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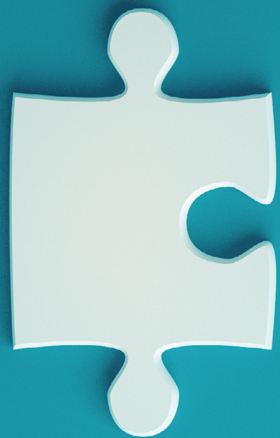
JRC SCIENCE FOR POLICY REPORT

SUPPORTING POLICIES ADDRESSING THE DIGITAL SKILLS GAP

Identifying priority groups in the context of employment



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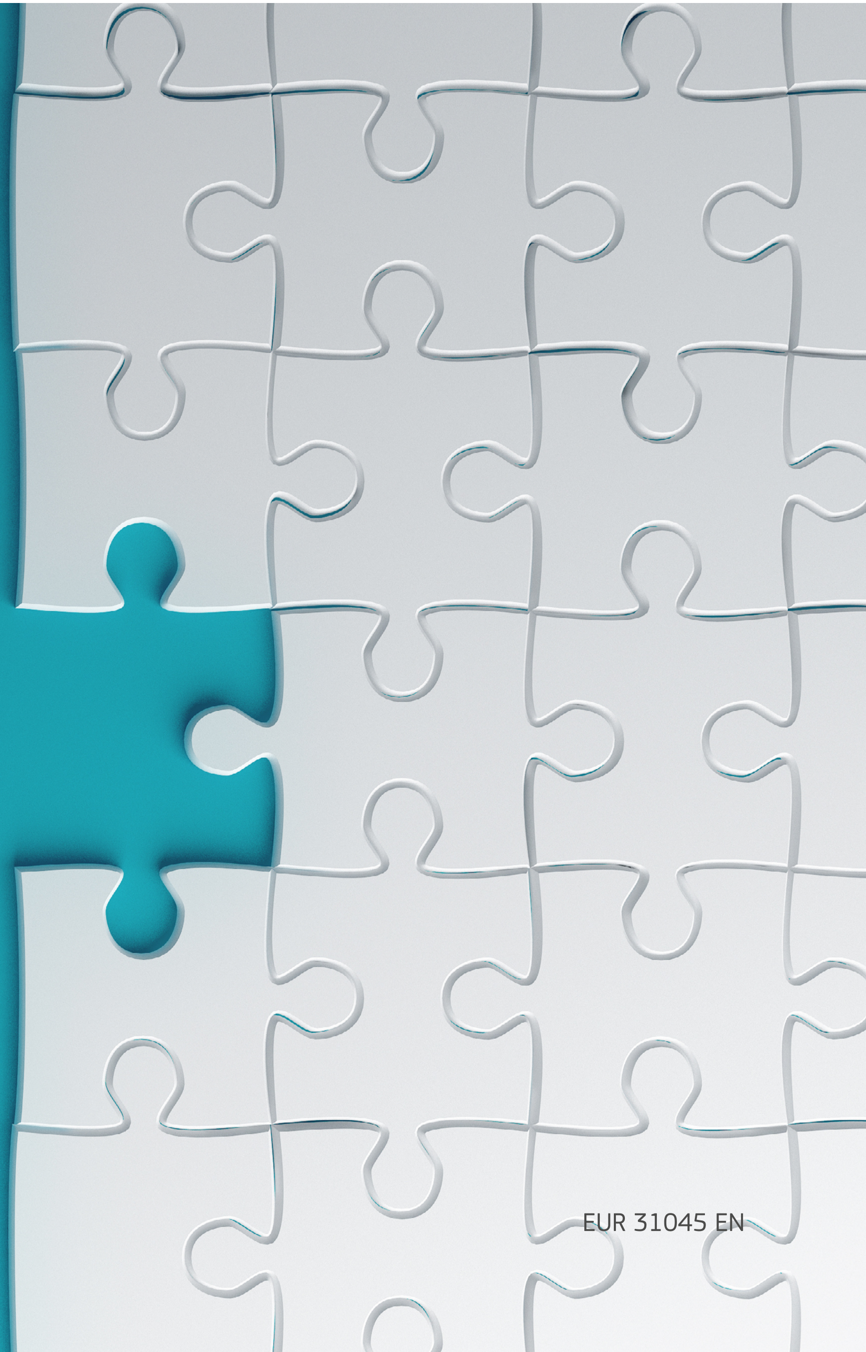

Joint Research Centre

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Supporting policies addressing the digital skills gap

Identifying priority groups in the context of employment

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Abstract

In a context of deficiency of digital skills in Europe to respond to the needs of the labour market, this report analyses the most recent data from Eurostat, OECD and CEDEFOP that refer to the digital skills gap in contexts of employment. In doing so it makes an attempt to clarify the differences between the existing data sets (relative to different methodological approaches) and concludes upon which would be the highest priority groups to take into account in those policies that seek to increase digital skills, providing a set of policy design recommendations.

With this research we aim to bring some light to the two questions – 1. which type of gaps exist and 2. which would be the priority target groups for policy action – and through these, support several of the latest Digital Decade targets on digital skills also mentioned in the European Social Pillar Action Plan; the European Skills Agenda actions, including Action 2: Strengthening skills intelligence; Action 3: EU support for strategic national upskilling action; and Action 6: The Commission support to digital skills for all; and the Digital Education Action Plan, Priority 2, Enhancing digital skills and competences for the digital transformation.

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1 Foreword

Digital skills have now become even more important than ever to enable people participate in our increasingly digital society and economy. Lacking digital skills or having a low level of digital skills has the risk of depriving individuals from opportunities for empowerment, social inclusion and employability. Various European policies recognise this. In January 2022 for instance, the European Commission made the proposal for a “Declaration on European Digital Rights and Principles”. The right to education, training and lifelong learning and the ability to acquire all basic and advanced digital skills for everyone is one of the principles of the Declaration.

Tackling digital skills challenges and addressing possible digital skills mismatches require reliable data and analysis. This report is a contribution to digital skills measurement in the context of employment. It analyses the most recent data from Eurostat, OECD and CEDEFOP, clarifies some of the major differences between the different data sets, and concludes with a list of highest priority groups for policies that aim to increase digital skills and reduce digital skills gaps and mismatches.

This report complements well the release of the new updated version of “DigComp 2.2”, the Digital Competence Framework for Citizens (DigComp), providing a common understanding across the EU and beyond, of what digital competence is. The new version was published in March 2022. It addresses emerging technologies, such as Artificial Intelligence and new phenomena such as misinformation and disinformation. It contains more than 250 new examples of knowledge, skills and attitudes statements on these new topics.
These reports are part of the JRC research on “Learning and Skills for the Digital Era”. Other key contributions to facilitate the digital transformation of education and training comprise the Digital Competence framework for Educators (DigCompEdu) and the digital competence self-reflection tools for teachers (SELFIEforTEACHERS) and for schools (SELFIE). In addition, there are the key competence frameworks for Personal, Social and Learning to Learn competences (LifeComp), for entrepreneurial competences (EntreComp) and for sustainability competences (GreenComp). More information on all our studies can be found on the JRC Science Hub.

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Executive Summary

Policy context

The issue of digital skills-mismatch in employment has been ranking high on the European policy agenda for a long time, as already set out in the EC Communication 'A new skills agenda for Europe' (COM(2016) 381, p. 2)[1] and in the new European Skills Agenda (COM (2020) 441 final/2, p. 3)[2].

To address that challenge, the European Skills Agenda[3] has set the ambitious objective to ensure that 70% of 16-74 year olds have at least basic digital skills by 2025, and the European Social Pillar Action Plan[4] the target that at least a minimum 80% of those aged 16-74 should have basic digital skills by 2030. The Digital Education Action Plan[5], in its Priority 2, aims also at Enhancing digital skills and competences for the digital transformation.

In spite of its policy relevance, research on this topic has not been sufficiently instrumental to guide policy action so far; in particular, it is still unclear which are priority target groups for policy action, and which type of digital skills gaps exist?

This research[6] aims to bring some light to the two questions above and, through them, support several of the latest European Skills Agenda actions, including: Action 2: Strengthening skills intelligence; Action 3: EU support for strategic national upskilling action; and Action 6: The Commission support to digital skills for all. It also aims at supporting the EC Communication Path to the Digital Decade[7] in its objective 'to (b) reinforce Member States' collective resilience and bridge the digital divide notably by promoting basic and specialised digital skills for all'.

Main findings

The analysis carried out contributes to a better understanding of the size and types of digital skills gaps in the context of employment, in support of the design of skilling policies.

The analysis has been carried out using different sources of data (CEDEFOP' 1st European Skills and Jobs Survey (ESJS), OECD Programme for the International Assessment of Adult Competencies (PIAAC) Adult Skills Survey, Eurofound European Working Condistions Survey (ECWS) and Eurostat Digital Skills Indicator).

1. COM(2016) 381, New Skills Agenda.
2. COM(2020) 441 final/2 on a 'European Skills Agenda for sustainable competitiveness, social fairness and resilience'.
3. Ibid.
4. https://ec.europa.eu/social/BlobServlet?docId=23696&langId=en
5. https://education.ec.europa.eu/focus-topics/digital-education/about/digital-education-action-plan
6. This research has been carried out under the LABOURCOMP AA No JRC 34969-2017 Work patterns in digital labour platforms and support for development of digital and entrepreneurial competences, Project: Support for development of digital and entrepreneurial competences (CompDev), WP B1: Linking DigComp to employment Opportunities.
7. COM(2021) 574 final, Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the 2030 Policy Programme "Path to the Digital Decade"

The main findings of the research can be summarized as follows:

- There is a lack of a standard definition used for the measurement of digital competences and the related proficiency levels, and also a diversity of data collection methodologies and years of collection, which have posed methodological challenges and limitations to the research work.

Supply digital skills gaps:

- In 2019, **40% of individuals aged 25-64** (a proxy for the working-age population) **had below-basic skills** (Eurostat). More research is needed to understand the barriers to access, use and development of digital skills among these individuals.
- **Nine priority groups**, shaped by factors such as age, education level, employments status and occupation types are concerned by the existing digital skills gap. The diversity of groups calls for different focused skilling approaches to consider the diversity of cognitive and language skills, age, education levels, etc.
- Among these groups, **young people with low education and NEETs** emerge as a significant, often invisible, priority group, in particular from the employability perspective.
- For **unemployed and inactive individuals**, policy actions could aim at stronger cooperation with Active Labour Market Policies (ALMP) and with education and training actors acting as labour market intermediaries, which, themselves, may require specific skilling policies' attention.
- There is a remaining **10% of adults not using internet**, which points to the need for specific access and use policies, across the priority groups.

In the context of employment:

- There is a limited **digital skills mismatch of active workers in a range between 3-11%**, relatively homogeneous across countries. For basic/moderate digital skills the skills gaps is rather homogeneous between occupations.
- A **job polarisation** is taking place concerning the use of ICT at work leading to very different experiences of work with potentially profound impacts on career development, occupational mobility and working life. In some occupations, workers never or almost never use ICT in their jobs, and have even seen a decrease in ICT use in the last years. These coexist with an increasing number of workers using ICT at high intensity. This polarisation calls for a dual approach including skilling actions towards those employed in low-skilled occupations, together with skilling actions to ensure (highly-skilled) individuals maintain the necessary skills to avoid skills obsolescence.
- There is an opportunity to work towards the **definition of the basic digital skills required by the "generic employee"**, instrumental for digital skills assessment and development of training offer.

Key conclusions

Research challenges linked to the nature of available data

The analysis has been carried out using different sources of data (CEDEFOP' 1st European Skills and Jobs Survey (ESJS), OECD PIAAC Adult Skills Survey, Eurofound European Working Conditions Survey (ECWS) and Eurostat Digital Skills Indicator).

Datasets use different definitions of digital competences for measurement and their related proficiency levels (such as low, basic, advanced), as well as different data collection methodologies for building the 'construct' of digital competence. They also correspond to data collected in different years, collected for different purposes and reflect complementary supply and demand perspectives. Not only the research has met methodological challenges due to these differences, but also the conclusions from the analysis should be read with caution, as possible interpretation errors introduced by these limitations may have occurred.

Which are priority target groups for policy action?

In 2019, **40% of individuals aged 25-64** (a proxy for the working-age population) **had below-basic skills** (Eurostat).

Out of this 40%, an average 10% of individuals in the EU did not use the internet in the 3 months prior to the survey. The remaining 30% of individuals used the internet but reported low or no digital skills. Policy actions will require both **promoting usage** as well as **supporting competence development**.

The analysis of both groups points to the following individual characteristics related to a higher probability of having low or no digital skills and not using internet (for groups G2 to G6):

Priority target groups for policy action that reported no ICT use or / and below-basic digital skills

Group	Factor	Characteristics
G1	Age & Education level	**Young** 16-24 years old, **with low-level formal education, and NEETs** (aged 16-35 not in employment, education or training)
G2	Age	Individuals **55-64 years old**
G3	Education level	Individuals 25-64 years old **with low-level formal education**
G4	Education level	Individuals 25-64 years old **with medium-level formal education**
G5	Employment status	Individuals **unemployed**
G6	Employment status	Individuals **inactive**
G7	Nationality	Nationals of **non-EU countries**
G8	Place of living	Individuals living in **rural areas**
G9	Employment status & occupation type	Individuals **employed in semi-skilled and low-skilled occupations**

The variety of socio-economic characteristics of the above groups suggest that, in order to design effective skilling actions, **focused research is required**, to better understand their needs, contexts and barriers to access and use of ICT and to develop digital competences.

Non internet users (10%) require specific attention in an employment context, as research shows that having any computer experience at all is the most relevant factor for labour market outcomes, even more important than the actual level of digital skills. Those having highest possibility of being in this group are those out of work and aged 45 and above and with low or medium-level education, and those in work with low-level education.

A significant group (24%) of **young people with low level education and young persons who are no longer in the education system and who are not working or being trained for work (NEET)** have lower digital competences, and would need special attention by digital skilling actions. Not only these would improve their direct employability prospects, but also to benefit from other positive impacts on employability that the acquisition of digital skills provides, such as increase in self-esteem, the ability to look for a job online, and the development of other transversal skills such as communication and collaboration as well as increasing the ability to continue studying – of particular relevance to this low-level educated group[8].

Unemployed and **inactive individuals** not only have less digital skills (55% of those unemployed and 67% of those inactive), but are also excluded from the opportunity to develop their digital skills at work by using digital devices, tools and applications or by following employer's training. Promoting ICT use for non-work activities is a path towards the development of digital skills, applicable also at work, and thus relevant for employability. This could complement specific digital skilling actions addressed to this group, including, for example, skills to search for jobs online effectively.

For this particular group, policy actions could aim at stronger cooperation with Active Labour Market Policies and with education and training actors acting as **labour market intermediaries** (such as social services, public and private employment services and the third sector) to ensure effective outreach, training design and adequate delivery channels. These intermediary actors, in turn, may also need to be digitally skilled themselves and supported.

To understand the digital skilling actions addressing **nationals of non-EU countries**, we need to consider that the major factors affecting digital skills level is the proficiency in the host country language[9], and, thus, there is an opportunity to link these skilling actions to migrant integration policy actions that would address host-country language learning[10].

Priority occupations

First, a **job polarisation** is taking place with regards to the use of ICT at work. A large proportion (above 75%) of those working as agricultural workers, craft workers, plant and machine operators, service and sales workers and in elementary occupations, have not only **never or almost never used ICT in their jobs** in 2015, but also have seen a **decrease in ICT use** in the period 2010-2015. These coexist with an increasing number of **workers using ICT at high intensity** as managers, professionals, technicians and clerks. These two groups will have very different experiences of work with potentially profound impacts on career development, occupational mobility and working life.

8. Green, A. E., de Hoyos, M., Barnes, S.-A., Owen, D., Baldauf, B. and Behle, H., *Literature Review on Employability, Inclusion and ICT, Report 2: ICT and Employability*, Centeno, C., Stewart, J. (Eds.), JRC Technical Report Series, JRC EUR 25792 EN, Institute for Prospective Technological Studies, Joint Research Centre, European Commission (2013).
9. See p. 50 in OECD, *Adults, Computers and Problem Solving: What's the Problem?*, OECD Publishing, 2015.
10. COM(2016) 377 final – Action Plan on the integration of third country nationals.

Therefore, **a dual approach is needed**. On one side, up/reskilling actions are needed towards those employed in low-skilled occupations, as they do not have the opportunity to use and learn to use ICT, with a view to **maintain/ develop their employability**. On the other, up/reskilling actions are needed to ensure (highly-skilled) individuals in most rapidly changing occupations maintain the necessary skills to do their jobs and **avoid skills obsolescence**.

As a complementary action, there is a need for **regular monitoring of skills needs**, by sector and occupation. Complementary agile and timely development of the **training supply in a lifelong-learning perspective** is also needed, including by formal and non-formal education and training actors. In particular, for those occupations requiring higher education, which are more likely to be affected by the technological change, the implication of high education institutions to address the training needs would be required. Policy actors, employers and education and training actors should reinforce their dialogue and cooperation within local ecosystems which all have complementary roles to play.

Finally, research findings point to **the opportunity to work towards the definition of the basic digital skills required by the "generic employee"**, which would require employers´ involvement to ensure occupation-specific digital skills needs are adequately assessed, and related training further developed.

Digital skills gaps are limited but exist across all countries and occupations

According to the three sources analysed, **3-11% of active workers present digital skills mismatch**. The interpretation of this limited share could be explained by the continued 'learning-by-doing' process that takes place while using technology in the workplace, and complemented by employer training actions for their employees to adapt to the continuous technologies, devices, applications and job tasks following the introduction of new technologies.

Furthermore, digital skills gaps are **relatively homogeneous across countries**, with an independence of the average level of digital skills of individuals in each country. In fact, they reflect the level of unmatched demand generated by the (ongoing) digital transformation of the different sectors, whether in an initial or more advanced phase. The analysis points to a relevant and rather homogeneous gap for basic/moderate digital skills between occupations, **ranging from 25%** of managers **to 35%** of building, crafts and related trade workers.

These findings call for **systematic policy actions across countries and across occupations** addressed to employed people, in cooperation with local sectoral employers and training actors to develop focused and effective skilling actions with adequate training content, design, access and effective enrolment approaches. However, **local (national and regional) contexts need to be analysed** to understand how the local conditions shaped by the levels of digital transformation of the industry and characteristics and digital skills of the population characterise the digital gaps. This analysis needs to involve the enterprise-relevant actors (managers, human resources, staff, etc.)[11] to understand the sectoral trends and needs, and the needs at occupation level.

In addition, financial **incentive programmes to small and micro enterprises** would be needed to promote training actions for employees on digital skills.

11. Kluzer, S., Centeno, C. and O´Keeffe, W., *DigComp at Work*, EUR 30166 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17857-6, doi:10.2760/887815, JRC120376.

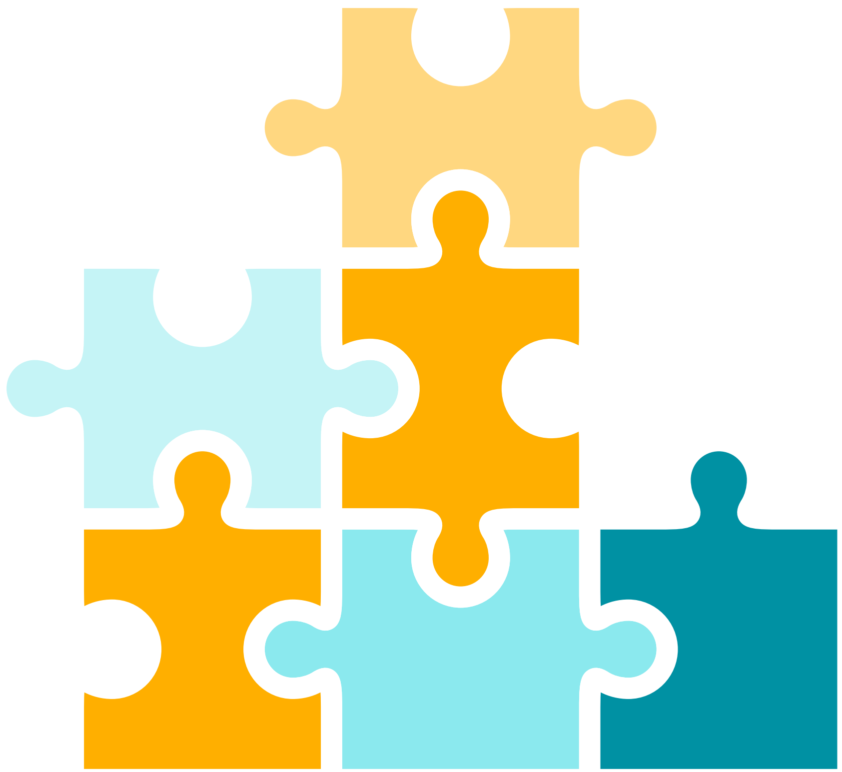
Supporting research actions

Finally, the analysis concludes that additional research actions could include, in a short-term perspective, the review of these results when new 2021 Eurostat (Digital Skills Indicator) and CEDEFOP 2nd ESJS data will become available in 2022. Longer-term research work could address the current lack of accurate and timely data on the evolution of the digital skills gaps that hamper policy-relevant statistics and relevant policy actions.

These latter could include: 1) research towards understanding the need for different definitions of digital competence for measurement and the opportunity for a closer alignment across datasets and organisations; 2) exploring the possibility of carrying out a detailed analysis of digital skills needs per occupation, sector and country/region and matching these with skills available; and, 3) exploring the possibility of incorporating in Eurostat yearly data collection exercises of essential supply and demand data to accurately assess the digital skills gap.

Related and future JRC work

Key research work ahead could include, in a short-term perspective, revisiting these results as Eurostat (Digital Skills Indicator) and CEDEFOP's 2nd ESJS data become available in 2022. Longer-term work could address the current lack of accurate and timely data on the evolution of the digital skills gaps that hamper policy-relevant statistics and relevant policy actions.



1. Introduction

1.1 Background

The issue of digital skills-mismatch in employment has been ranking high on the European policy agenda for a long time, as already set out in the EC Communication 'A new skills agenda for Europe' (COM(2016) 381, p. 2)[12] and in the new European Skills Agenda (COM (2020) 441 final/2, p. 3)[13]. Individual digital skills across Europe seem insufficient to meet the labour market demand, as suggested by aggregate statistics from both the supply side (measured as individual digital skills among workers) and from the demand side (measured as the level of skills required by enterprises for each worker´s occupation).

To address that challenge, the European Skills Agenda[14] has set the ambitious objective to ensure that 70% of 16-74 year olds have at least basic digital skills by 2025, and the the European Social Pillar Action Plan's[15] target, also mentioned in the Europe's Digital Decade[16] compass, sets the target of a minimum 80% of the population with basic digital skills by 2030.

In spite of its policy relevance, research on this topic has not been sufficiently instrumental to guide policy action so far; in particular, it is still unclear which type of digital skills gaps exist and which would be the priority target groups for policy action. Arguably, one of the reasons for this lack of clarity is given by the different definitions of digital skills and measurement methods. Part of the challenge is that data on individual skill levels and on occupational skill requirements are collected separately and hard to match, therefore estimates of mismatch are generally based on employers' perspectives alone.

With this research we aim to bring some light to the two questions above and, through them, support several of the latest European Skills Agenda actions, including: Action 2: Strengthening skills intelligence; Action 3: EU support for strategic national upskilling action; and Action 6: The Commission support to digital skills for all. It also aims at supporting the EC Communication Path to the Digital Decade[17] in its objective 'to (b) reinforce Member States' collective resilience and bridge the digital divide notably by promoting basic and specialised digital skills for all'. Finally, it also aims at contributing to the implementation of the Digital Education Action Plan[18], in its Priority 2: Enhancing digital skills and competences for the digital transformation.

1.2 Key skills trends in an employability context

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[19].

Digital competence has become crucial for employability. Not only considering its role as a transversal skill to develop employability[20], but also because around 85% of all EU jobs need at least a basic digital skills level[21].

12. COM(2016) 381, New Skills Agenda.
13. COM(2020) 441 final/2 on a 'European Skills Agenda for sustainable competitiveness, social fairness and resilience'.
14. Ibid.
15. https://ec.europa.eu/social/BlobServlet?docId=23696&langId=en
16. https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en
17. COM(2021) 574 final, Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the 2030 Policy Programme "Path to the Digital Decade"
18. https://education.ec.europa.eu/focus-topics/digital-education/about/digital-education-action-plan
19. Council Recommendation of 22 May 2018 on Key Competences for Lifelong Learning.
20. Green, A. E., de Hoyos, M., Barnes, S.-A., Owen, D., Baldauf, B. and Behle, H., *Literature Review on Employability, Inclusion and ICT, Report 2: ICT and Employability*; Centeno, C., Stewart, J. (Eds.), JRC Technical Report Series, JRC EUR
21. CEDEFOP (2018), *Insights into skills shortages and skill mismatch*.

The most recently available statistics[22] collecting information on digital skills in Europe[23] for the year 2019 show, however, **that 13% of the EU labour force had no digital skills, mostly because they did not use the internet, and an additional 24% did not have at least basic digital skills**, which are now required in most jobs[24]. Compared to the previous 2017 data, the share of the labour force with **no digital skills increased in 2019 by 3 percentage points, and the share with below-basic digital skills decreased only by 2 percentage points**. This means that the share of the EU labour force with basic or above-basic skills has **fallen from 64% in 2017 to 63% in 2019**. The results call for renewed focused action to develop labour force digital skills to ensure it can fulfil the labour market digital skills needs, and, for that purpose, understanding which digital skills are needed by which priority groups.

At the same time, the pace of change is accelerating due to the digital transformation, the 'robotisation' and 'cobotisation'[25] of an increasing number of tasks[26]. The greater capacity for data collection, processing and analytics, paired with machine learning and AI, suggests a future increase in tasks that require more analytical and digital skills from workers[27].

Indeed, recent Eurostat data[28] show that in 2018, the **job tasks of 16% employed internet users in the EU had changed** due to new software or computerised equipment in the 12 months prior to the survey. In the same period, **29% had to learn how to use new software or equipment for their job**.

Lastly, several studies report that although it remains crucial to develop digital skills that empower workers to thrive in a changing, digital economy, **comprehensive skills strategies should embed these within a broader set of transversal skills** relevant to employers such as soft skills and communication skills. In particular, research findings point to a) the increasing labour market needs for transversal, soft or non-cognitive skills[29,30]; b) the fact that these are required in combination with ICT skills[31]; and c) that their development mutually reinforce each other[32]. This evidence shows thus that the most effective means of improving employability and closing skills gaps are generic measures aimed at improving the capacity of workers to acquire new skills and learn in an evolving economy.

22. It is to be noted that Eurostat 2021 data will be released early 2022 and this analysis has considered 2019 data.
23. Provided by Eurostat, under the Digital Skills Indicators (DSI) for the year 2019.
24. CEDEFOP (2018), *Insights into skills shortages and skill mismatch*.
25. *Cobotisation* – When humans and robots cooperate for a more efficient production (https://www.lacroix-electronics.com/?s=cobotisation).
26. Eurofound (2019), *The future of manufacturing in Europe*, Publications Office of the European Union, Luxembourg.
27. Arregui Pabollet, E. et al., *The changing nature of work and skills in the digital age*, Gonzalez Vazquez, I. et al. editor(s), EUR 29823 EN, Publications Office of the European Union, Luxembourg, 2019.
28. Eurostat news release 199/2018 – 20 December 2018, *Internet use in the EU, 2018 – digitalisation at work*.
29. European Commission, DG CNECT, *ICT for work: Digital skills in the workplace*, 2017, prepared by Ecorys and Danish Technological Institute.
30. Source: Arregui Pabollet, E. et al. *The changing nature of work and skills in the digital age*, Gonzalez Vazquez, I., et al. editor(s), EUR 29823 EN, Publications Office of the European Union, Luxembourg, 2019, JRC, based on employment data from Cedefop and Eurofound (2018) and data on the task and tools of work from Bisello et al. (2019).
31. CEDEFOP's Skills Online Vacancy Analysis Tool for Europe (OVATE) and CEDEFOP, 'The great divide – Digitalisation and digital skill gaps in the EU workforce', #ESJsurvey INSIGHTS No 9, Thessaloniki: Greece, 2017.
32. Green. A. E., de Hoyos, M., Barnes, S.-A., Owen, D., Baldauf, B. and Behle, H., *Literature Review on Employability, Inclusion and ICT, Report 2: ICT and Employability*, Centeno, C., Stewart, J. (Eds.), JRC Technical Report Series, JRC EUR 25792 EN, Institute for Prospective Technological Studies, Joint Research Centre, European Commission (2013).

1.3 About this report

This report aims at identifying those **priority target groups** that need to develop digital skills in a context of employment and employability, and which types of skills they need. It therefore excludes considerations related to the need for skilling other groups such as younger and older people, parents with children in school age, etc. It includes an analysis of digital skills of European citizens of working age, taking into account a number of individual socio-demographic characteristics; an understanding of which skills are used at the workplace, in which sectors and occupations and through which employee profiles; and lastly it provides some analysis to understand the skills mismatches. The latter are crucial to rightly targeting skilling and upskilling actions, addressing the employer´s needs and, consequently, helping individuals find the right fit in the labour market.

This report focuses on the **digital skills needed by the 'generic' employee**, excluding ICT-specific jobs, providing much-needed insight in this specific field.

The **structure** of the report is as follows:

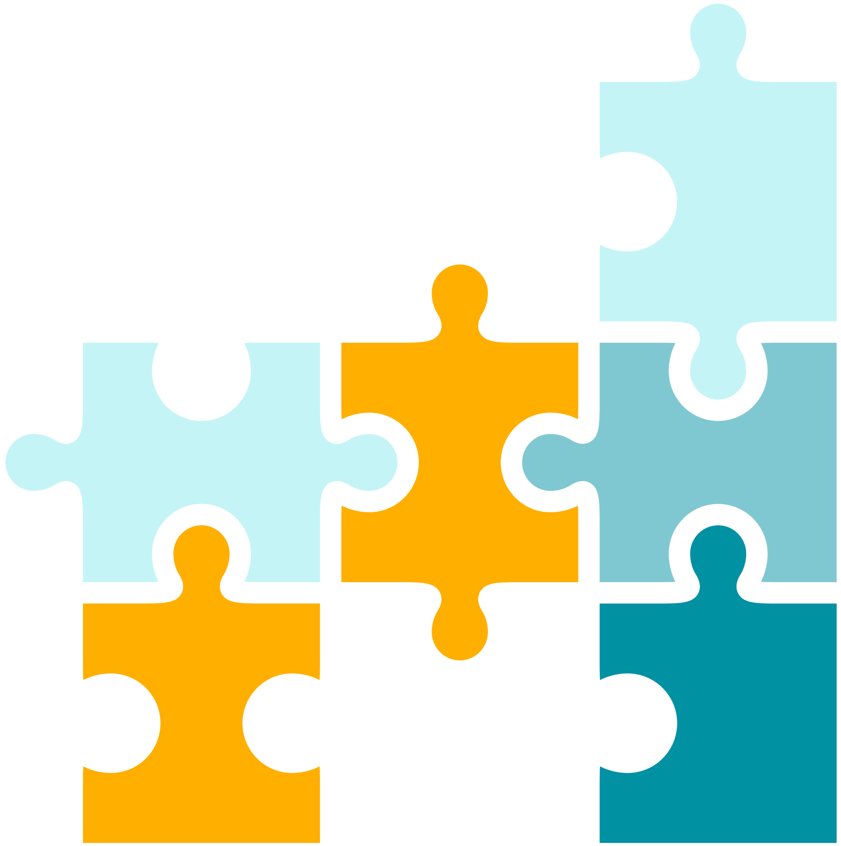
- Chapter 2 presents an overview, compares and analyses different data sources and definitions of "digital skills" and digital skills mismatches and related measurement methods;
- Chapter 3 presents an analysis of skills supply, i.e., the digital skills of the population, using Eurostat and OECD PIAAC Adult Skills Survey data;
- Chapter 4 presents an analysis of skills demand through the use of skills by employees at work across sectors and occupations, and some forecasts of skills demand and skills obsolescence, using CEDEFOP, OECD PIAAC Adult Skills Survey and Eurostat data;
- Chapter 5 presents some analysis of the digital skills gap using the same datasets;
- Chapter 6 presents the view of employers summarizing the findings of the EC study on "ICT for work: Digital skills in the work place" which allows to enrich the analysis with qualitative considerations; and,
- Chapter 7 summarizes and presents the conclusions and develops some policy considerations.

Due to the rapid pace of social and technological change, this picture will require constant updating, even more so in the uncertain post-COVID-19 period. In this new context, at least one common trend across occupations and sectors can be identified: the increasing share of people working from home for those "teleworkable" occupations[33], which is expected to increase the demand for the telework competences in the 'new normal'. However, this particular aspect has been excluded from the report, as new reports are being published to cover this aspect such as those from JRC[34,35,36], Eurofound[37,38], and CEDEFOP[39,40].

33. Sostero M, S Milasi, J Hurley, E Fernandez-Macias and M Bisello (2020), "Teleworkability and the COVID-19 crisis: a new digital divide?", JRC Working Papers Series on Labour, Education and Technology 2020/05, JRC121193, European Commission
34. Ibid.
35. Bisello, M and E Fernandez-Macias (2020), "A Taxonomy of Tasks for Assessing the Impact of New Technologies on Work", JRC Working Papers Series on Labour, Education and Technology 2020/04, JRC120618, European Commission.
36. Milasi S, I González-Vázquez and E Fernandez-Macias (2020), "Telework in the EU before and after the COVID-19: where we were, where we head to", JRC Science for Policy Brief.
37. Eurofound (2020a), *Living, working and COVID-19: First findings*, April 2020, Dublin.
38. Eurofound (2020b), 'Telework and ICT-based mobile work: Flexible working in the digital age', New forms of employment series, Publications Office of the European Union, Luxembourg.
39. CEDEFOP, 'Has the coronavirus crisis made us all crowdworkers?', 20 April 2020
40. CEDEFOP, 'Online working and learning in the coronavirus era', Briefing note, July 2020; and 'Developing and matching skills in the online platform economy – Findings on new forms of digital work and learning from Cedefop's CrowdLearn study', September 2020.

1.4 Methodology

This research has applied complementary methods. Firstly, it has carried out a review of a selection of skills-intelligence literature of major international datasets (CEDEFOP, OECD, Eurostat, Eurofound). Authors have then carried out a statistical descriptive analysis of the Digital Skills Indicator (DSI) derived from the 2019 Eurostat Survey on ICT usage in households and by individuals, complemented by a regression analysis of OECD PIAAC Adult Skills Survey data of 2011 and 2012. The comparison and integration of the different results have led to a set of policy-relevant conclusions and considerations on priority groups and needed digital skills.



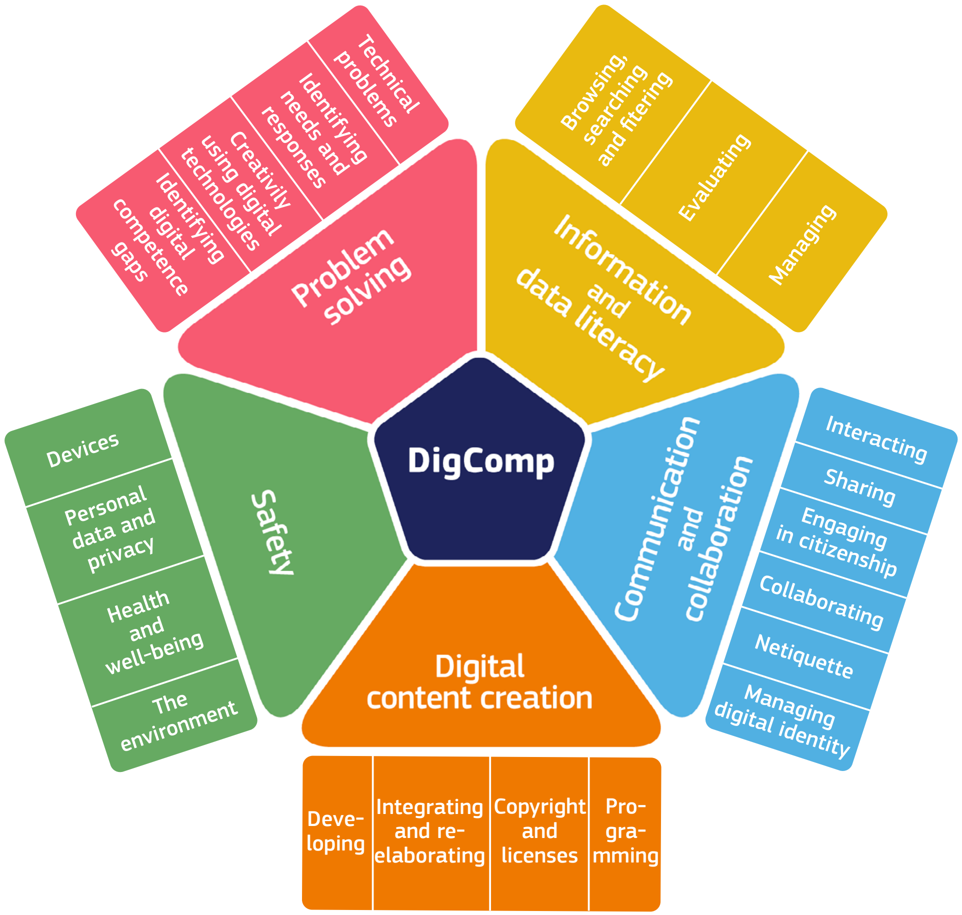
2. Measuring digital competence and methodological challenges

2.1 Different definitions of digital competence across data sets

When trying to identify priority target groups for upskilling and reskilling, it is imperative that both researchers and policy-makers use a common terminology. The first challenge faced during this research has been the lack of common definitions within different organisations in relation to what 'digital competences' or 'digital skills' means, leading to possible misunderstandings when interpreting descriptive statistics or inferential analyses estimating skills mismatch, as elaborated later in this Chapter.

The European Digital Competence Framework for Citizens, DigComp[41] illustrated in Figure 2.1 defines which competences are needed to use digital technologies in a confident, critical, collaborative and creative way to achieve goals related to work, learning, leisure, inclusion and participation in our digital society. The DigComp framework has 5 dimensions: 1. Competence areas (5) identified to be part of digital competence; 2. Competence descriptors and titles (21) that are pertinent to each area; 3. Proficiency levels (8) for each competence; 4. Knowledge, skills and attitudes applicable to each competence; and 5. Examples of use, on the applicability of the competence to different purposes.

Figure 2.1. DigComp 5 competence areas and 21 competences



41. Vuorikari, R., Kluzer, S. and Punie, Y., *DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and attitudes*, EUR 31006 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-48883-5, doi:10.2760/490274, JRC128415.. https://ec.europa.eu/jrc/en/digcomp.

Table 2.1 below describes the different approaches taken to define digital skills or digital competences of the sources used. For example, the Eurostat Digital Skills Indicator (DSI)[42] is a composite indicator based on selected activities related to internet or software use performed by individuals aged 16-74 in four specific areas (information, communication, problem solving and software skills). It is assumed that individuals having performed certain activities have the corresponding skills. Therefore, the indicator can be considered as a proxy of the digital skills of individuals. The survey asks whether the respondent has used ICT for any of the purposes listed, in the 3 months prior to the survey. The digital skills indicator is built on this.

CEDEFOP's European skills and job survey defines basic, moderate and advanced ICT skills based on the use of specific devices, software applications or programming. For the purpose of this report, we will not include CEDEFOP´s data on advanced ICT skills as these fall under 'specialised' ICT skills and would not apply to a 'generic employee'[43].

The OECD, in its Adult Skills Survey, provides the most sophisticated information, including ICT frequency and purpose of use, and also a proficiency level (more specifically, it gauges individuals' ability to solve problems in a technology-rich environment with its PSTRE indicator). The latter is measured through a set of ICT tests of increasing complexity. The lowest levels of proficiency are articulated among those with no computer experience, those who opted-out of taking the test using a computer and those who tried but failed the ICT core test and could therefore not perform the assessment using the computer. Then, for those who passed the ICT core test, the PSTRE levels include: below 1, 1, 2 and 3. To add some complexity, the level of proficiency of PSTRE combines three types of competences – cognitive (including both literacy and numeracy) and digital competence.

Lastly, the *ICT for work: Digital skills in the work place*[44] survey defined a set of 10 digital skills required by the worker in a specific occupation. The workplace managers were surveyed about each skill needed by type of occupation and level of proficiency of employees. These skills are clustered in basic, advanced and specialist digital skills. For the purpose of this study, we will only consider the analysis related to basic and advanced digital skills.

The **main datasets collecting information on digital skills and competences** at the individual level and used for this study are: Digital Skills Indicator (DSI) derived from the Eurostat survey on ICT usage by households and individuals; Eurostat's ICT use at work survey; Cedefop's European Skills and Job Survey; Eurofound's European Working Conditions Survey; OECD Adult Skills survey (part of the Programme for the International Assessment of Adult Competencies – PIAAC); and the *ICT for work: Digital skills in the workplace report*.

42. The indicator was developed in cooperation with users in the EC DG CNECT based on the DigComp framework and in the context of the Digital Single Market strategy (COM(2015) 192 final). Its definition can be found here: https://ec.europa.eu/eurostat/cache/metadata/en/tepsr_sp410_esmsip2.htm.
43. The revised 2nd ESJS (see Section 2.4.2) still adopts a basic, intermediate and advanced ICT job requirement perspective. However, this is done adopting a use-based approach, namely asking workers to what extent they use a range of simple to advanced digital applications (e.g. emailing, web browsing, Word-processing, programming, etc.) as part of their main job.
44. https://op.europa.eu/en/publication-detail/-/publication/7a51fb41-92ad-11e7-b92d-01aa75ed71a1/language-en

A comparison between these methods will help us to understand that each dataset has its strengths and weaknesses and captures a different dimension of digital competence. In particular, we can observe that:

- the target survey respondents vary – Eurostat ICT usage survey targets adults of 16-74 years old; Eurostat survey of ICT use at work surveys those in employment who are internet users; CEDEFOP ESJS targets adult employees; OECD PIAAC Adult Skills Survey targets adults 16-65 years old; and the 'ICT for work' study surveyed workplaces (managers);
- the definitions of digital skills vary from a quite sophisticated indicators used by OECD (PSTRE) and Eurostat (inspired by the DigComp European Digital Competence framework)[45] to more simple definitions used by other sources;
- the way in which skill levels are ranked (basic, moderate, proficient and so on) varies substantially between datasets, as they are closely linked to each definition of digital skills.

To illustrate how these different approaches can create confusion when interpreting and comparing data, the definition of a basic digital skill by Eurostat requires that the respondent has performed at least one action in all four areas of information, communication, problem solving and software in the last 3 months prior to the survey. CEDEFOP ESJS instead requires that the employee uses a PC, tablet or mobile device for emailing or internet browsing in their job.

Some of these differences may be explained by the different contexts in which these surveys take place. In particular, those surveys focusing on the use of ICT at work (CEDEFOP ESJS, Eurostat ICT at work, Eurofound) have a 'narrower' approach to digital competence focusing on those aspects that could be relevant and common across occupations, placing digital skills items within the overall worker context, among other working environment and skills-related questions.

45. https://ec.europa.eu/jrc/en/digcomp.

Table 2.1. Different approaches for defining and measuring digital skills and related levels

Source, target population and question	Definition of digital competence or digital skills	Definition of skills levels
Eurostat Digital Skills Indicator (DSI)[46] **Target population** Adults 16-74 **Question** Asks whether the respondent has used ICT for any of the purposes listed in the 3 months prior to the survey (self-reported).	**Information skills** • Copied or moved files or folders • Saved files on Internet storage space • Obtained information from public authorities/services' websites • Finding information about goods or services • Seeking health-related information **Communication skills** • Sending/receiving emails • Participating in social networks • Telephone/video calls over the internet • Uploading self-created content to any website to be shared **Problem-solving skills** A. Problem solving • Transferring files between computers or other devices • Installing software and applications (apps) • Changing settings of any software, including operational system or security programs B. Familiarity with online services • Online purchases (in the last 12 months) • Selling online • Used online learning resources • Internet banking **Software skills** A. Basic • Used word processing software • Used spreadsheet software • Used software to edit photos, video or audio files B. Above-basic • Created presentation or document integrating text, pictures, tables or charts • Used advanced functions of spreadsheet to organise and analyse data (sorting, filtering, using formulas, creating charts) • Have written a code in a programming language	**Information skills** Basic – one activity Above-basic – more than one activity **Communication skills** Basic – one activity Above-basic – more than one activity **Problem-solving skills** Basic – one or more activities only from A only or from B only Above-basic – at least one activity from A and B **Software skills** Basic – one or more activities from list A and none from list B Above-basic – at least one activity from list B

'Overall' digital skills assessment level

Individuals with '**no skills**' should be as follows	• 4 'none' (no items ticked in all four domains, no activities performed in all four domains, despite declaring having used the internet at least once during last 3 months) OR • those who never used the internet OR • those who did not used the internet in the last 3 months
Individuals with '**low**' level of skills (individuals with heavy weaknesses)	• from 1 to 3 'no skills' in the four domains
Individuals with '**basic**' level of skills (individuals with some weaknesses)	• at least 1 'basic' (but no 'no skills')
Individuals with '**above-basic**' level of skills (individuals without clear weaknesses)	• 'above basic' in all 4 domains

46. https://ec.europa.eu/jrc/en/digcomp.

Source, target population and question	Definition of digital competence or digital skills	Definition of skills levels
CEDEFOP ESJS[47,48] **Target population** Adult employees 24-65 years old **Question** 'The highest level of ICT skills required by EU employees so that they can carry out their job tasks' (self-reported).	**No ICT skills required**	
	Basic ICT level	Using a PC, tablet or mobile device for emailing or internet browsing.
	Moderate ICT level	Using word-processing or creating documents and/or spreadsheets.
	Advanced ICT level	Developing software, applications or programming, and using computer syntax or statistical analysis packages.
OECD PIAAC Adult Skills Survey[49] Problem-solving in technology-rich environments, defined as 'using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks.' **Target population** Adults 16-65 **Question** Test-based.	**Individuals who did not participate in the problem-solving in technology-rich environments (PSTRE) tests because of the following:**	
	No computer experience	Adults in this category reported having no prior computer experience.
	Failed ICT core	Adults in this category had prior computer experience but failed the ICT core test, which assesses the basic ICT skills, such as the capacity to use a mouse or scroll through a web page, needed to take the paper-based assessment.
	'Opted-out' of taking computer-based assessment	Adults in this category opted to take the paper-based assessment without first taking the ICT core assessment, even if they reported some prior experience with computers.
	PSTRE - Below Level 1	**Test result – Below 241 points** Tasks are based on well-defined problems involving the use of only 1 function within a generic interface to meet one explicit criterion without any categorical or inferential reasoning, or transforming information.
	PSTRE - Level 1	**Test result – 241 to less than 291 points** At this level, tasks typically require the use of widely available and familiar technology applications, such as email software or a web browser. There is little or no navigation required to access the information or commands required to solve the problem.
	PSTRE - Level 2	**Test result – 291 to less than 341 points** Tasks typically require the use of both generic and more specific technology applications. For instance, the respondent may have to make use of a novel online form. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g. a sort function) can facilitate the resolution of the problem. The task may involve multiple steps and operators.
	PSTRE - Level 3	**Test result – Equal to or higher than 341 points** Tasks typically require the use of both generic and more specific technology applications. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g. a sort function) is required to make progress towards the solution. The task may involve multiple steps and operators.

47. CEDEFOP (2018), 'Insights into skills shortages and skill mismatch. Learning from Cedefop´s European Skills and Jobs Survey', *Cedefop reference Series 106*.
48. See footnote 43.
49. OECD (2013), *OECD Skills Outlook 2013 – First Results from the Survey of Adult Skills*, OECD Publishing.

Source, target population and question	Definition of digital competence or digital skills	Definition of skills levels
ICT for work: Digital skills in the work place, digital skills survey[50] **Surveyed** Workplaces on skills needed for a set of specific occupations	**Basic digital skills**	Use a word processor (e.g. Word) Create a spreadsheet (e.g. Excel) Search for, collect and process information using ICT (e.g. online/Internet) Communicate through ICT using email Communicate through ICT using social media, Skype/video calls
	Advanced digital skills	Use software for design, calculation or simulation Programme and use CNC machines Programme and use robots
	Specialist digital skills	Undertake programming and software development Design and maintain ICT architecture for the workplace
Eurostat use of ICT at work[51] **Surveyed** Employed internet users **Question** Which devices used? Which activities performed?	**Using the following at work:** • computers, laptops, smartphones, tablets or other portable devices; • computerised equipment or machinery such as those used in production lines, transportation or other services.	**Performing activities** such as the following: • exchanging emails or entering data in databases; • creating or editing electronic documents; • using specific occupational software in their work; • using applications to receive tasks or instructions in their work • social media for work; • developing or maintaining IT systems or software in their work.
Eurofound European Working Conditions Survey[52] **Surveyed** Employed who used internet in the last 12 months	Use of computers, network, mainframe (2005, 2010) Use of computers, laptop or smartphone (2015)	Intensity is measured as: • all the time • almost all the time • around ¾ of the time • around ½ of the time • around ¼ of the time • almost never • never.

Source: Authors´ own elaboration using the sources referenced.

Throughout the report, a number of 'Methodological notes' are included to warn the reader about the possible misinterpretations when comparing different data analysis results due to these different approaches to defining and measuring digital skills.

Harmonising the different ways to define and measure digital skills would provide clearer and more accurate measurements of the digital skills gap to be addressed, as well as provide more adapted policy responses to reduce it. With that aim, the definition provided by the European Digital Competence Framework, DigComp, could be instrumental.

50. European Commission, DG CNECT, *ICT for work: Digital skills in the workplace*, 2017, prepared by Ecorys and the Danish Technological Institute.
51. Eurostat related dataset. *Use of ICT at work and activities performed*.
52. Eurofound (2017), *Sixth European Working Conditions Survey – Overview report (2017 update)*, Publications Office of the European Union, Luxembourg.

2.2 Different measurement approaches – use of ICT, competence in ICT and access to ICT

Different definitions map to different methods used to 'assign' a specific level of competence to a survey respondent, namely:

- usage levels are used as proxies for competence by Eurostat, CEDEFOP and Eurofound;
- alternatively, specific tests are administered to the respondent (OECD PIAAC).

One could assume that specific tests would provide a more accurate view of the level of the respondent´s competence. Interestingly, an OECD[53] study shows a strong, positive correlation between OECD 'proficiency in problem solving in technology-rich environments (PSTRE)' and Eurostat ICT access and use at country level[54]. An interpretation could be that access to ICT devices and networks makes it possible for adults to use them, and frequent use of ICT is likely to help in developing proficiency in the domain. At the same time, greater proficiency in these skills is likely to encourage more frequent use of ICT, which, in turn, is likely to prompt investments to increase access.

These findings point to **a certain 'equivalence' between these two measurement approaches**.

Furthermore, the same study shows that the proportion of adults who score PSTRE proficiency Level 2 or 3 in comparison to the proportion of households with internet access, by country, suggests that internet access explains about two fifths of the variation in proficiency between countries. The comparison of the proportion of adults who score proficiency Level 2 or 3 compared to the proportion of adults who use emails at least once a month shows that monthly **use of email** accounts for about three fifths of the variation in proficiency between countries. When considering **ICT access and email use together, these variables account for 70% of the variation in proficiency** between countries.

ICT access and ICT use together account for 70% of the variation in digital skills proficiency (PSTRE) between countries. Consequently, **the promotion of increased access to and use of ICT** can be, on its own, a driver for digital skills development.

53. See p. 37 in OECD, *Adults, Computers and Problem Solving: What's the Problem?*, OECD Publishing, 2015.
54. Eurostat, Community Survey on ICT usage in households and by individuals, November 2011. See Tables A2.1 and A2.5, cited in ibid., p. 37.

2.3. Measuring the digital skills gap

Understanding the digital skills gap is a key goal of this report. In that task, we have identified and compared several approaches taken by different data sets and researchers, which we describe here, highlighting their related methodological characteristics and limitations.

2.3.1 CEDEFOP's 1st ESJS Survey

The ESJS[55] survey collected information on the (digital) skill mismatches of adult EU employees.

Survey year: The survey was carried out on 2014, and a second survey has been carried out during 2021, with results planned to be published in 2022.

Focus: The first wave of the survey focused on obtaining deeper understanding of the complexities and drivers of skill mismatch in EU labour markets, for the purposes of informing the EU's vocational education and training, skills and employment agenda.

Target group: Adult employees, of 24-65 years old.

Relevant questions:

- The survey asked respondents to assess the extent to which their own skill level exceeds or lags behind those needed to do their jobs.
- Focusing on ICT skills, the survey asked respondents to provide an assessment of their mismatch, conditional on the level of ICT use (basic, moderate, advanced) in their work.
- The ESJS mismatch questions were phrased on a 0-10 scale, where 0 means that the level of an employee's (digital) skills is a lot lower than required to do the job, 5 matched to what is required and 10 a lot higher than required.

The statistics presented in *Chapter 5.1* show the percentage of respondents (employees) that have responded below 5 to the mismatch questions, per level of ICT use for the job (basic, moderate, advanced).

2.3.2 CEDEFOP's 2nd ESJS Survey[56]

Following an independent evaluation of the 1st ESJS, Cedefop decided to invest in a second wave of the ESJS, with fieldwork that took place in Summer 2021. Following extensive consultation, and to provide answers to ongoing concerns about the 'future of work and skills', it was agreed that the 2nd wave of the ESJS should adopt a stronger focus on the relationship between technological change, digitalisation and the skill mismatch of EU adult workers.

The 2nd ESJS aims to collect comparative information from all EU Member States, plus Norway and Iceland[57] enabling investigation of the impact of digitalisation on workers' skill mismatch[58] and their readiness to adapt to changing skill needs via remedial learning practices[59].

55. CEDEFOP (2017), The great divide, Digitalisation and digital skill gaps in the EU workforce, #ESJsurvey INSIGHTS No 9, Thessaloniki: Greece.
56. Source: Background Info 2nd European Skills and Jobs Survey, internal CEDEFOP document
57. In collaboration with Cedefop, the 2nd wave of the ESJS will also be carried out in 2022 in six Western Balkan countries and Israel by the European Training Foundation (ETF), hence providing a first comparative perspective on the digital skill demands of EU accession or partner countries.
58. E.g. mediated via its impact on workers' job tasks and skill needs.
59. Within the context of their organisational learning environment e.g. managerial and employee agency concerns, workplace practices, job performance incentives etc.

Innovations/changes in the 2nd ESJS questionnaire

The 2nd ESJS focuses on measuring:

- what EU+ adult workers do at work, namely the main tasks they carry out and by extension the level of literacy/numeracy/manual/interpersonal skills/problem-solving required by their jobs;
- the level of digital skills required for the (new) digital technologies they use, if any;
- the extent to which EU adult workers are exposed to technological change in their jobs;
- the extent to which exposure to digitalisation is associated with vertical or horizontal qualification mismatches, digital and other skill gaps of adult workers;
- the training received and skills developed to cope with (new) workplace demands.
- Specific questions have been added to measure the impact of the Covid-19 pandemic on work and learning behaviour.

Technologies/digitalisation at work

- More thorough coverage of the **level of digital technologies used at work** adopting a task-based approach e.g. use of computer devices/ software for writing emails / using word processors / spreadsheets / database management / coding at work etc.
- Understanding of **digital skill level of non-users of ICT at work**;
- Understanding of the level of digital skills associated with **both computer software and computerised machinery/equipment at work**;
- More thorough coverage of **incidence of new digital technologies introduced in workplace** as well as recent **changes to digital technologies (computer software or computerised equipment) used at work** at both the workplace and individual-job level.
- Specific measures of **learning and training times for major new technologies** in the workplace → proxy of level of **digital skill complexity**.
- **Incidence of use of AI methods at work**.
- Use of ICT methods for **working remotely**.

Automation

- Whether new digital technologies are perceived as realistic **threats to job security**?
- Whether new digital technologies are likely to make some of worker's **skills outdated**?
- If workplaces that saw new digital technologies being introduced are also associated with **diminishing staffing numbers**.

Job-skill requirements

- More thorough coverage of the **tasks and skill needs within jobs**, inspired by the Autor et al. (2003) task-based framework and using the STAMP survey (Handel, 2016) (i) foundation tasks (ii) problem-solving tasks (iii) inter-personal skills (iv) physical/manual tasks (v) routine/non-routine tasks.
- Changes in tasks and skill needs within jobs in last year.

Skill formation and mismatch

- **Qualification mismatches** (vertical and horizontal)
- Focus on **workers' perceptions of digital and non-digital skills adequacy/gaps**.
- Enhanced and improved questions on **recent training** (non-formal and informal) and remedial skills formation, with emphasis on use of online learning and accreditation.

Changing nature of work

- More thorough coverage of **incidence and recent changes in work organisation** (monitoring, autonomy, routineness, work intensity).

Data will start to be released in 2022.

2.3.3 Eurostat ICT use at work dataset

Survey year: Eurostat ICT use at work dataset[60] was collected in 2018, which included 'Use of ICT at work and activities performed' and 'Impact of ICT on tasks and skills'.

Target group: It includes data for:
A. Individuals who, at work, use any type of computers, portable devices or computerised equipment or machinery
B. Employees and self-employed who used internet within the last year.

The target group A is quite comparable with ESJS' sample of employees, which included all employees needing some level of ICT skills.

Relevant questions: It includes a set of questions related to the impact of ICT on tasks and skills:
- Individual's **main job tasks changed** as a result of the introduction of new software or computerised equipment
- Individuals **had to learn** how to use new software or computerised equipment for the job
- Individuals **needed further training** to cope well with the duties relating to the use of computers, software or applications at work
- Individuals' **skills correspond well** to the duties related to the use of computers, software or applications at work
- **Time spent on acquiring new skills** needed for work has **increased** because of the use of computers, laptops, smartphones or other computerised equipment
- Time spent on acquiring new skills needed for work has **decreased** because of the use of computers, laptops, smartphones or other computerised equipment
- Time spent on acquiring new skills needed for work **has not changed** because of the use of computers, laptops, smartphones or other computerised equipment

60. isoc_iw: see 'Use of ICT at work and activities performed' at https://ec.europa.eu/eurostat/databrowser/view/ISOC_IW_AP/default/table?lang=en&category=isoc.isoc_i.isoc_iw; and 'Impact of ICT on tasks and skills' at: https://ec.europa.eu/eurostat/databrowser/view/ISOC_IW_IMP/default/table?lang=en&category=isoc.isoc_i.isoc_iw

2.3.4 OECD PIAAC Adult Skills Survey and Pellizzari et al. analysis

Pellizzari et al. (2015)[61] have analysed the skills mismatch using OECD PIAAC Adult Skills Survey data for the 12 countries of the European Union participating in the programme in the first round (2012), plus the US.

Survey year: Carried out in two rounds in 2012 and 2014 in different sets of countries.

Target group: The dataset includes [only] employees that require some degree of ICT skills to do their job.

The dataset used includes only those test scores of individuals who could do the online test, excluding individuals who could not do the online test (because they never used a computer or did not pass the core ICT test) or opted-out of taking the computer-based assessment choosing the paper based option. The share of PIAAC respondents not taking the ICT module ranged from around 10% in the Netherlands and Sweden to 38% in the Slovak Republic and 36% in Poland.

Relevant questions: On the adequacy of ICT skills for work, the OECD survey's background questionnaire includes two questions asked to all workers who had used a computer in their current or previous job.

- The first asks whether the respondent "has the computer skills needed to do [his/her] job well" and
- The second asks whether "a lack of computer skills affected your chances of being hired for a job or getting a promotion or pay raise".

Both of these questions involve self-reported and subjective judgements, which might be influenced by cultural factors.

The analysis from Pellizzari et al. (2015), extending the methodology developed in Pellizzari and Fichen (2013, cited in Pellizzari et al. (2015)), explored a more sophisticated analysis of the measures of skills mismatch, to counter for the subjectivity related to these two questions.

In their work, they define every worker as well-matched if his/her ICT skills fall in between the minimum and maximum requirement of the occupation in which he/she is observed, as under-skilled if they fall below the minimum and over-skilled if they are above the maximum.

61. Pellizzari, M., Biagi, F. and Brecko, B. E-skills Mismatch: Evidence from PIAAC. Institute for Prospective Technological Studies Digital Economy Working Paper 2015/10. JRC98228.

3. Analysis of skills supply

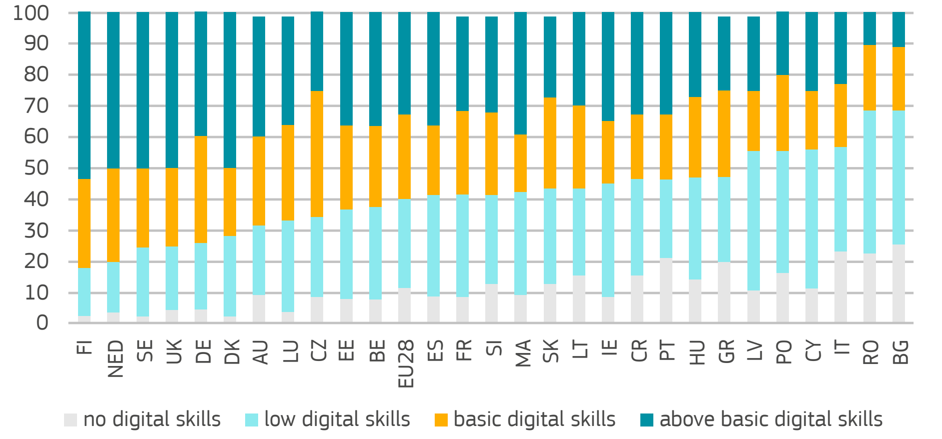
In this section we analyse the Digital Skills Indicator derived from the Eurostat survey on ICT usage in households and by Individuals, and OECD PIAAC Adults Skills Survey data to understand key groups of individuals of working age which have the lowest levels of digital skills, and hence those requiring greater attention from skilling policy actions. The use of two sources of data will allow for the comparison of data and, therefore, validation of these key groups. As a result, 8 groups (G1 to G8) of individuals emerge requiring policy attention, presented in *Section 3.4 Summary of findings on priority groups from a skills supply perspective*.

3.1 Analysis of the Eurostat's Digital Skills Indicator (DSI)

The Eurostat survey provides the most recently available statistics on the digital skills of European citizens, under the Digital Skills Indicator (DSI) for the year 2019. The figures below present the percentage of 'Individuals with no or below-basic digital skills and who did not used the computer in the last 3 months [prior to the survey]'[62]. See Table 2.1 for a detailed definition of the Eurostat DSI.

In 2019[63], **40% of individuals 25-64 years old** (as a proxy for the working age population) **had below-basic skills** (that is, the sum of those with ´no digital skills´ and those with ´low digital skills´). The following figure shows the distribution of digital skills levels of the 25-64-year-old individuals per country.

Figure 3.1. Digital skills of individuals 25-64 years old, per skill level and country, 2019



Source: Authors´ own analysis of Eurostat survey data for 2019.

There is a huge difference between countries. Finland and the Netherlands on one hand have 17% and 19%, respectively, and Bulgaria and Romania on the other hand have 69%. Similarly, there are key differences between countries in the share of individuals with above-basic digital skills, varying from 10% and 11% of individuals in Romania and Bulgaria, respectively, to 54% in Finland and 50% in the Netherlands, Sweden, the UK and Denmark. At the same time, the share of individuals with basic digital skills is more homogeneous across countries, varying from 19% in Malta and Cyprus to 34% in Germany and 41% in Czech Republic.

62. Indicator DESI_2A2_BDS that is collected in the Eurostat survey.
63. Eurostat bookmarks – Database, Skills analysis per socio-demographic variables, Country analysis. Extracted in May 2020.

Socio-demographic characteristics of the individuals with below-basic digital skills

The analysis (which details, including cross-country comparisons, can be found in Annex 1) of the 40% of 25-64-year-olds with below-basic digital skills per some socio-demographic variables shows the following conclusions:

- An average of **10%** of adults of 25-64 years old **did not use internet** in the last three months, prior to the survey, ranging from 1-2% in Sweden, Finland, Denmark, and Luxemburg to 22-25% in Romania and Bulgaria.
- When considering **age**, 18% of young people of 16-24 years old have below-basic skills. For this age group, if we consider **education level**, we identify that **almost a quarter of young people with low education levels** have below-basic skills (Group 1).
- An EU-28 average of **58% of 55-64-year-olds** have below-basic skills, ranging from 30% in Finland to 80% in Romania and Bulgaria, respectively (Group 2). Among those in this group, an average of **21%** of the individuals **did not use the internet** in the last 3 months prior to the survey.
- The level of digital skills is also associated with the **education level**, with **76% of low-level educated individuals of 25-64 years old** having below-basic digital skills , ranging from 46% and 99% across countries, except for Finland which level is 34%. **45% of those with a moderate formal education level have below-basic digital skills**. Both groups of low and medium level educated individuals appear as relevant priority groups (Groups 3 and 4, respectively).
- The analysis of **employment statuses** shows that an EU-28 average of **55%** of those **unemployed** and an average of 67% of those **inactive due to other reasons** have below-basic digital skills (becoming relevant Groups 5 and 6 needing attention).
- As much as 64% of **nationals of non-EU countries** (Group 7) have below-basic digital skills, with a 23-percentage-point difference to national individuals. However, uneven country patterns point to the need for additional country and contextual analysis to identify more precise target groups (for example per country of origin, gender, age, etc).
- Another relevant group of individuals relates to **those living in rural areas** (Group 8), with half of them (51%) having below-basic digital skills, 16% more than those living in urban areas.
- An analysis of the individuals by **income** quartile level shows that 60% of those **living in households in the first income quartile** (Group 9), and 51% of those living in a household in the second income quartile (Group 10), have below-basic digital skills.

Additional analysis of other socio-demographic characteristics showed small (0-3%) differences in the percentage of the population with a below-basic digital skills level with regards to **gender**, **full-time or part-time contracts** and **workers with permanent vs temporary contracts**.

In Table 3.1 below, we summarise the key findings of the priority groups, noting that for Group 7, nationals of non-EU countries, additional contextual analysis would be required.

Table 3.1. First summary of priority groups, based on the Eurostat DSI 2019 data analysis

Group	Factor	Characteristics	Eurostat DSI 2019 Below-basic skills	Eurostat DSI 2019 Did not use internet in the last 3 months prior to the survey
G1	Age & Education level	**Young** 16-24 years old, with **low-level formal education**	24%	
G2	Age	Individuals **55-64 years old**	58%	21%
G3	Education level	Individuals 25-64 years old **with low-level formal education**	76%	
G4	Education level	Individuals 25-64 years old **with medium-level formal education**	45%	
G5	Employment status	Individuals **unemployed**	57%	
G6	Employment status	Individuals **inactive**	67%	
G7	Nationality	Nationals of **non-EU countries**	64% (Additional contextual analysis would be required).	
G8	Place of living	Individuals living in **rural areas**	51%	
I1	Income level	Individuals living in households in the **1st income quartile**	60%	
I2	Income level	Individuals living in households in the **2nd income quartile**	51%	

Source: Authors´ elaboration

In the following Sections 3.2 and 3.3, an attempt is made to identify more accurately groups of individuals who have specific combinations of characteristics and have no computer experience or low-level digital skills using OECD PIAAC Adult Skills Survey data.

3.2 Analysis of OECD PIAAC Adult Skills Survey dataset – no computer experience

3.2.1 Introduction to the OECD PIAAC Adult Skills Survey assessment of problem solving in technology-rich environments (PSTRE)

The 2012 Survey of Adult Skills (16-65 years old), part of the OECD Programme for the International Assessment of Adult Competencies (PIAAC), includes an assessment of problem solving in technology-rich environments (PSTRE). This assessment measures the ability of adults to solve the types of problems they commonly face as ICT users in modern societies. The survey also collects information on the frequency with which adults use different types of ICT applications, both at work and in their daily lives[64].

The definition of ICT skills and the different proficiency levels in this survey are presented in Table 2.1 of Chapter 2. The PSTRE test was administered only to those respondents who (a) had at least some computer experience; (b) passed the core ICT test; and (c) did not opt out of executing the test using computers. Possible individual scores of those who passed the PSTRE test range from 0 to 500.

The PSTRE domain of the Adult Skills Survey covers a specific class of problems related to ICT that share the following assumptions: the availability of new technologies creates a new problem; to solve the problem, a person has to be able to use computer-based artefacts (applications, representational formats, computational procedures); these new problems are related to the handling and maintenance of 'technology-rich environments' themselves (e.g. how to operate a computer, how to fix a settings problem, how to use the internet browser in a technical sense). PSTRE thus represents a combination between 'computer literacy' (i.e. the capacity to use ICT tools and applications) and the cognitive skills (literacy and numeracy) required to solve problems, which will have an implication on the interpretation of the results with regard to digital skills.

In Sections 3.2 and 3.3, authors provide an analysis of adults with no computer experience and of PSTRE scores per socio-demographic characteristics.

64. The first survey was conducted in 2011-2012 in 24 countries, out of which 16 were from the EU-27. Out of these, only 12 participated in the optional problem-solving assessment: Austria, Belgium (Flanders), Czech Republic, Denmark, Estonia, Finland, Germany, Ireland, the Netherlands, Poland, the Slovak Republic and Sweden. The second round was carried out in 2014 in 9 additional countries, including Greece, Lithuania and Slovenia from the EU-28. Some of the analyses cover only the first round of countries (published by the OECD (2015), and also in Pellizzari et al. (2015)) and additional analyses carried out by the authors also include the second round of countries.

3.2.2 Analysis of adults with no computer experience, per education level and age

The variable 'computer experience' is analysed in relation to various socio-demographic characteristics of those not using computers. This group, together with those who failed the core ICT test and those that opted out of executing the test using computers, are excluded from the PSTRE dataset[65].

Figure 3.2 below presents the percentage of respondents with no computer experience by EU country, which shows a higher variation between countries, in particular, compared to the proficiency in PSTRE, from 2% of the population aged 16 to 65 in Sweden to 24% in Italy with an average of 12.5% across the EU participating countries. This country variation is in line with Eurostat DSI data analysed in Section 3.1.

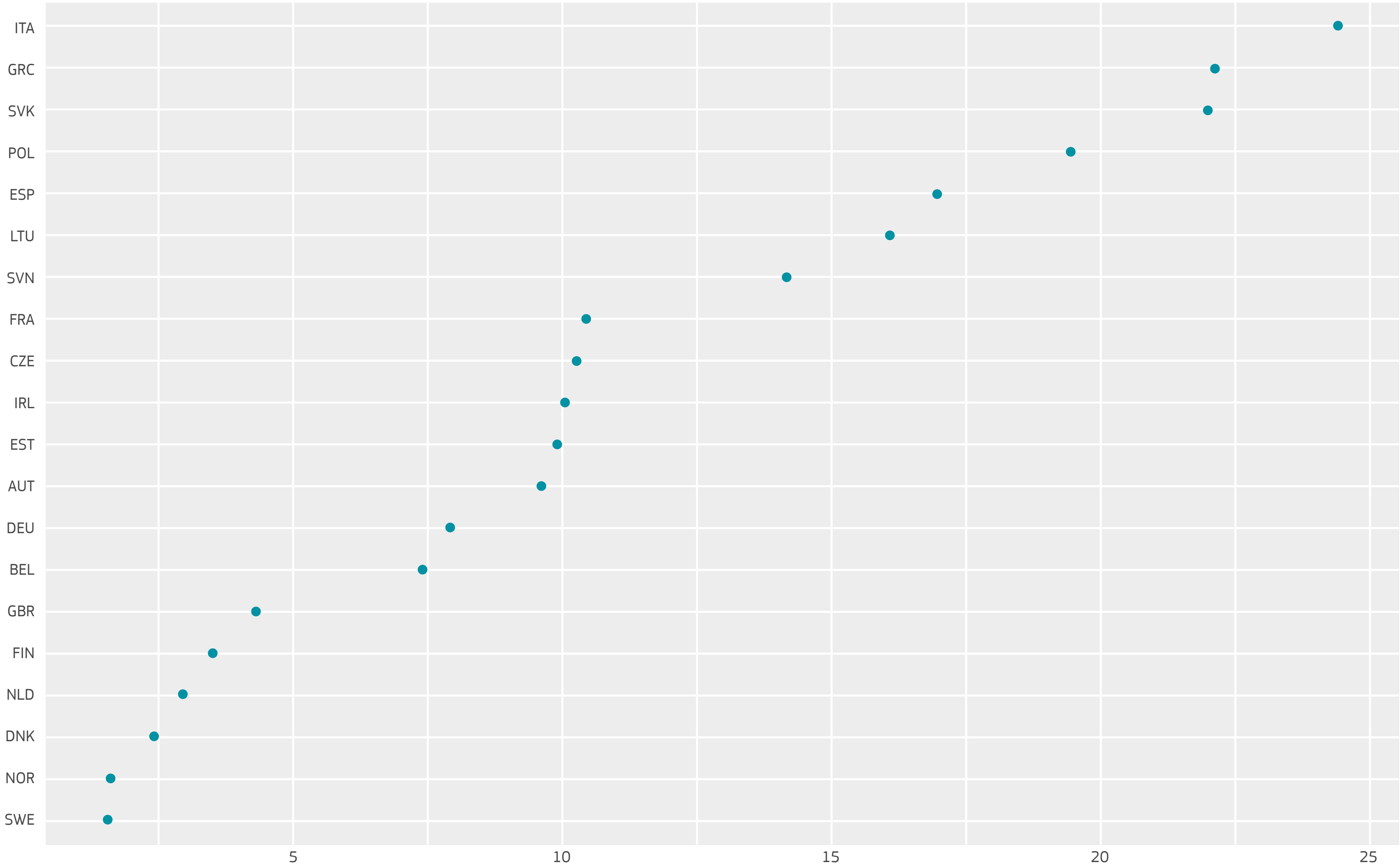
There is a high level of variation between countries in the percentage of individuals with no computer experience (more than 20%), and higher compared to the proficiency in PSTRE.

Figure 3.3 shows a more detailed analysis of the percentage of individuals with no computer experience per EU country, age and education level. This graph shows consistent effects for age and education. The percentage of those with no computer experience increases with age and decreases with education. What is more, age appears to have a different effect on the probability of no computer experience depending on the education level: we can see that the effect is particularly strong in the lowest educational category.

The combination of age and education points to the age groups of +45 years old with low and medium education level as the most vulnerable, with regards to individuals with no computer experience.

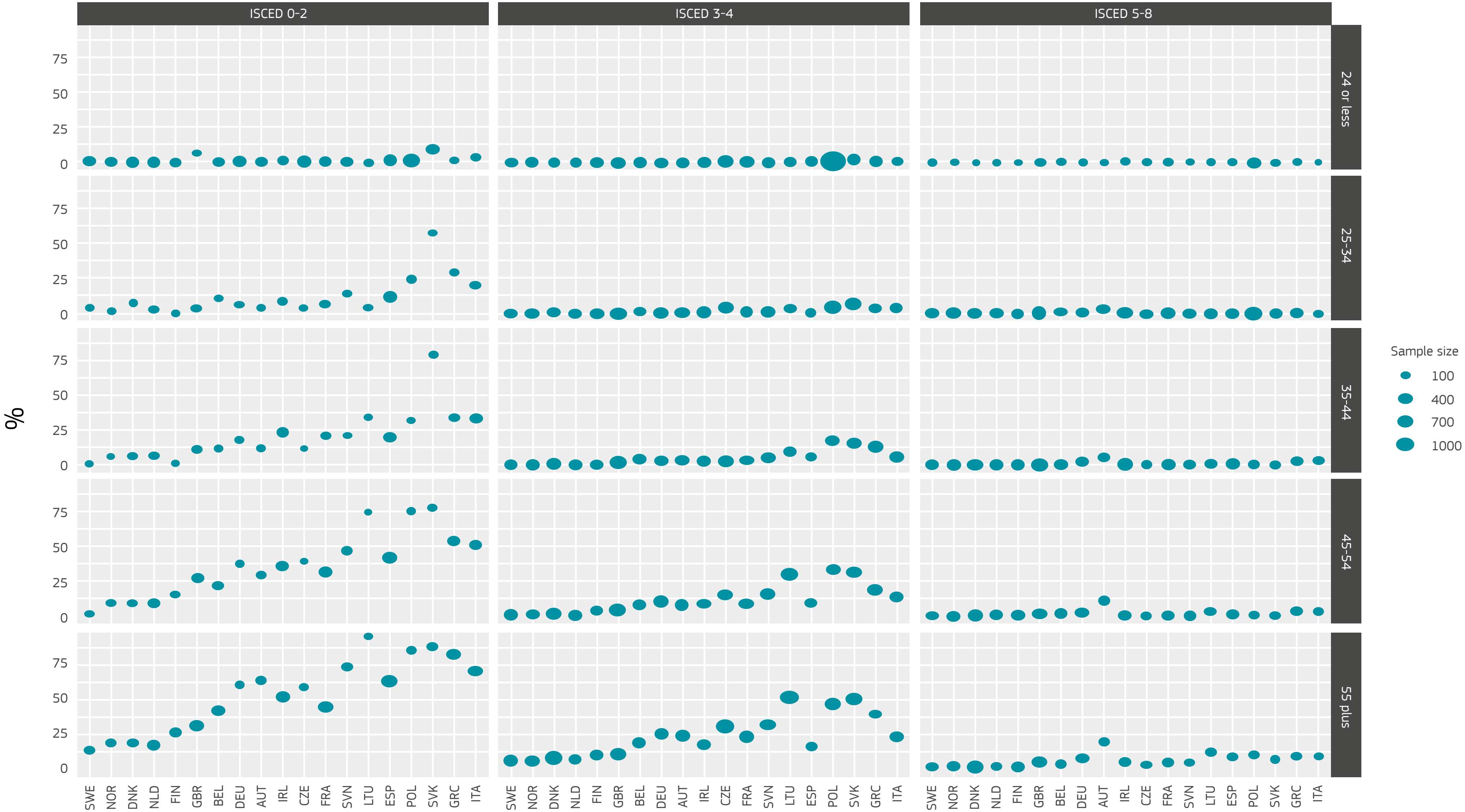
65. The share of respondents who failed the core ICT test and those who opted out of taking the computer-based test depended on local procedures used to administer the test, and may not reflect the real share of adults with no ICT skills. These are thus excluded from this analysis. OECD (2015), pp. 31-32.

Figure 3.2. Percentage of individuals with no computer experience, by country



Source: Authors´ analysis of the OECD PIAAC Adult Skills Survey, including countries participating in the first (2012) and second (2014) rounds.

Figure 3.3. Percentage of individuals with no computer experience by country, education level and age



Note: Countries are ordered with respect to overall percentage with no computer experience

Source: Authors´ analysis of the OECD PIAAC Adult Skills Survey, including countries participating in the first (2012) and second (2014) rounds.

3.2.3 Analysis of adults with no computer experience, per employment status

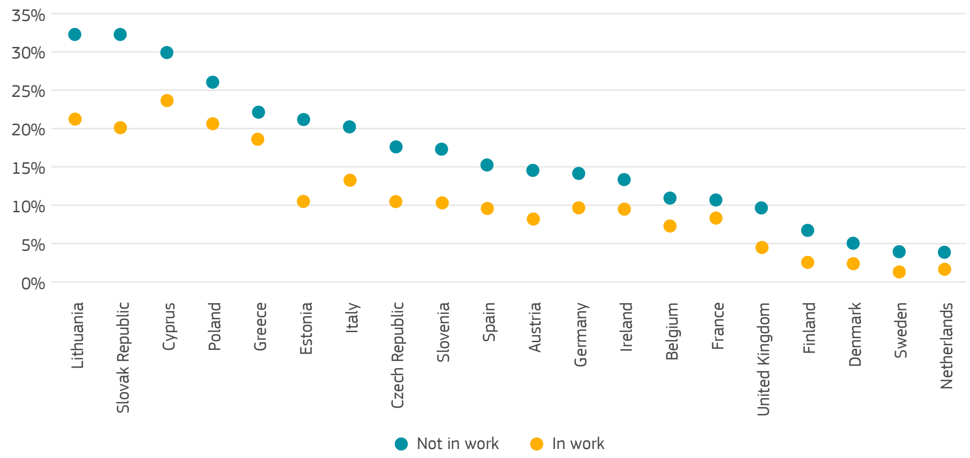
In this section we perform an analysis of the 12.5% of the total sample (see countries in Figure 3.2) that lacks any computer experience by employment status.

Figure 3.4 on the right shows the adjusted predicted probability of having no computer experience by country for people who are in work (employee or self-employed) and those who are not (either unemployed or inactive), after controlling for relevant socio-demographic factors: gender (being female); age (in 5 categories, where age 16-24 is the baseline); migrant status; education (high, medium, low, where low is the baseline); being single; and being a NEET (aged 16-35 not in employment, education or training).

Firstly, we observe that the probability of having no computer experience is higher for people who are not in work across all countries. Secondly, the difference between those in work (employed or self-employed) and those out of work (retired, unemployed, student or doing unpaid household work) becomes more pronounced as the proportion of people with no computer experience (which we can read as a proxy for computer illiteracy) increases.

Across all participating countries, those **out of work** have a **higher probability (vs. those in work) of having no computer experience**, and the difference is more pronounced as the percentage of people with no computer experience increases across countries.

Figure 3.4. Adjusted probability of having no computer experience – by people in work or not in workage



Source: Own elaborations using PIIAC data; chart shows marginal effect after probit regression where having no computer experience is the dependent variable and being in work is a regressor interacted with country dummies; the binary variable in work is equal to 1 if the respondent is employed or self-employed, and 0 if the respondent is retired, unemployed, a student or doing unpaid household work. Other control variables include: gender (being female); age (in 5 categories, where age 16-24 is the baseline); migrant status; education (high, medium, low, where low is the baseline); being single; and being a NEET (aged 16-35 not in employment, education or training).

Figure 3.5 below provides an analysis of the share of individuals with **no computer experience** per country, age, education level and employment status for EU participating countries[66].

The figure shows that as, for employment status, **inactive individuals** (i.e. out of the labour market) appear to be more at risk of having no computer experience, this primarily applies to those in the **lowest and middle education categories**.

The analysis of age, education and employment status across countries shows that the combination of **being inactive with low and medium education levels** provides the highest risk of having no computer experience.

Complementary results are provided by the regression analysis (reported in Table A2.1, in Annex 2) showing that the **stronger predictors of having no computer experience are age** and **education**.

In addition, complementing the results observed earlier in Section 3.2.2 (which pointed at the age groups of +45 years old with a low education level as most vulnerable), the analysis combining employment status with age and education, shows: a) that **the impact of age is somewhat mitigated by being in work** and that b) **the association of low-level education and no computer experience remains rather strong, even for workers**. As we have already seen in Figure 3.5 below from the descriptive statistics, the proportion of older people employed with low-level education and no computer experience is as high as 75% in some Member States.

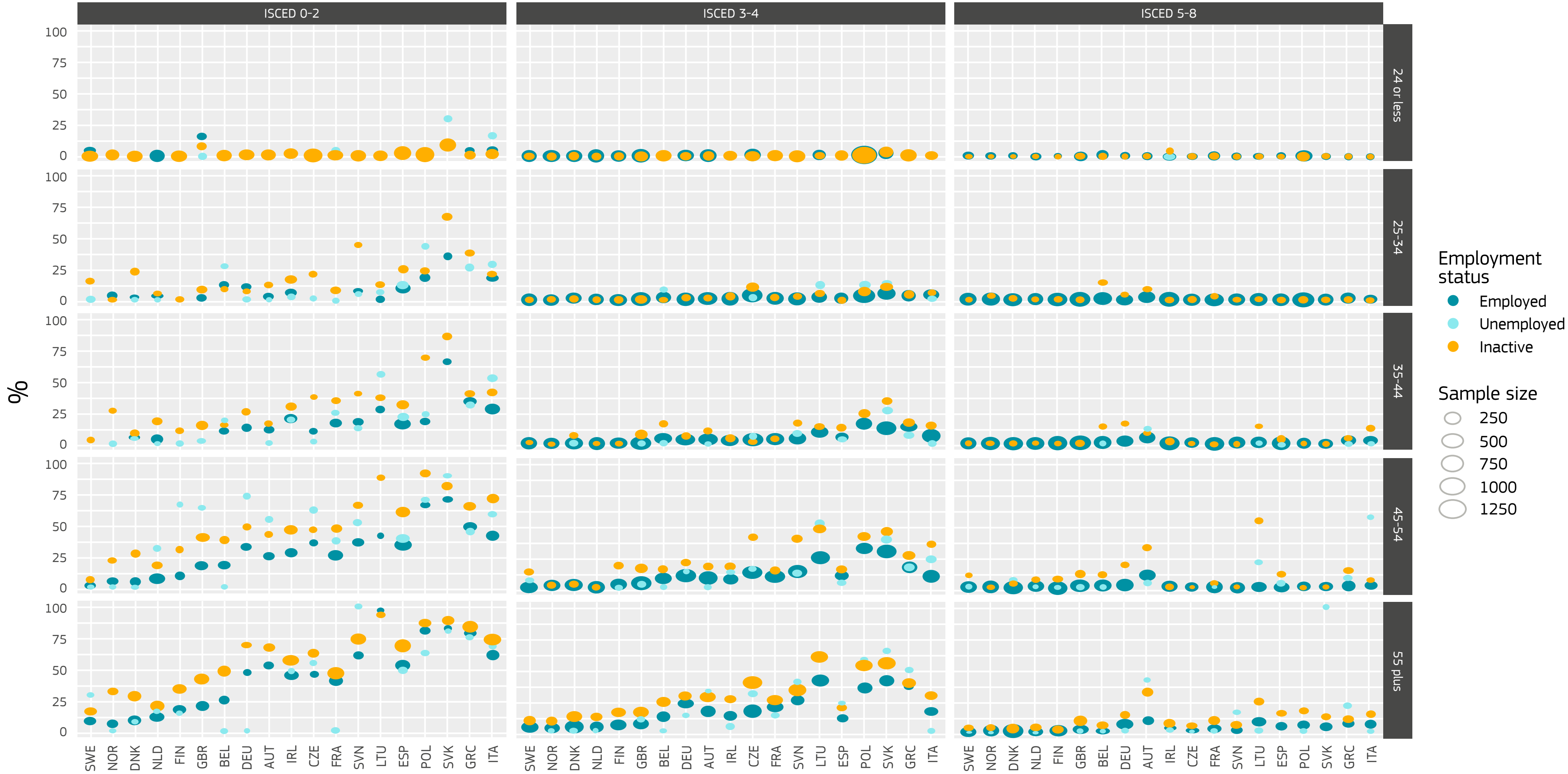
From the above results we could conclude the following, with regards to individuals with low computer experience:

For those out of work, individuals **aged 45 and above and with low or medium-level education** have a high probability of having no computer experience.

For those in work, the effect of increased age is mitigated by being in work, but **low-level education** remains a strong predictor of no computer experience.

66. Note that the figure illustrates that, in spite of a break down by many different criteria, the sample sizes are still reasonable to make valid inferences.

Figure 3.5. Percentage of individuals with no computer experience by country, age, education level and employment status



Note: Countries are ordered with respect to overall percentage with no computer experience

Source: Authors´ analysis of the OECD PIAAC Adult Skills Survey, including countries participating in the first (2012) and second (2014) rounds.

3.2.4 Analysis of adults with no computer experience – other variables

The regression analysis (reported in Table A2.1, in Annex 2) shows that **gender has no impact on having no computer experience** (once we take other variables into account).

Other demographic characteristics also show an association with the lack of computer experience, but the magnitude is smaller if compared with age and education. For instance, **migrants** are 4 percentage points more likely to lack computer experience (3.6 percentage points if they are in work); **people who are not part of a couple** (i.e. singles, divorcees or widowers) are about 1.7-1.4 percentage points more likely to lack computer experience. Lastly, young people (aged 16-34) not in employment, education or training (**NEETs**) are 2.5 percentage points more likely to lack computer experience, but in this case, the relationship is statistically weak.

If we focus on the sub-sample of **workers**, we find that the **economic sector** (public, private or non-profit), the **type of contract** a person has and the **size of the firm** in which they work are often highly associated with a lack of computer experience, but with a minor difference.

3.3 Analysis of the OECD PIAAC Adult Skills Survey dataset – PSTRE scores

3.3.1 Analysis of PSTRE, per socio-demographic characteristics

The variable 'proficiency in problem solving in technology-rich environments (PSTRE)' is analysed in relation to various socio-demographic characteristics[67]. The below Figure 3.6 illustrates how the country average scores on PSTRE vary per country, **education and age** for participating EU countries[68].

Firstly, it is worth noting that although countries differed remarkably in terms of a lack of basic computer experience, as illustrated above in Section 3.2.2, the level of more advanced ICT skills (among those who have at least basic skills) appears to be much closer between countries.

Secondly, the analysis[69] of the below figure provides some more detailed understanding of how these three variables (country, education and age) influence when analysing them together:

- PSTRE scores are related to **education** in the sense that people with higher education score higher on PSTRE than people with lower education. This is particularly clear **for those aged** 25 or over. In **the youngest age group, differences by education level are much less pronounced**;
- PSTRE scores are related to **age** in the sense that scores are lower, on average, for people in older age groups.

As for gender, men score slightly higher than women, but the difference is very small in absolute terms and it depends on age and education.

While not carried out by the authors, the OECD regression analysis of the variable 'proficiency in problem solving in technology-rich environments' concludes that socio-economic status (using parents´ education level as a proxy) is weakly related to the probability of performing at level 2 or higher in PSTRE. An interpretation of these findings is that education has an influence on the socio-economic status, and thus this latter variable is somewhat embedded in education.

Education level affects people's score on PSTRE, in particular **for those aged 25 or over**.

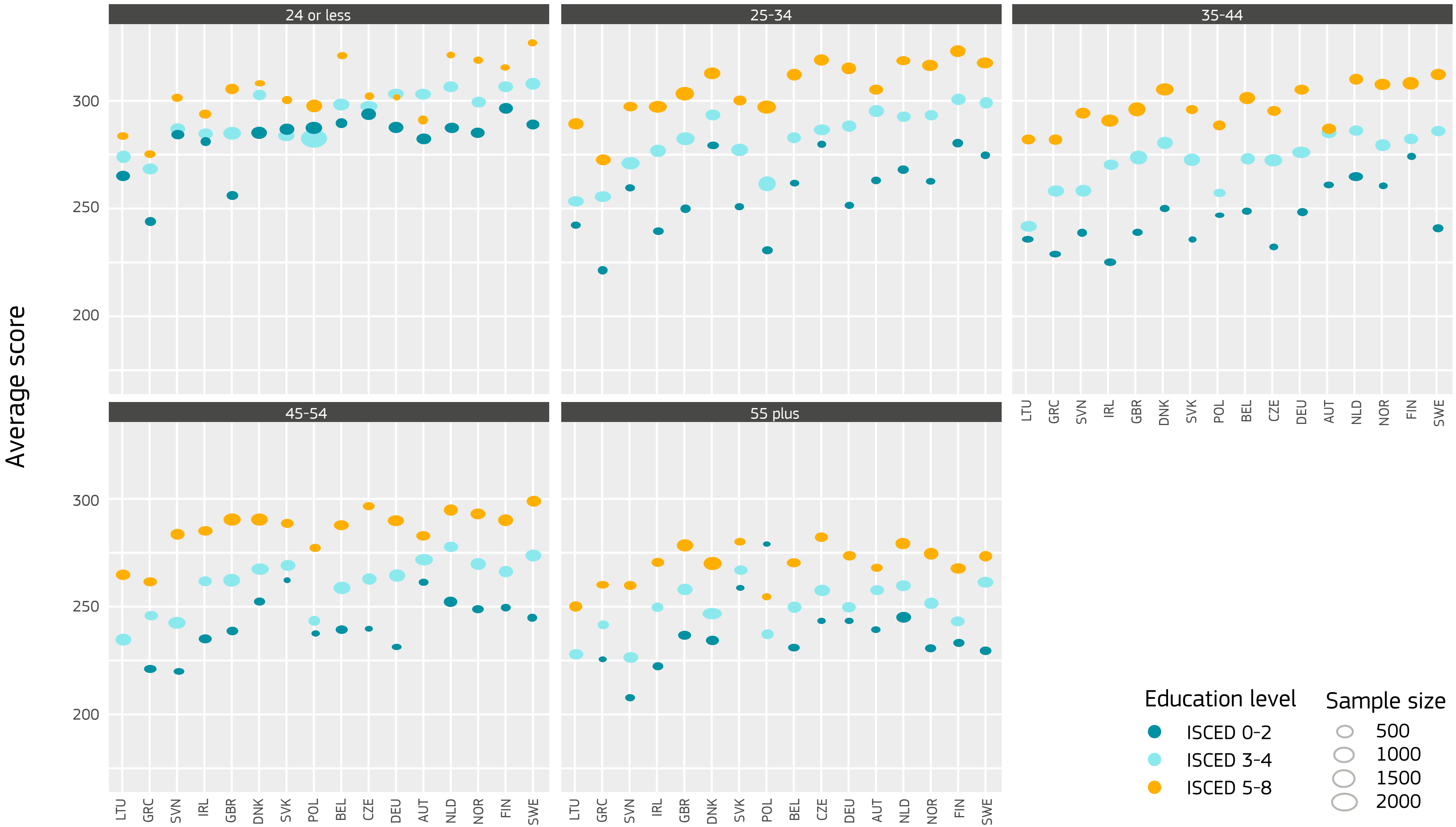
Age affects PSTRE scores in the sense that people in older age groups score lower.

Gender and socio-economic status are weakly related to PSTRE scores.

These findings are relevant to the previously identified groups, confirming G2, G3 and G4 of Table 3.1 in Section 3.1, and suggesting that **I1 and I2 are less relevant to practical policy action.**

67. Guided by previous research in OECD (2105), that identified that six characteristics are strongly related to the probability of being highly proficient (Level 2 or 3) in PSTRE and computer use: being highly proficient in literacy, being younger, having a parent with tertiary qualifications (used as a proxy for socio-economic status), having tertiary qualifications oneself, using emails at least once a month (used as a proxy for being a regular user of ICT) and participating in adult education and training.
68. Note that the figure illustrates that, in spite of a break down by many different criteria, the sample sizes are still reasonable to make valid inferences.
69. The detailed statistical analysis results are provided in Annex 2.

Figure 3.6. Problem solving in technology-rich environments by country, education and age



Source: Authors´ analysis of the OECD PIAAC Adult Skills Survey, including countries participating in the first (2012) and second (2014) rounds.

3.3.2 Analysis of PSTRE, per employment status

The analysis of Eurostat DSI data on below-basic digital skills of those in the labour force (employed vs unemployed) analysed in Section 3.1 showed relevant differences, pointing to employment status as a predictor for digital skills, and identifying two relevant priority groups (G5 : unemployed and G6 : inactive individuals).

In most countries participating in the OECD PIAAC survey, workers who were employed at the time of the survey or who had worked in the 12 months prior to the survey were 14% more likely than non-workers to perform at Level 2 or 3 in the assessment of PSTRE (with 37% vs 24% of adults)[70].

Additional analysis of the OECD PIAAC data showed that for those who are employed, no consistent pattern is observed regarding **contract type** (permanent, fixed-term or other) and PSTRE scores.

Employment status remains a predictor of higher PSTRE scores, in the sense that employed individuals are more likely to score higher.

3.3.3 Analysis of PSTRE, per occupational skills

Different occupations require different levels of skills. They also provide different opportunities to exercise and develop skills. For both reasons, there is likely to be an association between occupation type and proficiency in problem solving using ICT. Within OECD participating countries and among those respondents who provided information about their occupation, the OECD Adults Skills Survey reports that 39% of adults are in skilled occupations; 28% are in semi-skilled, white-collar occupations; 21% are in semi-skilled, blue-collar occupations; and 9% are in elementary occupations[71].

Differences in proficiency related to occupation examined[72] by comparing adults employed in skilled and elementary occupations provide the following: across OECD countries, 50% of adults in skilled occupations are proficient at Level 2 or 3 on the PSTRE scale compared to only 20% of adults in elementary occupations, a difference of 30 percentage points[73]. This difference ranges from 21 percentage points in Poland to 40 in the United Kingdom. Across countries, only 1% of those adults employed in skilled occupations lacked computer experience compared to 17% in elementary occupation.

Occupation type (skilled, semi-skilled, elementary) of those employed affects significantly PSTRE scores, and the probability of lacking computer experience.

70. OECD (2015), *Adults, Computers and Problem Solving: What's the Problem?*, OECD Skills Studies, OECD Publishing, Paris. Table A4.1.
71. Ibid, p. 58.
72. Ibid, p. 58.
73. Ibid, Table B4.1

3.3.4 Analysis of PSTRE score and labour market outcomes

In this section we assess the relation between labour market variables and the PSTRE score as the most interesting differences between the variables affecting computer experience (linked to basic ICT literacy) and more advanced ICT skills (measured by the PSTRE score) are related to **the labour market variables**.

First of all, young people not in employment, education or training (NEETs) are significantly less skilled than their counterparts – young people in education or training[74].

NEETs are significantly less skilled than their counterparts, i.e. young people in education or training.

Secondly, while people in work are significantly less likely to lack computer experience (hence having higher basic ICT literacy), they have a lower PSTRE score on average. The difference in score is very small and tends to be zero in a few countries, but it is, nonetheless, an interesting finding as it suggests that **computer experience is what really matters for labour market outcomes (being at work and wages)**.

This is confirmed by the OECD analysis[75], showing that adults who lack computer experience are less likely to participate in the labour force and are paid lower wages than those who have experience with computers. In addition, adults who use email at least once a month at home are more likely to participate in the labour force, and those who use email at least once a month at work are paid higher wages, showing a **clear link between work and computer use**.

Computer experience, and not the level of ICT skills, is what really matters for labour market outcomes (being at work and wages). This finding suggests that policy actions promoting (general) ICT use could be supportive to the employability and labour market outcomes of individuals.

Another difference is that people employed in the **public sector** appear to have, on average, a lower PSTRE score even though they are less likely to lack basic computer experience; but again, the impact is tiny (-2.1). When it comes to **firm size**, results suggest that people employed in larger firms (more than 1 000 employees) have higher PSTRE skills on average.

74. The counterparts to NEETs are young people in education or training, since we control for being employed.
75. OECD (2015), *Adults, Computers and Problem Solving: What's the Problem?*, OECD Skills Studies, OECD Publishing, Paris, p. 74

3.4 Summary of findings on priority groups from a skills supply perspective

These results provide the conclusions on priority groups for digital skilling actions, per socio-economic characteristics, identified through the combined analysis of Eurostat DSI data and OECD PIAAC data.

Table 3.2. Second summary of priority groups

Group[(1)]	Factor	Characteristics	Eurostat DSI 2019 Below-basic skills	Notes from the PIAAC analysis of survey data and PSTRE scores	Eurostat DSI did not use internet / PIAAC no computer experience	Lower digital skills / PSTRE score
G1[(2)]	Age & Education level	**Young** 16-24 years old, with **low-level formal education**, and **NEETs** (aged 16-35 not in employment, education or training)	24%	Differences in PSTRE related to education level seem less pronounced for this age group (*1) **NEETs** less skilled than their counterparts, i.e. young people in education or training		Y
G2	Age	Individuals **55-64 years old**	58%	Effect of age confirmed	21% / Y	Y
G3	Education level	Individuals 25-64 years old **with low-level formal education**	76%	Most vulnerable group, wrt no computer experience. Effect of education in this age group confirmed.	Y	Y
G4	Education level	Individuals 25-64 years old **with medium-level formal education**	45%	Vulnerable group, wrt no computer experience, in particular for those +45 years. Effect of education in this age group confirmed.	Y (in particular for those +45 years)	Y
G5	Employment status	Individuals **unemployed**	57%	Vulnerable group wrt no computer experience. Effect of being out of work on lower PSTRE.	Y	Y
G6	Employment status	Individuals **inactive**	67%	Vulnerable group wrt no computer experience. Effect of being out of work on lower PSTRE confirmed.	Y	Y
G7	Nationality	Nationals of **non-EU countries**	64% (Additional contextual analysis would be required).	Differences for migrants are not significant.	Not analysed	Y
G8	Place of living	Individuals living in **rural areas**	51%	N.A.	Not analysed	Y
G9	Employment status & occupation type	Individuals **employed in semi-skilled and low-skilled occupations**		Relevant groups scoring lower in PSTRE and among **those with no computer experience.**	Y	Y

(1) Groups I1 and I2, Individuals living in households in the 1st and 2nd income quartile have been discarded.
(2) For G1, a different result than that of Eurostat is found using PIAAC data. Given the methodological differences of the two datasets, the authors consider it wise to maintain this group as a policy target, suggesting further research.

4. Analysis of labour digital skills demand, ICT use at work

In this section we summarise the findings of different sources of data that document the demand for digital skills at work and, where available, per sector and occupation. For this purpose, complementary analyses are presented: results of individual surveys collecting use of ICT for work (CEDEFOP European Skills and Jobs Survey, Eurostat ICT use at work Survey, Eurofound Working Conditions Survey), a qualitative analysis and an ad-hoc survey of enterprises of the usage of ICT for work[76], and some complementary prospective analyses aiming at providing forecasts for skills demand in different sectors carried out by CEDEFOP and the OECD. The analysis points to new groups of employed people which deserve policy attention.

Due to the differences in definitions, methodologies, and years of data collection, the interpretation and comparison of these data need to be done with care, in particular, when attempting to compare demand and supply. A number of methodological notes accompany the analysis, which, for readability reasons, are presented inside boxes, and addressed to advanced readers only.

4.1 High demand registered for employee's digital skills

4.1.1 CEDEFOP European Skills and Jobs Survey

CEDEFOP's European Skills and Jobs Survey[77] (ESJS) carried out on adult employees (aged 24 to 65), collected in 2014 information on the highest level of ICT skills required by EU employees so that they can carry out their job tasks.

The survey distinguished between four broad ICT levels needed so that workers can do their job, namely: basic, moderate and advanced ICT level, and no ICT skills needed at all. Refer to Table 2.1 in Chapter 2 for a detailed definition.

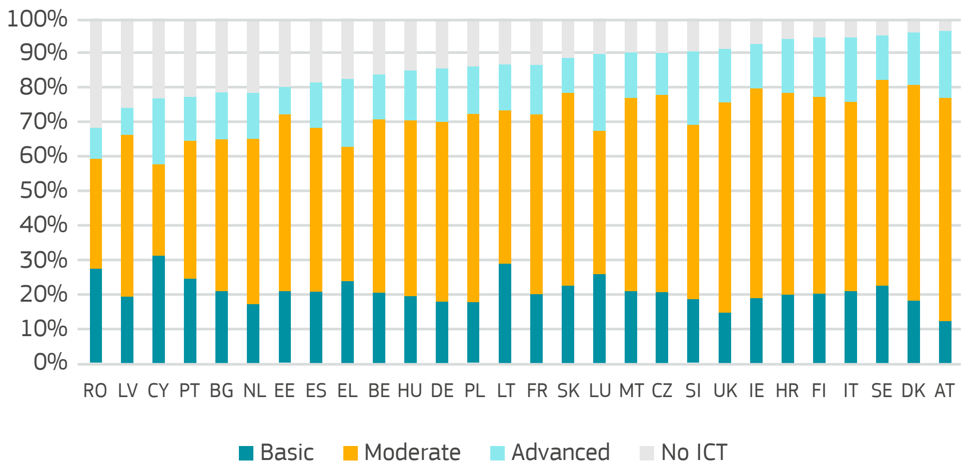
According to the analysis of individual skills needs[78], the majority (52%) of adult EU employees stated that a moderate ICT level is required to carry out their job tasks and another 19% require a basic level. Together, about 7 in 10 (71%) EU employees need some fundamental level (i.e. basic or moderate) of digital skills to perform their jobs. An additional 14% need advanced ICT levels, in contrast to another 14% who stated that they need no ICT skills at all in their jobs. All together, these figures contribute to the estimation that, **in 2014, 85% of the employees in the EU required at least a fundamental or basic level of ICT skills**.

Methodological note: *We cannot directly compare the skills gap based on CEDEFOP's results on the demand for (basic, moderate, advanced) digital skills with the level of individual digital skills provided by Eurostat – although some make that comparison. The definitions of basic ICT or moderate/above-basic skills differ significantly (see Chapter 1), in particular, the Eurostat definition of basic skills is more demanding than CEDEFOP's definition for 'basic' and 'moderate' ICT skills, leading to an underestimation of existing 'basic' skills among citizens to meet the labour market needs. In 2019, 60% of individuals 25-64 years old had basic digital skills or above and 89% had low, basic or above-basic digital skills (Eurostat DSI). Similar difficulties emerge from differences between the definitions of the upper-digital skills levels.*

76. European Commission, DG CNECT, *ICT for work: Digital skills in the workplace*, 2017, prepared by Ecorys and the Danish Technological Institute.
77. https://www.cedefop.europa.eu/en/projects/european-skills-and-jobs-survey-esjs
78. Cedefop (2015), 'Skills, qualifications and jobs in the EU: the making of a perfect match?', Cedefop reference series No. 3072.

As illustrated in Figure 4.1 below, Sweden, Denmark and Ireland are the EU countries in which more than 80% of their adult workforces need at least a fundamental level of ICT skills to do their jobs, in contrast to Cyprus, Romania and Greece, where the same holds for about 6 in 10 workers. Portugal, Bulgaria, Latvia and the Netherlands have the highest share of employees (over a fifth) reporting that their jobs do not need any ICT skills at all.

Figure 4.1. Level of ICT skills needed to do the job, adult employees, 2014, EU-28



Source: CEDEFOP (2017), Figure 1 (with separation of basic and moderate skills)

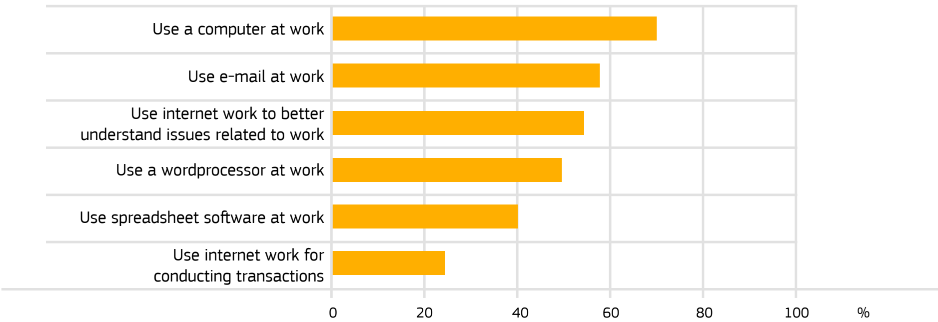
4.1.2 OECD PIAAC Adult Skills Survey

Data from the OECD Adult Skills Survey shows that in 2012 **about 70% of workers used computers at work** while about **28% did not use a computer at work**, on average, across participating countries (see Figure 4.2 below). The use of computers at work include the questions related to the use of email, the internet for understanding issues or conducting transactions and the use of spreadsheets and word processing. In Norway and Sweden, more than 80% of workers reported using computers at work, while more than 40% of workers in Italy, Poland, the Slovak Republic and Spain said that they did not use a computer at work. The survey also points to the fact that many workers use ICT with a similar frequency both in and outside of work.

Methodological note: *This 28% of workers who did not use computers at work in 2012 contrasts with CEDEFOP's survey in 2014, which found that only 14% of employees did not need ICT skills. This difference could reveal methodological differences or point to an evolution of the work place, revealing a change in ICT penetration. For example, Cedefop's definition includes not only computers, but digital devices – i.e. PC, tablet or mobile device – which means that a person using a mobile device at work would be classified having 'basic skills' in the ESJS, but as an individual 'with no computer experience' in the PIAAC Adult Skills Survey. Another explanatory methodological aspect could refer to the possible differences in surveys' sampling methods, which would require additional comparative analysis.*

Figure 4.2. Percentage of adults who use information technology applications at work

At least once a month (country average*), 2012



*Country average: average of 19 participating OECD countries and entities

Source: OECD (2015), Figure 4.2. Using information technologies at work.

Respondents of the OECD Adults Skills Survey PSTRE were also asked what **level of computer skills were needed to perform their job**[79] (Figure 4.3). Three different levels of computer skills were suggested by the questionnaire:

- straightforward (such as using a computer for straightforward routine tasks such as data entry or sending and receiving e-mails);
- moderate (for example word-processing, spreadsheets or database management); and
- complex (such as developing software or modifying computer games, programming using languages such as java, SQL, Php or Perl or maintaining a computer network).

Methodological note: *The complex uses of ICT as defined by this questionnaire would fall out of the scope of this analysis, which focuses on ICT skills for all employees.*

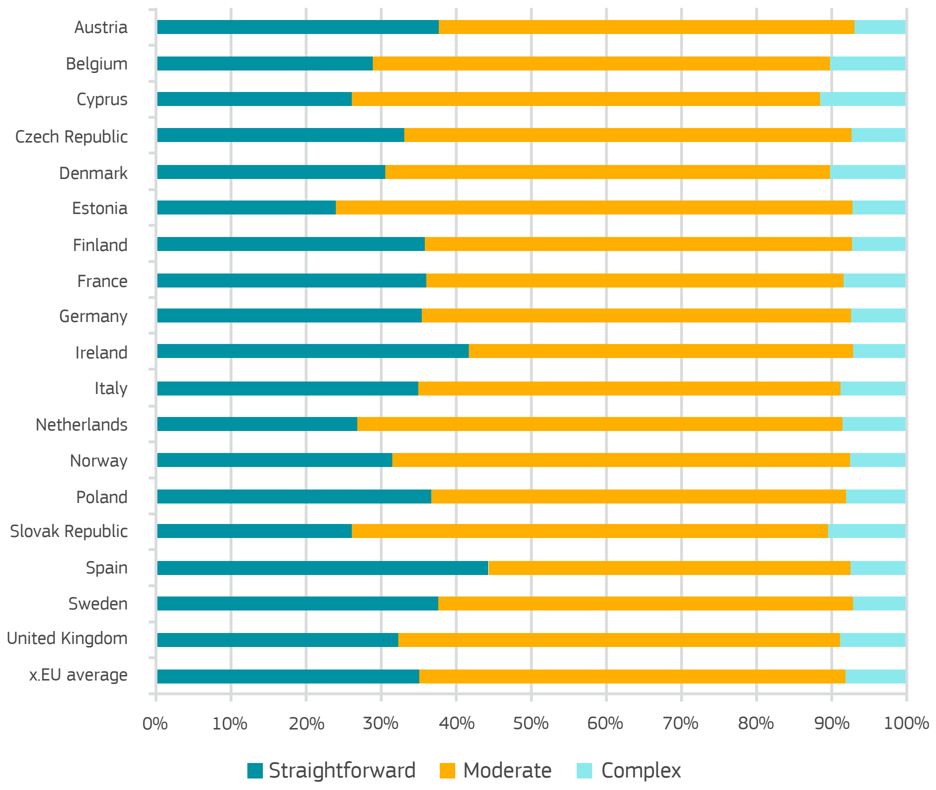
In the EU (overall), the vast majority of respondents reported the need for a moderate level (on average 61.4%) while 30.4% declared the need for a straightforward level and only 8.2% reported the need for complex computer skills. Data shows some but limited variations between countries.

Methodological note: *Methodological note: The group of individuals surveyed are those that responded to problem solving in technology-rich environments, which excludes all those that did not have computer skills or opted out of the test with a computer. This sample is thus not representative of the total number of employees. These data are fairly comparable to CEDEFOP ESJS data, if we exclude the share of workers not needing ICT for their jobs: basic level 22%, moderate 61% and advanced 17%.*

79. Pellizzari, M., Biagi, F. and Brecko, B., E-skills Mismatch: Evidence from International Assessment of Adult Competencies (PIAAC), Institute for Prospective Technological Studies Digital Economy Working Paper 2015/10, JRC98228, Table A4., 2015.

This figure could provide some hints with regards to the type and of digital upskilling actions needed, which, for the vast majority, may focus on the straightforward and moderate use of ICT. However, taking into account that the data was collected in 2012, it may not reflect the current needs of (rapidly changing) labour market demand.

Figure 4.3. Percentage of answers to the question 'What level of computer use is needed to perform your job?', 2012



Source: Pellizzari et al. (2015), Figure 7.

4.1.3 Eurostat ICT use at work

Eurostat data of ICT use at work shows that, at the beginning of 2018, **42% of people in the European Union (EU-27) aged between 16 and 74 years reported using at work** computers, laptops, smartphones, tablets, other portable devices, computerised equipment or machinery such as those used in production lines, transportation or other services. If we take into account that in 2018, in EU27, 73% of the persons aged 15-64 were in the labour force[80] according to Eurostat Labour Force Survey, we can approximate that **58% of those in the labour force** were using at work computers, laptops, smartphones, tablets, other portable devices, computerised equipment or machinery.

Of those internet users that were **employed, 71% reported using computers, laptops, smartphones, tablets or other portable devices** at work and 19% used computerised equipment or machinery[81].

Methodological note: *A direct comparison of Eurostat ICT use at work data with CEDEFOP data remains difficult. More detailed analysis is needed to compare the 54% measured by Eurostat with CEDEFOP's finding that 85% of the employees in the EU require at least a basic level of ICT skills.*

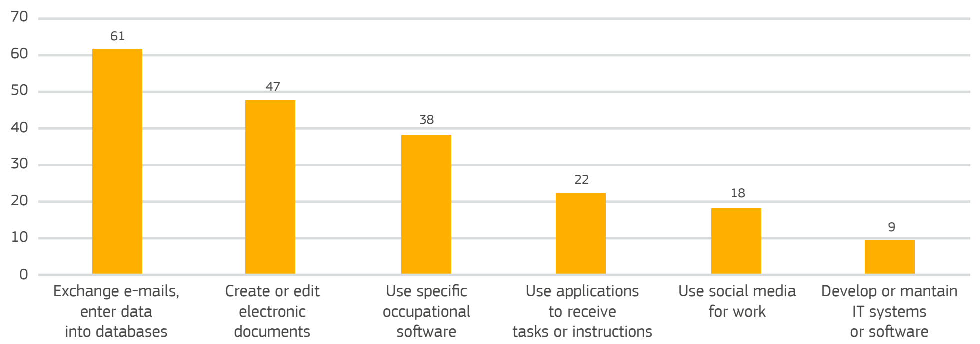
For example, taking into account that CEDEFOP´s survey is 3 years older, more analysis would be needed to better understand the inconsistency. Also, the age difference could account for some of this discrepancy, as Eurostat includes all individuals including those below 24 and above 64 years old. The inclusion of those above 65 years old could explain part of the difference of a lower Eurostat average. Another methodological difference is the fact that Eurostat includes employees and the self-employed, while Cedefop only employees. This could, again, explain part of the difference, as the percentage of self-employed having basic or above-basic skills is slightly lower than the percentage of employees with those digital skills levels.

80. Eurostat news release 199/2018 of 20 December 2018, Internet use in the EU, 2018 – digitalisation at work. Eurostat related dataset: *Use of ICT at work and activities performed*. Access to data here. Extracted on 21/3/2022.
81. https://ec.europa.eu/eurostat/databrowser/view/t2020_10/default/table?lang=en

The **most common work activities** with computers, laptops, smartphones, tablets or other portable devices or computerised equipment in the EU were exchanging emails or entering data in databases (61%), creating or editing electronic documents (47%) and using specific occupational software (38%). Applications to receive tasks or instructions were used by 22% of employed internet users and social media were used for work by 18%. 9% of employed internet users were involved in developing or maintaining IT systems or software. See Figure 4.4 below.

Methodological note: *Due to the different definitions used by Eurostat DSI and ICT use at work Surveys, a direct comparison between the two surveys is not feasible.*

Figure 4.4. Digital activities at work in the EU, 2018, Eurostat (% of employed who used internet in the last 12 months)



Source: Eurostat news release 199/2018 of 20 December 2018, Internet use in the EU, 2018 – digitalisation at work.

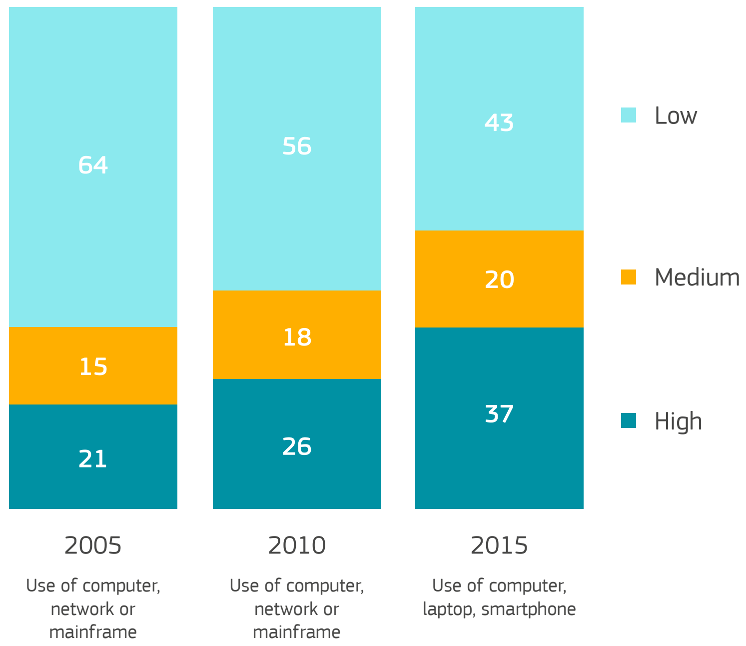
4.1.4 Conclusion

Across datasets, range between 54 and 70% of workers and 85% of employees declare using computers at work or needing at least basic digital skills to perform their job. However, more frequent/recent data collection exercises, reflecting technological developments, would be needed to provide a more accurate picture of the specific ICT skills needed by the labour market.

4.2 ICT penetration is taking place across sectors

According to the analysis[82] of the Eurofound European Working Conditions Survey, the penetration of digital technology is spreading as the number of workers using ICT devices increased between 2005 and 2015. In 2010, some 26% of workers reported a high intensity[83] of ICT use at work; in 2015, that figure had risen to 37%. Conversely, over the same period, the proportion reporting a low intensity of ICT use, or none, declined from 56% to 43% (Figure 4.5).

Figure 4.5. Use of ICT at work – proportion of workers, by intensity of use, EU-28, 2005–2015 (%), Eurofound

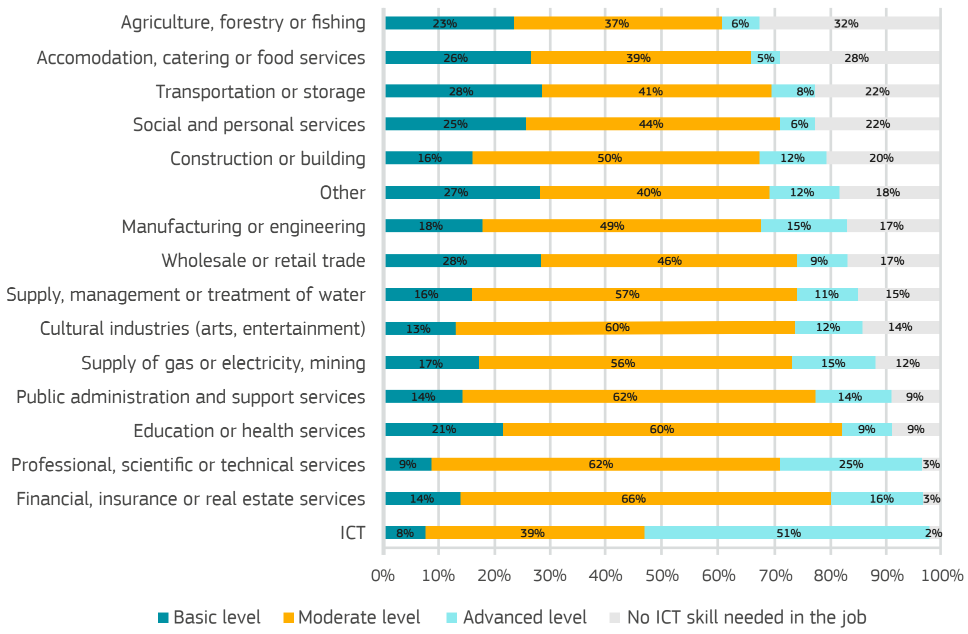


Source: Eurofound (2017), Figure 73.

82. Eurofound (2017), Sixth European Working Conditions Survey – Overview report (2017 update), Publications Office of the European Union, Luxembourg.
83. Intensity is measured as: all the time, almost all the time, around ¾ of the time, around ½ of the time, around ¼ of the time, almost never and never (See Eurofound EWCS Questionnaire).

Complementary sources confirm this trend. CEDEFOP's ESJS analysis of ICT skills needs to do the job per sector in 2014 shows (in Figure 4.6) that ICT has significantly penetrated all sectors, with only an average 15% of workers reporting that they need no ICT skills in their job. There are however some differences between sectors with the share of employees needing some (basic, moderate or advanced) level of ICT skills ranging from 68% in agriculture, forestry and fishing and 98% of those working in the ICT sector.

Figure 4.6. Level of ICT skills needed to do the job by sector, adult employees, 2014, EU-28, Cedefop

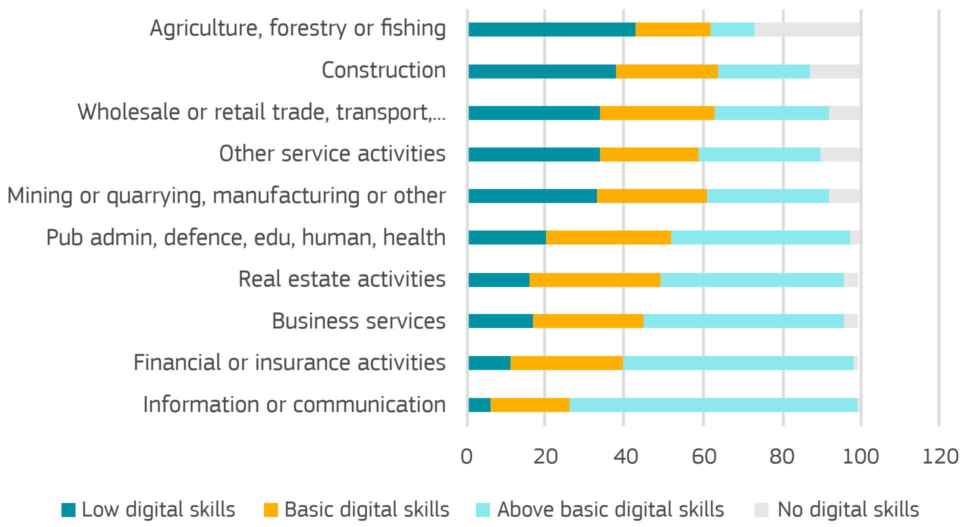


NB: Share of valid responses to the question: 'Which of the following best describes the highest level of information and communication technology skills required for doing your job?'

Source: Cedefop (2018), Figure 23 (reordered)

A complementary perspective is the level of digital skills of employees, per economic sector (Eurostat DSI data, 2019), provided in Figure 4.7, which presents a compatible view. However, due to methodological differences and differences in data collection year, a detailed comparison of both datasets would present strong limitations.

Figure 4.7. Share of individuals per digital skill level and sector, Eurostat, 2019



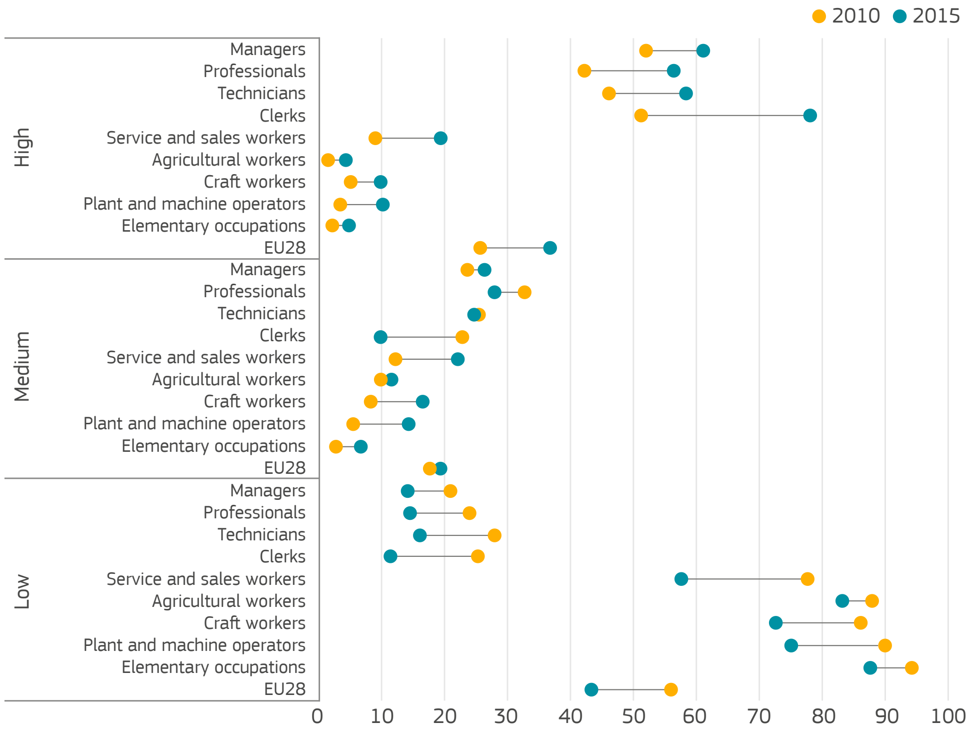
Source: Authors´ own analysis of Eurostat Survey, 2019.

4.3 There are marked differences in ICT skills needs across occupations

According to Eurofound European Working Conditions Survey (EWCS) data[84], the intensity of workers' use of ICT technologies varies between occupations. Figure 4.8 on the right shows the individual proportion of each occupational group that uses ICT with high, medium or low intensity. In addition, it shows the trend in these figures from 2010 to 2015. Firstly, we can see a **polarisation in the use of ICT across occupations**: while most agricultural workers, craft workers, plant and machine operators, service and sales workers and those in elementary occupations either never or almost never use ICT (low intensity), the rest of the occupations, managers, professionals, technicians and clerks largely use ICT (high level of intensity). Secondly, Figure 4.8 also shows that **between 2010 and 2015 the polarisation has increased** in the sense that there was an increase in the use of ICT by those occupations that were already using ICT more intensely and a reduction for those who were not using it intensely.

This data is confirmed by CEDEFOP ESJS's analysis[85], which shows that a high proportion of those working in elementary occupations (56%), skilled agricultural (42%), craft and trade workers (37%), plant and machine operators (36%) do not need ICT skills to perform their job.

Figure 4.8. Percentage of workers working with ICT, by occupation and intensity of use, in 2010 and2015, EU-28, Eurofound

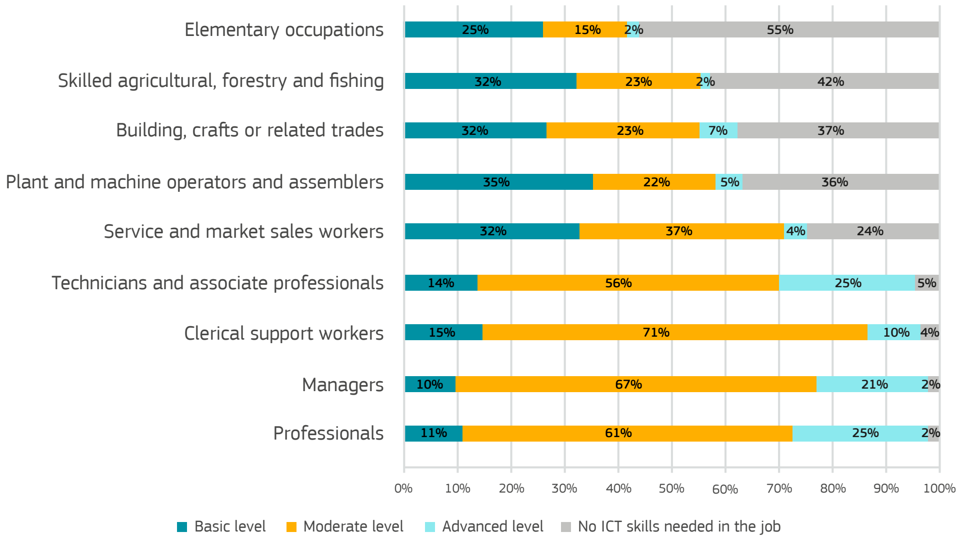


Source: Eurofound (2017), Figure 74.

84. Eurofound (2017), Sixth European Working Conditions Survey – Overview report (2017 update), Publications Office of the European Union, Luxembourg.
85. CEDEFOP , '*Skills, qualifications and jobs in the EU: the making of a perfect match?*', 2015, Cedefop reference series No. 3072.

Taking into account that the definition of basic ICT skills used by CEDEFOP is 'using a PC, table or mobile device for email or internet browsing', we could sum up the share of workers that need no ICT or basic level of ICT skills. These calculations would point to 81% of those working in elementary occupations, 72% plant and machine operators, 74% skilled agricultural workers, 63% craft and trade workers and 56% service and sales workers, requiring no ICT skills or basic ICT skills to do their jobs in contemporary labour markets (Figure 4.9). This confirms the same vulnerable groups as the EWCS described above.

Figure 4.9 - Level of ICT skills required by occupation, adult employees, 2014, EU-28



NB: Share of valid responses to the question: 'Which of the following best describes the highest level of information communication technology skills required for doing your job?'

Source: Cedefop, ESJS (2015)

A **job polarisation** is taking place with regards to the use of ICT at work. A large proportion (above 75% according to Eurofound) of those working **as agricultural workers, craft workers, plant and machine operators, service and sales workers and in elementary occupations, have not only never or almost never used ICT in their jobs** in 2015, but also have seen a **decrease in ICT use** in the period 2010-2015.

These coexist with an increasing number of workers using ICT at high intensity as managers, professionals, technicians and clerks. These two groups will have very different experiences of work with potentially profound impacts on career development, occupational mobility and working life.

4.4. Which digital skills for which jobs?

If we focus our analysis in the world of work, research[86,87], shows that different jobs in different sectors in different countries require different types of digital competences at different proficiency levels. For example, Table 9 (pp. 22-23) of Kluzer et al. (2020) contains a detailed analysis of the 21 digital competences (based on DigComp) needed by 25 different job profiles, and the required proficiency levels, defined in cooperation with employers.

The *ICT for work* report provides, for 60 occupations, an assessment of the importance of digital skills (at the less granular level of Basic, Advanced or Specialist) required to perform day-to-day activities (See Table 4.3, pp. 75-76).

86. Kluzer S., Centeno C. and O´Keeffe, W., *DigComp at Work*, EUR 30166 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17857-6, doi:10.2760/887815, JRC120376.
87. European Commission, DG CNECT, *ICT for work: Digital skills in the workplace*, 2017, prepared by Ecorys and Danish Technological Institute.

Integrating these findings, a kind of generalisation could be made regarding the most demanded skills across jobs:

- On one side, Kluzer et al. (2020)[88] find that **seven digital competences** are present in over 75% of the 25 Professional Digital Profiles examined, and three competences are present in about a third of the profiles, as illustrated below.

DigComp competence area	DigComp competence	Present in % of profiles
1. Information and data literacy	1.1 Browsing, searching and filtering data, information and digital content	75%
2. Communication and collaboration	2.1 Interacting through digital technologies	75%
	2.3 Engaging in citizenship through digital technologies	33%
	2.4 Collaborating through digital technologies	75%
3. Digital content creation	3.1 Developing digital content	75%
	3.2 Integrating and re-elaborating digital content	33%
	3.3 Copyright and licences	33%
	3.4 Programming	75%
4. Safety	4.1 Protecting devices	75%
	4.2 Protecting personal data and privacy	75%

- On the other, the ICT for work report concludes that **basic digital skills** are the most commonly required in all the occupations, "search for, collection and processing of information via the internet and communicating using email".

4.5 High pace of technological change across sectors and technology obsolescence

Technological change is taking place across sectors[89], beyond the ICT sector (only 3% to 4% of total EU employment), and digitalisation permeates most economic activities and occupations.

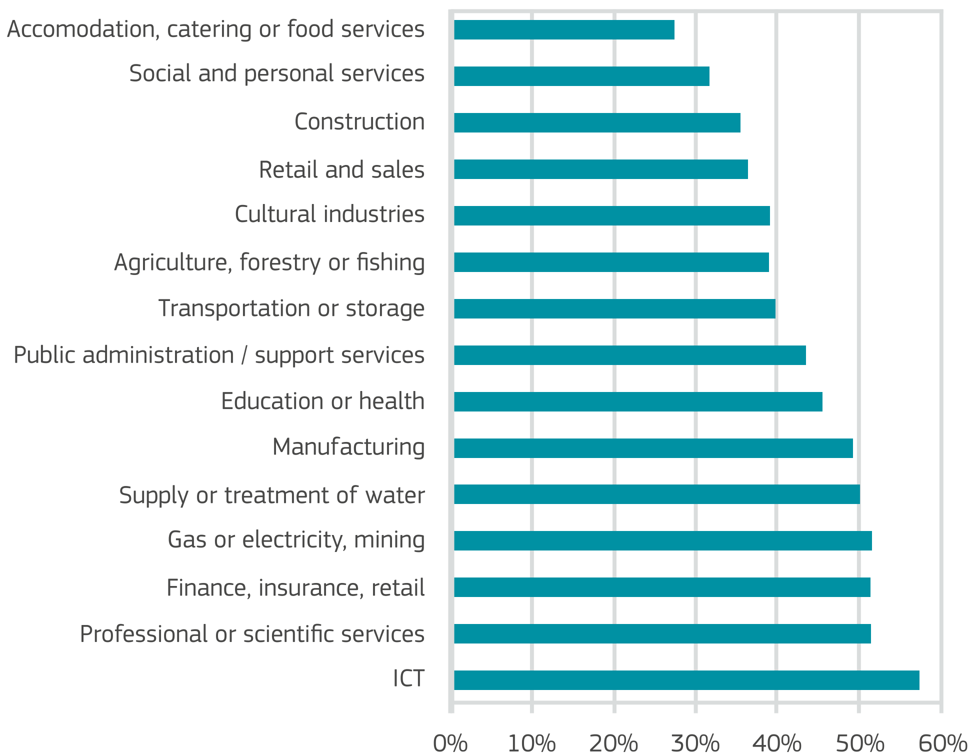
CEDEFOP's European Skills and Jobs Survey (ESJS) has revealed that a significant share (43%) of EU workers have seen the technologies they use (machines, ICT systems) change in the past 5 years or since the time they started their current employment, while 47% experienced changes in their working methods or practices. More than half of employees in Ireland, Malta, Slovenia, Finland, Sweden and the UK felt the impact of changing technologies used for their work.

The pace of change has even accelerated. According to Eurostat[90], in 2018, the job tasks of 16% of employed internet users in the EU had changed due to new software or computerised equipment in the 12 months prior to the survey. Those with higher education were more likely to be affected by this change than those with medium- and low-level education (20%, 14% and 9%, respectively). Additionally, 29% had to learn how to use new software or equipment for their job.

88. See Table T.9 in Kluzer S., Centeno C. and O´Keeffe, W., *DigComp at Work*, EUR 30166 EN,
Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17857-6, doi:10.2760/887815, JRC120376.
89. CEDEFOP (2018), 'Insights into skills shortages and skill mismatch. Learning from Cedefop´s European Skills and Jobs Survey',
Cedefop reference Series 106.
90. Eurostat news release 199/2018 of 20 December 2018, Internet use in the EU, 2018 – digitalisation at work.

CEDEFOP's analysis of **technological change across sectors** shows that new technologies are more prevalent in the rapidly changing ICT sector where 57% of all jobs have experienced change, but **close to half of workers were also affected in several other sectors** including gas, electricity and mining (51%), financial, insurance and real-estate services (51%), professional, scientific and technical services (51%) and manufacturing/engineering (49%) (Figure 4.10).

Figure 4.10. Share of adult employees who experienced changes in technologies used in the workplace in the past 5 years by economic sector, 2014, EU-28



NB: Share of EU adults employees who experienced changes to the technologies (machinery, ICT systems) they used in the past five years/since they started their main job.

Source: CEDEFOP (2018), Figure 2.

Technological change is more likely to affect individuals employed in high-skilled occupations, most notably technicians and associate professionals (54%), managers (50%) and professionals (50%) (Figure 4.11).

Figure 4.11. Share of adult employees who experienced changes in technologies used in the workplace in the past 5 years by occupation, 2014, EU-28

NB: Share of EU adults employees who experienced changes to the technologies (machinery, ICT systems) they used in the past five years/since they started their main job.

Source: CEDEFOP (2018), Figure 3.

According to CEDEFOP (see Table 4.1), ICT technicians (67%) and ICT professionals (60%), science and engineering technicians (57%) and professionals (51%) as well as production and specialist services managers (55%), health professionals (55%) and electronic and electrical trades workers (55%) are most likely to have experienced changing technologies in their workplaces.

Table 4.1. Share of adult employees who experienced changes in the technologies used in the workplace in the last 5 years by occupation, 2014, EU-28

Occupation	% of group	Occupation	% of group	Occupation	% of group
ICT technician/Associate professional	67%	Metal, machinery and related trades worker	46%	Protective service worker	36%
ICT professional	60%	Business and admin professional	44%	Driver or mobile plant operator	36%
Science and engieneering associate professional	57%	Other associate professional	44%	Skilled forestry, fishery and hunting	36%
Production or specialised services manager	55%	Chief executive, senior official or legislator	43%	Other skilled trade (building, crafts or related trade)	35%
Health professional	55%	Other clerical support worker	43%	Sales worker	33%
Electrical and electronic trades worker	55%	Customer services clerk	41%	Labourer in mining, construction, manufacturing (building, crafts or related trade)	32%
Science and engieneering professional	51%	Numerical and material recording clerk	41%	Another building and related trades worker	31%
Business and admin associate professional	50%	Legal, social and cultural professional	40%	Labourer in mining, construction, manufacturing (elementary occupations)	31%
Stationary plant or machine operator	50%	Skilled agricultural worker	40%	Personal services worker	27%
Administrative or commercial manager	48%	Assembler	40%	Personal care worker	27%
Hospitality, retail or other services	48%	Agricultural, forestry and fishery labourer	40%	Food preparation assistant	27%
Teaching professional	48%	General or keyboard clerk	38%	Other elementary worker	22%
Health associate professional	48%	Street and other sales or services worker	38%	Agricultural, forestry and fishery labour	18%
Legal, social and cultural professional	48%	Street or related sales/services labourer	37%	Cleaner or helper	12%
Handicraft and painting worker	48%	Teaching associate professional	36%		

NB: Share of EU adults employees who experienced changes to the technologies (machinery, ICT systems) they used in the past five years/since they started their main job.

Source: CEDEFOP (2018), Table 2.

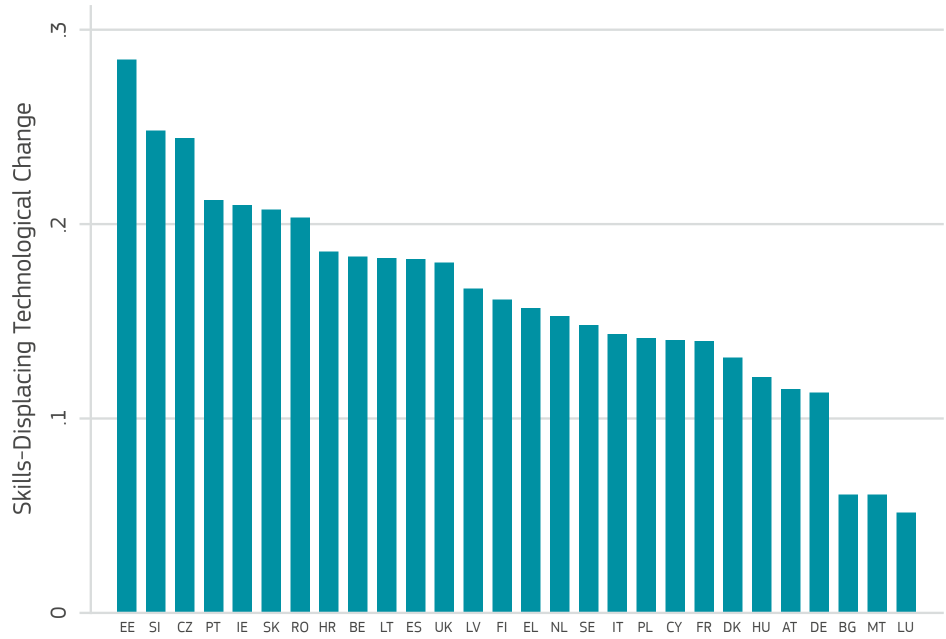
The conclusion is that a **dual approach** is needed. On one side, up/reskilling actions are needed to ensure (highly-skilled) individuals in most rapidly changing occupations maintain the necessary skills to do their jobs and **avoid skills obsolescence**. On the other, up/reskilling actions are needed towards those employed in low-skilled occupations, as they do not have the opportunity to use and learn to use ICT, with a view to maintain/develop their **employability**, countering **the polarisation effects**.

4.6 Skills obsolescence due to technology

The combined information collected by CEDEFOP's ESJS on the incidence of past technological change in workplaces, together with the anticipated likelihood of skills becoming outdated in the next 5 years (as reported by employees), allows an investigation of the susceptibility of EU jobs to the risk of technological skills obsolescence[91].

Mc Guinness et al. (2021) have studied the incidence of skills-displacing technological change (SDT, defined as a situation where a worker experienced changing workplace technologies over the past 5 years and anticipates a high likelihood of some of their skills becoming outdated in the next 5 years), across the 28 EU countries, as shown in Figure 4.12[92]. Approximately 16% of EU-28 employees experience skills-displacing technological change, with the highest rates observed in Estonia (28%), Slovenia (25%), Czechia (24%), Portugal (21%) and Ireland (21%).

Figure 4.12. Share of adult employees at risk of skills-displacing technological change, EU-28



Notes: ranking of countries based on incidence of STD. Some caution is called for when interpreting the statistics for Malta, Luxemburg and Cyprus due to relatively small sample sizes of 498, 489 and 492 individuals, respectively.

Source: Analysis of CEDEFOP ESJS in McGuinness et al. (2021).

91. CEDEFOP (2018), 'Insights into skills shortages and skill mismatch. Learning from Cedefop´s European Skills and Jobs Survey', Cedefop reference Series 106.
92. ESJS data in McGuinness et al. (2021), 'Skills-displacing technological change and within-job reallocation effects on tasks and skills: Challenging technological alarmism?'

Table 4.2 shows the occupations that are most susceptible to SDT and those that exhibit a relatively stable skills profile, affected to a lesser degree by technological progress. It is evident that higher-skilled, professional workers employed in ICT, managerial and engineering-related occupations are more likely to experience changing technologically-induced skills profiles in their jobs. On the other hand, employees in the primary sector, transport and food preparation jobs and in elementary or personal service occupations are relatively insulated from technological innovation that can render skills outdated in the medium term.

The ESJS also highlights that much of the adjustment of humans to technological obsolescence will take place within workplaces, in the form of continuous and on-the-job learning.

Table 4.2. Degree of technological skills obsolescence[1] across occupations[2] (2-digit), EU-27 and UK

ICT technician	32%
ICT professional	32%
Other plant operator	22%
Production or specialised services manager	21%
Electrical and electronic trades worker	20%
Science and engieneering technician	20%
Teaching technician	19%
Teaching professional	18%
Stationary plant or machine operator	18%
Handicraft and painting worker	18%
Health professional	18%
Chief executive, senior official or legislator	17%
Metal, machinery and related trades worker	17%
Administrative and commercial manager	17%
Science and engieneering professional	17%
Other technician	17%
Legal, social and cultural technician	16%
General or keyboard clerk	16%
Other clerical support worker	16%
Business and administration technician	16%
Health technician	15%
Skilled agricultural, forestry and fishery labourer	15%
Business and administration professional	15%
Customer services clerk	15%
Street and other sales or services worker	15%
Hospitality, retail or other services	15%
Numerical and material recording clerk	15%
Assembler	15%
Legal, social and cultural professional	15%
Skilled labourer in mining, construction, manufacturing	14%
Protective service worker	13%
Worker in another skilled trade	13%
Skilled forestry, fishery and hunting	12%
Subsistence farmer, fisher, hunter	12%
Food preparation assistant	11%
Sales worker	11%
Labourer in mining, construction, manufacturing	11%
Another building and related trades work	10%
Driver or mobile plant operator	10%
Personal services worker	9%
Personal services care	9%
Street or related sales and services	7%
Other elementary worker	7%
Cleaner or helper	6%
Agricultural, forestry and fishery labourer	5%

Note 1: Ranking of occupations based on share of adult employees affected by SDT.
Note 2: Degree of technological skills obsolescence, or Skills-displacing technological change (SDT) is defined as a situation where a worker experienced changing workplace technologies over the past five years and anticipates a high likelihood of some of his/her skills becoming outdated in the next five years.

Source: Cedefop first European skills and jobs survey (ESJS), McGuinness S. et al. (2021)

According to McGuinness et al. (2021), '**skills-displacing technological change primarily affects high-skilled jobs and tends to be accompanied by greater provision of training and workplace learning** that outweighs any skills obsolescence effects spurred by new technologies' and that 'these employees have greater job-skill complexity and are more likely to experience an increase in task variety within their current job, compared to employees unaffected by technological change'.

They also found out, based on ESJS data, that '**medium- and lower-skilled jobs are less likely to benefit from any positive reinforcement and upskilling effects of technological progress**'. 'In the absence of any dynamic skills churning in medium- and lower-skilled occupations, any technological progress is more likely to facilitate skills obsolescence and substitute machines for labour.' Their evidence highlights that 'job polarisation and automation does not only arise due to the higher routine intensity of middle-skill jobs, but because of the lack of any associated reallocation effects on job tasks and skills within jobs.'

Finally, they conclude that 'while SDT can be associated with positive reinstatement and upskilling effects, **employees subject to changing technologies tend to experience, on average, greater job insecurity'** which needs to be taken care of by skilling policies.

4.7 Summary of findings

With regards to the target policy groups, the analysis presented in this section points to two new priority groups of employed people that would require policy attention for skilling actions.

Target priority groups among those employed

Group	Characteristics	CEDEFOP, Eurofound, Eurostat findings
E3	**Employed in occupations that require no or low use of ICT** – in elementary occupations, skilled agricultural, craft and trade workers, plant and machine operators, service and sales workers.	Low intensity of ICT and decreasing trend leading to increasing polarisation of jobs with digital skills (Eurofound, CEDEFOP).
E4	**Employed** within **occupations that require an intensive level of ICT use**	They report highest increase of ICT use in previous 5 years (Eurofound)
	Employed in high-skilled occupations – technicians and associate professionals, managers and professionals. Workers employed in ICT, health, managerial and engineering-related occupations	Technological change more likely to affect those (CEDEFOP) more vulnerable to technological obsolescence.
	Employed with high-level education	They are the ones reporting a higher level of job task changes in 12 months previous to the survey due to technological change (Eurostat)

Another important finding with regards to the digital skills needed for employment is that we can observe some commonalities across job profiles and occupations:

- **Seven digital competences** (according to DigComp reference framework) are present in over 75% of the 25 professional digital profiles examined: 1.1 Browsing, searching and filtering data, information and digital content; 2.1 Interacting through digital technologies; 2.4 Collaborating through digital technologies; 3.1 Developing digital content; 3.4 Programming; 4.1 Protecting devices; 4.2 Protecting personal data and privacy.
- **Basic digital skills** are the most commonly required in all the occupations.

There is the **opportunity to define the basic digital skills required by the "generic employee"**. This action would require **employers´ involvement** to ensure occupation-specific digital skills needs are adequately assessed.

5. Understanding the digital skills gap

In this chapter we make an attempt to better understand the digital skills mismatch by analysing the three major datasets that provide individual level data of own perception of whether the skills they have are sufficient to perform their job: CEDEFOP ESJS, Eurostat use of ICT at work and OECD PIAAC Adult Skills survey. The analysis tries to identify differences across countries and occupations.

To facilitate reading, all detailed methodological measurement considerations are presented in Section 2.4 *Measuring the digital skills gap*, including detailed description of the definitions used by skill mismatches.

5.1 Sizing the digital skill gap between employees using ICT in their jobs

CEDEFOP ESJS

The ESJS survey[93] collected information on the (digital) skill mismatches of adult EU employees.

Using the classification of employees suffering from a skills gap (i.e. who provided a response below 5), Figure 5.1 depicts the share of those employees in the EU-28 Member States dependent on whether their job needs either a basic, moderate or advanced ICT level.

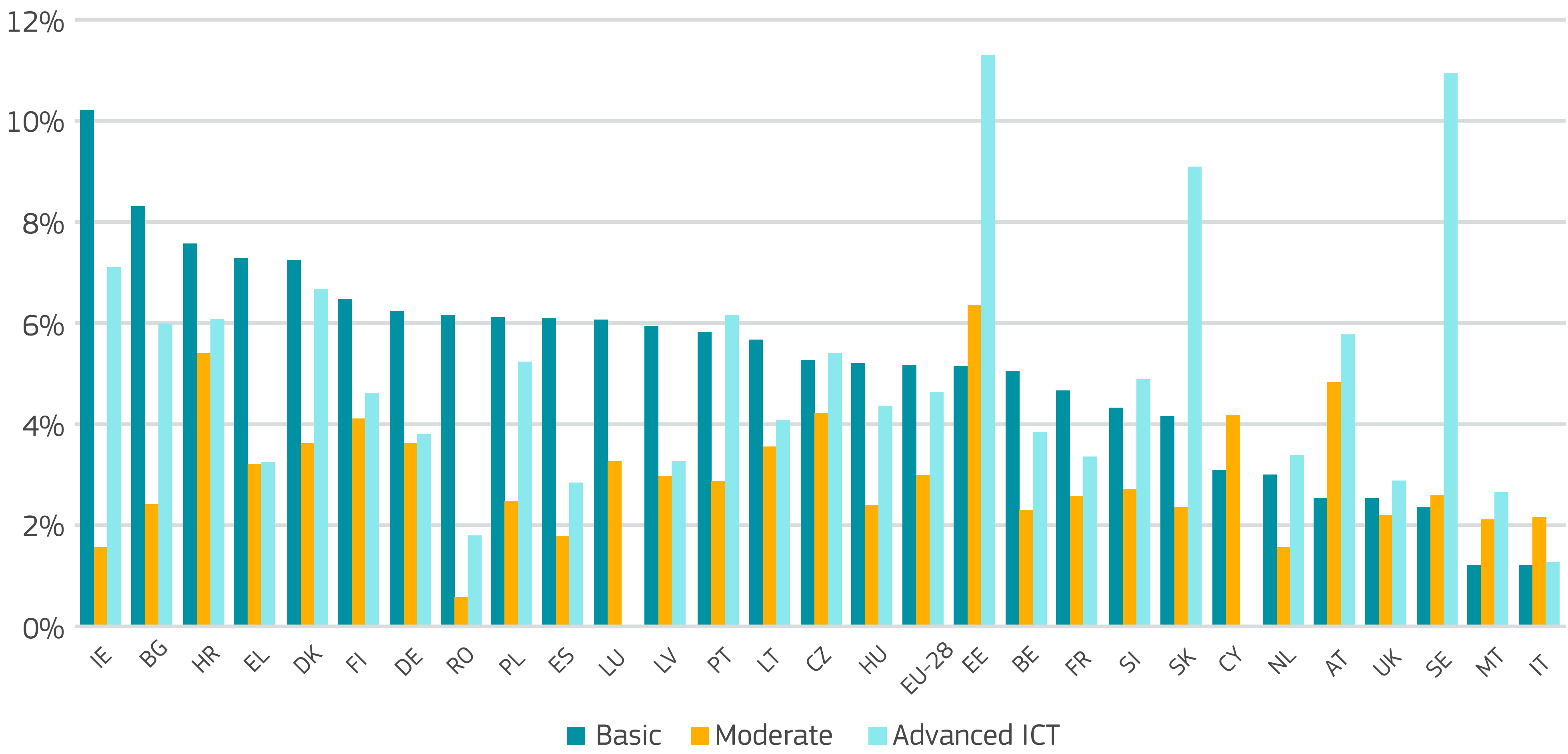
Around **3.78% of the European workforce suffers from a digital skills gap**, ranging from 3% for those needing moderate ICT skills to do their job (61% of the sample employees) to 5% for those needing basic (22%) or advanced ICT skills (17% of the sample employees) to do their job.

The values are **fairly homogeneous across countries** – with the exception of Estonia, Sweden and Slovakia, where the levels of employees whose job requires advanced ICT skills and suffers a skills gap show values between 9% and 11%. These values point to the fact that the level of digital skill gaps does not necessarily reflect the general level of digital skills in the country. Instead, the skills gap could reflect the level of unmatched demand generated by the ongoing digital transformation of the different sectors. In key sectors, the training of employees and the development of their digital skills can lag behind the evolution of digital technology, whether in an initial or more advanced phase. For example, Estonia and Sweden are, according to Figure 3.1, above the EU-28 average for the population with advanced ICT skills, and show, in Figure 5.1, a higher-than-EU-28-average digital skills gap for jobs requiring advanced ICT skills (11% vs EU-28 average 5%). This is confirmed by the ICT for work report based on an employer's survey (see Chapter 6).

These figures illustrate that, **with the aim of reducing the digital skills gap, digital skilling actions are needed in all countries, irrespective of the level of digital skills of the working age population** (25-64 years old).

93. CEDEFOP (2017), 'The great divide – Digitalisation and digital skill gaps in the EU workforce', #ESJsurvey INSIGHTS No 9, Thessaloniki: Greece.

Figure 5.1. Incidence of digital skills gap by level of digital skills needed by the job, adult employees, 2014, EU-28



Source: CEDEFOP. Note: Digital skills gap defined as values less than 5 on mismatch scale.

The CEDEFOP figures appear rather aligned with other research findings of both the Eurostat use of ICT at work survey and the OECD PIAAC Adult Skills Survey data analysis presented below.

Eurostat use of ICT at work

This Eurostat dataset of the Use of ICT at work and activities performed, is quite comparable with ESJS sample of employees which included all employees needing some level of ICT skills.

According to Eurostat, in 2018, almost **two thirds (64%) of individuals** who, at work, use any type of computers, portable devices or computerised equipment or machinery in the EU-28, assessed their skills relating to the use of computers, software or applications at work as adequate for their duties.

In contrast, as illustrated in Figure 5.2, **11% admitted that they would need additional training on skills relating to the use of computers, software or applications at work** to cope well for their current duties.

For those 18 out of the 28 countries where data is available, an average of 22% of employees reported that the time spent on acquiring new skills needed for work has increased because of the use of computers, laptops, smartphones or other computerised equipment.

Figure 5.2. Individuals that needed further training to cope well with the duties relating to the use of computers, software or applications at work, 2018, EU-28

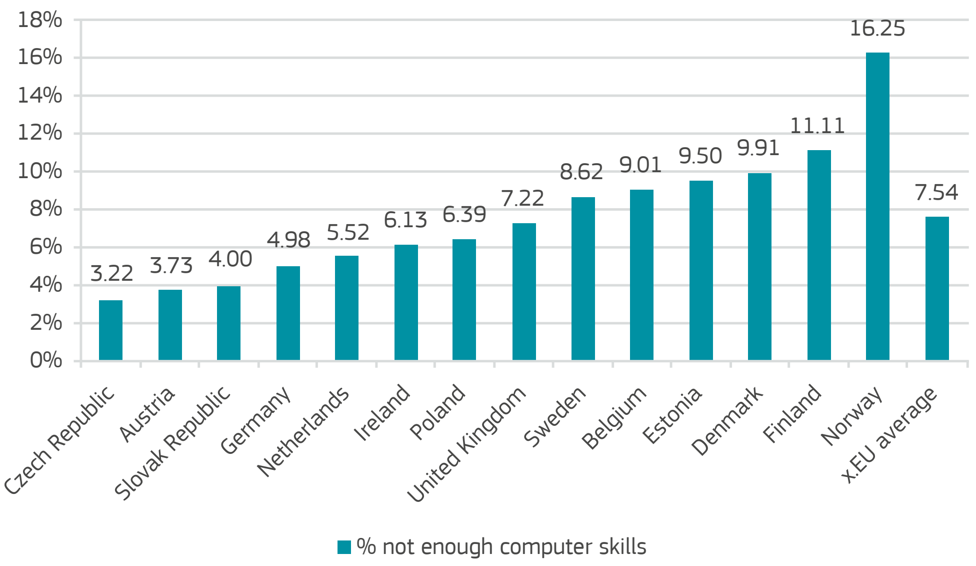
Source: Eurostat, ICT usage at Work, Impact of ICT on tasks and Skills, 2018 (data for Sweden not available)

OECD PIAAC Adult Skills Survey

Similar results are provided by other research[94] which has analysed the skills mismatch using OECD PIAAC Adult Skills Survey data for the 13 countries of the European Union participating in the programme (plus the USA). See Section 2.3 for a detailed description of the methodology used.

The results provide that, on average, **7.54 % of workers (who have used a computer in their current or previous job) report lacking the necessary computer skills,** with that share ranging from 3.2% in the Czech Republic to 16.25% in Norway. 63% have the computer skills to do their job well and 28% do not use the computer at work (See Table A4.4a in Pellizzari et al. (2015)).

Figure 5.3. Negative answers to the question 'Do you think you have the computer skills you need to do your job well?', PSTRE

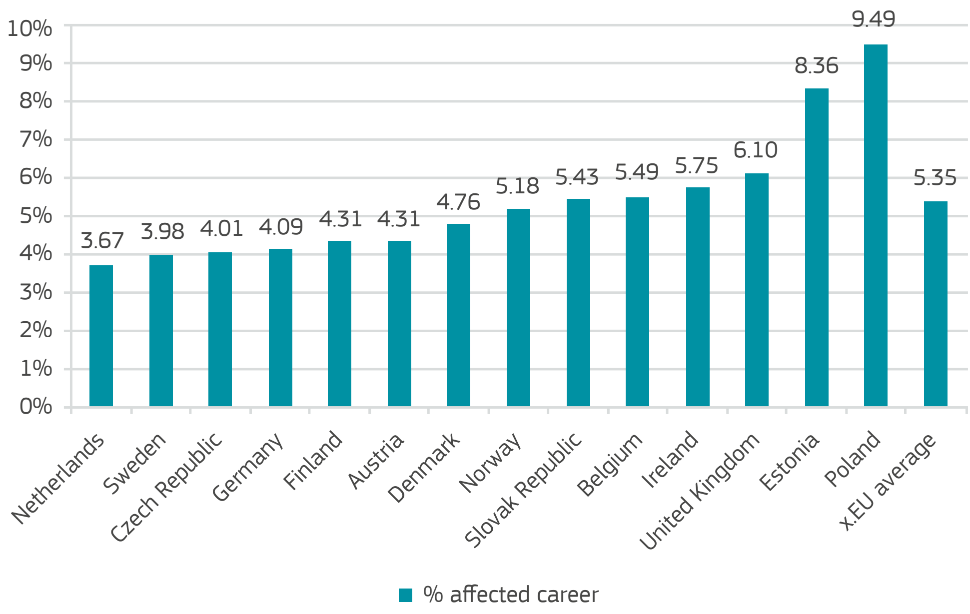


Source: Pellizzari et al. (2015), Figure 4.

94. Pellizzari, M., Biagi, F. and Brecko, B., 'E-skills Mismatch: Evidence from PIAAC', Institute for Prospective Technological Studies Digital Economy Working Paper 2015/10, JRC98228.

Similarly, in the 13 EU countries (overall), **5.35% of respondents reported that a lack of computer skills has affected their chances of being hired, promoted or paid more** (Figure 5.4). Country averages range from 3.67% in the Netherlands to 9.49% in Poland.

Figure 5.4. Positive answers to the question 'Has a lack of computer skills affected your chances of being hired for a job or getting a promotion or pay raise?'



Source: Pellizzari et al. (2015), Figure 6.

While closely related, the two questions cover different aspects of the adequacy of respondents' skills. Indeed, some workers may have adequate computer skills for their current job precisely because their lack of computer skills prevented them from moving to another job requiring more advanced computer skills or because a failure to be hired, promoted or paid more in the past prompted them to improve their computer skills.

Additional analysis of the measures of skills mismatch, to counter the subjectivity related to these two questions (see above), provides the following results: on average, about **87% of the workers in the final sample are well-matched**, about 10% are over-skilled and **3% under-skilled**.

According to the three sources analysed (CEDEFOP, Eurostat and OECD PIAAC Adult Skills Survey), **the digital skills mismatch of active workers seems rather homogeneous across countries and limited, in a range between 3-11%**.

The explanation of this small share could be linked to the continued 'learning by doing' process that takes place while using technology at the workplace, as illustrated by Eurostat data[95]. This may also be explained by the fact that employers train their employees to new technologies, devices, applications and job tasks[96].

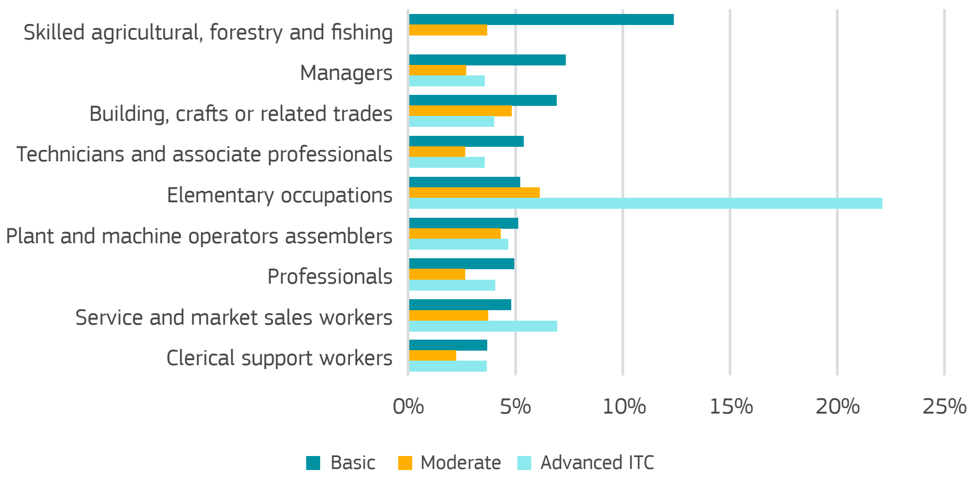
95. Eurostat news release 199/2018 of 20 December 2018, [Internet use in the EU, 2018 – digitalisation at work](#).
96. Ibid.

5.2 Digital skills gap per occupation type

This section presents an overview of CEDEFOP´s analysis of the digital skills gap per occupation type based on the ESJS data, presented in Figure 5.5 below.

We can observe that a **rather homogeneous digital skills gap (2-7%) exists across occupations and the levels of digital skills needed to do the job**, with two marginal exceptions. In particular, larger skills gaps are reported by employees in 'Skilled agricultural, forestry and fishing occupations' and in 'Elementary occupations', which are occupations characterised by high level of employees reporting no or low use of ICT, as identified in Chapter 4.

Figure 5.5. Incidence of digital skills gap by level of digital skill needed by job and occupation, adult employees, 2014, EU-28



Source: CEDEFOP. Note: Digital skills gap defined as values less than 5 on mismatch scale.

The analysis of the PIAAC Adults Skills Survey dataset presented in Figure 5.6 of the 'share of workers reporting lack of computer/ICT skills to do their job well' per occupation confirms the above findings from CEDEFOP, in what regards a **moderate difference between occupations skills gap**, except for higher values for occupations that require no or ow ICT use, such as 'Skilled agricultural, forestry and fishing workers'[97] and 'Building, crafts and related trade workers'.

Figure 5.6. Share of workers who report lack of ICT/computer skills to perform their job

Source: OECD PIAAC Adult Skills Survey, author's analysis.

We can conclude that:

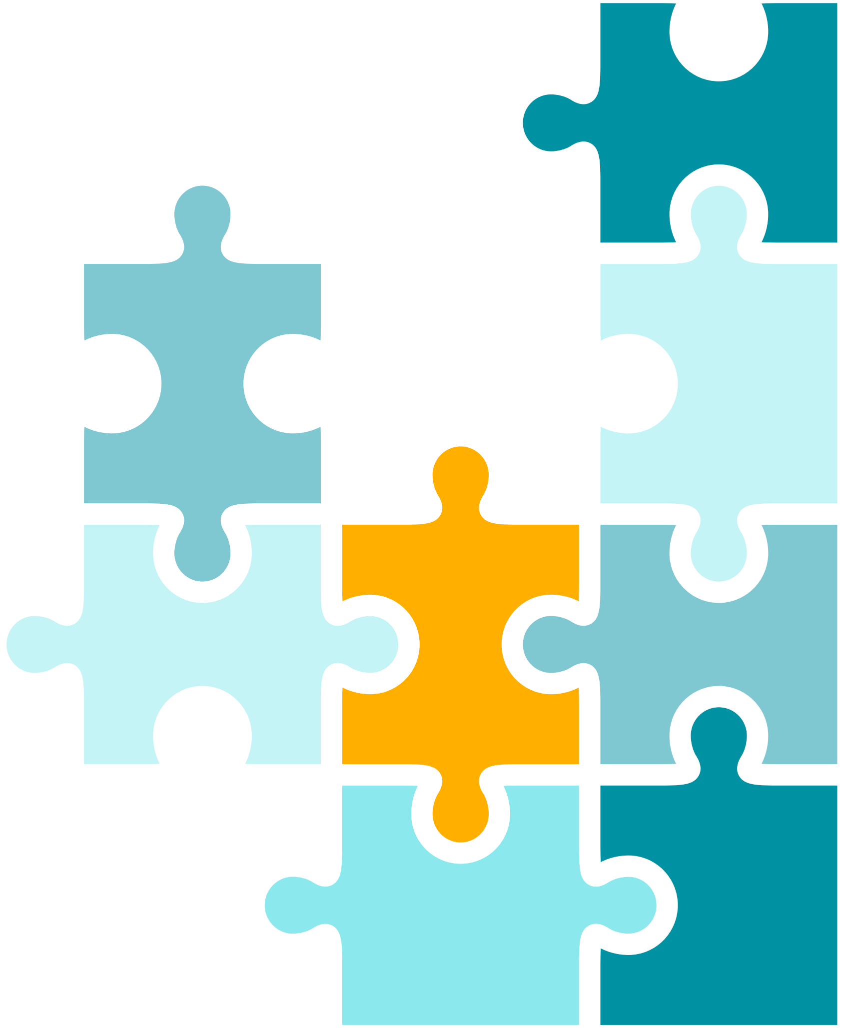
A rather homogeneous digital skills gap exists across occupations and levels of digital skills needed to perform the job.

97. There may be marginal effects for those groups with lower skill needs on average; small deviations in increasing skill needs could manifest in larger reported skills gaps.

5.3 Summary of findings

Firstly, the actual country average for the **digital skills mismatch of active workers seems homogeneous across countries and limited in a range between 3-11%**, according to the three sources analysed (CEDEFOP, Eurostat, OECD PIAAC Adult Skills Survey).

Secondly, data show that a **rather homogeneous digital skills gap exists across occupations and levels of digital skills needed to perform the job**.



6. Employers' perspective[98]

98. This chapter is an extract of key findings of the study: European Commission, DG CNECT, *ICT for work: Digital skills in the workplace*, 2017, prepared by Ecorys and the Danish Technological Institute.

6.1 Digital skills needs of employees

The study *ICT for work*[99] collected extensive qualitative information on 12 job profiles exemplifying a variety of occupations for which developments in ICT and its use have led to substantial changes in the job tasks and the skills needed to carry out the job and have impacted job quality. The 12 job profiles included dairy farmer, machine operator, industrial designer, building electrician, transport clerk, car mechanic, police detective, Vocational Education and Training (VET) teacher, property caretaker, doctor in a hospital, animator and desktop publisher.

The study provides illustrative examples of the digital skills required by specific jobs that are not office-based, providing a picture of how digitisation is increasingly penetrating and transforming existing jobs and their quality, using qualitative information. See, in Chapter 2, the definitions used by the study for basic, advanced and specialist skills.

In the next sections, detailed findings from the same ICT for work study are provided.

6.2 Digital skills needs across occupations

Evidence from the European Digital Skills Survey[100] of workplaces carried out within the ICT for work study provides information on the **ICT skills needs** per occupation and their relative importance for carrying out the job and concludes that in the European Union, the proportion of workplaces requiring their employees to possess digital skills **varies greatly according to the type of job and the type of digital skills**. The demand for digital skills is clearly related to the job role of the worker.

- '**Basic digital skills are the most commonly required in all the occupations**. However, the evidence indicates that this requirement is particularly the case **for high and medium-skilled jobs**. Almost all workplaces require their managers to possess basic digital skills, and around 90% of employers state that professionals, technicians, clerical workers or skilled agricultural workers are required to possess at least basic digital skills. Eight out of ten workplaces require basic digital skills for sales workers. Although in much smaller proportions, workplaces also often require basic digital skills for building workers (almost half of workplaces), plant machine operators (34% of workplaces) and even employees in elementary occupations (27% of workplaces)' (p. 7).
- Nevertheless, as **digital skills are less likely to be required for the low-skilled or the unskilled** (or frequently not required at all, even at basic level), **a skills polarisation** seems to be taking place, confirming previous findings from analyses based on Eurostat and CEDEFOP datasets pointing to a polarisation in digital skills needs.
- '**The basic digital skills more frequently required for all the job categories** are those related to the "search for, collection and processing of information via the internet and communicating using email' (p. 79).
- '**Advanced digital skills are much less required by employers**. It is mostly professionals (54% of workplaces), technicians (52%) and to a lesser extent clerical workers (45%), managers and building workers (31% of workplaces in both cases) who are required to have this type of digital skills, while they are considered much less important for all other occupations. Advanced and specialist digital skills are very much related to specific sectors (in particular manufacturing and information and communication) and are more likely to be required in larger workplaces' (p. 98).
- **Workplaces' characteristics** (such as economic sector, size, market of reference and characteristics of workforce) influence the digital skills needs in the different job categories.

99. Ibid.

100. *ICT for Work: digital skills at the Workplace*. The survey was carried out among a representative sample of 7 800 workplaces in **six EU Member States** (Germany, Finland, United Kingdom, Portugal, Sweden and Slovakia), which are **statistically representative** of 4 295 345 workplaces in the six countries as a whole, and **of 13 803 113 workplaces in the entire Europe Union** (EU-28). Such workplaces operate in **12 economic sectors** with different levels of digital intensity: agriculture; manufacturing; electricity and gas supply; construction; wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities; information and communication; professional, scientific and technical activities; administrative and support service activities; education; human health and social work activities.

6.3 The digital skills gap in European workplaces

Digital skills gap is defined in the *ICT for work study* as 'a level of digital skills of the existing workforce in a workplace which is less than required to perform a job adequately'. **15% of workplaces report the existence of digital skill gaps in their workforce**, indicating that a proportion of their employees are not fully proficient in carrying out tasks involving the use of digital technologies.

The analysis per size of workplace shows that larger employers are more likely than smaller employers to report digital skills gaps. 57% of large workplaces report issues of digital skills gaps, followed by small and medium-sized workplaces (24% and 23%, respectively), while micro-sized workplaces appear to be less likely to have digital skills gaps (12%).

At **sectoral level**, digital skills gaps are more frequently reported in the 'Manufacturing' (22%), 'Construction' (19.5%), 'Commerce, transport, accommodation and food' (18%) and 'Education and health' (17%) sectors, being the average proportion of workplaces reporting digital skills gaps (14.8%). In the agricultural sector, only 0.6% of the workplaces consider that they have digital skills gaps.

At **country level**, workplaces in Portugal and Finland report the lowest digital skills gap (3% and 10%, respectively). Sweden and Germany have the highest proportion of workplaces stating that they experience digital skills gaps issues (27% and 22%, respectively).

At occupational level, digital skills gaps exist across all occupations and types of digital skills, meaning that a proportion of workforces in all occupations is not fully proficient in carrying out tasks involving the use of digital technologies. These results are in line with earlier findings from the analysis of CEDEFOP, Eurostat and PIAAC data. Digital skills gaps are in this study, however, more likely to be found among the high-skilled (managers, technicians) and in medium-skilled (clerical workers, sales workers) occupations, and to a lesser extent in the low-skilled occupations, with the exception of workers in elementary occupations. These results contrast with earlier findings that the skills gaps are rather homogenous across occupations (see Section 5.2).

The fact that the speed at which workers are being provided with the right digital skills in the right locations is frequently slower than the speed at which digital technologies are evolving is a factor contributing to the digital skills gap. Age also affects skills gaps, as older workers are less likely to be equipped with digital skills than younger ones.

Digital skills gaps exist across all occupations.

Factors of digital skills gap include: the (lower) **speed at which workers are being provided with the right digital skills** in the right locations compared to the speed at which digital technologies are evolving; **age**; **workplace size**, large workplaces (+250 employees) reporting higher levels than small and medium ones; sectoral and geographical **context**.

6.4 Actions undertaken to address the digital skills gap and difficulties

Results also show that, even if workplaces report that a proportion of their workforce is not fully proficient in carrying out tasks involving the use of digital technologies, they often do not recognise that existing in-house skills gaps impact workplace performance and hence often do not take action to deal with the issue. The report finds out that:

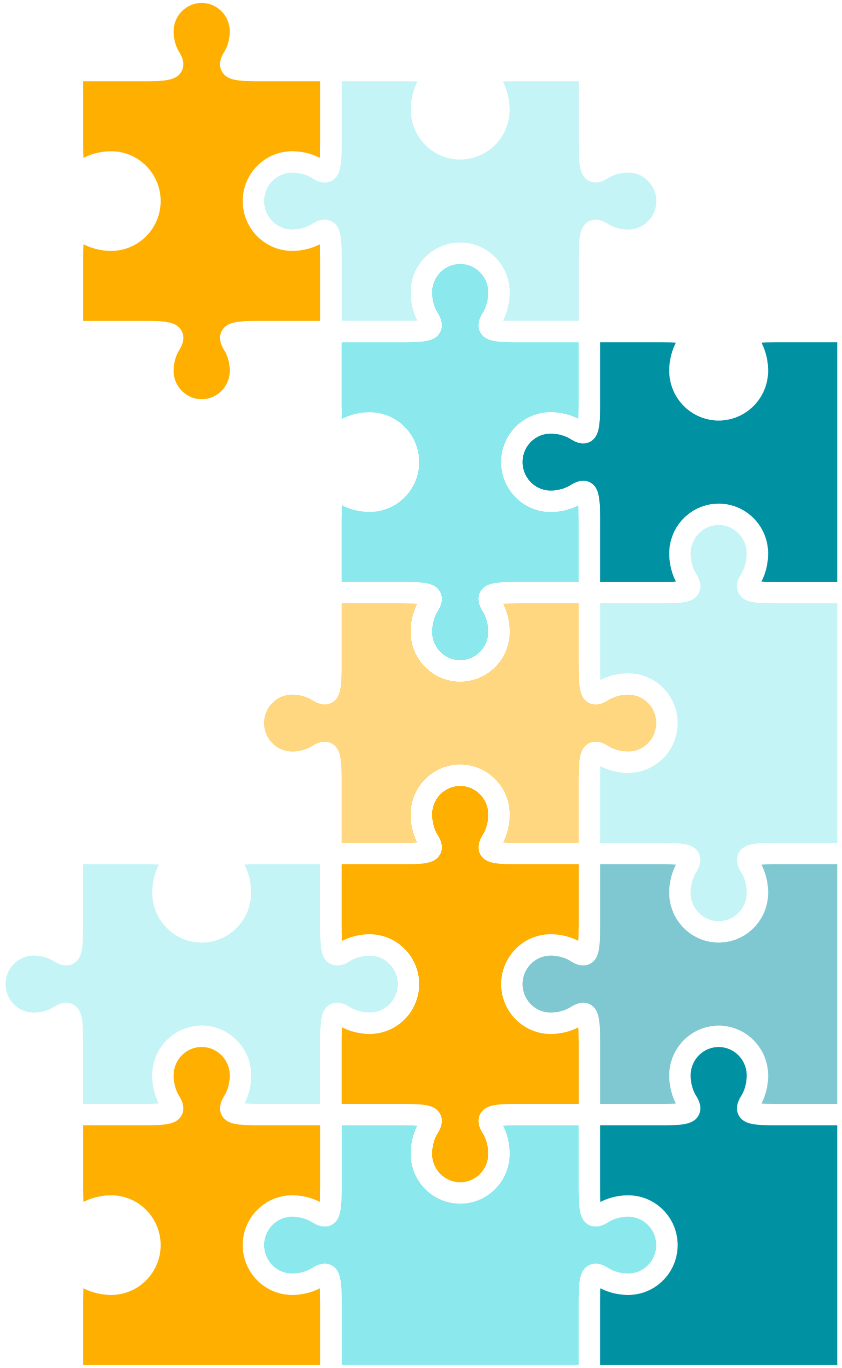
- only 12% of workplaces with digital skills gaps have undertaken actions to tackle the problem, and 11% have plans to do so:
  - only 9% of micro-sized workplaces have undertaken actions to deal with digital skill gaps, versus almost one third of medium-sized and large workplaces;
  - workplaces in the 'Education' and 'Health' sectors are those most frequently taking action to deal with digital skills gaps or plan to do so.
- with regards to types of actions, training (including on-the-job training, development programmes and external training) is the most common action undertaken to tackle digital skill gaps. Other types of actions undertaken relate to work organisation changes, for example, changing working practices (49% of workplaces that took action), reallocating tasks (47%) and hiring permanent staff or outsourcing tasks to reduce digital skills gaps in their workforce (around 33%).

The most commonly reported barrier when tackling digital skills gaps is the excessive cost of most available options to enhance the skills of workers. Across sectors, the excessive cost (of training, hiring temporary staff or outsourcing tasks) is an issue mostly reported by workplaces in the 'Agriculture' and 'Construction' sectors. Micro-sized workplaces are most likely to report the excessive cost of most of the available options. Only limited proportions of large workplaces encounter difficulties when taking action to tackle digital skills gaps, with the exception of digital skills shortages in the overall labour market, which is reported by 37% of large-sized workplaces.

The above levels of enterprises taking action are somewhat below Eurostat survey data on enterprises that provided training to develop/upgrade their personnel's ICT skills. This shows that 21% of all enterprises (excluding financial services) did provide training to 'other, non-ICT specialists' personnel. There is however consistency between the two datasets on the impact of enterprise size on the decision to carry out skilling actions: where 17% of small (10-49 employees), 37% of medium (25-249 employees) and 62% of large enterprises (above 250 employees) have provided training to develop and upgrade ICT skills of non-ICT specialist personnel.

A **small proportion of workplaces with digital skills gaps (12%) have undertaken actions** to tackle the problem.

Cost is reported as mayor barrier to taking actions to enhance the skills of workers (training, hiring temporary staff or outsourcing tasks), which affects mostly micro and small enterprises.



6.5 Summary of findings

The findings of the *ICT for Work* study and its survey confirm the previous conclusions with regards to ICT skills needs, occupation and on the nature of the digital skills gap.

The study provides complementary valuable qualitative information on the different actions undertaken by enterprises to remedy the digital skills gap, although only a small percentage of them did take action (12%) to remedy the digital skills gap. Cost appears to be the major barrier, especially among micro and small enterprises.

This study also points to the contextual nature of the digital skills gaps, which call for local contextual analysis of the sectoral developments, level of digitisation, labour demand and supply characteristics in order to effectively address the digital skills gaps in each context.

7. Conclusions and policy considerations

This report aimed at better understanding the nature and size of digital skills gaps in the labour market as well as at identifying priority groups and skills demand for effective skilling policy action.

Research challenges linked to the nature of available data

The authors would like to point to the fact that, due to the lack of standard definitions, the different sources of data (CEDEFOP ESJS, OECD PIAAC Adult Skills Survey, Eurofound EWCS, Eurostat) considered for the analysis: 1st, use **different definitions** of digital competences and proficiency levels (such as low, basic, advanced); 2nd, use **different data collection methodologies** for building the 'construct' of digital competence; 3rd, are collected in **different years** and for **different purposes**; and 4th, also reflect complementary **supply and demand** perspectives. Therefore, conclusions from this analysis should be read with caution due to possible interpretation errors and the limitations due to the lack of comparability of the data used.

In addition, due to the recent Brexit, data availability for EU27 and EU28 countries differs across datasets, and researchers had to make use of the available country group for an approximation of EU average values.

Need-focused approaches for different priority groups

In 2019, 40% of individuals aged 25-64 (a proxy for the working-age population) had below-basic skills (Eurostat). For policy design and action, we need to distinguish between the 10% of individuals who did not use the internet in the 3 months prior to the survey, and the 30% of individuals who used the internet but reported low digital skills.

The review of existing sources complemented by the authors´ analysis provided the following priority groups as requiring attention by digital skilling actions:

Priority target groups for policy action that reported no ICT use or / and below-basic digital skills

Group	Factor	Characteristics
G1	Age & Education level	**Young** 16-24 years old, with **low-level formal education**, **and NEETs** (aged 16-35 not in employment, education or training)
G2	Age	Individuals **55-64 years old**
G3	Education level	Individuals 25-64 years old **with low-level formal education**
G4	Education level	Individuals 25-64 years old **with medium-level formal education**
G5	Employment status	Individuals **unemployed**
G6	Employment status	Individuals **inactive**
G7	Nationality	Nationals of **non-EU countries**
G8	Place of living	Individuals living in **rural areas**
G9	Employment status & occupation type	Individuals **employed in semi-skilled and low-skilled occupations**

In general, to reach out and train individuals in the above groups, we need to understand their socio-economic characteristics, needs and contexts, so that outreach actions, communication, content and course design, delivery methods and training courses can be shaped accordingly (in terms of age, educational level, migrant background, etc). Thus **focused and contextual analysis** is required to design effective skilling actions.

Non internet users (10%) require specific attention in an employment context, as research shows that there is correlation between computer use and ICT skills, and between ICT use and employment outcomes. Having any computer experience at all is the most relevant factor for labour market outcomes, even more important than the actual level of digital skills.

In addressing non-internet users, digital skilling actions need to be complemented by the promotion of ICT access and ICT use. These measures need to be supported by an accurate understanding of current barriers to ICT access and use. Those having highest possibility of being in this group are those out of work and aged 45 and above and with low or medium-level education, and those in work with low-level education.

From a socio-economic inclusion perspective, **young people with low level education and NEETs**, would need special attention, not only to improve their direct employability prospects, but also to benefit from other positive impacts on employability that the acquisition of digital skills provides. For example, digital skills contribute to an increase in self-esteem, the ability to look for a job online, the development of other transversal skills such as communication and collaboration as well as increasing the ability to continue studying – of particular relevance to this low-level educated group[101].

Unemployed and **inactive** individuals, not only have less digital skills (55% of those unemployed and 67% of those inactive), but are also excluded from the opportunity to develop their digital skills at work by using digital devices, tools and applications (Eurostat, ICT for work report), possibly complemented by training provided by the employer. On the other hand, digital skills increase individuals' employability, as mentioned above. Promoting ICT use (for non-work activities) is a path towards the development of digital skills, applicable at work, and thus relevant for employability. This could complement specific digital skilling actions addressed to this group, including, for example, skills to search for jobs online effectively.

For this particular group, policy actions may require stronger cooperation with Active Labour Market Policies (ALMP) policies and with education and training actors acting as **labour market intermediaries** (such as social services, public and private employment services and the third sector) to ensure effective outreach, training design and adequate delivery channels. In addition, these actors – who deliver a set of employability-related services – need to be digitally skilled themselves and supported. This is needed to allow them to act effectively in digital (up-)skilling-related functions addressed to unemployed people including an understanding of labour market needs, assessing individual skills, designing a personal learning plan and providing career advising services.

To understand the relevant actions towards **nationals of non-EU countries**, local contextual analyses are required. In addition, specific attention is required in policy design as the major factors affecting proficiency in PSTRE are related to literacy proficiency in the host country language[102], and, thus, it is expected that digital skilling actions addressed to this group would be embedded within migrant integration policy actions that would address host-country language learning[103].

101. Green, A. E., de Hoyos, M., Barnes, S.-A., Owen, D., Baldauf, B. and Behle, H., *Literature Review on Employability, Inclusion and ICT, Report 2: ICT and Employability*, Centeno, C., Stewart, J. (Eds.), JRC Technical Report Series, JRC EUR 25792 EN, Institute for Prospective Technological Studies, Joint Research Centre, European Commission (2013).
102. OECD (2015), *Adults, Computers and Problem Solving: What's the Problem?*, OECD Skills Studies, OECD Publishing, Paris. p.50.
103. COM(2016) 377 final – Action Plan on the integration of third country nationals.

Priority occupations

First, a **job polarisation** is taking place with regards to the use of ICT at work. A large proportion (above 75% according to Eurofound) of those working as agricultural workers, craft workers, plant and machine operators, service and sales workers and in elementary occupations, have not only **never or almost never used ICT in their jobs** in 2015, but also have seen a decrease in ICT use in the period 2010-2015.

These coexist with an increasing number of **workers using ICT at high intensity** as managers, professionals, technicians and clerks. These two groups will have very different experiences of work with potentially profound impacts on career development, occupational mobility and working life.

Therefore, a **dual approach is needed**. On one side, up/reskilling actions are needed to ensure (highly-skilled) individuals in most rapidly changing occupations maintain the necessary skills to do their jobs and **avoid skills obsolescence**. On the other, up/reskilling actions are needed towards those employed in low-skilled occupations, as they do not have the opportunity to use and learn to use ICT, with a view to maintain/develop their **employability**, countering **the polarisation effects**.

In addition, as suggested in the new European Skills Agenda´s 'call for collective action, mobilising business, social partners and stakeholders, to commit to working together, in particular within the EU's industrial eco-systems', there is a need for **regular monitoring of skills needs**, by sector and occupation. Complementary agile and timely development of the **training supply in a lifelong-learning perspective** is also needed, including by formal and non-formal education and training actors. In particular, for those occupations requiring higher education, which are more likely to be affected by the technological change, the implication of high education institutions to address the training needs would be required. Policy actors, employers and education and training actors should reinforce their dialogue and cooperation within local ecosystems which all have complementary roles to play.

In addition, research points to the **opportunity to work towards the definition of the basic digital skills required by the "generic employee"**. This action would require employers´ involvement to ensure occupation-specific digital skills needs are adequately assessed, and related training further developed.

Digital skills gaps across all countries and occupations

The actual **digital skills mismatch of active workers seems limited in a range between 3-11%**, according to the three sources analysed (CEDEFOP, OECD PIAAC and Eurostat). The interpretation of this limited share could be explained by the continued 'learning-by-doing' process that takes place while using technology in the workplace, and complemented by employer training actions for their employees to adapt to the continuous technologies, devices, applications and job tasks following the introduction of new technologies.

Furthermore, digital skills gaps are **relatively homogeneous across countries**, with an independence of the average level of digital skills of individuals in each country. In fact, they reflect the level of unmatched demand generated by the (ongoing) digital transformation of the different sectors, whether in an initial or more advanced phase. The speed at which workers are being provided with the right digital skills in the right locations is frequently slower than the speed at which digital technologies are evolving, generating the skills gap.

Analysis points to a **relevant and rather homogeneous gap for basic/ moderate digital skills between occupations**, ranging from 25% of managers to 35% of building, crafts and related trade workers.

These findings call for an opportunity for **systematic policy actions across countries and across occupations** addressed to employed people, in cooperation with local sectoral employers and training actors for focused and effective skilling actions with adequate training content, design, access and effective enrolment approaches. However, **local (national and regional) contexts need to be analysed** to understand how the local conditions shaped by the levels of digital transformation of the industry and characteristics and digital skills of the population characterise the digital gaps. This analysis needs to involve the enterprise-relevant actors (managers, human resources, staff, etc.)[104] to understand the sectoral trends and needs, and the needs at occupation level.

Research[105] shows that an effective approach to define the digital skills at occupational level consists in defining the digital knowledge, skills and attitudes that a professional must possess to adequately perform the tasks that require the use of digital tools and applications in a given job or occupation category (by using, for example, DigComp as a reference framework). This approach allows the development of specific assessment tools to identify the current or candidate employee´s level of competences in relation to those needed for the job, and the design of adapted training courses to allow the acquisition of defined competences. It is crucial to involve employers (managers and human resources staff) in the definition of the occupational digital profiles for the specific sectors addressed[106].

104. Kluzer, S., Centeno, C. and O´Keeffe, W., *DigComp at Work*, EUR 30166 EN,Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17857-6, doi:10.2760/887815, JRC120376.

105. See in Section S1. Defining competence needs a set of Examples, Actions, Tips and Resources to perform this activity of Centeno, C., *DigComp at Work Implementation Guide*, O'Keeffe, W., editor(s), EUR 30204 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18581-9 (online), doi:10.2760/936769 (online), JRC120645.

106. Ibid.

Employers as a critical target group

The research points to the key role played by the employers and their own level of digital awareness and skills in the digital transformation processes as well as in the skilling role of their employees. There is thus a need to raise awareness among employers of:

- how to strategically address and manage the **digital transformation** in the business processes, addressing market opportunities, cost and competition challenges, etc.;
- the role of digital technologies to support and improve business performance, productivity and internal organisation; and
- **the need for digital skills** as an enabler for this transformation, and as a consequence of the incorporation of new digital technologies in the workplace.

In addition, **financial incentive programmes to small and micro enterprises** would be needed to promote training actions for employees on digital skills.

Supporting research actions

The analysis has pointed to the need for some additional research for the following purposes.

Need for accurate and timely data on digital skills gaps

Policy-relevant statistics are hampered by the current lack of accurate and timely data on the evolution of the digital skills gaps. In particular, there are too many diverging definitions of digital competence, and data are not collected often enough (PIAAC only has one dataset, running from 2012 to 2014; CEDEFOP runs every 5 years, with the most recent data collection in 2014; EWCS every 5 years, with the most recent data collection in 2015). To address these, some complementary actions are suggested, in support of the new European Skills Agenda Action 2.1 'Improving skills intelligence: the foundation for up- and reskilling':

- longer-term work towards understanding the rationale and need for different definitions of digital competence and the opportunity for a closer alignment of digital skills across datasets and organisations covering supply and demand perspectives (Eurostat, OECD, CEDEFOP, Eurofound). For that purpose, the definition provided by the European Digital Competence Framework, DigComp, could be instrumental;
- explore the possibility of carrying out a detailed analysis of digital skills needs per occupation, sector and country/region (using skills needs of Cedefop´s ESJS) and matching these with skills available (from the Eurostat survey). This would allow a clearer view of the digital gaps;
- explore the possibility of incorporating in Eurostat yearly data collection exercises of essential supply and demand data to accurately assess the digital skills gap.

We also need better and more frequent data on the skills required by employers to support balanced and effective policy design in a technology-driven and fast-changing labour market.

Impact of COVID-19

While not covered in this report, as research was carried out prior to the pandemic, it would be advisable to research the impact of COVID-19 on the skills requirements of employers from a shorter- and longer-term perspective, and in particular, those that affect the digital competences needed for remote workers to effectively work from home. An increasing number of employers are declaring their intention to incorporate telework as a common practice[107].

This 'teleworker digital competence profile' would be an initial work supporting the subsequent development of diagnostic tools and training material, adapted to different levels and types of occupations.

The authors would also like to point out that, the impact of COVID-19 on working practices (telework) as well as on other areas of life may have driven many individuals into more frequent and intensive online activities (online schooling, shopping, administration, health), which will have likely changed the landscape of ICT use and related skills in the EU. It is also probable that deeper skills gaps may have appeared among those more distant from ICT access and use. A detailed review of the conclusions of this report will be needed once the next sets of data from different sources are available.

Future outlook perspectives

The following two datasets will be released by mid 2022:

- CEDEFOP's 2nd ESJS, which objective is to collect comparative information from all EU Member States enabling investigation of the impact of digitalisation on workers' skill mismatch and their readiness to adapt to changing skill needs via remedial learning practices. See section 2.4.2 for a detailed description of the 2nd ESJS.
- New Eurostat 2021 household survey.

In the light of the conclusions of this report, a review of these two new datasets would be the natural next step to further analyse the digital skills gap and support the design of digital up/re/skilling strategies, policies and actions, and related research.

107. The Economist, May 2020.

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Annexes

Annex 1. Analysis of priority groups and across-country comparison of Eurostat DSI data, 2019

This Annex 1 provides a detailed analysis of the priority groups presented in Chapter 3, 'Section 3.1 Analysis of Eurostat's Digital Skills Indicator (DSI)'.

The following Table A1.1 provides the average values for the EU-28 in 2019 for the % of individuals with below-basic digital skills for some socio-demographic variables. Those values marked in red are at least 5 percentage points above the average EU-28 value for the reference group (either individuals of 25-64 years old or young people of 16-24 years old).

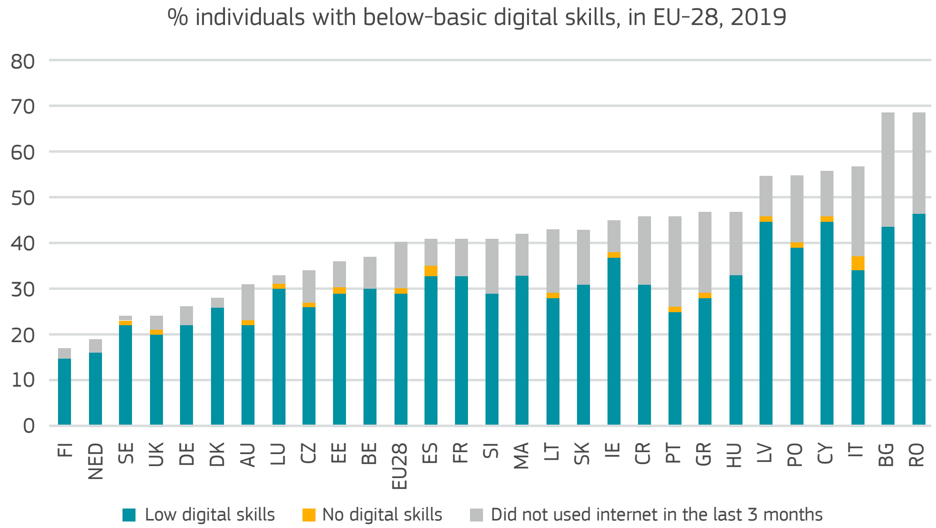
Table A1.1 Analysis of % of individuals with below-basic digital skills

Individuals		% individuals with **no digital skills**	% individuals with **low digital skills**	Total % of individuals with **below-basic digital skills (sum of ´no skills´ and ´low skills')** (Red: 5 pp above average of reference group - see in text)	Group reference for later analysis
Individual 25-64 (used as **reference group**)		**11**	**29**	**40**	
Age	16 to 24 years old	2	16	18	
	25 to 64 years old	11	29	40	
	45 to 54 years old	11	32	43	
	55 to 64 years old	23	35	58	G2
Young 16-24 per **education level**	*All young 16-24 years old*	2	16	18	
	With low-level education	4	20	24	G1
	With medium-level formal education	1	15	16	
	With higher formal education	1	6	7	
Aged 25-64 per **education level**	*With low-level education*	30	46	76	G3
	With medium-level formal education	10	35	45	G4
	With higher formal education	1	11	12	
Aged 25-64 **Employment status**	Employees, self-employed, family workers	6	26	32	
	Unemployed	21	36	57	G5
	Retired or other inactive	27	40	67	G6

Individuals		% individuals with **no digital skills**	% individuals with **low digital skills**	Total % of individuals with **below-basic digital skills (sum of ´no skills´ and ´low skills')** (Red: 5 pp above average of reference group - see in text)	Group reference for later analysis
Aged 25-64 in **urban / rural areas**	Living in cities	11	25	36	
	Living in towns and suburbs	14	28	42	
	Living in rural areas	19	32	51	G8
Aged 25-64 **Nationality**	Nationals	14	27	41	
	Nationals of a non-EU country	20	44	64	G7
Aged 25-64 **Income**	First quartile	27	33	60	I1
	Second quartile	17	34	51	I2
	Third quartile	10	30	40	
	Fourth quartile	5	20	25	

Figures A1.0 to A1.10 below provide an **analysis per country** of the different groups with below-basic digital skills. As expected, it shows huge country differences for each of the priority groups. This means that, although the socio-demographic characteristics of priority groups may be relevant in most of the countries, their **relative priority would vary according to each country's context**.

Figure A1.1. % of individuals 25-64 years old with below-basic digital skills, per country (reference group), in EU-28, 2019

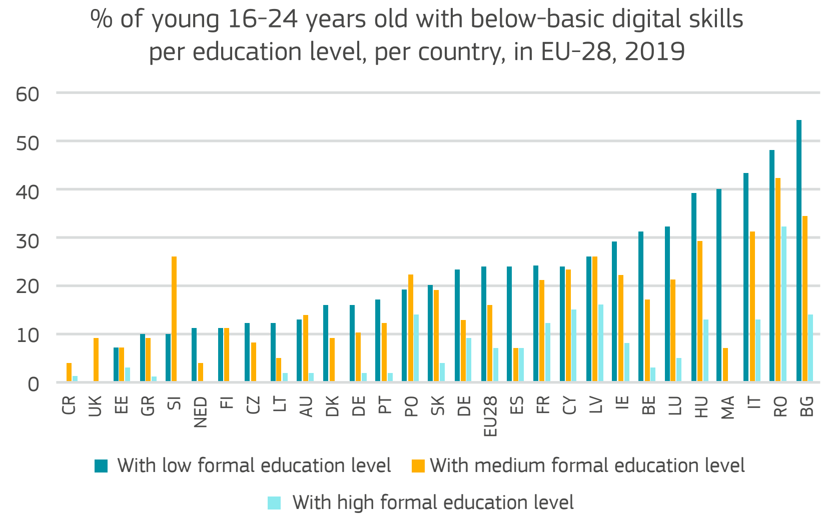


Source: Authors´ own analysis of Eurostat survey data for 2019.

An initial analysis of the share **of individuals 25-64 years old with below-basic digital skills** with a differentiation in the **three categories** (those who have low digital skills, those with no digital skills and those who could not be assessed because they did not use the internet in the last 3 months) shows that there is an EU-28 average of **10% of individuals who did not use the internet in the last 3 months**, varying from 1-2% in Sweden, Finland, Denmark and Luxembourg to 20-25% in Portugal, Italy, Romania and Bulgaria.

Figure A1.2. % of young 16-24 years old with below-basic digital skills, per education level, per country, in EU-28, 2019

G1 Young 16-24 years old with <u>low-/medium-education</u> level

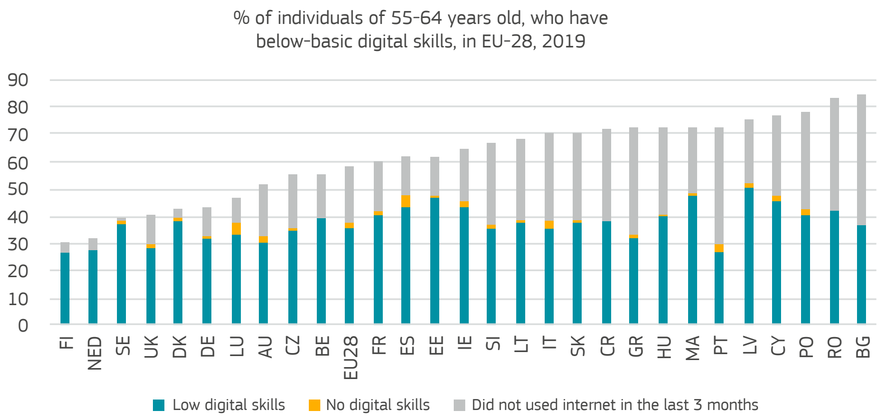


Source: Authors´ own analysis of Eurostat survey data for2019.

Although the average **percentage of young people with below-basic digital skills** is small compared to the reference population (25-64 years old), i.e. 18% compared to 40%, a more detailed analysis of this young group shows that 24% of **young people with low-level education** have below-basic digital skills with huge country differences of up to 54%. In a number of countries, there is also a significant share of young people with a medium level of formal education who have below-basic digital skills, with an EU-28 average of 16%, up to more than 40% in Romania.

Figure A1.3. % of individuals 55-64 years old with below-basic digital skills, per country, in EU-28, 2019

G2 Individuals of 55-64 years old



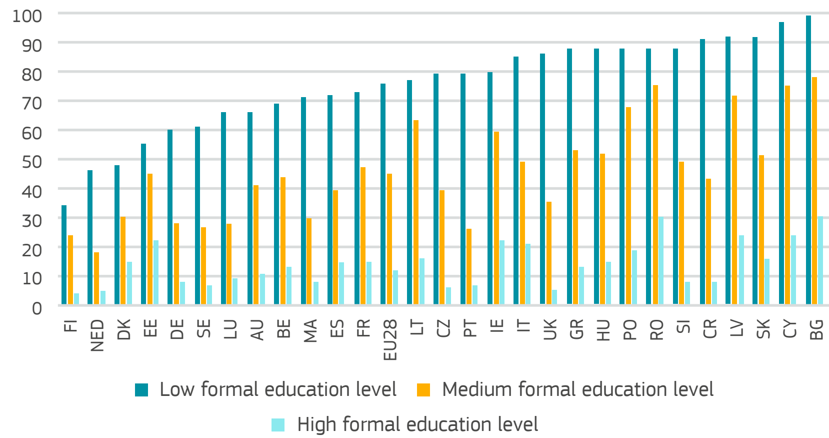
Source: Authors´ own analysis of Eurostat survey data for 2019.

The **analysis across countries** of individuals of 55-64 years old with below-basic digital skills shows a worrying 30% (in Finland and the Netherlands) to above 80% in Romania and Bulgaria, with an EU-28 average of 58%.

While the percentage of individuals with low digital skills is fairly homogeneous across countries, varying from 26-27% in Finland, Portugal and the Netherlands to 43-47% in Ireland, Cyprus, Estonia and Malta, the **percentage of individuals who did not use the internet in the last 3 months** shows more marked differences, varying from 1-4% in Sweden, Denmark, Finland and the Netherlands, to 42% in Romania and 48% in Bulgaria, with an average of 21% for the EU-28.

Figure A1.4. Individuals 25-64 years old with below-basic digital skills, per education level, per country, in EU-28, 2019 (ordered by % of individuals with low formal education level)

G3 Individuals 25-64 years old with low formal education level

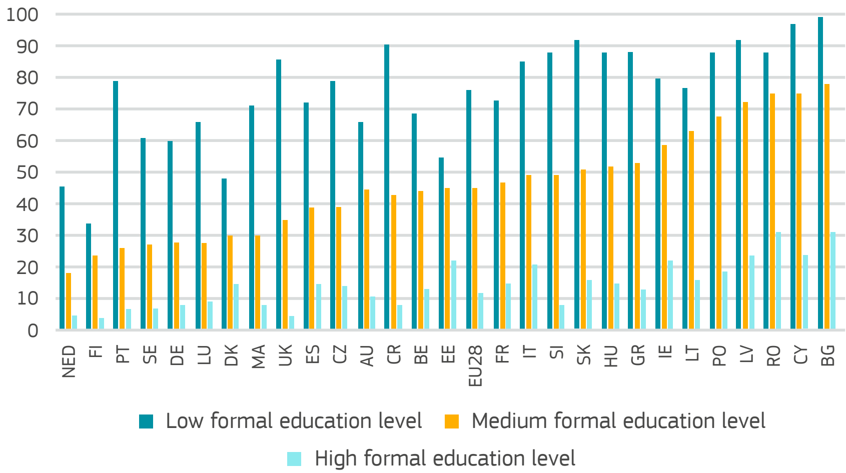


Source: Authors´ own analysis of Eurostat survey data for 2019.

The EU-28 average **at 76% of individuals of 25-64 years old with low-level formal education** that have below-basic digital skills calls for clear policy attention adressed to this target group. Furthermore, the analysis across countries shows that this group **needs attention in all countries**, as, except for Finland (with 34%), in all the countries the share ranges from 46% in the Netherlands up to 97% and 99% (in Cyprus and Bulgaria). The gap between the share of low-level formally educated individuals and the percentage of higher formally educated individuals with below-basic digital skills is huge, varying from 30% in Finland to 81% in the UK. The average gap in the EU between individuals with low and high education levels is 64%.

Figure A1.5. Individuals 25-64 years old with below-basic digital skills, per education level, per country, in EU-28, 2019 (ordered by % of individuals with medium formal education level)

G4 Individuals 25-64 years old with <u>medium formal education</u> level



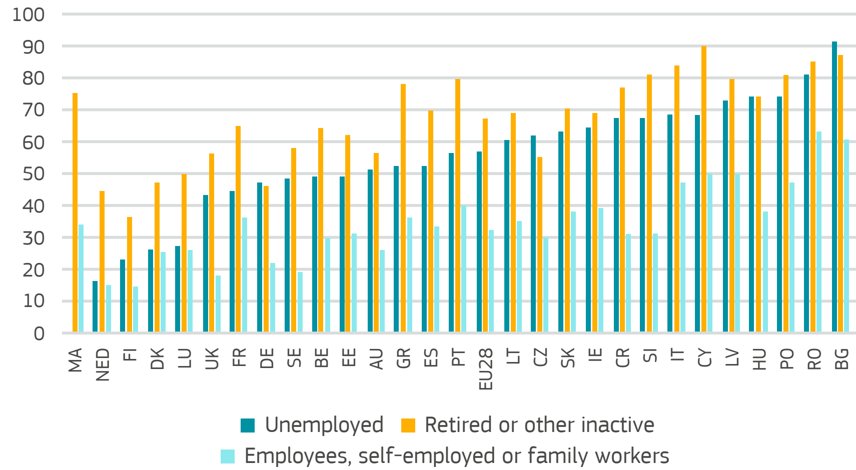
Source: Authors´ own analysis of Eurostat survey data for 2019.

The analysis of **individuals with a medium formal education level** with below-basic digital skills shows a very different situation between countries, with nevertheless a somewhat 20% improvement compared to individuals with a low formal education level. The share ranges from 18% in the Netherlands and 24% in Finland to 75% in Romania and Cyprus and 78% in Bulgaria, with an **EU-28 average of 45%**.

The gap between the share of individuals with a medium formal education level with below-basic digital skills and those with a higher formal education level varies significantly between countries between 13% in the Netherlands and 49% in Poland and 51% in Cyprus. The average gap in the EU-28 is 33%.

Figure A1.6. % of individuals 25-64 years old with below-basic digital skills, per employment status, per country, in EU-28, 2019 (ordered by % of individuals unemployed)

G5, G6 25-64 years old, unemployed & inactive

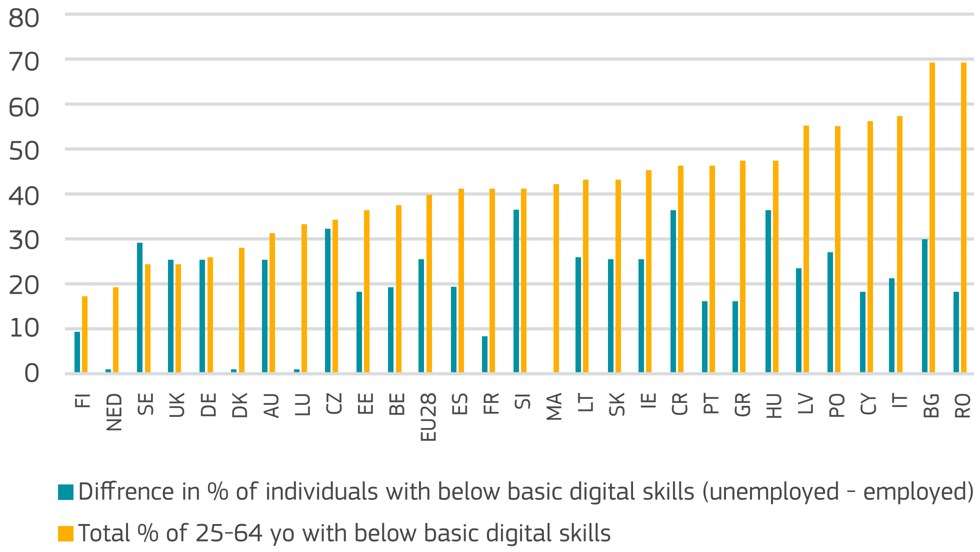


Source: Authors´ own analysis of Eurostat survey data for 2019.

A range between 16% (in the Netherlands) and above 90% (in Bulgaria) of individuals unemployed have below-basic digital skills, with an EU average of 57%. The differences between countries are huge.

For those retired or inactive due to other reasons, the share of individuals' below-basic digital skills increases, with an EU-28 average of 67% (10 percentage points higher than for the previous group), ranging from 36% in Finland to close to 90% in Cyprus and Bulgaria.

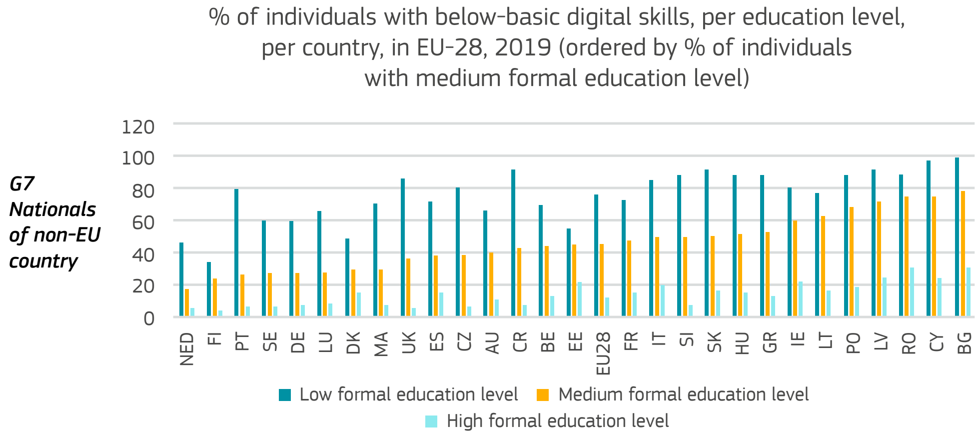
Figure A1.7. Analysis of % gap (unemployed-employed) of individuals 25-64 years old with below-basic digital skills, per country, in EU-28, 2019



Source: Authors´ own analysis of Eurostat survey data for 2019.

On average, across EU-28 MS (excluding Malta), **the percentage gap for individuals' below-basic digital skills between those unemployed and those employed is 21%**, ranging from close to 0% in the Netherlands, Luxemburg, Denmark and Malta, to 36% in Hungary.

Figure A1.8. Individuals 25-64 years old with below-basic digital skills, per nationality, per country, in EU-28, 2019

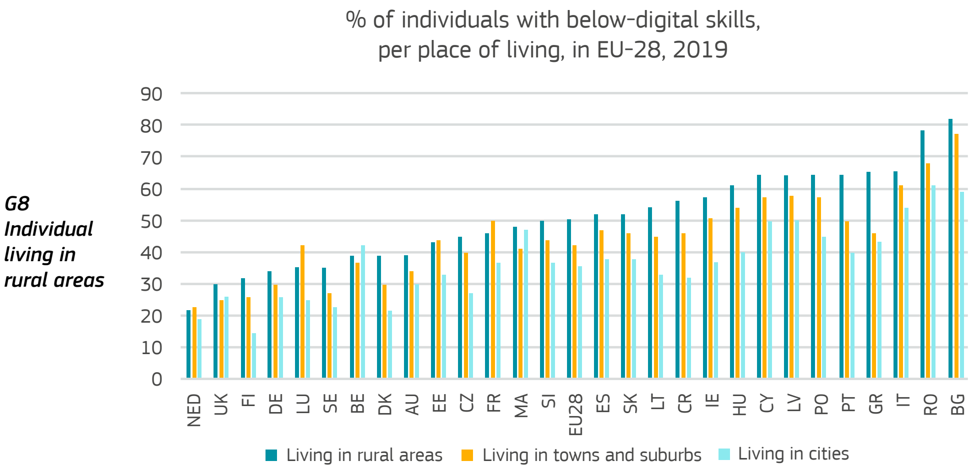


Source: Authors´ own analysis of Eurostat survey data for 2019.

On average, for those countries where data is available (missing data for Bulgaria, Croatia, Hungary, Slovakia and the UK), **64% of nationals of non-EU countries** have below-basic digital skills, with a 23-percentage-point difference with national individuals.

However, data shows unclear patterns across countries, showing that, in some cases, non-EU nationals have a similar or lower probability of having below-basic digital skills. Additional country and contextual analysis would be needed to better identify the (non-EU nationals') target groups requiring skilling actions.

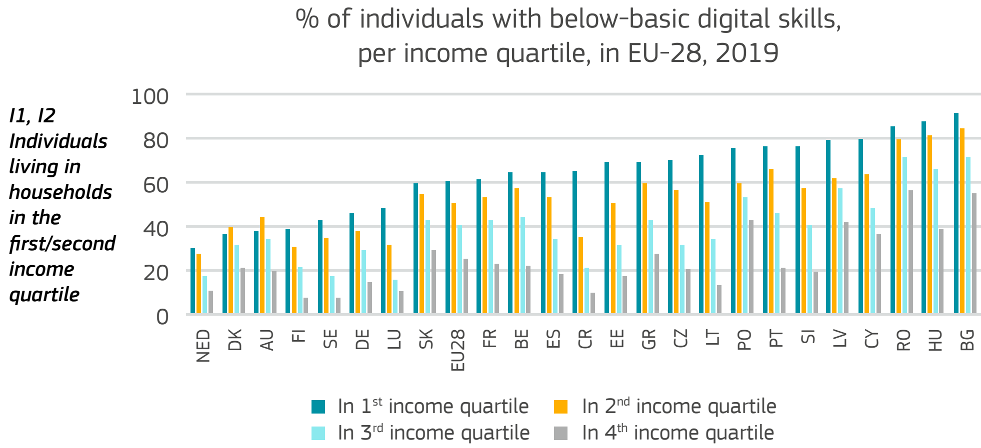
Figure A1.9. Individuals 25-64 years old with below-basic digital skills, per place of living, per country, in EU-28, 2019



Source: Authors´ own analysis of Eurostat survey data for 2019.

Except for Belgium, there is a **consistent gap between the share of individuals living in rural areas with below-basic digital skills and the share of those living in cities**, ranging from 1% in Malta to 23-24% in Bulgaria, Croatia and Portugal, with **an average gap of 14%** across the 28 EU MS.

Figure A1.10. Individuals 25-64 years old with below-basic digital skills, per income quartile, per country, in EU-28, 2019



Source: Authors´ own analysis of Eurostat survey data for 2019.

On average, across the EU-28, the share of individuals with below-basic digital **skills in households in first and second income quartiles** are 60% and 51%, respectively.

While consistent across countries, the **gap between the percentage of individuals in households in first and second income quartiles with below-basic digital skills and those in other quartiles** shows considerable differences. The gap between the first and fourth quartiles ranges from 15% in Denmark to 59% in Lithuania, with an average value of 40% in the EU-28. The gap between the second and the fourth quartile ranges from 17% in the Netherlands and Poland to 45% in Portugal.

Annex 2. Details of the JRC analysis of the OECD PIAAC Adult Skills Survey

Some detailed analyses of the OECD PIAAC Adult Skills Survey are presented in this annex, focusing on EU countries of both the first (2012) and second (2014) rounds. The 15 EU-28 countries included in the analysis are: Austria, Belgium (Flanders), Czech Republic, Denmark, Estonia, Finland, Germany, Ireland, the Netherlands, Poland, the Slovak Republic, Sweden (2012), Greece, Lithuania and Slovenia (2014).

Regression analysis on the probability of having no computer experience

Table A2.1. Marginal effects on the probability of having no computer experience

	(1)	(2)
	Whole sample	Only people in work
Y=1: No computer experience	0.125	0.072
Female	0.005	-0.003
	(0.003)	(0.004)
Age groups: 16-24 = baseline		
25-34	0.038***	0.016***
	(0.003)	(0.003)
35-44	0.098***	0.048***
	(0.004)	(0.004)
45-54	0.188***	0.101***
	(0.004)	(0.004)
55 plus	0.269***	0.167***
	(0.005)	(0.007)
Migrant	0.041***	0.035***
	(0.005)	(0.006)
Education: below high school = baseline		
High school	-0.160***	-0.129***
	(0.005)	(0.008)
Above high school	-0.234***	-0.184***
	(0.005)	(0.008)
Single	0.017***	0.014***
	(0.003)	(0.004)
In work	-0.050***	
	(0.004)	
NEET (age 16-34)	0.025*	
	(0.013)	

	(1)	(2)
	Whole sample	Only people in work
Y=1: No computer experience	0.125	0.072
Contract type: permanent = baseline		
Fixed-term		0.022***
		(0.006)
Other (temp-agency / apprenticeship / no contract)		0.031***
		(0.009)
Firm size: 1-10 = Baseline		
11 to 50 people		-0.007
		(0.005)
51 to 250 people		-0.019***
		(0.005)
251 to 1 000 people		-0.036***
		(0.005)
more than 1 000 people		-0.050***
		(0.007)
Economic sector: private = baseline		
Public sector		-0.016***
		(0.004)
Non-profit		-0.004***
		(0.013)
Country-fixed effects	YES	YES
Pseudo R^2	0.2581	0.3161
Obs.	114 986	59 126

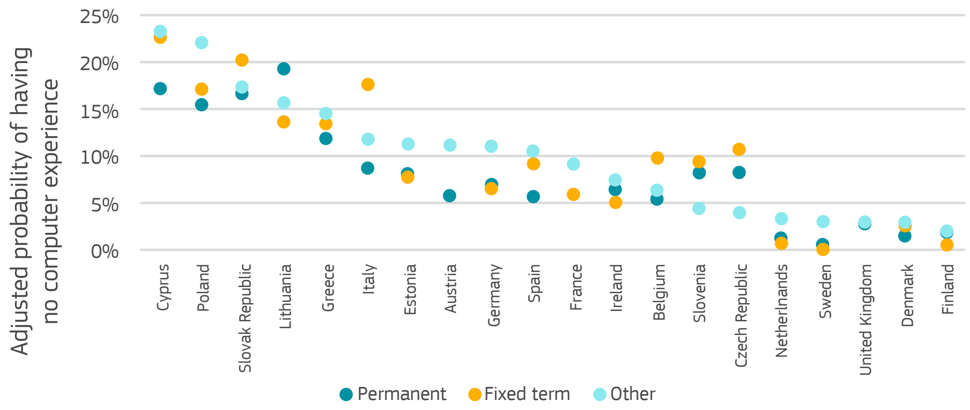
Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Analysis of the relation of economic sector, contract type and size of firm with computer experience

If we focus on the sub-sample of workers, we find that the economic sector (public, private or non-profit), the type of contract a person has and the size of the firm in which they work are often significantly associated with a lack of computer experience, but with a few differences.

The **average impact of contract types is fairly small**. For instance, workers with a fixed-term contract are 2.2 percentage points more likely to lack computer experience than those on permanent contracts, while workers with no contracts or other types of contract (including agency work, apprenticeships and so on) are 3.1 percentage points more likely to lack computer experience than those on permanent contracts. However, the relationship between type of contract and computer experience varies between countries, as shown in Figure A2.1. While it would seem that for the majority of countries the probability of having no computer experience is lower for those who have a permanent contract, and higher for those who have fixed-term contracts or no contract at all, this is not always the case. For instance, in Lithuania, respondents with a permanent contract are more likely to say that they have no computer experience; in Italy, people on fixed-term contracts are nearly twice as likely not to have computer experience as those on permanent contracts; while in Slovenia or the Czech Republic, respondents with no employment contracts are actually less likely to lack computer experience than those on permanent contracts.

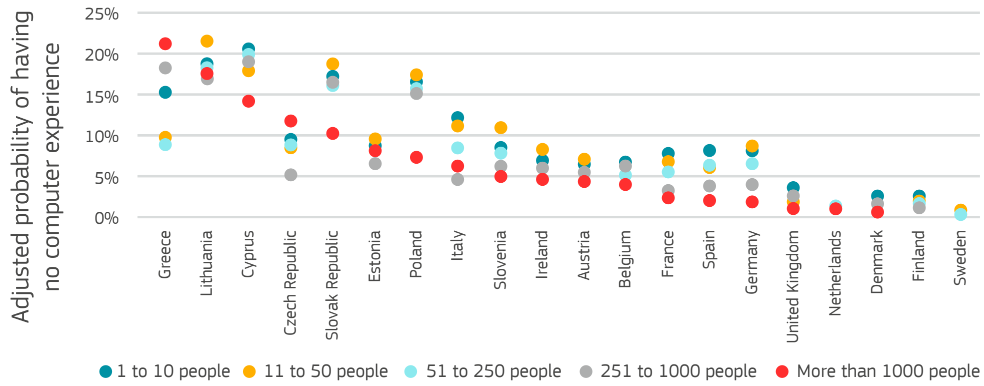
Figure A2.1. Adjusted probability of having no computer experience – by country and type of contract



Source: Own elaborations using PIIAC data; chart shows marginal effect after probit regression where having no computer experience is the dependent variable and contract type is interacted with country dummies. Other control variables include: gender (being female); age (in 5 categories, where age 16-24 is the baseline); migrant status; education (high, medium, low, where low is the baseline); being single; and firm size (5 categories, size 1-10 is the baseline).

Employees working for **larger firms** are significantly less likely to lack computer experience, but even in this case the impact is fairly small. On average, respondents who work in a firm with more than 1 000 employees are 5 percentage points less likely to lack computer experience than those employed in micro firms (1-10), whereas the difference between micro firms (1-10) and small/medium firms (11-50) is not statistically significant. The only country in which workers in large firms are significantly more likely to lack computer experience than workers in smaller firms is Greece, as shown in Figure A2.2. In contrast, Poland is the country in which workers in larger firms are by far less likely to lack computer experience, compared to workers in smaller firms (-9.2 percentage points).

Figure A2.2. Adjusted probability of having no computer experience – by country and firm size



Source: Own elaborations using PIIAC data; chart shows marginal effect after probit regression where having no computer experience is the dependent variable and firm size is interacted with country dummies. Other control variables include: gender (being female); age (in 5 categories, where age 16-24 is the baseline); migrant status; education (high, medium, low, where low is the baseline); being single; and firm size (5 categories, size 1-10 is the baseline).

Lastly, **public-sector** employees are 1.6 percentage points less likely to lack computer experience than private-sector employees, whereas being employed in the non-profit sector makes no difference.

Table A2.1. Dependent variable = log of PSTRE score

	PSTRE score	PSTRE score
	(1)	(2)
VARIABLES	(all sample)	(workers only)
Female	-6.509***	-6.273***
	(0.274)	(0.359)
Age groups: 16-24 = baseline		
25-34	-11.033***	-2.461***
	(0.464)	(0.687)
35-44	-21.261***	-12.118***
	(0.504)	(0.683)
45-54	-34.174***	-24.900***
	(0.505)	(0.686)
55 plus	-48.282***	-37.117***
	(0.490)	(0.759)
Migrant	-14.464***	-15.098***
	(0.583)	(0.717)
Education: below high school = baseline		
High school	14.779***	17.883***
	(0.426)	(0.739)
Above high school	38.037***	42.283***
	(0.450)	(0.723)
Single / widowed / divorced	0.850***	-0.497
	(0.314)	(0.404)
In work	-2.043***	
	(0.337)	
NEET (age 16-34)	-19.631***	
	(0.958)	

	PSTRE score	PSTRE score
	(1)	(2)
VARIABLES	(all sample)	(workers only)
Contract type: permanent = baseline		
Fixed-term		-2.131***
		(0.567)
Other (temp-agency / apprenticeship / no contract)		-0.174
		(0.850)
Firm size: 1-10 = Baseline		
11 to 50 people		1.815***
		(0.509)
51 to 250 people		4.507***
		(0.508)
251 to 1 000 people		8.078***
		(0.592)
more than 1 000 people		9.970***
		(0.689)
Economic sector: private = baseline		
Public sector		-3.658***
		(0.387)
Non-profit		2.225**
		(1.025)
Country-fixed effects	YES	YES
Constant	290.849***	274.651***
	(0.693)	(1.070)
Observations	71 580	40 057
Adj. R-squared	0.269	0.273

Bootstrapped standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

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