILLS, we included friend support as an indicator of social wellbeing in the longitudinal research (D5.2). At **the within-subject level**, we found that communication skills have an effect on friend support. That means that, among those children who increased their communication skills, the friend support was also increased. On the other hand, we revealed no associations for friend support with the other dimensions of digital skills. It seems that increasing communication skills might be crucial for receiving higher friend support. At **the between-subject level**, we found no associations between digital skills dimensions and friend support.

In **the ESM research**, we focused on the daily associations of digital technology usage and social wellbeing that were represented by loneliness. We identified the within-subject associations of ICT use, social media use, and loneliness: children who use ICT and social media more than their average might feel more lonely on the days of the higher usage. On the between-subject level, this research found a positive association between ICT use and loneliness: children who use ICT reported more loneliness. However, the effects of these associations are very small and we do not know the causality for these relationships. It is also possible that when children feel more lonely they use more ICT.

Importantly, insights from the different **qualitative research** projects in WP6 converge in showing how children and young people argue for expanded and complex definitions of digital skills, that are inseparable from personal, emotional and interpersonal skills, as well as from their life circumstances.

The children and adolescents participating in **non-formal programming skills workshops** challenge the dominant understanding of programming skills as a necessary condition to be competitive on the labour market (D6.2). In fact, although they have appropriated the adults' discourse on programming workshops as a gateway to the labour market and an investment in their digital education, they emphasised the playful and creative dimensions of their participation in informal digital skills practices. They also challenged the usual framing of programming skills as an individual achievement, for this does not translate into beneficial outcomes for children's social wellbeing. Most workshops are informed by a narrow definition of programming digital skills as an individual achievement, which is intrinsically beneficial for children and young people. However, this framework can pose a challenge for children and young people from lower socioeconomic backgrounds and migrant communities. These individuals may face barriers to participation because they struggle to see how programming skills are connected to their real-life experiences and circumstances. This highlights the importance of making digital skills and programming education more accessible and relevant to a diverse range of backgrounds and life situations. To foster the inclusivity of programming digital skills workshops in non-formal learning contexts, it is crucial that the digital skills practices are close to children's and young people's interests and needs.

For **young people with internet-related mental health difficulties**, technical, information navigation and communication skills heavily overlap with personal and interpersonal skills: managing online spaces and communication is, for them, also a way of managing their lives, and trying to improve their wellbeing. More specifically, technical, information navigation and communication skills help young people with mental health difficulties determine who is trustworthy online, and, consequently, find social support from peers on social media (D6.1). However, because of the affordances of digital platforms, the possibility of deceptive identities exists and threatens the social and psychological wellbeing of vulnerable young people.

Likewis, **young refugees** often acquire digital skills that are closely intertwined with life skills, as these skills become essential for their socio-emotional and cognitive development. Additionally, these skills are vital for navigating the risks that are inherent in their transnational lives, which can include challenges ranging from emotional disconnection with family members to the life-threatening risks they face when seeking safety while fleeing war and destitution (Baptista et al., 2022).

We discovered only slight connections between digital skills and social wellbeing. Our research indicated that children with stronger communication and interaction skills tend to receive more social support from their friends. However, when it comes to daily ICT usage, we identified a link with social wellbeing. Specifically, children who engage in higher-than-average ICT and social media usage may experience increased feelings of loneliness during these periods of elevated usage.

7.3 Physical wellbeing

In the current research, there are only a few studies that have investigated the relationships of digital skills and physical wellbeing. McLean and colleagues (2017) 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. Enhanced digital skills were associated with a more favourable body image, as assessed through overall feelings regarding appearance, contentment with weight, appraisals received from others about one's physicality, and the impact of body size and form on self-assessment.

In ySKILLS longitudinal research (D5.2), we measured physical activity performed by children weekly. We found **no relationship** between all of the dimensions of digital skills and physical activity at either **the within-subject and between-subject level**s. It may not be surprising that there is no direct relationship between digital skills and physical activity. However, digital skills could impact physical activity indirectly through activities related to certain digital skills. In other words, the influence of digital skills on physical activity may manifest through the specific digital activities or behaviours that individuals engage in, rather than being a direct link. Testing the possible indirect relationships and digital skills as a mediator of physical wellbeing is a task for future research to explore.

We also measured only physical activity in the longitudinal research of ySKILLS, but physical wellbeing has much more indicators, such as body image mentioned in the previous study, eating behaviours, and patterns of sleep. In the **ESM research** (D5.4), we focused on associations between the ICT usage and indicators of sleeping, such as bedtime, sleep duration, sleep quality, and falling asleep easily. On the within-subject level, we found that if children

had a phone in bed before sleep and if they were messaging more than average, they reported that they fall asleep more easily. This is quite a surprising finding, but messaging and social media use also had a negative effect on earlier bedtime. So children who do more messaging or use social media more than on an average day, may go later in the bed, but possibly fall asleep more easily. However, if children had their phone in bed before sleep, it decreased their sleep duration on these days. At the between-subject level, we found that children who use more social media and messaging, report later bedtimes. For children with higher social media use and higher browsing, the sleep duration is shorter. However, all of the within-subject and between-subject effects on sleep patterns were small. There might be some effects, but, in general, it seems that the impact of digital technology use on children's sleep is relatively minor.

The ySKILLS research did not discover any significant impact of digital skills on physical activities when looking at the same individuals. However, it did find that children who use the internet more tend to engage in fewer physical activities. Additionally, when examining how much time children spend on ICT (Information and Communication Technology) activities on a daily basis, we observed effects on their sleep patterns. The results were quite varied, with some effects even showing a positive influence. This suggests that there is a need for more in-depth research in this area to better understand these relationships.

7.4 Cognitive wellbeing

Similar to the other types of wellbeing, there is limited research on cognitive wellbeing and digital skills. In the systematic review (D2.1), one identified study found no relationship between cognitive wellbeing and digital skills (Dindar, 2018). Cognitive wellbeing was measured via the PISA Creative Problem-Solving Test (OECD, 2012), and digital skills were assessed through gaming. However, other studies found a positive relationship between digital skills and academic performance (Scherer, Siddiq, Sánchez Viveros, 2019; Tirado-Morueta et al., 2017). The meta-analyses of 105 studies found a moderate effect for learning computer programming on cognitive skills, including creativity, reasoning, and mathematical skills (Scherer, Siddiq, Sánchez Viveros, 2019). It was also found that school achievement and literacy benefited the least from learning programming.

In the ySKILLS longitudinal research, we measured cognitive wellbeing by children's self-evaluation of their school performance. So it is only one specific aspect of cognitive wellbeing. At **the within-subject level**, we found positive effects for the information seeking dimension and for digital skills knowledge on the school performance. This suggests that an increase in the information-seeking dimension and knowledge items positively influenced improvements in school performance. Surprisingly, an increase in content creation skills over time had a negative impact on school performance, albeit a small one. While the precise cause for this negative effect is not certain, it is possible that a third variable is at play, influencing both variables. For example, engaging in extensive online activities, such as spending significant time creating YouTube videos, may positively impact content creation skills but negatively affect school performance. This illustrates the complex interplay of factors affecting these outcomes. Future research should focus on an explanation for this relationship.

In **the qualitative studies** in WP6, we revealed that digital skills might be important for cognitive development of vulnerable children. For instance, migrant children developed digital skills that are relevant for their academic performance, and to compensate with poor education

trajectories. For example, refugee teenagers report turning to YouTube to learn the language of their country of destination, or basic literacy and numeracy skills they did not learn in their home countries (Baptista et al., 2022). However, and in line with research on misinformation, disinformation and conspiracy theories among adults, greater information navigation skills of vulnerable children may generate potential adverse effects. This could include increased skepticism towards mainstream news media, with children turning to alternative sources for information.

In the **fMRI research** (D5.5), we found no relationships between children's digital skills or online activities and performance or brain activity in closed or open arithmetic tasks. Surprisingly, we found signs of negative associations of information navigation and processing skills and content creation and production skills with performance in fast-paced, attention-demanding linguistic tasks. Similarly, the working memory capacity was negatively related to information navigation and processing skills and content creation and production skills. However, it should be noted that these results were observed in cross-sectional rather than longitudinal settings, and therefore the causality of these findings remains an open question. For example, the results do not necessarily suggest that obtaining higher digital skills would lead to lower working memory skills, as it is also possible that adolescents with lower working memory skills are more prone to develop their digital skills. Moreover, there was a positive relation between ySKILLS performance tests and the working memory capacity. The performance in the attention-demanding linguistic tasks was better in adolescents who engaged in moderate amounts of gaming in their daily lives (but not those who gamed excessively) than in those gaming little. However, again due to the cross-sectional settings, future longitudinal research should clarify the causal direction of these relationships.

The ySKILLS research found mixed associations between digital skills and school performance. Children with higher information navigation and processing skills reported better school performance, but children with higher content creation and production skills reported lower school performance. However, the individual increase of communication and interaction skills had a positive effect on school performance. These findings highlight the complexity of the relationship between digital skills and academic achievement.

8 Towards a New Model of Digital Literacy

In developing the new model, we build on the conceptual model of ySKILLS (Figure 1) introduced at the start of this report. We also build on our theoretical conceptualisation of digital literacy consisting of knowledge and skills elements as well as functional and critical aspects (see Figure 2). In this conceptualisation, digital skills are part of the broader concept of digital literacy which is a fundamental building block of our new model (see Figure 4). The results of both ySKILLS longitudinal research and the systematic review of literature (D2.1) show that digital literacy is related to (and preceded by) both individual and social factors, as well as digital engagement variables. It could be hypothesised that digital literacy might have a direct or indirect impact on wellbeing. However, most findings showed an indirect impact, except that gaining some digital skills (communication and interaction skills) is directly associated with increased academic performance.

Learning from ySKILLS findings and theorising during the conduct of the project, and inspired by the previous theoretical model from EU Kids Online (Livingstone, Mascheroni, Staksrud, 2018), among others, we created **a new theoretical model** – see Figure 4. Given that digital literacy mediates between antecedents and consequences, in the new model we have positioned the variables differently from the original ySKILLS model, making it clearer how the variables are interrelated and inviting new hypotheses to be tested. Further, the in-depth theorisation of digital literacy (including critical knowledge and functional skills) developed during the ySKILLS project has also necessitated a more complex depiction in the model – to show the importance of the four dimensions - and again, inviting new hypotheses for future research. In this last section, we explain how the new version of the model can be of general value to future researchers and policy makers. For this reason also, the new model is more streamlined than the original ySKILLS model, omitting details about the ySKILLS methods.

In this new model, reflecting ySKILLS' distinctive focus, and its empirical findings, **digital literacy occupies the central position** among the other concepts and variables. Digital literacy includes functional skills and critical knowledge, as we explained in the "Conceptualisation of digital skills" section (see also Figure 2). Digital literacy is multidimensional, consisting of technical and operational, information navigation and processing, communication and interaction, and content creation and production skills and knowledge. As we saw in the previous sections, each dimension might be differently associated to digital literacy antecedents and consequences: see also the Table 6, which summarises these relationships. Digital literacy can also play the role of moderator between other concepts: individual/social factors and digital engagement; ICT access and online activities; digital engagement and wellbeing.

Individual and social factors are possible antecedents of digital skills (see previous sections in this report), but they are also related to digital engagement (i.e., ICT access and online activities). Individual factors include gender, age, personality characteristics (e.g., self-efficacy, self-esteem), individual perceptions and attitudes, mental health problems, leisure activities, and ICT related attitudes (e.g., perceptions of ICT, digital self-efficacy). Social factors include socioeconomic status, peer variables (e,.g., peer support), parental variables (e.g., parental mediation of ICT use, parental support) teacher variables, and other community variables.

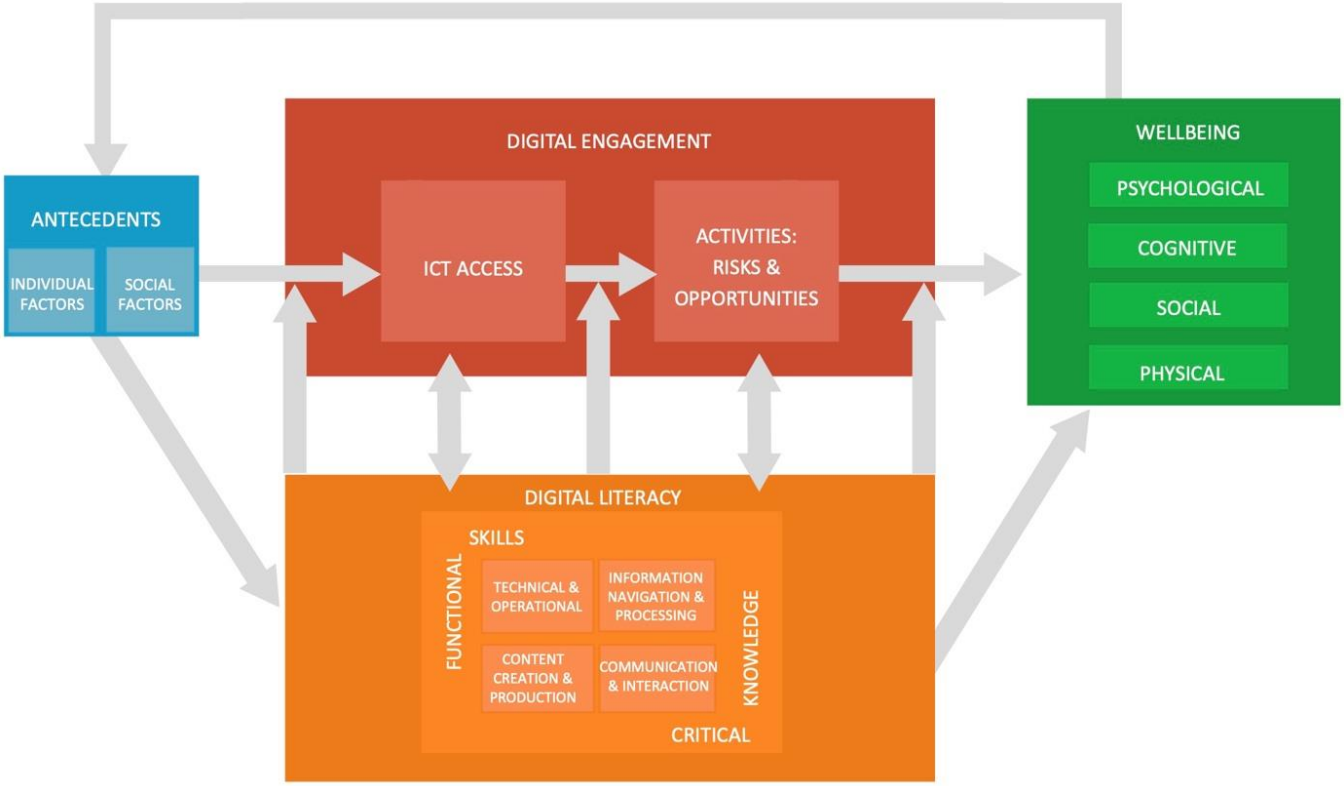


Figure 4: New theoretical model of ySKILLS.

Digital engagement includes ICT access and online activities, which consist of online opportunities and risks. The variable 'CT access' was added in comparison to the preliminary ySKILLS model because we identified it as an important variable in both the systematic review (D2.1) and in the qualitative research with marginalised or vulnerable children. The "digital engagement" box includes online activities, which consist of online opportunities (e.g., online learning, political participation, seeking for health online information) and online risks (e.g., cyberbullying, cyberhate, harmful content, online addictions). It is conceived inclusively, recognising that digital engagement has become vital in the digital age. It cannot be encapsulated by simple measures of 'ICT use' or 'screen time' and, indeed, includes a host of factors, circumstances, motivations and activities that invite further exploration.

Wellbeing is the main outcome in this model, which is similar to the preliminary ySKILLS model. Wellbeing has different dimensions: cognitive wellbeing (e.g., perception), physical wellbeing (e.g., sleeping, physical activity, eating), psychological wellbeing (e.g., emotional state, life satisfaction, self-efficacy, depression), and social wellbeing (e.g., peer support, family support). The impact of digital engagement on wellbeing can occur in the short term (i.e., effect on the current emotional state) or long term (i.e., effect on life satisfaction).

8.1 Overview of the relations of the different dimensions of the digital skills

In this new conceptual model, digital literacy is described as a compound concept. The ySKILLS research differentiated four dimensions of digital literacy with skills and knowledge elements[3]. We present Table 6 to show the global picture of the relations between the different dimensions of the digital literacy and other variables. From this table, we can summarise how the parts of the model are related to the dimensions of digital literacy:

- **Individual factors** are related to all digital skills dimensions (including programming) as well as to overall digital knowledge. There is a positive relationship between self-efficacy, daily activities online, and all of the digital skill dimensions.
- The results for **social factor** variables are much less clear. Variables such as content creation and production skills, programming skills, and digital knowledge have no relation to any of variables in the social context that were part of the ySKILLS longitudinal research (D5.2). The parental mediation strategies (both enabling and restrictive) were related only to technical and operational skills.
- **Online risks** are related to some of the digital skills dimensions. We found one significant within-subject relationship: an individual increase in content creation and production skills had an effect on higher exposure to intentional and unintentional harmful content. However, there was no association between technical and operational skills, communication and interaction skills, and online risks in our research. Children with higher knowledge items reported higher exposure to cyberhate, harmful content, and sexual content.
- Variables within **online opportunities** relate to all of the dimensions of digital skills. Children with higher content creation and production skills reported higher values in all of the variables of online opportunities. We found some within-subject relations: the individual change in technical and operational skills had an effect on more frequent communication with friends. An individual's increase in communication and interaction skills increased daily online activities and communication with friends. Surprisingly, higher programming skills were associated with lower communication with friends.
- We found only a few (and weak) direct relationships between digital literacy and **wellbeing**. Technical and operational skills had no associations with wellbeing. Children with better information navigation and processing skills reported higher school performance. On the other hand, children with higher content creation and production skills reported lower school performance. We found only one, albeit an important, within-subject effect: the individual improvement of communication and interaction skills had a positive effect on school performance.

[3] Statistically programming had distinct characteristics and was, therefore, measured separately even if conceptually it can be seen as part of technical or content creation skills. Further research is needed to unpack these different elements of programming.

Table 6	Associations of digital skills dimensions, programming and knowledge items						
		Technical and operational skills	Information navigation and processing skills	Communication and interaction skills	Content creation and production skills	Programming	Knowledge items
Individual factors	Age	B: +	B: +	B: +	B: 0	B: 0	B: +
	Gender	B: + boys	B: + boys	B: + girls	B: 0	B: + boys	B: 0
	Self-efficacy	B: + W: +	B: + W: +	B: + W: +	B: + W: +	B: + W: 0	B: + W: 0
	Daily activities	B: + W: 0	B: + W: +	B: + W: +	B: + W: 0	B: + W: 0	B: + W: 0
	Internet use	B: +	B: 0	B: +	B: +	B: 0	B: +
Social factors	Socioeconomic status	B: 0	B: +	B: 0	B: 0	B: 0	B: 0
	Parental mediation - restrictive	B: - W: -	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0
	Parental mediation - enabling	B: - W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0
	Family support	B: 0	B: 0	B: +	B: 0	B: 0	B: 0
	Friend support	B: +	B: 0	B: +	B: 0	B: 0	B: 0
Online risks	Cyberhate	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: + W: 0	Int. B: + W: 0	Int. B: 0 W: 0
		Unint. B: 0 W: 0	Unint. B: - W: 0	Unint. B: 0 W: 0	Unint. B: 0 W: 0	Unint. B: 0 W: 0	Unint. B: + W: 0
	Harmful content	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: + W: +	Int. B: 0 W: 0	Int. B: + W: 0
		Unint. B: 0 W: 0	Unint. B: 0 W: 0	Unint. B: 0 W: 0	Unint. B: 0 W: +	Unint. B: 0 W: 0	Unint. B: + W: 0
	Sexual content	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: 0 W: 0	Int. B: + W: 0
		Unint. B: 0 W: 0	Unint. B: 0 W: 0	Unint. B: 0 W: 0	Unint. B: + W: 0	Unint. B: 0 W: 0	Unint. B: + W: 0
Online opportunities	Digital cont.creation	B: 0 W: 0	B: 0 W: 0	B: + W: 0	B: + W: +	B: + W: 0	B: 0 W: 0
	Daily online activities	B: 0 W: 0	B: + W: 0	B: 0 W: +	B: + W: 0	B: 0 W: 0	B: 0 W: 0
	Communication with friends	B: + W: +	B: - W: 0	B: + W: +	B: + W: 0	B: - W: -	B: 0 W: 0
	Civic engagement	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: + W: 0	B: 0 W: 0	B: + W: 0
	Searching for health info	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: + W: +	B: 0 W: 0	B: 0 W: 0
	Music/video watching	B: + W: 0	B: 0 W: 0	B: 0 W: 0	B: + W: 0	B: - W: 0	B: + W: 0
	Learning new things	B: 0 W: 0	B: + W: 0	B: 0 W: 0	B: + W: 0	B: + W: 0	B: + W: 0
Wellbeing	Psych: life satisfaction	B: 0 W: 0	B: 0 W: 0	B: + W: 0	B: 0 W: 0	B: - W: 0	B: 0 W: 0
	Social: friend support	B: 0 W: 0	B: 0 W: 0	B: + W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0
	Physical: phys. activities	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0	B: 0 W: 0
	Cognitive: school performance	B: 0 W: 0	B: + W: 0	B: 0 W: +	B: - W: 0	B: 0 W: 0	B: + W: 0

Note. (+) = positive relationship; (-) = negative relationship; (0) = no relationship. (B) = between-subject; (W) = within-subject.

As demonstrated thus far, there are substantial differences in the relationships between various dimensions of digital skills and the broader concepts within the model. Figure 5 shows these different relationships in the model thus:

- The darkest grey arrows show moderate relationships between the concepts.
- The light grey arrows reveal weak relationships between the concepts.
- The dotted light grey arrows mean that we do not have enough results or that it was not the focus of the ySKILLS research.

In the ySKILLS research, we found associations among individual factors, social factors, and digital skills. It appears that these associations differ: individual factors are much stronger predictors than social factors. Individual factors are closely related to all dimensions of digital skills, wheras social factors are linked to only certain dimensions (see Table 6). Digital skills are associated with ICT access and with online opportunities: we found moderate relations to several dimensions of digital skills. On the other hand, digital skills are weakly associated with online risks: there are only a few relations to some of the digital skill dimensions. Similarly, the relation between digital skills and wellbeing is weak.

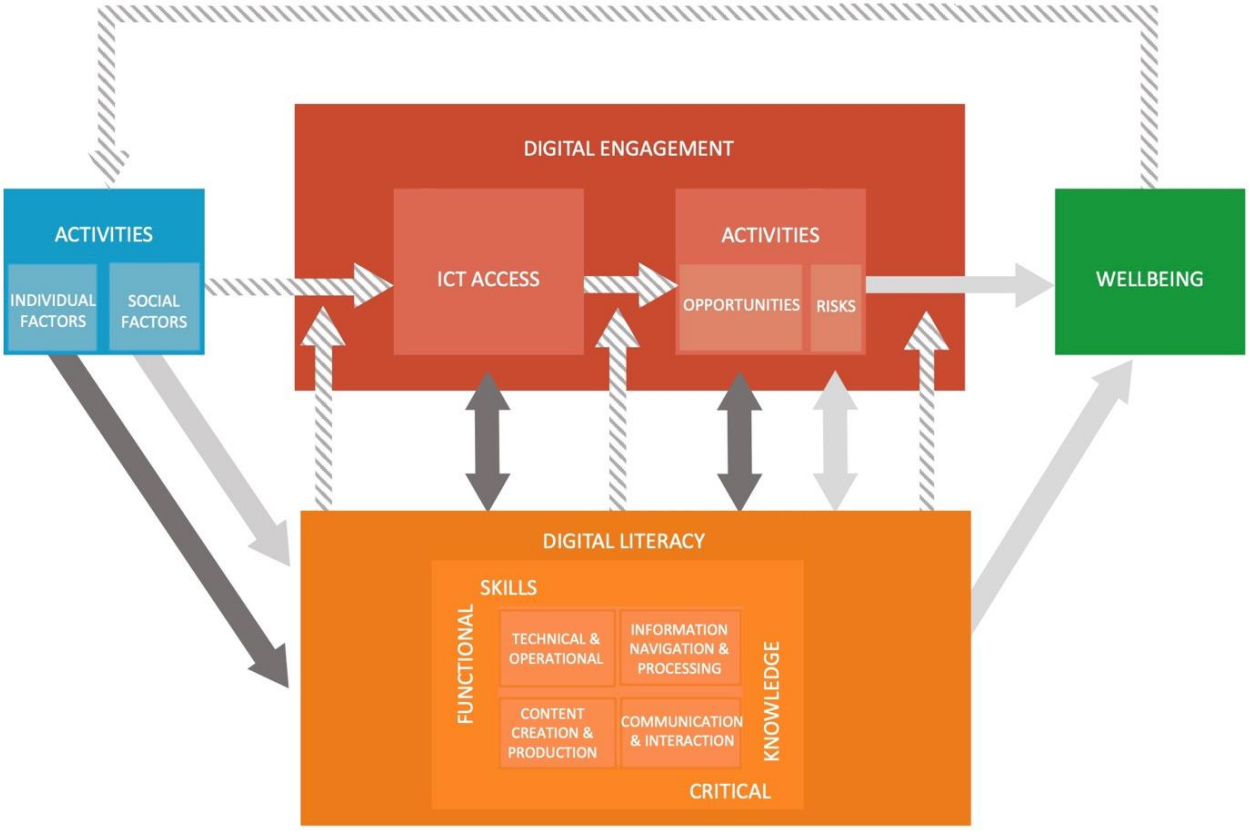


Figure 5: New theoretical model that displays relations of digital skills to other concepts.

8.2 New ySKILLS model: Comparison to previous theoretical models

The ySKILLS model builds on digital inequalities research, such as that of the **From Digital Skills to Tangible Outcomes** project (**DiSTO**), which looks at the links between digital and socio-economic and socio-cultural inequalities (Helsper, 2021; Scheerder, van Deursen & van Dijk, 2017; van Dijk, 2020). The theoretical models underpinning this work distinguish between 1st (access), 2nd (use and skills) and 3rd (outcomes of digitisation) levels of digital inclusion and examines how these differ between those that have historically been disadvantaged and those who have occupied more privileged positions in society. ySKILLS has adapted the classification of the four domains of digital literacy from this research (van Deursen, Helsper & Eynon, 2016; van Laar et al, 2017). ySKILLS has made significant progress by refining the conceptualisations of digital skills independently from attitudes, self-efficacy, uses, and outcomes in a manner that distinguishes it from other research, such as the DigComp framework. It refined the existing conceptualisations in this field by emphasising the need to distinguish functional skills and critical knowledge and the importance of both in shaping digital opportunities of different groups. This conceptualisation was supported by the empirical work (surveys and performance tests) validating these theorisations and hypothesised subdimensions. However, digital inequalities research has largely focused on adults and conceptualisations of wellbeing and of skills and literacy have often focused on employment and economic opportunities rather than areas more relevant to young people's everyday lives. Studies that link historical inequalities to digital inequalities amongst young people are often focused on more instrumental skills and outcomes of digital engagement such as learning opportunities and outcomes (see Vosloo & Helsper, 2023). ySKILLS has developed a more universally applicable model that allows for understanding digital literacy as well as its relationship to a variety of inequalities amongst young people. In this it is important that ySKILLS defines inequalities not only along the lines of the more common socio-demographic factors but also includes social and psychological vulnerabilities and exclusions.

The development of the ySKILLS model was also impacted by the **DSMM model** which helps to understanding of the media effects (Valkenburg & Peter, 2013). The DSMM differentiated three types of types of susceptibility to media effects: dispositional, developmental, and social susceptibility. In the ySKILLS model, we distinguish more simply antecedents as individual and social factors. The ySKILLS model also displays more details about the digital engagement (differentiating ICT access, online risks and opportunities). However, the most important advantage to the DSMM model is that the ySKILLS model proposes digital literacy in a central position of the model. Furthermore, it shows that digital literacy can have consequences for digital engagement, for wellbeing and can also become moderator between central concepts of the model. We can say that the ySKILLS model is not covering broadly media effects as DSMM, but is rather focused on the understanding to the role of digital skills and digital engagement on children's wellbeing. The ySKILLS model was also inspired by the **iMEW model** (Smahel et al., 2020) which also differentiated more types of wellbeing as the output and proposed possible long-term and short-term effects. In comparison to iMEW model, the ySKILLS model helps much more to understand the role of digital skills in the process of media effects.

One of the key commitments of **EU Kids Online** research has been to integrate the assessment of digital skills and literacy into a broader analysis of both online opportunities and risks, rather than treating these topics as separate entities. The research recognises the importance of understanding the interdependencies among access, skills, opportunities, risks, and wellbeing. This holistic approach is vital for society to effectively intervene in teaching digital skills in ways that help maximise opportunities and minimise risks. Only with such a holistic approach

can children's rights and wellbeing be supported. Inevitably, a holistic approach is complex, for multiple factors interact with each other, and they do so across several time scales (immediate, short term, and long term - even, over a lifetime; Bronfenbrenner, 2005). Since digital skills are both the consequence of digital access and activities and the antecedent of wellbeing outcomes in a digital world, untangling their importance is challenging, as ySKILLS results attest. In the EU Kids Online model (Livingstone et al., 2018), digital skills are characterised as entwined with digital practices - for example, it was held that if a child uses social media privacy settings, that implies they also know how to use them. ySKILLS has made some progress in distinguishing knowledge from practice (through use of both survey and performance measures), recognising that use may not always imply knowledge, and nor does knowledge determine use. Hence Figure 3 (above) represents a conceptual advance that opens up new research questions and insights. Further, the EU Kids Online survey has included measures relating to the different dimensions of digital skills but it has not analysed how each dimension contributes distinctively to the outcomes of digital engagement in the way that ySKILLS has. Nonetheless, some big challenges remain. Livingstone et al. (2018, p.11) argue that "the research agenda no longer concerns children's relationship with the internet as a medium but, more profoundly, it concerns their relationship with the world as mediated by the internet." To advance this, researchers and other stakeholders should specify more clearly the desired and possible outcomes of living in a digital world, thereby expanding the range of future research questions.

9 Conclusions

There is a substantial body of literature and ongoing scholarly debate concerning the definition of digital skills. This debate is accompanied by discussions on the most effective methods for assessing who is more likely to possess digital literacy and what potential consequences may arise from a lack of digital literacy.

ySKILLS' modelling and testing of a model based on a thorough review of the literature led to the **conceptualisation of digital literacy** in four domains: Technical & Operational, Information Navigation & Processing, Communication & Interaction, and Content Creation & Production. An important contribution of ySKILLS has been the validation of this conceptualisation through extensive qualitative (cognitive interviews), internal (measurement equivalence and distinctiveness testing) and external (relation to known factors) validity testing. A significant development has been the distinction between skills and knowledge elements (and associated validated tools to measure these) of digital literacy. The youth Digital Skills Indicator (yDSI) survey instrument, one of the main outputs of the ySKILLS project, includes answer scales validated in different languages that allow for minimal impact of common issues in survey research using self-report measures, such as social desirability or confirmation bias. The ySKILLS performance tests designed around real life tasks are the first of their kind in being based on a thorough theoretically based conceptualisation of digital literacy. This means the ySKILLS project provides tools to do large-scale population research (i.e., the yDSI) as well as in class performance testing which can be adapted to and discussed in classroom and formal educational settings to further understanding of and educational practices around digital skills distribution and training.

The development of the yDSI and performance tests marks a significant milestone in the field, as these instruments were created for the first time using a comprehensive theoretical framework that encompasses a wide spectrum of digital skills and knowledge. What makes this achievement even more remarkable is that it was specifically designed for and validated with young people. This pioneering effort is further enhanced by its integration into the only longitudinal study capable of establishing connections between digital literacy and not only its precursors but also its causal outcomes.

The ySKILLS research has provided valuable insights regarding the differentiation between individual and social factors as antecedents of digital literacy (D2.1). We found that the majority of individual factors tend to have stronger relationships with various dimensions of digital skills compared to social factors (D5.2). However, this pattern is not universal, as some individual factors, like personality characteristics, may have lower or no significant relationship with digital literacy (as seen in D2.1). One of the innovative aspects of ySKILLS lies in its ability to differentiate between and within-subject levels within a longitudinal research design. Interestingly, we observed only a limited number of within-subject effects of social factor variables on dimensions of digital literacy. This implies that a positive change in social factors, such as an increase in family or peer support, does not necessarily lead to an automatic increase in children's digital literacy. Instead, it appears that children from specific social environments tend to have better digital literacy. For example, children with strong family and peer support tend to exhibit higher communication and interaction skills, while children from families with higher socioeconomic status tend to have superior information navigation and processing skills. At the within-subject level, we found that an increase in daily online activities had a positive effect on higher information navigation/processing skills and higher communication/interaction

skills. This suggests that children may develop digital literacy by engaging in a wide variety of online activities, indicating the importance of hands-on experience in building digital skills.

The ySKILLS research has reaffirmed previous findings that digital literacy is indeed connected to **digital engagement and online learning** (D2.1, D5.2). However, it has also brought new insights by demonstrating that different dimensions of digital skills may be linked differently to various online activities. Notably, communication and interaction skills were found to have a positive impact on the increase in daily online activities, both at the between-subject and within-subject levels. This effect was unique, as no other dimension of digital skills showed a within-subject effect. Furthermore, the research shed light on the specific role of programming skills, which had a negative effect on communication among friends. This intriguing finding suggests the need for further investigation. In contrast, the ySKILLS longitudinal research revealed that the relationships between digital skills dimensions and online risks are relatively weak (D5.2). Most of the within-subject effects of digital skills dimensions on online risks were not significant, except for content creation and production skills, which had an effect on the increase in exposure to harmful content. Additionally, content creation and production skills were associated with exposure to cyberhate and sexual content at the between-subject level. Further research is needed to understand the reasons behind these relationships. Moreover, the research showed that the connection between digital skills and wellbeing is also relatively weak (D5.2). However, it added a new dimension by demonstrating that communication and interaction skills have a positive effect on school performance. This finding carries important implications for policy-making in the context of education.

The **qualitative research** conducted in WP6 complements, integrates, and enriches the results of the longitudinal survey and systematic evidence review in several significant ways. It highlights that even in societies where almost all children and young people have access to the internet, there are persistent areas of compounded vulnerabilities. These vulnerabilities alter both the direct and indirect effects of digital skills on digital engagement, experiences of online risks, and overall wellbeing. In essence, the qualitative findings suggest that digital skills alone may not be sufficient to protect vulnerable children and young people from the adverse consequences of online risks on their wellbeing. This is due to the challenging life circumstances they often face, such as limited access to formal and informal educational opportunities, lack of family or peer support, difficult mental health conditions, and dispersed family networks, among others. These factors can accumulate and compound the risks they encounter online. Moreover, the nature of digital media, driven by data-driven business logic, algorithmic selection and recommendations, and the toxic popularity dynamics influenced by algorithmic visibility structures, also plays a significant role in shaping their online experiences. The qualitative findings advocate for a more expansive and nuanced definition of digital skills. Such skills should be viewed in conjunction with the specific life circumstances and socio-material contexts in which individuals find themselves. Additionally, digital skills should be seen as interconnected with personal, emotional, and social skills.

Based on the findings from the ySKILLS research, we are introducing **a new theoretical model** (Figure 4), where digital literacy takes on a central role among various other concepts. In this model, digital literacy is recognised as a multidimensional construct, encompassing technical and operational literacy, information navigation and processing literacy, communication and interaction literacy, as well as content creation and production literacy. The model also incorporates individual and social factors, digital engagement variables, and different dimensions of wellbeing, including psychological, social, physical, and cognitive aspects. Furthermore, the model suggests that digital literacy can serve as a moderator in relationships

between other concepts, such as between individual/social factors and digital engagement, between ICT access and online activities, and between digital engagement and wellbeing. We strongly recommend further research to explore and better understand the moderating role of digital skills within these relationships. This expanded framework provides a valuable foundation for future investigations and policy considerations.

In the ySKILLS model, improving children's wellbeing is the main desired outcome. This in itself is ambitious, and yet it may not be ambitious enough. Lundy (2020) **distinguishes wellbeing from children's rights**, observing that it is possible to optimise one without optimising the other. Specifically, improving children's wellbeing may not also promote their civil rights and freedoms in a digital world. Moreover, efforts to promote such freedoms can put children at risk, leading some policymakers to seek to limit children's freedoms to ensure their safety. In the language of child rights, the task is to find a way to make children's best interests - a holistic judgement that considers all their rights - a priority. In D7.5 (Livingstone, Stoilova, Rahali, 2023), we examine the array of ySKILLS findings to answer the question: does gaining digital skills help realise children's rights in a digital age? The answer is a qualified 'yes' but it also evidences how rights and wellbeing should be distinguished both empirically and conceptually, and how each calls upon a different though overlapping set of stakeholders to take action to improve children's outcomes. It may also be suggested that **wellbeing is but one component of children's rights** - this is the position taken by Child Rights by Design (Livingstone & Pothong, 2023), where wellbeing is recognised as an important policy goal along with children's rights to privacy, safety, agency, development and others. Yet another position is to argue that implementing children's rights is a goal agreed upon internationally, through the near-universal ratification of the UN Convention on the Rights of the Child (1989). Since society is far from realising children's legal rights, adding the expectation of ensuring their wellbeing may seem an even more idealistic prospect. Nonetheless, insofar as rights and wellbeing express the best outcomes that can be hoped for, they serve as valuable goals for researchers (as well as policymakers). ySKILLS research has shown that digital skills can play a genuine role in contributing to these outcomes.

The ySKILLS research has demonstrated that digital literacy can play a significant role in promoting positive outcomes for youth, particularly in terms of their overall wellbeing. This presents a clear challenge for **policymakers, educators, and even industry stakeholders**. Each of these groups has the capacity to take actions that will enhance digital literacy and facilitate the transition from digital literacy to improved wellbeing. The ySKILLS research complicates this pathway by highlighting the diverse dimensions of digital literacy, addressing both potential negative (risky) outcomes as well as clear benefits, and recognising the various sources of inequality and exclusion that can impact young people. Nevertheless, it also underscores the imperative of actively pursuing this goal. When striving to enhance the outcomes of children and young individuals in a digital world, it is crucial not to underestimate or overemphasise the significance of promoting their digital literacy (D7.3). The wealth of insights and theories generated by ySKILLS offers numerous opportunities for future policy and practice. It encourages us to explore multiple avenues to improve the experiences and prospects of young people in the digital age.

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