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Measuring Digital Skills across the EU: Digital Skills Indicator 2.0

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Contents

Abstract

This short technical report presents the updated methodology for the measurement of digital skills using the Digital Skills Indicator (DSI). The DSI was first piloted in 2014 and today, it is used to monitor the ambitious policy target of reaching a minimum of 80% of the EU population with at least basic digital skills by 2030.

The report presents the updated Digital Skills Indicator (DSI 2.0). It first describes the Digital Competence Framework, which is used as an underlying theoretical framework, and then present results of the empirical validation of the DSI 2.0. The analysis confirms the high overall psychometric quality of the items that comprise DSI 2.0. The analysis also provides an empirical validation of DSI's underpinning conceptual framework, DigComp 2.0. Results generally support the robustness of cross-country comparisons on the indicator.

The revised indicator is the result of work carried out in 2019-2022 within Eurostat's Information Society Statistics Working Group in order to modernise the indicator by adapting it to the revised conceptual framework (DigComp 2.0) as well as to keep it up with technological progress since the first version was published in 2015. The DSI is used for the purpose of the Digital Economy and Society Index (DESI). DESI is an annual report published by the European Commission that monitors the progress of EU Member States on their digital development.

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1   Introduction

The importance of digital competence was already recognised by the European Parliament and the European Council in 2006 in its recommendation on Key Competences for Lifelong Learning[1] when it identified digital competence as one of eight key competences essential for all individuals in a knowledge-based society. The update in 2018[2] defines digital competence as follows:

> *"Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking." (Council Recommendation on Key Competences for Lifelong Learning, 22 May 2018, ST 9009 2018 INIT).*

Recognising the crucial role of digital competence in today's society, in the Digital Compass for Europe's digital decade, the EU has set the ambitious policy targets of reaching a minimum of 80% of the population with basic digital skills by 2030. For the purposes of cross-country monitoring of digital skills, an EU-wide indicator on digital skills is used. The indicator is called the Digital Skills Indicator (DSI). This report presents details of the DSI 2.0 update and outlines its background based on previous Methodological notes [1, 2].

The DSI was first introduced by the European Commission's 2010 Digital Agenda for Europe which proposed "EU-wide indicators of digital competence and media literacy" (action 62). Following a pilot in 2014, DG CNECT and the Eurostat Information Society Statistics Working Group agreed to create and publish a "Digital Skills Indicator" based on the Digital Competence Framework for Citizens [3], and to be populated with data collected through the EU survey on the use of ICT by Households and Individuals[3]. This methodology was applied fully for the first time using the 2015 survey results. From 2021 onwards, the DSI is planned to be released bi-annually. The figures of the overall indicator are used by the Commission as part of the Digital Economy and Society Index (DESI[4]).

1.1   Purpose, methodology and scope of this report

The current report presents an update of the Digital Skills Indicator (DSI 2.0). The revised indicator is the result of work carried out in 2019-2022 within Eurostat's Information Society Statistics Working Group and follows the methodology laid out by the OECD/JRC Handbook on constructing composite indicators [4]. The aim was to modernise the indicator by adapting it to DigComp 2.0 [5] as well as to keep it up with technological progress since the first version was published in 2015. The report first describes the Digital Competence Framework (DigComp 2.0), which is used as an underlying theoretical framework, and then present results of the empirical validation of the updated Digital Skills Indicator (DSI 2.0).

1.2   Structure of the report

The report is structured along the following lines. Following the introduction and background, section 2 provides a more detailed definition of digital competence and the DigComp framework. Section 3 presents the application of the DigComp framework for cross-country EU-wide monitoring of digital skills also providing an overview of the empirical validation. Conclusions are given in Section 4.

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[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:394:0010:0018:en:PDF
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&rid=7
[3] https://ec.europa.eu/eurostat/cache/metadata/en/isoc_i_esms.htm
[4] https://digital-strategy.ec.europa.eu/en/policies/desi

2 What is digital competence?

In 2006 the European Parliament and the European Council published a recommendation on key competences for lifelong learning[5]. The recommendation provided a European Reference Framework on Key competences for Lifelong learning in which eight key competences[6] were identified and defined. The Reference Framework had grown out of the need recognised and expressed at previous European Councils[7] for a European framework to define the basic skills to be provided through lifelong learning as a key measure in Europe's response to globalisation and the shift to a knowledge-based society.

Key competences are defined as those which all individuals need for personal fulfilment and development, active citizenship, social inclusion and employment. Furthermore, *competences* are defined as *a combination of knowledge, skills and attitudes appropriate to the context*. For digital competence, essential knowledge, skills and attitudes are described in the 2018 update the following way [6]:

> *"Individuals should understand how digital technologies can support communication, creativity and innovation, and be aware of their opportunities, limitations, effects and risks. They should understand the general principles, mechanisms and logic underlying evolving digital technologies and know the basic function and use of different devices, software, and networks. Individuals should take a critical approach to the validity, reliability and impact of information and data made available by digital means and be aware of the legal and ethical principles involved in engaging with digital technologies.*

> *Individuals should be able to use digital technologies to support their active citizenship and social inclusion, collaboration with others, and creativity towards personal, social or commercial goals. Skills include the ability to use, access, filter, evaluate, create, program and share digital content. Individuals should be able to manage and protect information, content, data, and digital identities, as well as recognise and effectively engage with software, devices, artificial intelligence or robots.*

> *Engagement with digital technologies and content requires a reflective and critical, yet curious, open-minded and forward-looking attitude to their evolution. It also requires an ethical, safe and responsible approach to the use of these tools.*

From the above, it can be appreciated that digital competence is a broad concept, including much more than basic/operational skills in the use of digital technologies – though these are fundamental to it.

2.1 The DigComp Framework

The work on operationalising digital competence following the Council Recommendation resulted in the publication of the first Digital Competence Framework for Citizens, also known by its acronym DigComp, in 2013. It defined digital competence as a combination of 21 competences grouped in five main areas [3]. The DigComp framework was developed by the Joint Research Centre on behalf of the Directorate General (DG) for Education and Culture; and DG Employment, Social Affairs and Inclusion European Commission.

Reference frameworks such as the DigComp framework create an agreed vision of what is needed in terms of competences to overcome the challenges that arise from digitisation in almost all aspects of modern lives. Their aim is to create a common understanding using an agreed vocabulary which can then be consistently applied in all tasks from policy formulation and target setting to instructional planning, assessment and monitoring.

Table 1 provides an overview of the conceptual reference model of the DigComp 2.0 framework [5]. The model outlines 21 competence descriptors in five areas (Information and data literacy; Communication and collaboration; Digital content creation; Safety; and Problem solving). Further methodological details are described in DigComp 2.2: Annex 1 [7].

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[5] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:394:0010:0018:en:PDF

[6] Literacy competence, Multilingual competence, Mathematical competence and competence in science, technology and engineering, Digital competence, Personal, social and learning to learn competence, Citizenship competence, Entrepreneurship competence, Cultural awareness and expression competence.

[7] Starting with the Lisbon European Council (23-24 March 2000)

Table 1. The DigComp 2.0 conceptual reference model [5].

Competence areas Dimension 1	Competences Dimension 2
1. Information and data	**1.1 Browsing, searching and filtering data, information and digital content** To articulate information needs, to search for data, information and content in digital environments, to access them and to navigate between them. To create and update personal search strategies. **1.2 Evaluating data, information and digital content** To analyse, compare and critically evaluate the credibility and reliability of sources of data, information and digital content. To analyse, interpret and critically evaluate the data, information and digital content. **1.3 Managing data, information and digital content** To organise, store and retrieve data, information and content in digital environments. To organise and process them in a structured environment.
2. Communication and collaboration	**2.1 Interacting through digital technologies** To interact through a variety of digital technologies and to understand appropriate digital communication means for a given context. **2.2 Sharing through digital technologies** To share data, information and digital content with others through appropriate digital technologies. To act as an intermediary, to know about referencing and attribution practices. **2.3 Engaging in citizenship through digital technologies** To participate in society through the use of public and private digital services. To seek opportunities for self-empowerment and for participatory citizenship through appropriate digital technologies. **2.4 Collaborating through digital technologies** To use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge. **2.5 Netiquette** To be aware of behavioural norms and know-how while using digital technologies and interacting in digital environments. To adapt communication modes and strategies to the specific audience, to be aware of cultural and generational diversity in digital environments. **2.6 Managing digital identity** To create and manage one or multiple digital identities, to be able to protect one's own reputation, to deal with the data that one produces through several digital tools, environments and services.

Table 1 (continued). The DigComp 2.0 conceptual reference model [5].

3. Digital content creation	**3.1 Developing digital content** To create and edit digital content in different formats, to express oneself through digital means. **3.2 Integrating and re-elaborating digital content** To modify, refine, improve and integrate information and content into an existing body of knowledge to create new, original and relevant content and knowledge. **3.3 Copyright and licences** To understand how copyright and licences apply to information and digital content. **3.4 Programming** To plan and develop a sequence of understandable instructions for a computing system to solve a given problem or perform a specific task.
4. Safety	**4.1 Protecting devices** To protect devices and digital content, and to understand risks and threats in digital environments. To know about safety and security measures and to have due regard to reliability and privacy. **4.2 Protecting personal data and privacy** To protect personal data and privacy in digital environments. To understand how to use and share personally identifiable information while being able to protect oneself and others from damages. To understand that digital services use a "Privacy policy" on how personal data is used. **4.3 Protecting health and well-being** To be able to avoid health-risks and threats to physical and psychological well-being while using digital technologies. To be able to protect oneself and others from possible dangers in digital environments (e.g. cyber bullying). To be aware of digital technologies for social well-being and inclusion. **4.4 Protecting the environment** To be aware of the environmental impact of digital technologies and their use.
5. Problem solving	**5.1 Solving technical problems** To identify technical problems when operating devices and using digital environments, and to solve them (from trouble-shooting to solving more complex problems). **5.2 Identifying needs and technological responses** To assess needs and to identify, evaluate, select and use digital tools and possible technological responses to solve them. To adjust and customise digital environments to personal needs (e.g. accessibility). **5.3 Creatively using digital technologies** To use digital tools and technologies to create knowledge and to innovate processes and products. To engage individually and collectively in cognitive processing to understand and resolve conceptual problems and problem situations in digital environments. **5.4 Identifying digital competence gaps** To understand where one's own digital competence needs to be improved or updated. To be able to support others with their digital competence development. To seek opportunities for self-development and to keep up-to-date with the digital evolution.

3 Updating the EU-wide indicator on digital skills

The DigComp framework has been developed for the purpose of describing in detail the competences that individuals need to be digitally competent. It can be used to guide the formulation of a limited set of cross-country statistical indicators.

For the purpose of the Digital Skills Indicator, the focus is on *activities that individuals carry out using digital technologies*. It is assumed that individuals having performed certain activities have the corresponding skills. In other words, from the DigComp framework's point of view, the Digital Skills Indicator mainly reflects the focus on skills (the ability and capacity to carry out processes to complete tasks and solve problem), not on the components of knowledge or attitudes. For this purpose, the EU Survey on the use of ICT in Households and by Individuals is a suitable source of variables as, over many years, it has developed a broad set of questions on activities carried out on the internet in the last 3 or 12 months. It covers a representative sample of the EU population between the ages of 16 and 74 (see Annex).

As breakdowns of the survey results can be obtained for different socio-economic groups, it is possible to look not only at the digital competence of society as a whole, but also at various segments such as the employed and the unemployed, for example to examine the situation on the labour market [8]. Additionally, a variety of other socio-economic factors (e.g. age, education level, income level, gender) are available to look at digital skills of groups such as the socially- disadvantaged. The selected activities related to internet or software use that individuals aged 16-74 perform are presented below, the criteria for computing the overall indicator is presented in 3.2.

3.1 Activities measured as proxies for digital skills

The selected activities are divided in five areas of DigComp 2.0, they are the following: Information and data literacy, Communication and collaboration, Digital content creation, Safety and Problem solving [5]. The new area in DSI 2.0 is Safety. Below, the activities are listed under the component areas:

- The first codes (e.g. i1, i2) are as they appear in the database used for computations and how they are referenced in Section 3.3;
- Eurostat variable names are indicated at the end (e.g. IUIF, IHIF);
- The new items added to DSI 2.0 are indicated with an asterisk*.

Activities are collected, for example, from the "Use of the internet" module where the question was formulated as the following: "*For which of the following activities did you use the internet (including via apps) in the last 3 months for private purpose? (tick all that apply)*". Answers were given as a binary yes/no.

3.1.1 Information and data literacy

Definition in the Digital Competence Framework 2.0: *To articulate information needs, to locate and retrieve digital data, information and content. To judge the relevance of the source and its content. To store, manage, organize digital data, information and content.*

Activities used for calculating the information and data literacy skills:

- i1: Finding information about goods or services (IUIF);
- i2: Seeking health-related information (IHIF);
- i3: Reading online news sites, newspapers or news magazines (IUNW1)*;
- i4: Activities related to fact-checking online information and its sources (TICCSFOI, TICIDIS, TICNIDIS, TICXND)*.

Levels of information skills:

- Basic: one activity (I_DSK2_IL_B);
- Above basic: more than one activity (I_DSK2_IL_AB);
- At least basic: basic or above basic skills (I_DSK2_IL_BAB).

3.1.2 Communication and collaboration

Definition in the Digital Competence Framework 2.0: *To interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity. To participate in society through public and private digital services and participatory citizenship. To manage one's digital identity and reputation.*

Activities used for calculating the communication and collaboration skills:

- c1: Sending/receiving emails (IUEM);
- c2: Telephoning/video calls over the internet (IUPH1);
- c3: Instant messaging (IUCHAT1)*;
- c4: Participating in social networks (IUSNET);
- c5: Expressing opinions on civic or political issues on websites or in social media (IUPOL2)*;
- c6: Taking part in online consultations or voting to define civic or political issues (IUVOTE)*.

Levels of communication and collaboration skills:

- Basic: one activity (I_DSK2_CC_B);
- Above basic: more than one activity (I_DSK2_CC_AB);
- At least basic: basic or above basic skills (I_DSK2_CC_BAB).

3.1.3 Digital content creation

Definition in the Digital Competence Framework 2.0: *To create and edit digital content. To improve and integrate information and content into an existing body of knowledge while understanding how copyright and licences are to be applied. To know how to give understandable instructions for a computer system.*

Activities used for calculating the digital content creation skills:

- d1: Using word processing software (CWRD1);
- d2: Using spreadsheet software (CXLS1);
- d3: Editing photos, video or audio files (CEPVA1);
- d4: Copying or moving files (such as documents, data, images, video) between folders, devices (via e-mail, instant messaging, USB, cable) or on the cloud (CXFER1)*;
- d5: Creating files (such as documents, image, videos) incorporating several elements such as text, picture, table, chart, animation or sound (CPRES2);
- d6: Using advanced features of spreadsheet software (functions, formulas, macros and other developer functions) to organize, analyse, structure or modify data (CXLSADV1);
- d7: Writing code in a programming language (CPRG2).

Levels of digital content creation skills:

- Basic: one or two activities (I_DSK2_DCC_B);
- Above basic: 3 or more activities (I_DSK2_DCC_AB);
- At least basic: basic or above basic skills (I_DSK2_DCC_BAB).

3.1.4 Safety

Definition in the Digital Competence Framework 2.0: *To protect devices, content, personal data and privacy in digital environments. To protect physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.*

Activities used for calculating the safety:

- s1: Managing access to own personal data by checking that the website where the respondent provided personal data was secure (MAPS_CWSC)*;

- s2: Managing access to own personal data by reading privacy statements before providing personal data (MAPS_RPS)*;

- s3: Managing access to own personal data by restricting or refusing access to own geographical location (MAPS_RRGL)*;

- s4: Managing access to own personal data by limiting access to profile or content on social networking sites or shared online storage (MAPS_LAP)*;

- s5: Managing access to own personal data by refusing allowing use of personal data for advertising purposes (MAPS_RAAD)*;

- s6: Changing settings in own internet browser to prevent or limit cookies on any of the respondent devices (PCOOK1)*.

Levels of digital content creation skills:

- Basic: one or two activities (I_DSK2_SF_B);

- Above basic: 3 or more activities (I_DSK2_SF_AB);

- At least basic: basic or above basic skills (I_DSK2_SF_BAB).

3.1.5 Problem solving

Definition in the Digital Competence Framework 2.0: *To identify needs and problems, and to resolve conceptual problems and problem situations in digital environments. To use digital tools to innovate processes and products. To keep up-to-date with the digital evolution.*

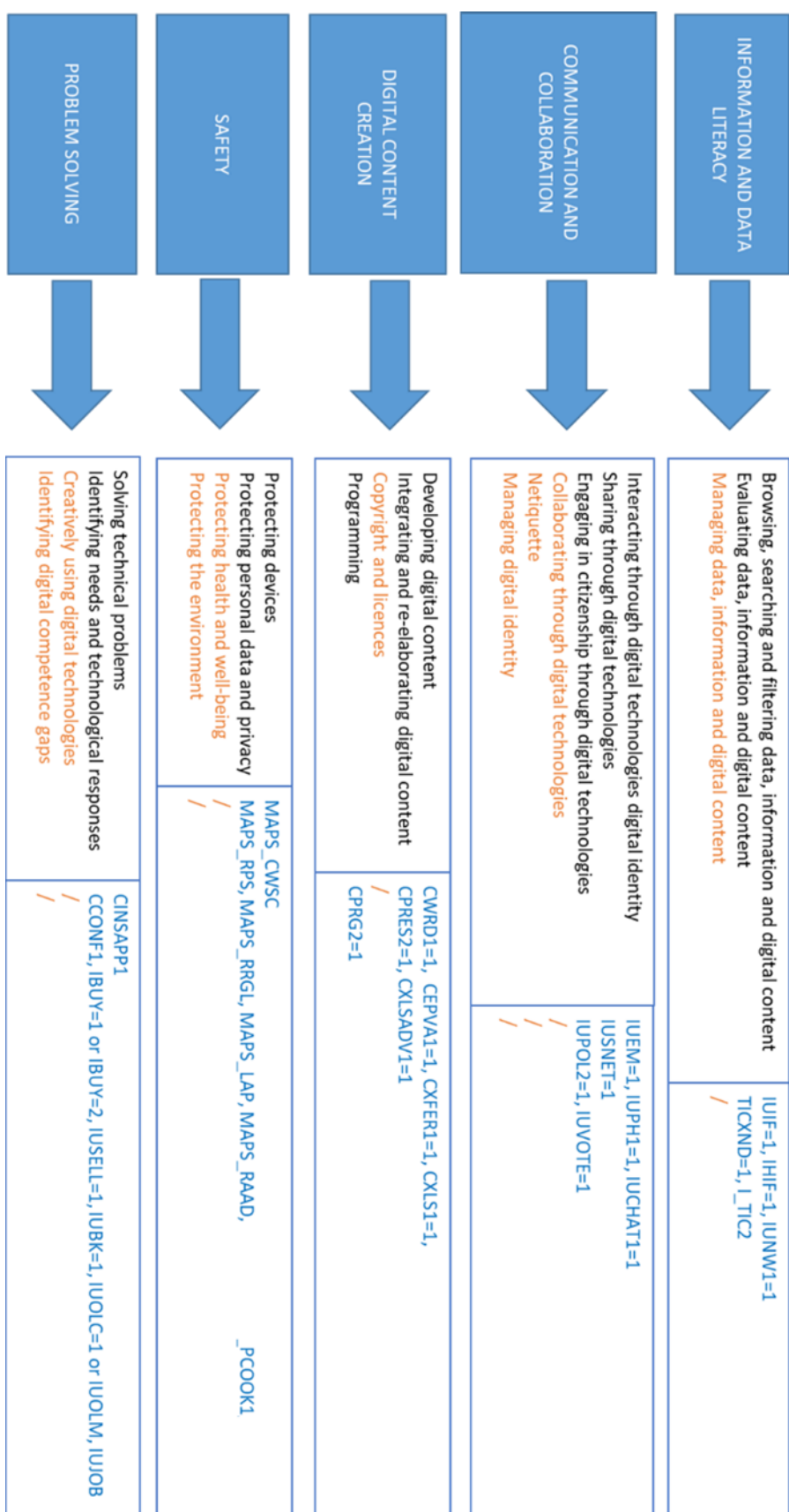Activities used for calculating the problem solving skills:

- p1: Downloading or installing software or apps (CINSAPP1);

- p2: Changing settings of software, app or device (CCONF1);

- p3: Online purchases (in the last 12 months) (IBUY=1 or IBUY=2);

- p4: Selling online (IUSELL);

- p5: Used online learning resources (IUOLC or IUOLM);

- p6: Internet banking (IUBK);

- p7: Looking for a job or sending a job application (IUJOB)*.

Levels of problem solving skills:

- Basic: one or two activities (I_DSK2_PS_B);

- Above basic: 3 or more activities (I_DSK2_PS_AB);

- At least basic: basic or above basic skills (I_DSK2_PS_BAB).

Table 2 shows the mapping between the DigComp 2.0 conceptual model [5] and the Eurostat variables collected from the survey on the use of ICT in households and by individuals. It links each DigComp 2.0 competence to the corresponding variable(s), the latter are indicated using blue colour. Thanks to the current update, the DSI 2.0 now covers 12 out of 21 DigComp competences. The new competences added are: Evaluating data, information and content; Engaging in citizenship through digital technologies; Protecting devices; and Protecting personal data and privacy. The competences that are currently not covered by the composite indicator are marked in orange. The DigComp 2.0 framework will continue to guide further work of the Task Force on the survey on the use of ICT in households and by individuals. It will be an ongoing process to bring more DigComp competences, which are currently not covered, into future iterations of the DSI.

Table 2. The DigComp 2.0 conceptual model mapped to the Eurostat variables. The competences depicted in orange are not considered for DSI 2.0.

Category	Competence	Eurostat variables
INFORMATION AND DATA LITERACY	Browsing, searching and filtering data, information and digital content	IUIF=1, IHIF=1, IUNW1=1 / TICXND=1, I_TIC2
	Evaluating data, information and digital content	
	Managing data, information and digital content	/
COMMUNICATION AND COLLABORATION	Interacting through digital technologies digital identity	IUEM=1, IUPH1=1, IUCHAT1=1
	Sharing through digital technologies	IUSNET=1
	Engaging in citizenship through digital technologies	IUPOL2=1, IUVOTE=1
	Collaborating through digital technologies	/
	Netiquette	/
	Managing digital identity	/
DIGITAL CONTENT CREATION	Developing digital content	CWRD1=1, CEPVA1=1, CXFER1=1, CXLS1=1,
	Integrating and re-elaborating digital content	CPRES2=1, CXLSADV1=1
	Copyright and licences	/
	Programming	CPRG2=1
SAFETY	Protecting devices	MAPS_CWSC, MAPS_RPS, MAPS_RRGL, MAPS_LAP, MAPS_RAAD, _PCOOK1
	Protecting personal data and privacy	CINSAPP1, CCONF1, IBUY=1 or IBUY=2, IUSELL=1, IUBK=1, IUOLC=1 or IUOLM, IUJOB
	Protecting health and well-being	/
	Protecting the environment	/
PROBLEM SOLVING	Solving technical problems	
	Identifying needs and technological responses	
	Creatively using digital technologies	/
	Identifying digital competence gaps	/

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3.2   Overall Digital Skill Indicator

According to the variety of activities performed, two levels of skills are computed for each of the five areas ("basic" and "above basic"). Then, based on the component indicators for each area, an overall digital skills indicator is calculated as a proxy of the digital skills of individuals ("basic", "above basic" or "at least basic skills").

It is important to note that the DSI takes a criterion-referenced approach meaning that at least 1 activity is needed across all five component areas rather than a simple sum of 'yes' responses. This is designed for the purpose to inform targeted policy-making and initiatives. Additionally, in DSI 2.0, when skills are below the base criterion, the following indications are given ("low", "narrow", "limited", "no skills")[8].

Individuals with "above basic" (I_DSK2_AB) level of skills:

- "above basic" in all 5 areas.

Individuals with a "basic" (I_DSK2_B) level of skills:

- if all 5 areas are at least basic level (some can be "basic" and some can be "above basic", but not all 5 areas are "above basic").

Individuals with at least basic level (I_DSK2_BAB) of skills:

- if individuals fall either into "above basic" or "basic" category of skills.

Individuals with "low" (I_DSK2_LW) level of skills:

- if individuals have "basic" or "above basic" level in 4 areas and "no skills" in 1 area (4 out of 5).

Individuals with "narrow" (I_DSK2_N) level of skills:

- if individuals have "basic" or "above basic" level in 3 areas and "no skills" in 2 areas (3 out of 5).

Individuals with "limited" (I_DSK2_LM) level of skills:

- if individuals have "basic" or "above basic" level in 2 areas and "no skills" in 3 areas (2 out of 5).

Individuals with "no skills" (I_DSK2_X):

- if individuals have "no skills" in 4 areas or "no skills" in all 5 areas despite declaring having used the internet at least once during last 3 months.

Individuals for whom the digital skills could not be assessed (I_DSK2_NA):

- individuals that have not used the internet in the last 3 months.

For formula (Annex 2) and references to original variables collected by the survey on the use of ICT in households and by individuals, please see Eurostat Methodological Manual[9]. Eurostat also provides an online interface where aggregated data is available for anyone to access it[10].

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[8] https://ec.europa.eu/eurostat/cache/metadata/en/isoc_sk_dskl_i21_esmsip2.htm
[9] https://ec.europa.eu/eurostat/web/digital-economy-and-society/methodology
[10]https://ec.europa.eu/eurostat/databrowser/view/ISOC_SK_DSKL_I21/default/table?lang=en&category=isoc.isoc_sk.isoc_sku

3.3 Empirical validation

A number of analyses were conducted to assess the overall psychometric quality and measurement invariance of the updated Digital Skills Indicator (DSI 2.0). Analyses were conducted in three steps, the first two of which are shortly summarised in this report. The third step was conducted in order to provide strategic direction to future work in this area.

- Step 1: Analysis of general psychometric quality of the item set

- Step 2: Construct validation via analysis of the factor structure of the item set

- Step 3: Further in-depth analysis to suggest or guide future refinements to the item set.

Overall, the scale reliabilities are good, indicating highly reliable measurement tool (Cronbach's alpha and EAP based reliability 0.90; McDonald's omega 0.91 (Step 1), see Table 3.

The DSI 2.0 overall scale and subscales show strong measurement properties, both for the pooled international (EU) sample and the individual countries, demonstrating configural measurement invariance (i.e. whether the same items measure each latent variable across groups). The overall construct of digital competence is confirmed by a dimensionality analysis, which also confirms the five sub-scales (see Table 4). In other words, the analysis showed that overall the measurement tool (DSI 2.0) is a good representation of theorized concept (i.e. the DigComp framework) (Step 2).

3.3.1 Analysis of general psychometric quality of the item set

The items of the full scale were analysed for their psychometric properties of the total index based on all items. The psychometric characteristics of the items in the tool, e.g. item fit statistics and reliability on pooled sample are presented in Table 3. Additionally, country-by-country analysis, which is not shown here, has also generally confirmed the strong psychometric properties of the items.

The results presented in Table 3 indicate that the summary index constructed from all items has a very high reliability (above 0.90). Twenty-four out of 30 items have excellent psychometric properties. Four of them have moderate discrimination (c2, c4, c5, p7) and therefore provide less information on respondents' digital skills relative to other items. Three of the items show some problems with fit to the overall construct (c3, c4, p6) which most probably is related to the measurement invariance issues.

Table 3. Item fit statistics for DSI 2.0: pooled international sample.

	Item. total[11]	Item. Tot.woi[12]	Item. mean[13]	Alpha. drop[14]	2PL -IRT-a[15]	2PL -IRT-b[16]	IRT- RMSD[17]	Status
i1	0.522	0.473	0.740	0.899	1.191	-1.439	0.093	OK
i2	0.433	0.373	0.633	0.900	0.739	-1.103	0.084	OK
i3	0.433	0.378	0.740	0.900	0.838	-1.740	0.114	OK
i4	0.466	0.414	0.246	0.900	1.075	1.103	0.055	OK
c1	0.534	0.492	0.819	0.898	1.822	-1.648	0.084	OK
c2	0.387	0.330	0.740	0.901	0.664	-2.028	0.114	Moderate discrim.
c3	0.453	0.404	0.793	0.900	0.958	-1.989	0.123	Moderate misfit
c4	0.396	0.335	0.658	0.901	0.610	-1.447	0.153	Moderate misfit and moderate discrim.
c5	0.329	0.279	0.163	0.902	0.709	2.347	0.071	Moderate discrim.
c6	0.336	0.296	0.097	0.901	1.029	2.397	0.035	OK
d1	0.689	0.648	0.524	0.895	2.534	-0.289	0.067	OK
d2	0.653	0.608	0.401	0.896	2.341	0.134	0.068	OK
d3	0.576	0.527	0.327	0.898	1.596	0.481	0.066	OK
d4	0.664	0.621	0.602	0.896	2.177	-0.584	0.090	OK
d5	0.674	0.632	0.400	0.895	2.469	0.136	0.082	OK
d6	0.549	0.504	0.223	0.898	2.110	0.849	0.080	OK
d7	0.309	0.279	0.056	0.901	1.667	2.225	0.021	OK
s1	0.488	0.434	0.320	0.899	1.091	0.666	0.083	OK
s2	0.524	0.472	0.319	0.899	1.205	0.624	0.103	OK
s3	0.370	0.305	0.404	0.902	0.611	0.461	0.106	OK
s4	0.583	0.532	0.453	0.897	1.289	-0.022	0.070	OK
s5	0.567	0.516	0.372	0.898	1.240	0.351	0.085	OK
s6	0.573	0.521	0.498	0.898	1.235	-0.222	0.074	OK
p1	0.677	0.634	0.509	0.895	2.113	-0.245	0.062	OK
p2	0.645	0.601	0.379	0.896	2.037	0.226	0.101	OK
p3	0.550	0.501	0.693	0.898	1.341	-1.113	0.109	OK
p4	0.356	0.305	0.183	0.901	0.802	1.926	0.078	OK
p5	0.525	0.475	0.291	0.899	1.356	0.708	0.065	OK
p6	0.550	0.498	0.636	0.898	1.266	-0.855	0.161	Moderate misfit
p7	0.283	0.236	0.135	0.902	0.660	2.857	0.050	Moderate discrim.
Reliability:								
Alpha	0.902							
EAP	0.901							
McDonald's omega	0.907							

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[11] Correlation of the item with the total test score
[12] Correlation of item with total test score (scored without item)
[13] Proportion of respondents indicating a positive response (all items are binary)
[14] Cronbach's alpha value for scale if item were dropped (compared to the alpha at the bottom of the table)
[15] 2-parameter logistic item response theory model slope (discrimination) value
[16] 2-parameter logistic item response theory model difficulty value
[17] Item response theory root mean square deviation (item fit).

3.3.2 Construct validation via analysis of the factor structure of the item set

To represent the factor structure of the item set, a bi-factor model is used. It considers the interconnected but independent role of area-specific abilities and a common general factor of digital competence (g factor). It implies that an underlying g factor shapes general digital competence, but also that specific sets of competences contribute to within-individual differences in general digital competence. The model assumes the latent structure where each item is directly related with general factor and to one of a set of mutually orthogonal specific factors, representing the portion of variance in items, which are not explained by the general factor and are specific for given set of items [9]. Those specific factors may have a dual nature. On the one hand, they can relate to the specific dimensions substantially important for the whole structure. On the other hand, they may reflect differences in measurement instruments - and therefore be considered as disturbing factors. In this application, it is assumed that the g-factor reflect general competences and specific factor reflects areas of competences. Other models tested were the one-dimensional model and 5-dimensional (5D) model.

Table 4. Fit indices for the 3 models tested

	cfi	tli	srmr	rmsea
Model 1: One-dimensional model	0.963	0.960	0.086	0.064
Model 2: 5-dimensional model	0.983	0.982	0.064	0.043
Model 3: The bi-factor model	0.991	0.989	0.052	0.033

All three models ware assessed according to commonly used fit measures (Table 4). The fit used for comparisons are (in parenthesis values for thresholds indicating good fit are provided): Root Mean Square Error of Approximation (RMSEA ≤ 0.06), Tucker Lewis Index (TLI ≥ 0.95), Comparative Fit Index (CFI ≥ 0.95), Standardized Root Mean Square Residual (SRMR ≤ 0.08).

The fit analysis suggests that overall the measurement tool is a good representation of the theorised concept (i.e. digital competence under the DigComp framework). Both the 5D model (Figure 1) and bi-factor model (Figure 2) fit very well to data with a slight advantage of bi-factor model. The 5D model suggests that the structure of the framework is aligned with the empirical data. The bi-factor model indicates underlying main dimension providing a support for using an overall score as a main indicator insofar as it confirms that some items contribute both to a single factor as well as specific sub-factors.

To support future developments or refinements to the DSI with good empirical evidence, it is suggested to further explore the dimensionality of the DSI, both for the pooled EU sample and within individual Member States.
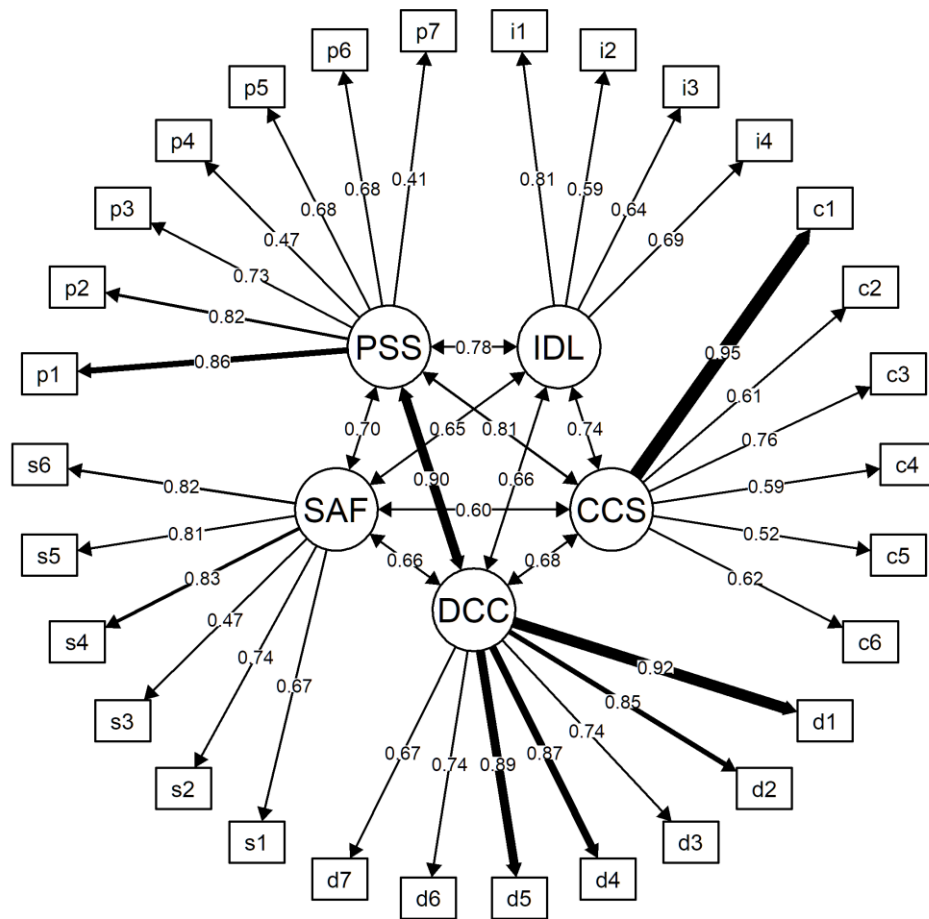
Figure 1. Graphical representation of 5-D model model assumes that 5 different, but related, latent traits describe test takers' patterns of responses to the sets of items suggesting strong multidimensionality.
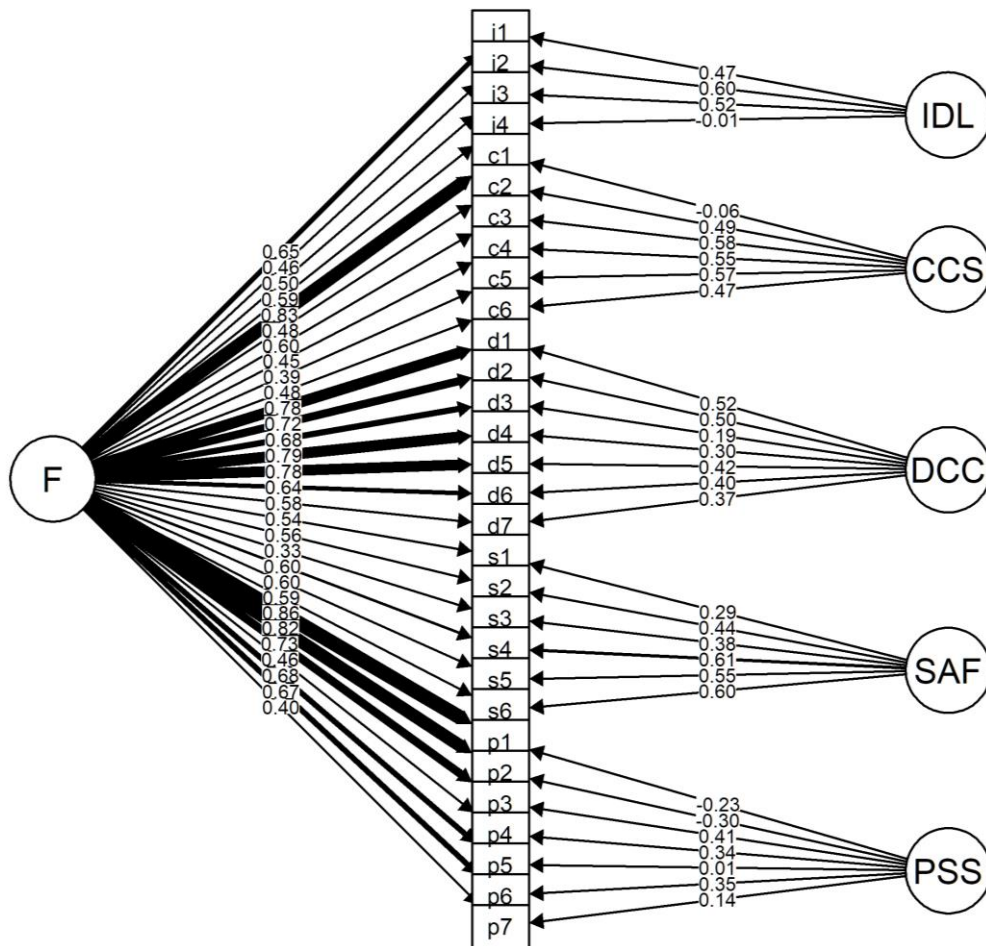
Figure 2. Graphical representation of bi-factor model shows the interconnected but independent role of area-specific abilities and a common general factor of digital competence.

4   Conclusions

This report presented the background context for updating the Digital Skills Indicator (DSI) on the basis of the Digital Competence Framework, DigComp 2.0, and then provided the results of analyses that were designed to assess the psychometric quality of DSI 2.0. The analysis also included an empirical test of the validity of the DigComp framework, which describes digital competence along five dimensions (Information and data literacy; Communication and collaboration; Digital content creation; Safety; and Problem solving).

Two key conclusions may be drawn.

- First, the DSI 2.0 item set is of high psychometric quality, both at the individual item level and at the scale level. Specifically, 24 of the 30 items have excellent psychometric properties, while four have moderate discrimination and three exhibit some slight issue with fit to the overall construct. Both the overall DSI 2.0 and its five sub-components or sub-scales show high reliability.

- Second, dimensionality analyses which compared the relative fit of three models (one dimension, five dimensions and a bi-factor model) indicated that the bi-factor model provides a superior fit relative to the other two models. The bi-factor model confirms the existence of a single main dimension while also showing that some items contribute both to a single factor and specific sub-factors.

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List of figures, tables and abbreviations

List of abbreviations and definitions

DigComp   Digital Competence Framework for Citizens

DESI   Digital Economy and Society Index

DG   Directorate General

DSI   Digital Skills Indicator

JRC   The Joint Research Centre of the European Commission

EU   European Union

Annexes

Annex 1. : Sample sizes for each country

Table 5 shows the sample sizes for each country. More information on sampling and population coverage is available by Eurostat on the metadata page[18].

Table 5. Sample sizes for participating countries.

Country	Freq
Austria	4137
Belgium	5611
Bulgaria	6227
Cyprus	3213
Czech Republic	5010
Germany	17714
Denmark	4147
Estonia	3913
Greece	3215
Spain	11538
Finland	2579
France	11539
Croatia	2652
Hungary	6089
Ireland	1232
Italy	27270
Lithuania	4323
Luxembourg	1383
Latvia	5035
Malta	1396
Netherlands	4898
Poland	7681
Portugal	4647
Romania	12679
Sweden	3850
Slovenia	1377
Slovakia	2863

For the analyses described in the remainder of this document (confirmatory factor analysis, dimensionality assessment, sub-score reliability), in order to ensure equal contributions from each EU country, a random sub-set of 1,000 records was drawn from each.

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[18] https://ec.europa.eu/eurostat/cache/metadata/en/isoc_sk_dskl_i21_esmsip2.htm

Annex 2. : Formula and references to original variables collected by the survey on ICT usage by households and individuals. If fewer variables were collected, the recommended 10 are marked in bold.

DSK2_IL		***Digital skills - Information and data literacy (Eurostat computed)***		Individuals where IU=1
	0	If no condition from the following list is met, then 0 **(none)**		
	1	If one condition is met, then 1 **(basic)**		
	2	If several conditions are met, then 2 **(above basic)**		
	9	Not applicable (IU=Blank or IU<>1)		
		List of conditions for DSK2_IL:		
		IUIF=1, IHIF=1, **IUNW1=1**, TICCSFOI=1 or TICIDIS=1 or TICNIDIS=1 or TICXND=1		
DSK2_CC		***Digital skills - Communication and collaboration (Eurostat computed)***		Individuals where IU=1
	0	If no condition from the following list is met, then 0 **(none)**		
	1	If one condition is met, then 1 **(basic)**		
	2	If several conditions are met, then 2 **(above basic)**		
	9	Not applicable (IU=Blank or IU<>1)		
		List of conditions for DSK2_CC:		
		IUEM=1, **IUPH1=1**, **IUCHAT1=1**, IUSNET=1,IUPOL2=1, IUVOTE=1		
DSK2_DCC		***Digital skills – Digital content creation (Eurostat computed)***		Individuals where IU=1
	0	If no condition from the following list is met, then 0 (none)		
	1	If one or two conditions are met, then 1 **(basic)**		
	2	If more than 2 conditions are met, then 2 **(above basic)**		
	9	Not applicable (IU=Blank or IU<>1)		
		Lists of conditions for DSK2_DCC:		
		CWRD1=1, CXLS1=1, CEPVA1=1, CXFER1=1, CPRES2=1, CXLSADV1=1		
		CPRG2=1		
DSK2__SF		***Digital skills – Safety (Eurostat computed)***		Individuals where IU=1
	0	If no condition from any of the following list is met, then 0 **(none)**		
	1	If one or two conditions are met, then 1 **(basic)**		
	2	If more than 2 conditions are met, then 2 **(above basic)**		
	9	Not applicable (IU=Blank or IU<>1)		
		List of conditions for DSK2_SF:		
		MAPS_CWSC=1, MAPS_RPS=1, MAPS_RRGL=1, **MAPS_LAP=1**, MAPS_RAAD=1, PCOOK1=1		
DSK2_PS		***Digital skills - Problem solving (Eurostat computed)***		Individuals where IU=1
	0	If no condition from any of the following list is met, then 0 **(none)**		
	1	If one or two conditions are met, then 1 **(basic)**		
	2	If more than 2 conditions are met, then 2 **(above basic)**		
	9	Not applicable (IU=Blank or IU<>1)		
		Lists of conditions for DSK2_PS:		
		CINSAPP1=1, **CCONF1=1**, IBUY=1 or IBUY=2, IUSELL=1,		

DSK2		IUOLC=1 or IUOLM=1, IUBK=1,IUJOB=1 ***Digital skills - Overall skills (Eurostat computed)*** Computed on the basis of combining the values of the five components, DSK2_IL, DSK2_CC, DSK2_DCC, DSK2_SF, DSK2_PS, as follows:	Individuals where IU=1
	0	No skills (score of 0 on 4 or 5 components)	
	1	Limited (score of 0 on 3 components)	
	2	Narrow (score of 0 on 2 components)	
	3	Low (score of 0 on 1 component)	
	4	Basic (score of at least 1 on each of 5 and less than 2 on 1 or more of 5 components)	
	5	Above Basic (score of 2 on all 5 components)	
	9	Not applicable (IU=Blank or IU<>1)	
		DSI items not included in DSI 2.0: • Copied or moved files or folders (CCPY); • Saved files on Internet storage space (CC); • Transferring files between computers or other devices (CXFER); • Obtained information from public authorities/services' websites (IGOV12IF); • Uploading self-created content to any website to be shared (IUUPL)	